CHAPTER 3: EXISTING CONDITION AND ENVIRONMENTAL EFFECTS

Chapter 3 presents relevant resource components of the existing environment – that is the baseline environment, and describes the environmental effects of the various alternatives to those resources. It is organized into the following sections:

Fire / Fuels
Vegetation
Wildlife
Fisheries and Aquatic Resources
Hydrology
Soils
Roadless
Scenery
Recreation
Minerals
Lands
Air Quality
Heritage Resources
Unroaded Analysis
Roads Analysis
Social Analysis
Economic Analysis

FIRE AND FUELS

ANALYSIS AREA

The analysis area boundary for disclosing the effects of fire and fuels includes the Basin Creek watershed and extends approximately 1.5 miles east to include the Roosevelt Drive subdivision. The area is bordered on the south and west by the Continental Divide and on the north by private land (Appendix B, Map 7). The Basin Creek watershed contains Butte's municipal watershed, consisting of two reservoirs located on Basin Creek. The project file provides detailed documentation of individual stand conditions and the process used for selection of representative stands used in analyzing the project area. Information sources included stand records and field surveys conducted in the 1980s as well as field review conducted in 2002 and 2003.

REGULATORY FRAMEWORK

Deerlodge Forest Plan

The management response for wildland fires under the existing Deerlodge Forest Plan requires that fires be suppressed (excluding wilderness areas covered under an approved Fire Management Guide or Plan) using the appropriate suppression response. Suppression strategies on the Deerlodge National Forest include confine, contain, and/or control of wildland fire. Prescribed fire can be used for the enhancement and maintenance of big game forage, livestock forage, and the timber resource, and for the disposal of activity created slash. In the Research Natural Area, wildfire will be suppressed unless the Intermountain Research Station Director and Forest approve the burning of natural or human ignited fires. The Beaverhead-Deerlodge National Forest Plans are currently under revision, so this analysis reflects direction given in the existing Deerlodge Forest Plan.

Federal Wildland Fire Policy and Program Review

In 1995, the Federal Wildland Fire Policy and Program Review was initiated (USDI/USDA et al 1995). The principles of this review include the following: 1.) firefighter and public safety are the first priority; 2.) wildland fire is an essential ecological process and natural change agent; and 3.) fire management plans must be based on the best available science. This policy contains direction to allow wildland fire use and prescribed fire to restore fire's natural role in appropriate areas where approved plans are in place. A full range of wildland fire management responses is available in the Deerlodge Forest Plan and fire management plan, including wildland fire use for resource benefits allowed in the Anaconda-Pintler Wilderness area. Such wildland fire use fires are managed under the 1995 Federal Wildland Fire Policy (USDI/USDA et al 1995a) and the 1998 Wildland and Prescribed Fire Management Policy Implementation Procedures Reference Guide (USDI/USDA 1998). It is anticipated that over time more areas of the forest will have approved fire management plans that will allow a wider range of fire management options.

National Fire Plan

The National Fire Plan provides national direction for hazardous fuels reduction, restoration, rehabilitation, monitoring, applied research and technology transfer and established the framework for a 10-Year

Comprehensive Strategy. This project is responsive to the hazardous fuels reduction and restoration portion of the National Fire Plan.

AFFECTED ENVIRONMENT

Introduction

Essentially all operable ground in the Basin Creek analysis area was harvested, and then slashed and burned, during the mid to late 1800s to support Butte's mining activities. Today, most of the area contains 100 year-old lodgepole pine stands with little surface fuel. Harvest did not occur on steep and rocky terrain that contains a mix of Douglas-fir and lodgepole pine with dead and downed woody material. In these areas, fuel accumulations are as high as 35 tons/acre. Previous fires stayed small and were generally lightning-caused. A mountain pine beetle epidemic is currently killing large numbers of lodgepole pine greater than 5 inches in diameter at breast height (DBH), creating large amounts of standing snags and a future accumulation of dead and down woody debris, both of which pose a safety hazard to firefighters while engaged in fire suppression activities. These future heavy fuel accumulations and areas with high potential for crown fire pose a resistance to control to firefighters in the event of a wildland fire.

Fuel accumulations, also referred to as fuel loading, and crown fire hazard rating are the primary measurement indices used to address the existing and future hazardous fuels situations within the analysis area.

Other elements of the fire and fuels situation discussed in this chapter include a description of the wildland/urban interface, and detailed explanations of the fire ecology, fire behavior, and fire effects within the analysis area.

The Wildland Urban Interface

The Federal Register, January 4, 2001, describes the three categories of wildland/urban interface (WUI) considered in the National Fire Plan.

Category 1: Interface Community

The Interface Community exists where structures directly abut wildland fuels. There is a clear demarcation between residential, business, and public structures and wildland fuels. Wildland fuels do not generally continue into the developed area. The development density for an interface community is usually three or more structures per acre, with shared municipal services. Fire protection is generally provided by a local government fire department with the responsibility to protect the structure from both an interior and an advancing wildland fire.

Category 2: Intermix Community

The Intermix Community exists where structures are scattered throughout a wildland area. There is no clear line of demarcation; wildland fuels are continuous outside of and within the developed area. The development density in the intermix community ranges from structures very close together to one structure

per 40 acres. Fire protection districts funded by various taxing authorities normally provide life and property fire protection and may also have wildland fire protection responsibilities.

Category 3: Occluded Community

The Occluded Community generally exists in a situation, often within a city, where structures abut an island of wildland fuels (e.g. park or open space). There is a clear line of demarcation between structures and wildland fuels. The development density for an occluded community is usually similar to those found in the interface community, but the occluded area is usually less than 1,000 acres in size.

The Basin Creek analysis area falls into Category 2: Intermix Community. This includes permanent and summer residences on Roosevelt Drive, in Herman Gulch, China Gulch, and Basin Creek, and other values such as timber production areas, Butte's municipal watershed, and numerous outbuildings and other structures. These areas encompass not only the sites themselves, but also the continuous slopes and fuels that lead directly to the sites. When wildland fire enters these areas the suppression efforts require a large commitment of firefighting resources. During the fires of 2000, large portions of otherwise high priority fires remained un-staffed because resources were committed to structure protection. Experienced fire managers know that the intermix area is one of the most dangerous environments in which to conduct fire suppression operations. Poor ingress and egress compromise firefighters' escape routes. Hazardous materials and other manmade materials produce toxic gases when burned and pose significant threat to firefighters and the public. The high values at risk (homes, vehicles, domestic animals, etc) can lead even the most seasoned wildland firefighters to take risks that he or she would not consider in the wildland environment.

Recent research (Cohen 2000a) addresses home ignitibility, or the potential for a home to ignite, in the WUI. Cohen concludes that homes ignite via one of two processes, direct flame contact with the structure and lofted firebrands landing on a receptive fuel (house). The Structure Ignition Assessment Model (SIAM), developed by Cohen (Cohen 1995), and results from the International Crown Fire Modeling Experiment (Alexander et al 1998) generally concur that a flaming front at a distance of 40 meters or more from a structure does not deliver sufficient heat energy to ignite the exterior of a home. However, lofted firebrands are also a principle ignition factor, and in the 2000 Cerro Grande Fire in New Mexico, surface fires ignited homes while leaving green needles on trees around the home (Cohen 2000b). Homes can ignite without fire spreading near the structure, when firebrands are lofted downwind from fires. The firebrands collect on and ignite flammable home materials (such as roofs) and adjacent flammables (such as woodpiles, decking, or landscaped vegetation). Firebrands that result in ignitions can originate from fires at a distance of 1 kilometer or more (Cohen 2000a). Cohen concludes, "Because homeowners typically assert their authority for the home and its immediate surroundings, the responsibility for effectively reducing home ignitability can only reside with the property owner rather than wildland agencies."

The above-cited research exclusively addresses home ignitibility, and not some of the other issues and problems faced by resource managers, fire professionals and residents when considering fire in the WUI. When fire enters the WUI there remains the potential for loss of life, property and other values even if homes have been made fire safe. The number of property owners who would take the responsibility to reduce the ignitibility of their homes and maintain that condition over the ensuing decades is uncertain. There also exists the potential loss of vehicles, other structures, domestic animals, and infrastructure (roads, utility lines, water supply, etc.). When fire enters areas adjacent to private land, there is high probability that firefighting resources will be deployed and members of the public may be exposed to the above-mentioned hazards even if all homes have been made fire safe. Many homeowners would likely find

it undesirable to live in an intensely or severely burned forest even if their home has survived the passage of fire. Not only are aesthetic values decreased for most people, but the risk of flooding and landslides can put homes and lives at risk during subsequent precipitation events.

The increased risk of major economic and resource losses due to fire was very evident during the 2000 fire season. For example, on the Valley Complex Fires in the Bitterroot Valley, almost every fire within the main Bitterroot River drainage affected, or had the potential to affect, the wildland/urban interface area. This included many residences that were in heavily wooded areas and were relatively remote. No zoning or building restrictions currently exist in Silver Bow County that would limit fire hazard around homes in the analysis area. Bridges with low weight capacities and narrow roads that lack turnarounds can limit emergency vehicle access to homes and limit escape routes. Firefighters experience difficulty in reaching and successfully protecting homes surrounded by thick forest. Even if firefighters can access property, they often cannot remain on site due to the extreme fire behavior and intense heat caused by heavy fuel loadings adjacent to the buildings. In addition, greater human use of the intermix area leads to a higher incidence of human-caused fire starts, and a greater risk that fires originating on private land will spread to National Forest land.

Because of the problems and complexities associated with the Intermix Community, resource managers and fire managers find it desirable to exclude, to the extent possible, wildland fire from these areas, and prefer to use prescribed fire to manage fuels; however, sociopolitical constraints may preclude or limit its implementation (Kalabokidis and Omi 1998, DellaSalla et al 1995). Limitations include public attitudes toward smoke, fear of escaped fire, and potential negative visual effects of burns. Mechanical treatment of fuels is often necessary to provide for firefighter safety and minimize future loss of property and natural resources. Hazardous fuel situations (woody fuels less than 3” diameter and fine fuels) can be proactively managed before wildland fires occur, and such practices can effectively decrease fire spread, resistance to control, and resource impacts (Kalabokidis and Omi 1998, Pollet and Omi 1999). Fuel treatments in and near the Intermix Community also serve to protect National Forest lands from the risk of wildland fire spreading from private property.

Fire Ecology

Prior to human settlement of the area, fire was historically the dominant agent of change and filled a very important role in Rocky Mountain ecosystems. Fires are natural modifiers of the vegetation, sometimes killing all trees and above-ground parts of vegetation (high intensity, lethal fire), and sometimes killing only smaller trees or no trees at all and only burning understory grasses and shrubs (low intensity, non-lethal fire). Fire releases nutrients to soils and streams. They affect the amount of dead, woody debris and snags on a site, and soil moisture and stream-flows because they change the amount of precipitation available for runoff, overland flow, and ground water accumulation. Sometimes fires consume forest floor organic soil layers and are followed with hard rains before soil conditions recover. This can cause the watershed-forming processes of erosion, altering hill-slopes and stream channels.

Following is a summary of fire ecology and the interrelationship of vegetation with fire for the sites characteristic of the Basin Creek Fuels Analysis Area. It is important to understand this vital relationship to assess the current health of the ecosystem and the potential effect of our actions.

Data gathered throughout the Beaverhead National Forest in a fire history study conducted from 1992-1994 (Barrett, 1997) contains historical fire frequency information by fire groups. Fire groups are defined as the dominant tree species and associated vegetation that responds in a similar fashion to fire. The frequency

and severity of a fire that typically occurred are key factors in identifying each fire group. General fire intervals were determined by cutting cross sections of tree bases and analyzing fire scars from sample trees in different fire groups. Finding trees with complete scar records in the analysis area was difficult due to extensive logging in the late 1800s. Ages of sample trees ranged from 165 to 300 years old. Table 3.3 below and the information that follows describe the fire groups and habitat types within the Basin Creek fuels analysis area, and Map 10 depicts the Fire Groups present in the fuels analysis area.

Table 3.3: Fire Groups within the Basin Creek Fuels Analysis Area (refer to Fisher and Clayton 1983 for more detailed information on fire groups)

Fire Group	Description of Group	Acreage totals by fire group
0	A miscellaneous, heterogeneous collection of special habitats	848
4	Warm, dry Douglas-fir habitat types. Low to mid elevation sites	567
5	Cool, dry Douglas-fir habitat types	265
6	Moist Douglas-fir habitat types. Low to mid elevation sites	9824
7	Cool habitat types usually dominated by lodgepole pine	1058
10	Cold, moist upper subalpine and timberline habitat types	1120
		Total Acres: 14, 319

Fire Group Zero

Group Zero is a miscellaneous collection of habitats that do not fit into the Montana habitat type classifications.

Group Zero will not burn readily under normal summertime conditions. Fire managers can take advantage of this fact when developing pre-attack plans and when delineating fire management areas, units, or zones. These sites can also serve as anchor points and safety zones for fuel breaks during prescribed burning and wildland fire suppression.

Scree refers to slopes covered with loose rock fragments, usually lying near the maximum possible angle of repose so that any disturbance causes minor rock slides down the face of the slope. Scree slopes may be treeless or they may support scattered trees with sparse undergrowth. The discontinuous fuel often makes scree slopes unburnable.

Forested rock is usually a steep canyon wall or mountainside composed of rock outcrops, cliffs, and occasional clumps of trees clinging to ledges and crevices. Surface fires do not burn well because of the vertical and horizontal discontinuity of ground fuels. The probability of crown fires depends on the density and arrangement of trees on the rock face.

A wet meadow is an opening in the forest that is characterized by herbaceous vegetation and abundant water. Sub-irrigation is common during at least some part of the growing season. Mountain meadows are frequently too wet to burn during the fire season. In midsummer, wet meadows often act as natural firebreaks, but during the late summer and early fall they may carry grass fires. In some situations, especially when meadows are dominated by grass, they may burn in early spring following snowmelt and prior to green up.

Fire Group Four

Group Four consists of Douglas-fir habitat types where ponderosa pine usually occurs as a major seral or climax species; however, due to the high elevation and cold climate of Butte, ponderosa pine is rarely found. In the Douglas-fir climax series types, naturally occurring fire will maintain grasslands and open stands of Douglas-fir. Fire suppression over the last 80-120 years has increased the density in once open Douglas-fir stands and encouraged the succession of sage/grassland parks to contain Douglas-fir saplings.

Ages of sample trees range from 165-300 years old. Mean fire intervals in the Douglas-fir/grassland zone was 47 years. Intervals ranged from 23 to 65 years. Approximate fire years were in 1699, 1726, 1762, 1798, 1827, 1852, 1895 and 1918 (Barrett 1997). The resulting intervals are probably an overestimation of the average time between fires. This can be expected because some fires failed to scar sample trees or subsequent fires have burned them off. Fires on the driest sites probably went undetected because sparse fuels and old growth trees were often confined to rocky outcrops. This coincides with a study of fire history at the forest/grassland ecotone in southwest Montana by Arno and Gruell (1983). They found mean fire intervals (MFI) to be between 41 and 45 years. They also estimated that at least one fire was missed at each site, resulting in a MFI of about 35 years. Historic fire played a role in keeping Douglas-fir stands open by burning the seedlings, saplings, and thin-barked pole-sized trees. Ignitions were both from lightning and Native Americans who used fire to signal, drive game, route enemies, and green-up pastures (Barrett 1980).

Fire Group Five

Group Five habitat types support Douglas-fir stands even under the influence of periodic fire. Douglas-fir is the indicated climax species on these sites, but shares them with lodgepole pine. Under historic conditions, fire occurred less frequently within Group 5 than it did in Fire Group 4. The relatively light fuel loads, sparse undergrowth, and generally open nature of the stands would appear to favor long fire-free intervals. However, Arno and Gruell (1983, 1986) estimate a mean fire interval of 35 to 45 years in pre-settlement stands in southwestern Montana.

Fire Group Six

Fire Group Six habitat types occur throughout western Montana usually at elevations of 3,000 to 6,500 feet. Douglas-fir is both the indicated climax species and a vigorous member of seral communities. Results for 15 relatively moist Douglas-fir and lodgepole pine dominated stands in the Montana forest zone (fire group 6) suggest that a mixed severity fire regime prevailed before ca. 1900. Sampled fire frequency for this group was virtually identical to those in Fire Group 5, ranging from about 15 to 60 years long, and the 15 – stand mean fire interval was 32 years. The years since last fire statistics for the Fire Group 6 stands was 20 percent longer than for the Fire Group 5 sampled stands—about 125 years on average.

Fire Group Seven

Fire Group Seven contains cool habitat types dominated by lodgepole pine. Results from sampling 40 stands in Fire Group Seven suggest a pattern of fires that burned at mixed severities and short intervals before European settlement of the west. For example, the sampled fire intervals for lodgepole pine ranged from about 25 to 60 years on average, and the mean fire interval of 40 sampled stands was 46 years (Barrett 1997). This suggests the area has had recurring low to moderate intensity surface fires that burned

ground fuels and left remnants of large, live trees in the overstory. There were occasional hotspots where a stand was largely killed through bole heating or a “run” through the tree crowns. Sampled stands revealed that fires burned, on average, every 16-19 years between 1734 and 1900. The study suggests that heavy fuel accumulation probably did not occur across the landscape because long fire free intervals rarely occurred. Additionally, Losensky (2002) recently looked at vegetation and fire history in the Trail Creek Drainage on the Wisdom Ranger District. Multiple scarred lodgepole pines were common in the study area indicating both large scale and localized fires of light to moderate severity, and a fire in a particular stand every 30-40 years, on average. Stand replacement conditions may have developed about every 75-100 years. The study suggests open grown lodgepole pine stands with significantly fewer stems per acre as compared to today. Stands were mostly composed of lodgepole pine, and since lodgepole pine has thin bark and is easily damaged by fire, multiple fire scarred lodgepole pine trees throughout the drainage indicate that frequent, light to moderate fire intensities often maintained historic stand conditions.

Fire Group Ten

Fire Group Ten consists of high-elevation forests near and at the timberline. All the stands lie above the climatic limits of Douglas-fir, and many stands are above the cold limits of lodgepole pine. Subalpine fir or mountain hemlock is the indicated climax in all of the upper subalpine habitat types in western Montana. Whitebark pine and Englemann spruce are long-lived seral species and, like lodgepole pine, occur on some upper subalpine sites. Fire is secondary to site factors (climate and soil) as an influence of forest development on these sites. However, the exclusion of fire from these sites has been found to reduce stand and landscape diversity in subalpine forests resulting in the reduction of stand and landscape diversity. Results from Fire Group 10 suggest mixed severity fire regimes in 60 percent of sampled stands with the remainder producing data for stand replacing fires on northerly aspects. The data imply a relatively long mean fire interval (70 year MFI, with ranges from 38-124 year MFI), and fire has generally been excluded from this fire group for 150 years (Barrett 1997). The cold, moist, rocky, snowbound, unproductive, and otherwise fire resistant environment that characterizes many of the sites not only makes fires infrequent, but also severely limits their area extent. Lightning does ignite fires, but the scarcity of continuous fine surface fuels coupled with the rain that commonly accompanies thunderstorms in these areas usually limits fire spread and severity. Murray (1998) found that fires were historically mixed severity and not stand replacing fires and that since the 1870s; fires have been less frequent and more severe. Such figures are difficult to interpret because a fire may involve only one or two trees in a stand. For this reason the concept of fire frequency does not apply well in upper subalpine and timberline stands.

Fire Occurrence

There have been 21 fires in the Basin Creek fuels analysis area from 1948-2002. Nine have been human caused, nine ignited from lightning strikes, and three have unknown causes. These fires ranged from 1/10 of an acre to 5 acres in size. Human caused fires are generally concentrated adjacent to private property in Herman Gulch and Roosevelt Drive.

The Gold Flint Fire was the largest fire that has occurred in terrain and fuels similar to the Basin Creek area on the Beaverhead-Deerlodge N.F. This fire burned in lodgepole pine and Douglas-fir on steep, rocky terrain north of Homestake Pass in August of 1988, a drought year. The fire was wind driven and made one run to the top of the ridge. The fire was contained the following day at 400 acres.

Any year can show a lot of variation in the number, size and location of fire starts. These starts are displayed on Map 11: Fire Occurrence in the Basin Creek Fuels Analysis Area; the number on the map corresponds to a data table that includes name, location, size, date, and cause. This map and table can be found in the project file. Fires ignited in a suppression zone that reach over 10 acres are generally fires that have escaped initial attack and become extended attack (fires lasting for at least several days). Extended attack fires require a significantly larger commitment of suppression resources than do initial attack fires and can lead to shortages in firefighting resources.

FIRE BEHAVIOR

The potential for wildfires to put lives, property and environmental values at risk is a much discussed and debated topic in recent years. It is important for managers, policy makers and the public to understand potential wildfire behavior and effects, along with the potential for other disturbances, such as insect and disease activities, and their potential interaction with fire. Wildland fire hazard can be directly related to age, stand structure, and live and dead fuel loads and their resulting effects on fire behavior.

Fire behavior is the manner in which a fire reacts to available fuels, weather, and topography. A change in any of these components results in a change in fire behavior (DeBano 1998). Fire behavior is most often characterized by flame length, rate of spread, and fireline intensity (Rothermel 1983). Rate of spread is readily observed in the field, and intensity is estimated by observed flame length. These two observations can be assessed by firefighters to conclude whether conditions are conducive to spotting and crowning and often help determine strategies and tactics (Rothermel 1983). Favorable conditions for crown fires include heavy accumulations of dead and downed litter, conifer reproduction and other ladder fuels, and continuous tree canopies (Rothermel 1991). Experience has shown that firefighters can more safely fight a fire if it stays small (low rate of spread: largely determined by small fuels), has lower intensities (determined by fuel structure and accumulation), has relatively little spotting potential (determined by potential firebrand source, how far they travel, and probability of ignition upon landing), and low resistance to control (suppression force required to control a unit of fire perimeter; determined by amount of dead and down fuels).

Fire behavior is complex with many contributing factors, all of which fall into the categories of topography (slope, aspect, elevation), weather (climate, air temperature, wind, relative humidity, forecasts) and fuels (size, type, moisture content, total loading) (Agee 1993). These three elements comprise the fire environment, the surrounding conditions, influences, and modifying forces that determine fire behavior (NWCG, 1996).

Fire behavior information was derived using the Forest Vegetation Simulator (FVS), The Fire and Fuels Extension (FFE), First Order Fire Effects Model (FOFEM), and Fire Area Simulator (FARSITE). These models are designed to quantitatively assess consequences of various management options. The project file contains the methods, assumptions and actual results of all the individual runs that were used in this analysis.

Models simulate complex systems and are only predictions of future conditions. Simulation models are useful to inform decision-makers and as support tools to document scientific basis for land management decisions (Eav 2002). Models are helpful in providing overall trends in hazards and factors contributing to those hazards and they provide land managers a tool for alternative comparison. They are simplified abstractions of reality (Atkins and Lundberg 2002). During the analysis of the Basin Creek watershed, models were used to compare alternatives and their potential effects on the land.

The Forest Vegetation Simulator (FVS, Wykoff et al 1982) was chosen to predict current and future hazards related to fire and mountain pine beetle. The model is able to simulate stand conditions over time and is responsive to many types of management actions including burning and tree removal. It requires stand exam data, e.g., species, diameter, height, etc., to start a simulation, and produces numerous output tables that describe, in various levels of detail, stand attributes such as structure, composition, growth and mortality over time.

The Fire and Fuels Extension (FFE, Crookston 2002) to the Forest Vegetation Simulator (FVS) was used to link changes in the forest vegetation due to growth, natural or fire-based mortality, and management, with changes in fire behavior. FFE models standing dead trees, surface fuels including fallen dead trees, other coarse woody debris, litter, duff, and fire effects. The FFE simulates the dynamics of snags and fuels, including their creation and depletion, through management, fire, or decay. We chose fire type, crowning index, torching index, flame length, and future fuel loading as our measures of fire hazard. Fire's actual effects on trees and fuels can be simulated or the potential intensity as it changes over time can be reported. Fire effects include tree mortality, exposed mineral soil, fuel consumption and smoke production.

The First Order Fire Effects Model (FOFEM, Reinhardt 1997) calculates the quantitative fire effects information used in FFE such as tree mortality, exposed mineral soil, etc., but adds an additional soil heating component. The purpose of this model is to quantify the effects of fire intensity, duration and soil conditions on soil heating under both smoldering duff fires and flaming surface fires.

Stand Characteristics

Stands in the analysis area were grouped in strata, which are defined as like species, size and density of individual stands as determined from aerial photographs. Stands representative of each stratum were sampled in the field and this information was then used to run the various models. Table 3.4 below describes the current condition of the predominate vegetation types by strata described in Chapter 3, Vegetation Existing Condition on pages 3.55 – 3.57 and characteristics that influence fire behavior are displayed. The year 2008 was chosen to represent the condition following the climax of the Mountain Pine Beetle epidemic.

Table 3.4: Stand characteristics for existing strata in 2003 and in 2008, following the anticipated climax of the Mountain Pine Beetle epidemic. *MPB mortality is the difference in basal area (square feet/acre) from 2003 to 2008. Therefore, this number may include some additional (i.e. not related to the beetle) mortality as well as 5 years of basal area growth.

		Douglas-fir pole		Mature Lodgepole Pine		Lodgepole Pine Pole		Mature Douglas-fir		Mature Subalpine Fir	
	Stand #	41404424		41505528		41503308		41601105		41504427	
	Year	2003	2008	2003	2008	2003	2008	2003	2008	2003	2008
Stand Attributes	Species Mix	83% DF 17% LP	88% DF 8% LP 4%O	58%LP 31%AF 11% S	33% LP 46%AF 21%O	99%LP 1%DF	69%LP 13%AF 7%DF 1%O	96% DF 4%LP	96%DF 4%LP	93% AF 3% S 1% LP	93% AF 3% S 1% LP
	Fuel model	100% 8	96% 8 4% 2	97% 8 3% 10	35% 8 42% 10 22% 5	100% 8	100% 8	100% 8	79% 8 21% 10	44% 8 56%10	86%10 14% 12
	BA (sq ft/ac)	83	69	194	56	190	127	146	124	191	169
	Trees/acre	322	356	551	631*	1088	1313	4126	4063	8004	7624
	Height (ft)	71	72	80	79	56.5	55	69	68	80.7	82.7
	Diameter	6.9	5.9	8	4	5.7	4.2	2.5	2.4	2.1	2
	Fuel loading (tons/acre)	4.6	4.7	9.4	12.6	4.7	5.5	4.9	5.7	17.7	19.3
	MPB Mortality (BA)*		14		139		63		22		22

Figure 3.1 illustrates the acres in the analysis area by forest type (strata). The mature size classes are most abundant. The pole-size class is next with no seedling size classes found. Sapling size classes are present as colonization in the once open sage/grass parks. The lodgepole pine forest type dominates the analysis area and comprises 61 percent of the total acres while Douglas-fir is represented on 16 percent of the acres and subalpine fir on 2 percent. The majority of subalpine fir is classified as old growth.

This size class distribution is reflective of past fire suppression and logging history, which clearcut all operable ground in the late 1800s. The distribution today of all relatively even-aged 100-150 year old trees is in stark contrast with historic vegetation: a relative abundance of the seedling/sapling class, less of the pole and mature size classes, and more of the larger size classes (Losensky 1993; Habeck 1990). This shift in relative size classes has important implications for fire, and insect and disease hazard.

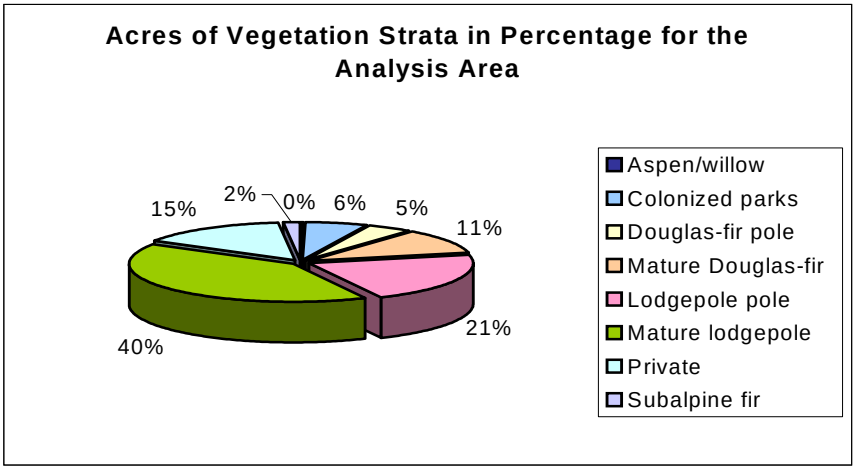


Figure 3.1: Relative abundance of strata occurrence.

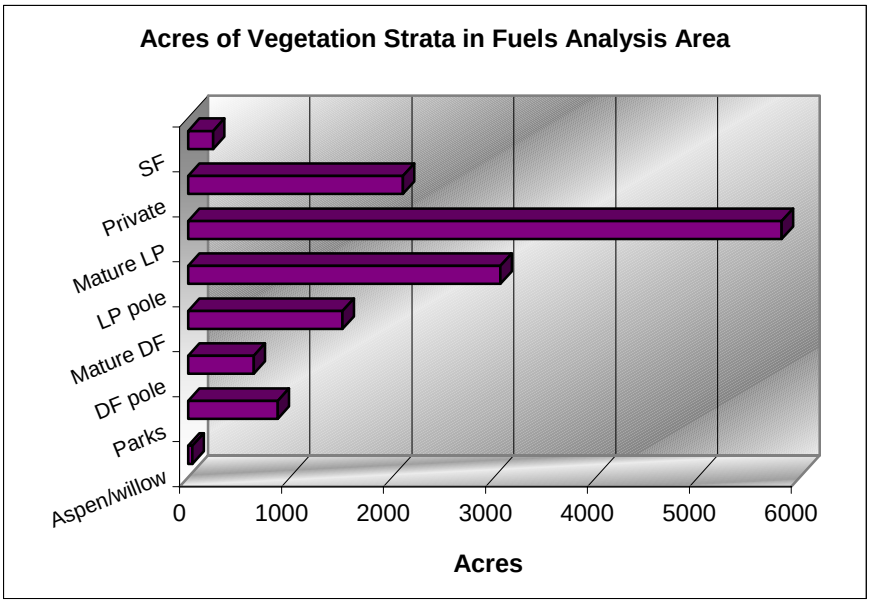


Figure 3.2: Vegetative Strata by acre

A **fuel model** is defined as 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 spread model (Reinhardt and Scott 2001)—there are 13 fuel models. They are tuned to the fine fuels that carry the fire and describe the conditions at the head of the fire. In 2003 all strata are predominantly Fuel Model 8, with the exception of subalpine fir stands, draw bottoms, and areas that were left un-logged at the turn of the last century. These areas contain both Fuel Model 8 and Fuel Model 10. Fire behavior in Fuel Model 8 is characterized by slow-burning ground fires with low flame lengths, although heavy “jackpot” fuel accumulations may occasionally cause flare-ups under severe weather conditions. Fire behavior in Fuel Model 10 is generally more intense, due to higher fuel loadings from over maturity, past fire suppression, and other natural

disturbances. Crowning out, spotting, and torching of individual trees are more frequent in this fuel situation, leading to potential fire control difficulties (Anderson 1982).

Table 3.5: Fuel model descriptions

Fuel model	Typical fuel complex
	Grass and grass dominated
1	Short grass (1 foot)
2	Timber (grass and understory)
3	Tall grass (2.5 feet)
	Chaparral and shrub fields
4	Chaparral (6 feet)
5	Brush (2 feet)
6	Dormant brush, hardwood slash
7	Southern rough
	Timber litter
8	Closed timber litter
9	Hardwood litter
10	Timber (litter and understory)
	Slash
11	Light logging slash
12	Medium logging slash
13	Heavy logging slash

Basal area (BA) is the cross-sectional area, in square feet/acre, of trees determined at breast height. Mature lodgepole pine has the highest basal area at 194 sq. ft., followed by subalpine fir at 191 sq. ft. Douglas-fir pole stands contain the lowest basal area with 83 sq. ft. In 2008, following mortality from Mountain Pine Beetle, mature lodgepole pine stands drop to 56 sq. ft. per acre. All stands lose basal area in 2008 due to lodgepole pine mortality from the Mountain Pine Beetle, but this effect is greatest in the mature lodgepole pine stands. Trees per acre (TPA) is defined as the number of trees of all size classes in one acre. Height is the average height of the 40 tallest trees in the stand in feet, and diameter is the average diameter at breast height of all trees in the stand. Trees of the same species and of a larger diameter are often more resistant to fire because they have thicker bark protecting the cambium layer. See Table 3.4, for values associated with these characteristics.

Fuel characteristics affecting fire behavior are vegetative density, species composition, amount of surface fuel, arrangement of fuels and moisture content (Rothermel 1983). Fuels contribute to the rate of spread of a fire, the intensity/flame length of the fire, how long a fire is held over in an area (residence time), and the size of the burned area (Rothermel 1983, Agee et al 2000.) In a national survey, nearly 80 percent of all wildland firefighters identified fuel reduction as the single-most important factor for improving their margin of safety on wildland fires (Tri-Data 1996). Manipulating fuels allows firefighters and land managers the most control in wildland fire management, by modifying fire behavior in the fire environment through a reduction in fire intensity and severity (Pollet and Omi 1999).

Fuel loadings are usually measured in tons per acre and define the amount of fuel available for burning in a given area. There are three categories of fuels that affect fire behavior; 1) fine fuels such as grass or forbs, 2) small woody fuels less than three inches in diameter and 3) large woody fuels greater than three inches in diameter. Fine fuels are the major contributors to fire spread, carrying the ignition and flaming front of a fire (Rothermel 1983). Without these fine fuels, many fires will not get large. However, eliminating fine fuels (litter, duff, and grasses) is neither possible nor desirable. Small woody fuels influence a fire's rate of spread and fire intensity, and small woody fuels lose their moisture faster, start easier, and burn more readily than large woody fuels (Agee 1993). Under a frequent fire regime it is possible to maintain fine fuels at lower levels and various patch sizes than under a less frequent fire regime, but fine fuels will always exist. Aside from eliminating the fine fuels that contribute to fire spread, only the total amount and arrangement can be modified to benefit fire control efforts. From a firefighter's perspective, it is better to construct fireline through 2 inches of this small material to reach mineral soil (therefore stopping fire spread) than to dig through 10 inches of fine fuels because fireline construction will progress faster and the fire could potentially be contained at a smaller size. Large woody fuels (greater than 3" diameter) remain burning after the fire front has passed (Andrews 1986) and contribute to fire intensity. Large woody fuels also contribute to the development of large fires and high fire severity (Brown et al 2001). As they burn, live needles and twigs of pole-sized trees and overstory branches may ignite and "torch," throwing embers to the wind, and possibly igniting other nearby tree crowns.

Large, dead and down woody debris is a major component of Rocky Mountain forests. Graham et al (1994) conducted studies on coarse woody debris (woody residue larger than 3 inches in diameter) in the Rocky Mountains. They state that "Forested ecosystems evolved with a continual flux of coarse woody debris (CWD). The creation and accumulation of CWD depends on forest type, successional stage, insect and disease activity, weather events, fire-return intervals, decay rates, and timber management activities. During the last 100 years, the fire frequencies in all of the Rocky Mountain ecosystems have been greatly extended, potentially increasing CWD accumulations." They maintain that CWD performs many physical, chemical and biological functions in forest ecosystems and make conservative recommendations by habitat type to ensure that enough organic matter is available after timber harvest to maintain long-term productivity. Their study included granitic and volcanic soils on the Beaverhead-Deerlodge National Forest, Butte and Jefferson ranger districts. They recommend 7-15 tons/acre in the Subalpine fir/whortleberry type, 11-23 tons/acre in the Subalpine fir/beargrass type, 4-9 tons/acre in the Douglas-fir/ninebark type, and 13-24 tons/acre in the Douglas-fir/pinegrass type. Fuel loadings are closely related to site productivity but past management practices can produce loading very different than historical averages. Large woody debris has desirable attributes for a forest in terms of nutrient cycling, wildlife habitat, moisture retention in the forest and thus the potential productivity of the forest. Therefore a balance between fire hazard and these other values needs to be maintained.

FFE has rule sets for assigning fuel loads based on habitat type and percent cover values. The model was shown to overestimate the amount of down woody debris in these stands. Fuels transects have shown fuel loading averages of 6 tons per acre within the Basin Creek area. These loadings do not approximate historic fuel levels, because of past logging history and subsequent slash disposal. Un-logged areas, drainage bottoms and northwest slopes contain fuel loadings from 15-35 tons/acre. Existing fuel loads were entered into the model at 6 tons per acre of material greater than 3 inches in diameter to match actual conditions on the ground in the year the stand was inventoried. Tons per acre displayed for 2003 "current conditions" reflect additional mortality and decay since the inventory date. The subalpine fir type was not harvested in the late 1800s and therefore has greater average fuel loading, approaching 18 tons to the

acre. The model closely approximated fuel loading for subalpine fir habitat types, so we did not enter initial fuel loads for time of inventory in these stands.

Mountain Pine Beetle Mortality (MPB Mort) is the basal area of trees killed by the mountain pine beetle in a given area. The MPB can have a substantial effect on fuel loading and stand structure over time. By killing trees they create snags, which become down woody debris and may add substantially to fire intensity in droughty conditions. Snags also pose a serious threat to firefighter safety. The main passage of a fire through an area may occur quickly; however, as discussed above, fires remain burning in jackpots of large fuels and in standing dead snags long after the fire front has passed. As the base of the snags burn out, snags may fall unexpectedly, posing a serious threat to firefighters working in that area. The killing of overstory trees also creates openings in the canopy allowing the establishment and/or growth of understory trees. This leads to the development of two and multi-storied stands, which adds to the potential for crown fires with the increase of ladder fuels. However, these openings, in the short term, act to reduce the crown fire potential in stands where mature lodgepole pine is killed.

Mountain Pine Beetle mortality was calculated in the analysis area by surveys conducted in the fall and winter of 2001-2002 by entomologists from the Regional Office State and Private Forestry Division. The results from these surveys were used as input for the model to simulate mortality projections. Copies of these surveys are located in the project file.

The development of Mountain Pine Beetle populations that can successfully attack trees in large numbers is affected by many variables, including species, tree size, density, age, and weather/climate. Lodgepole pine is the only tree species in the analysis area that is susceptible and it is displayed in Table 3.4 that the mature lodgepole pine has experienced the most mortality at 139 sq. ft. of basal area. Until the needles fall from these dead trees, they exist as fine fuels in the canopy and may increase the rate of spread in event of a wildland fire.

Fire Behavior

Current condition of predominant vegetation types by strata and associated fire behavior are displayed in Table 3.6. The following characteristics were pulled from the FFE model runs to use as comparisons between strata.

Table 3.6: Fire Behavior for existing strata in 2003 and in 2008, following the anticipated climax of the Mountain Pine Beetle epidemic

		Douglas-fir pole		Mature Lodgepole Pine		Lodgepole Pine Pole		Mature Douglas-fir		Mature Subalpine Fir	
	Stand #	41404424		41505528		41503308		41601105		41504427	
	Year	2003	2008	2003	2008	2003	2008	2003	2008	2003	2008
Fire Behavior	Flame Length										
	severe	1	1.2	1	8.8	0.9	0.9	0.9	1.7	73.4	83.4
	moderate	0.5	0.6	0.5	1.4	0.5	0.5	0.5	0.9	1.9	5.1
	Type of fire										
	severe	surface	surface	surface	passive	surface	surface	surface	surface	active	active
	moderate	surface	surface	surface	surface	surface	surface	surface	surface	surface	passive
	Canopy Bulk Density (kg/m3)	0.062	0.048	0.137	0.038	0.119	0.083	0.173	0.174	0.144	0.167
	Canopy Base Height (ft)	4	4	4	4	12	15	22	6	3	2
	Torching Index (mph)	35	28	43	5	162	204	303	48	0	0
	Crowning Index (mph)	32	38	18	46	19	26	14	14	14	12.4
	Crown Fire Hazard Rating	Low	Low	Mod	Mod	Mod	Low	Mod	Mod	High	High

Heavy concentrations of fuels and state of decay contribute to **fire persistence** (the ability for a fire to remain burning on a site, even if current conditions are not conducive to fire spread), **burnout time** (the amount of time necessary to consume a piece of fuel of a certain diameter), and **resistance to control** (resistance to fireline construction efforts) (Brown et al 2001, Anderson 1969, and NWCG 1996). One way to measure resistance to control is by flame length. Flame length is the distance measured from the tip of the flame to the middle of the flaming zone at the base of the fire. Low resistance to control typifies fires that are relatively easy to suppress in the shortest time frames. Fires in the low hazard category may correspond to the shortest flame length and intensity levels. High resistant fuels typically consist of the older age conifer fuel types with significant fuel loads or shrub lands with extreme fuel loads. These fuels can often produce extreme flame lengths and fire intensities where the ability to directly suppress fires is impeded. For example, a "High" resistance to control means that work will be difficult for dozers, and very difficult for hand crews, and line holding will be difficult." Fire hazard and resistance to control reach high ratings when large woody fuels exceed 25 to 30 tons per acre in combination with small woody fuels of 5 tons per acre or more (Brown et al 2001). Line construction rates for initial attack hand crews are lower in the fuel models with larger diameter fuels than in the other common fuel models found on the Beaverhead-Deerlodge NF (NWCG 1998, Anderson 1982). Roussopoulos and Johnson (1975) interpreted flame length in terms of difficulty to control and potential for severe fire behavior. Table 3.7 displays hazard rating, flame lengths, and the implications for fire suppression.

Table 3.7: Haul Chart—Relates crown fire hazard rating with flame length and the consequences for fire suppression

Hazard Rating	Flame Length	Fire Suppression Interpretation
Low	Less than 4 feet	Fires can generally be attacked at the head or flanks by persons using hand tools. Handline should hold the fire.
Moderate	4.1-8.0 feet	Fires are too intense for direct attack on the head by handcrews. Handline cannot be relied on to hold fire. Equipment such as dozers, engines, and aircraft retardant can be effective. Fires are potentially dangerous to personnel and equipment
High	8.1-10.9 feet	Fires may present serious control problems, i.e., torching, crowning, and spotting. Control efforts at the head will probably be ineffective
Extreme	Greater than 11 feet	Crowning, spotting, and major fire runs are probable. Control efforts at the head of the fire are ineffective.

FFE runs for a severe fire in 2003 showed one-foot flame lengths or less for all stands except mature subalpine fir. These low flame lengths can be attributed to the lack of understory vegetation or down logs from past logging. The number of trees, fuel loading and understory layers present in the mature subalpine fir stands produce flame lengths of 73.4 feet. In 2008, following the mountain pine beetle epidemic, the flame length for mature lodgepole pine climbs to 8.8 feet.

Increased fire persistence, resistance to control, and burnout time negatively influence firefighter safety by hampering suppression actions and increasing firefighter exposure to environmental hazards. The higher the fuel loading at the time of a fire, the larger, more intense, and harder to control it will be. Take, for example, a campfire. If you build it small, you have to get very close to attain any heat from it. If you throw more wood on the fire, you are able to stand a little further away and still attain heat from it. However, if you were to place a great deal of wood on the fire, in large chunks, you might have to start backing away. Certainly, if you continued to stack the wood on, at some point the flame lengths would be four foot and you would not be able to approach the edge of the fire. A four foot flame length is the point at which firefighters can no longer initiate direct attack (Rothermel 1983). The campfire with more fuel burns at a higher *intensity.* The larger the chunks of firewood you placed on the fire, the longer it would burn. Small campfires, with small branches and twigs might only burn for a couple hours; large campfires could burn for days. This is the campfire's *residence time*. You might easily put out the small campfire; however, the larger campfire might be more difficult because it is posing a *resistance to control.*

"Extreme" fire behavior implies a level of fire behavior characteristics that ordinarily preclude methods of direct control. The contribution of small and large fuels to fire behavior is discussed above. One or more of the following fire behavior characteristics is usually involved: high rate of spread, crowning, spotting, presence of fire whirls, and strong convection column. Extreme fire behavior results in unpredictability because such fires often exercise some degree of influence on their environment and behave erratically, sometimes dangerously (NWCG 1996).

Long range spotting is also associated with extreme fire behavior and severely affects the ability of firefighters to confine a fire. Spotting occurs when burning embers are lofted in front of the main fire and land in receptive fuels to start new fires. Spotting is determined by three factors: (1) the source of the firebrands, (2) how far they travel, and (3) the probability of ignition on landing (Rothermel 1983). Short-range spotting is not significant because these spots are often overrun by the main fire and contribute little to forward fire spread. Long-range spotting is caused by embers lofted in the fire's convection column and can be carried a mile or more in front of the main fire to start new fires that will burn independently of the main fire. Firebrands can be lofted by torching trees, a concentration of ground fuels burning with enough intensity to loft firebrands, or a fire whirl. Long range spotting is hard to predict except for the fact that it is associated with high fire intensities, torching, crowning, and fire whirls (Rothermel 1983). Tree torching is determined by weather, total fuel load, live fuel moistures (for those fuel models that include this as an input) and ladder fuels (Andrews and Chase 1989). Fires exhibiting long-range spotting pose some of the greatest threats to firefighter safety because they are extremely difficult to control. Reducing excessive fuel loads, ladder fuels, and crown spacing reduces the incidence of extreme fire behavior.

There are two fire indices produced by the FFE model that can be used to examine potential fire behavior. These are crowning index and torching index, and the interplay of the indices with specified weather and fuel loadings results in a fire type being assigned (Beukema et al 2000). Stands are dynamic and change over time and as they change, the associated fire indices and behavior also change. This chapter focuses on the current or existing condition in 2003, and includes the 2008 conditions to illustrate what effects the mountain pine beetle mortality will have on these indices. The torching index indicates the wind speed needed to move the flames burning in the ground fuels into the crowns of the trees. The lower the torching index value, the greater the possibility of torching. The potential flame length and the canopy base height drive this index. Canopy base height is the height in feet from the ground to the bottom of the tree canopy. This includes ladder fuels such as lichen, dead branches, and small trees (Reinhardt and Scott 2001). In 2003, the only stands with sufficient ladder fuels in the understory to drive a fire into the crowns were the mature subalpine fir stands with a torching index of zero mph. These stands have over 8,000 trees per acre and nearly 18 tons to the acre of fuels on the ground. In 2008, the mature lodgepole pine decreases from a 42.8 mph torching index to 5 mph, indicating an increase in the potential for fires moving into tree crowns. This change can be attributed to the dead trees increasing the fuel loading from 9.4 to 12.6 tons per acre and increased number of small trees regenerating in the openings. Figure 3.3 below illustrates the change in torching indices from 2003 to 2008 by strata classes. The actual values associated with Figure 3.3 can be found in Table 3.6.

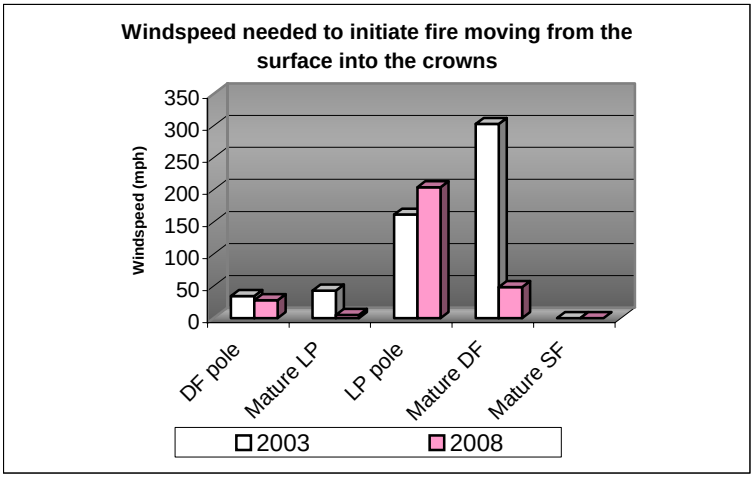


Figure 3.3: Torching Indices for 2003 and 2008

The crowning index indicates the wind speed needed to have a running crown fire. The lower the crowning index value, the greater the potential for continued crowning. This is largely a function of canopy bulk density. Canopy bulk density is a measure of how much volume (branches) is present in tree crowns within a stand. The denser the canopy and the steeper the slope, the less wind needed to sustain a crown fire. Crowning index gives an indication of the potential for fire to spread from stand to stand, the behavior that drives medium to large fires. A crown fire is a fire that burns in the elevated canopy of a stand and is characterized by long flame lengths, high fireline intensities, high resistances to control, and high rates of spread.

We chose to group crowning and torching index values into three crown fire hazard classes based on the occurrence of windspeeds recorded on the forest weather stations during fire season. See Tables 3.8 and 3.9 below.

Table 3.8: Windspeeds were classified into three hazard categories based on the likelihood that that windspeed range would occur on the forest. Occurrences were taken from weather stations on the Forest.

Windspeed hazard rating	Windspeed (mph)	Occurrence on forest
High	0-19	95%
Moderate	20-29	4%
Low	30+	1%

Table 3.9: Based on the windspeeds from Table 3.8 above, the crown fire hazard rating matrix was developed to determine the likelihood that a fire would develop into a crown fire.

	Torching Index			
Crowning Index	Windspeed	≤ 19 mph	20-29 mph	≥ 30 mph
	≤ 19	High	High	Moderate
	20-29	High	Moderate	Low
	≥ 30	Moderate	Low	Low

Torching index and crowning index from the fire behavior table (Table 3.6) can be used in the crown fire hazard rating matrix to find the rating for each strata. For example in 2003, the lodgepole pine pole strata have a torching index of 162 and a crowning index of 19, giving it a rating of moderate. The mature lodgepole pine strata have a torching index of 43 and a crowning index of 18, a crown fire hazard rating of moderate. The subalpine fir stands have high crown fire hazard ratings, and the Douglas-fir pole stands fall into the low hazard class. This index is important because a stand classified as a surface fire type may have a high torching index, which means it lacks ladder fuels to help fire get into the crown, but may have a low crowning index which means that once fire gets into the crown, it is easily sustained. The mature Douglas-fir stands in the analysis area are a good example of this. The crowning index is 14 mph and the torching index is 303 mph. This means that these stands are a high hazard for supporting crown fires from another source (stand to stand) but incapable of getting a fire into the crowns within the stand. The model thus assigns a surface fire type to this stand based on the very high windspeeds (303 mph) required to move fires from the ground to the tree canopy *in that stand*.

The crown fire potential decreases in all stands where lodgepole pine is killed by Mountain Pine Beetle. This is most noticeable in the mature lodgepole pine where the crowning index goes from a crowning index of 18 mph (high crown fire hazard rating) in 2003 to a crowning index of 46 mph (low crown fire hazard rating) in 2008. The mountain pine beetle kills the trees and acts as a thinning agent by opening up the canopy, making the stands less susceptible to crown fires.

Figures 3.4 and 3.5 show the percentage of acres in the analysis area that are at high risk of supporting crown fire.

Figures 3.4 and 3.5: The following pie charts illustrate the change in crown fire risk associated with Mountain Pine Beetle mortality from 2003 to 2008. *N/A refers to sagebrush/grass vegetation types and/or private land.

Figure 3.4: Relative abundance of acres at high, moderate, and low risk of crown fire in 2003.

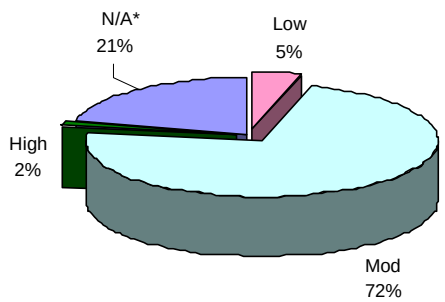
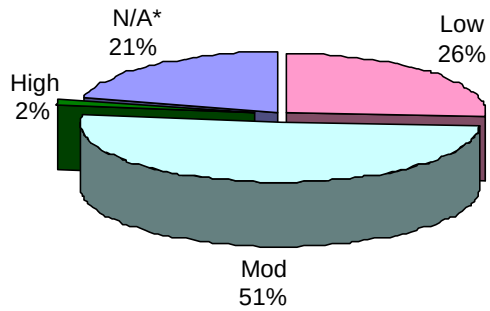


Figure 3.5: Relative abundance of acres at high, moderate and low risk of crown fire in 2008.



When both crowning index and torching index are relatively high the fire danger is relatively low. Stands in this condition would be a low priority for treatment. Conversely stands with low indices would be a better place to expend limited resources. It is therefore important to determine if hazard exists within a stand and/or adjacent stands in order to develop effective fuel treatments.

The potential for fire is a function of weather, fuel conditions and topography and the interplay of these variables. Fire behavior varies considerably with short-term weather and longer-term climatic conditions (drought) through time. Long-term drought conditions can dry out large diameter trees, which can then take a long time period to regain moisture. Short-term events, such as a rainstorm, can influence fire events by retarding large fire growth. Extreme fire years are mostly controlled by long-term climate, while extreme fire events can be influenced through both long-term climate and short-term weather. Two different weather conditions were modeled to provide a sense of how that variable influences fire behavior. One represents a moderate fire under the average summer day weather and average climatic conditions. The second represents a severe fire under extreme fire weather conditions and very dry climatic conditions. They are displayed in Table 3.10.

Table 3.10: Weather and fuel moisture conditions used to model fire behavior and fire effects in the FFE model

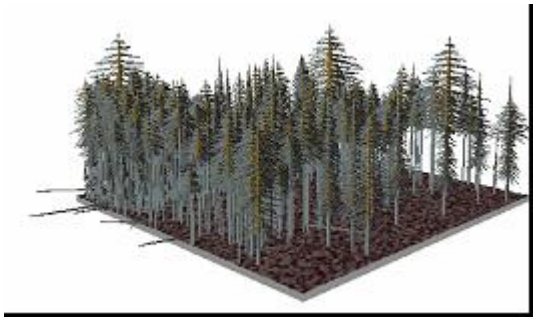
	Moderate Fire	Severe Fire
20-foot Windspeed	6	20
Temperature	70	70
Percent Fuel Moisture		
1-hour (0-1/4")	12	4
10-hour (1/4-1")	12	4
100-hour (1-3")	14	5
1000-hour (>3")	25	10
Duff	125	15
Live	150	70

FFE simulates fire type based on the conditions *within* the particular stand that is modeled. The FFE model predicts three types of fire behavior:

Surface fire: The fire burns on the ground through the dead and down material but below the forest canopy. Surface fuels consist of needles, leaves, grass, dead and down branch wood and logs, shrubs, low brush, and short trees (as seen on right).

Passive fire: The fire burns on the ground and in the crowns of individual or small groups of trees, but fire is not sustained in the crown (as seen on right).

Active fire: The entire surface and canopy are engulfed in flame, but the fire remains dependent on the surface fuels for fire spread (as seen on right).



In 2003, all forest types under moderate and severe fire conditions burn as surface fires with the exception of the mature subalpine fir, which burns as an active fire under severe conditions. In 2008, the mature lodgepole pine changes from the surface to the passive fire type under severe fire conditions and the mature subalpine fir changes from surface to passive fire under moderate fire conditions. These comparisons illustrate the change in fire potential as forests grow and change over time, and the effect of mountain pine beetle mortality in the mature lodgepole pine forest type.

Fuel size, configuration and loading affect fire type. These variables are integrated in the fuel model. As addressed in the fuel model discussion in Table 3.5, when fuel models change from an 8 (timber with very little down logs or understory vegetation) to a 10 (timber with litter, down logs and understory vegetation), the amount of passive and active fire increases. As expected, fire intensity increases with the fuel loading and the amount of small trees regenerating in the understory. The mature lodgepole pine and subalpine fir

stands change as a result of mortality and the combined effect of increased fuel loads and small trees growing in the understory.

Stand layering has considerable affect on fire type and increases as stands age. Stand layering has two somewhat contrary effects on fire behavior, one is to add ladder fuels that facilitate flames reaching into the canopy of the forest resulting in passive or active fires; the second effect is to reduce the within-stand wind speed on the fire, which can reduce the potential for the flames to reach the canopy of the forest, thus reducing the amount of passive and active fire. The FFE model accounts for this interaction by using canopy base height and canopy closure calculations to determine if fire can get into the crown. Canopy base height is the lowest height in feet above the ground at which there is sufficient amount of live and dead branches to move a fire into the canopy. Canopy base height includes fuels such as shrubs and understory trees. If the crown canopy is within reach of predicted flame lengths and there are adequate ladder fuels, torching and crowning fires will result. The model uses percent canopy cover to calculate mid-flame wind speed, thus incorporating density effects on within stand wind speed. The only types present in the analysis area that currently (2003) have stand layering are the mature subalpine fir types, riparian bottoms and the edges of colonized sage/grass parks that abut mature trees. The intensity of fire increases with stand layering.

Fire Effects

For the following explanations, FVS-FFE was used to simulate a fire under both moderate and severe fire weather conditions using the existing vegetative conditions in 2003 and again in 2008. Here, mortality refers to the percent of the basal area killed by fire under both severe and moderate fire weather conditions shown in Table 3.11 below. This affects wildlife in the number of snags created, hydrology and soils as surface water runoff, and firefighter safety in the event of a possible fire in both the near (snag burnout) and extended future (creation of future heavy fuel loads). Like Mountain Pine Beetle mortality, fire mortality creates heavy future fuel loads as snags fall to the ground. Mortality is a function of the size and species of trees in the stand, environmental conditions, and existing fuel loads. The variation in mortality illustrates that forest types dominated by species resistant to fire have substantially less mortality. For example a surface fire under moderate conditions in the mature lodgepole type results in an average of 55 percent mortality while the average is 40 percent in the mature Douglas-fir type.

Fire managers are obligated to compare alternatives based on the amount of smoke produced. FFE estimates smoke production, or the emission of particulate matter in tons per acre less than 2.5 microns in diameter (see: Air Quality Existing Condition for more information).

Table 3.11: Fire Effects for existing strata in 2003 and in 2008, following the anticipated climax of the Mountain Pine Beetle epidemic, should a fire burn under severe and/or moderate fire weather conditions.

		Douglas-fir pole		Mature Lodgepole Pine		Lodgepole Pine Pole		Mature Douglas-fir		Mature Subalpine Fir	
	Stand #	41404424		41505528		41503308		41601105		41504427	
	Year	2003	2008	2003	2008	2003	2008	2003	2008	2003	2008
Fire Effects	Mortality (%BA)										
	Severe	24	16	55	74	69	69	40	40	100	100
	Moderate	24	16	55	56	69	69	39	40	53	62
	Smoke (T/A < 2.5)										
	Severe	0.14	0.14	0.34	0.31	0.29	0.2	0.19	0.17	0.62	0.6
	Moderate	0.08	0.08	0.21	0.16	0.17	0.11	0.11	0.1	0.27	0.29
	Fuel Consumed (>3"), tons/acre										
	Severe	4.1	2.67	4.04	5.65	8.9	1.9	4.5	1.86	3.46	5.37
	Moderate	3.8	2.18	1.21	5.05	8.2	1.58	4.2	1.64	3.92	4.74
	Fuel Remaining (>3"), tons/acre										
	Severe	1.1	7.03	5.36	6.95	2.5	3.6	1.2	3.84	3.32	3.93
	Moderate	1.4	7.52	8.19	7.55	0.6	3.92	1.6	4.06	2.88	4.56

Fire Size

Predicting where a fire will start and the number of acres it will burn is difficult due to annual variation in ignition sources, short and long term climate, and fuel flammability. The FARSITE and PROBACRE models both make predictions relative to fire size, but neither predicts when or where a fire will start.

The FARSITE (Fire Area Simulator) model was used to spatially and temporally simulate the spread and behavior of fires in the analysis area. FARSITE can be used for both short and long term projections of potential fires. The model predicts rate of spread, flame length, fire line intensity, final fire size, and fire type. Fuel model, canopy base height, canopy bulk density, crown closure, and top height were taken from FFE, and these, along with a DEM (digital elevation model), and historic weather conditions from the Jefferson weather station were used to run the FARSITE model. The selected weather file represents the "worst-case" scenario, and ignition points were chosen based on historic fire starts in the analysis area (see Appendix B, Map 11). The model then ran for a 5-day period. This procedure was repeated several times and then the values for rate of spread, flame length, fire line intensity, and fire type were averaged. Table 3.12 illustrates some possible fire sizes over a 5-day period should a fire occur in the analysis area in 2003. The largest final fire size was used for comparison, to represent the worst-case fire scenario.

Table 3.12: Possible acreages, from the FARSITE model, of a fire occurring in the analysis area over a 5-day period in 2003 (based on actual fires from Appendix B, Map 11 Fire Occurrence)

Fire starting near:	2003 acres
Herman Gulch	176
Basin Creek Reservoir	644
Roadless Area	142

PROBACRE predicts the number of acres that could be burned in the future, over a chosen timeframe. This program assesses the risk of catastrophic consequences from a single or series of wildfire events and the long-term probability that a combination of these events would result in a total burned area in excess of a user-specified number (7500 acres, or approximately one half of the analysis area, in this case). The program bases its probabilities on fire occurrence history. We used Fire Family Plus to obtain fire occurrence and weather pattern history for the Butte Ranger District, so probabilities are for the entire ranger district and not the Basin Creek area alone. For this analysis, we chose a 30-year period, which corresponds to both the fire occurrence history data from the forest and the length of the effects analysis for the project. According to the program, there is zero probability that a fire or any number of fires will exceed a 150-acre threshold on the Butte Ranger District in the next 30 years. This program does not account for insects and disease epidemics or large fuel accumulations related to them.

Because a good portion of the Butte Ranger District was heavily logged in the late 1800s, fuel conditions have not existed across the landscape in the past 100 years like they will in the Basin Creek Analysis Area in the next 30 years. Therefore, although FARSITE modeled fires in 2003 that stayed small and were generally surface fires, and PROBACRE found a zero probability of total burned acres exceeding 150 acres over the next 30 years, the potential for extended drought periods still exists and there is a possibility that an extreme, unpredictable fire year such as the one seen in 2000 will happen sometime in the future. The area could still experience a fire that would behave outside of predictions.

Access

The Basin Creek analysis area has six different access roads (see Map 12 in Appendix B). The condition of a road, its width, number of turnouts, bridge weight limitations, powerline crossings, and number of entrances and exits to the road system all determine its effectiveness in a potential wildland fire incident. Jeep trails, ATV trails and foot trails exist within the analysis area as well, and some of these can be accessed by small fire engines. The following table and discussion identifies the roads and trails, their accessibility, structures and improvements, and potential hazards and safety concerns, along with response times for fire personnel traveling from Butte and from Whitehall.

Table 3.13: Main roads in the analysis area and associated suppression concerns

	Roosevelt Drive	Herman Gulch	China Gulch	Basin Creek
Accessibility	Adequate for all engine access	Adequate for any engine up to Forest boundary, then road narrows and is suitable for type 3-6 engines only; ½ mile from FS boundary, suitable for ATVs only	Limited access from the north end by type 6 engines and ATVs, need permission from land owner, road ties in at Roosevelt Dr., but open only to ATVs	Access for all engine types
Type of Road	Main county road	County road, well maintained, but washes and becomes soft during heavy run-off	Two track road, travel restricted at its junction w/ Roosevelt Dr. Permission required at junction with Basin Creek Rd.	County road, well maintained
Structures or Improvements	Approx. 75 structures in the Roosevelt Dr. subdivision, with 150+ outbuildings	Approx. 5 residences and 3 special use cabins, several out buildings—most have adequate defensible space	No structures	10 residences, 3 special use cabins, approx. 12 outbuildings; water treatment facility
Hazards or Safety Concerns	High amounts of high speed traffic, power lines, propane, hazmat, septic tanks, narrow cattle guards	Lack of turn-arounds, popular party spot, bon fires near heavy fuels	Limited access, lack of water, over hanging brush	Narrow in places, chlorine tanks for treating water
Suppression Aids	Engine fill sites are limited, one private 3,000 gallon	Water in the creek leading up Herman Gulch, but engine fill site would need improvement to support even a small fire	None currently identified—possible beaverpond at upper end	Staging area at road's end in Basin Creek Park
Response Time	From Butte: 20-30 minutes; from Whitehall: 45 minutes	From Butte: 10 minutes.; from Whitehall: 50 minutes	From Butte: 15 minutes; from Whitehall: 45 minutes	From Butte: 20 minutes; from Whitehall; 60 minutes

The Roosevelt Drive Road is the main access route for residents in the Roosevelt Drive and Lime Kiln area. The road starts at its junction with Highway 2, east of Roosevelt Drive and continues into Roosevelt Drive, where it meets the junction of the Lime Kiln and Highland Road, and then the road leads to Thompson Park. This road is the primary access route for all people living in the Roosevelt Drive subdivision and is the only exit for motorists should the road to the west of the subdivision be blocked, posing a potential congestion problem in the event of a wildland fire. The Roosevelt drive road is a county road and is maintained its entire length, year round. It is passable by vehicles meeting in opposite directions. Many of the homes in the Roosevelt area are located off the main county road and their individual driveways have not been assessed. Limited knowledge of structures and their contents, (hazardous, or burnable material), makes this area one of concern.

The Basin Creek Road is a county maintained road and offers both the ingress and egress for all residents of the Basin Creek area and from Herman Gulch. Other roads that extend off from the Basin Creek Road but outside the analysis area would add additional traffic in the event of an emergency. There are approximately 10 residences and numerous. Logging has occurred along the road and would potentially slow the spread of a ground or surface fire. Water sources are limited but could be constructed.

The Herman Gulch Road extends off the Basin Creek Road. This road was once the main route in and out of Roosevelt Drive, but is currently impassable to passenger vehicles. Along the road, there is a popular spot for parties and bon fires. This spot is located beneath a beetle-killed lodgepole pine hillside below the Roosevelt Drive Subdivision. In the event of a wildfire in the Herman Gulch Drainage, two-way travel would be greatly limited, posing an immediate hazard to residential escape travel.

The China Gulch Road is located just beyond the Herman Gulch Road and contains no structures. This road leaves the main Basin Creek road and travels through private ground before entering the National Forest. Permission for access must be obtained prior to use in wildland fire suppression.

Table 3.14: Secondary travel routes in the analysis area and associated suppression concerns

	Trails	Roadless	Research Natural Area
Accessibility	Approx. a dozen trails	Bear Gulch Trail #108	None
Type of Road	ATV and jeep trails, location and condition unidentified	Motorized ATV trail	None
Structures or Improvements	None known	None	
Hazard or Safety Concerns	Entry and exit are unknown, hazards unidentified	Remote, poor access	Remote, poor access
Suppression Aides	None known	None	None
Response Time	Unknown	Two hour minimum from both Butte and Whitehall	Two hour minimum from both Butte and Whitehall

Trails and Two Track Routes

There are approximately four trails accessible by ATVs in the area located just west of the Roosevelt Drive subdivision and east of the Basin Creek reservoirs. They offer excellent opportunities for access by hand crews on foot or ATV's and may offer adequate anchor points for low to moderate intensity ground and surface fires. These trails interconnect in places.

Roadless Area and RNA

The Bear Gulch Trail #108 provides motorized ATV access into the Roadless Area. All other access into the Roadless Area or RNA is by foot or air travel (i.e. smokejumpers or helicopter transport).

SUMMARY OF EXISTING CONDITION

Douglas-fir stands exist on approximately 16 percent of the project area. These stands have high canopy bulk densities and a moderate crown fire hazard rating and are creating a hazardous fuels situation in the Basin Creek watershed and Intermix Community in China Gulch, Herman Gulch, and along Roosevelt Drive.

Lodgepole pine trees exist on approximately 60 percent of the project area. A Mountain pine beetle epidemic is killing these trees. State and Private Forestry entomologists estimate that 70 percent of the lodgepole pine greater than seven inches in diameter and 30 percent of the lodepole pine 5 to 7 inches in diameter will die by 2008. Trees killed by the mountain pine beetle and left standing with red needles also pose a fire hazard to the Intermix Community. Standing dead and downed fuels are expected to increase as the mountain pine beetle epidemic continues to kill logdepole pine. The future condition of this hazardous fuels situation is described under the No Action Alternative in the Effects to Fire and Fuel section.

EFFECTS TO FIRE AND FUELS

ANALYSIS AREA

This section provides information concerning the potential consequences to the environment associated with each alternative and presents the scientific and analytical basis for the comparison of alternatives presented in Chapter 2. The primary analysis area used for assessing the influence of alternatives on fire and fuels is the Basin Creek Fuels Analysis Area (see Map 7 in Appendix B), as described in the existing condition.

ANALYSIS METHODS

The indicators used to evaluate the effects of the action alternatives on fire processes include: acres where future fuel loads are reduced to 10-15 tons/acre; acres where crown fire hazard attains a “Low” rating; and acres of colonized sage/grass parks where conifer encroachment has been reduced. This discussion analyzes the potential effects (environmental consequences) associated with the implementation of each alternative to the fire and fuels resource. All direct, indirect, and cumulative effects are disclosed and effects are quantified where possible. Direct environmental effects are those effects occurring at the same time and place as the initial action. For example, thinning of tree crowns has a direct effect on the canopy bulk density of a stand. Indirect effects are those that occur later in time or are spatially removed from the activity, but would be significant in the foreseeable future. A reduction in canopy bulk density would have an indirect effect on crown fire behavior. Cumulative effects result from incremental effects of actions, when added to other past, present, and reasonably foreseeable future actions. Cumulative effects can be the result of actions on other federal, state, county or private lands, and result from individually minor but collectively significant actions taking place over a period of time.

Fire behavior information was derived using the Forest Vegetation Simulator (FVS), Fire and Fuels Extension (FFE), and First Order Fire Effects Model (FOFEM), as discussed on pages 3.11 – 3.12. These models were chosen to estimate stand and fire behavior characteristics and fire effects for 2008 and 2028 for all alternatives. The year 2008 was chosen to display forest conditions following the mountain pine beetle epidemic for the No Action alternative and to display conditions following alternative implementation in the case of the action alternatives. The year 2028 was chosen to represent future fuel conditions after the majority of the mountain pine beetle killed trees had fallen; this was the year that FVS predicted the highest fuel loadings on the ground. The Fire Area Simulator (FARSITE) was used to analyze fire size for the Existing Condition and the No Action Alternative.

DIRECT AND INDIRECT EFFECTS COMMON TO ALL ALTERNATIVES

The probability of a fire starting in the analysis area is the same with all alternatives. This probability is very small and it is far more likely that a fire will start outside the area and move into it. The Basin Creek Watershed is currently open to public access and receives frequent human use. Human caused fires may occur due to the area’s proximity to private land and human access, especially considering the adjacency of the wildland-urban interface to wildland fuels. Because Silver Bow County has open burning regulations, residents living in that area may burn ditches, weeds and other debris. This increases the risk of fires starting on private land and moving onto the Forest.

DIRECT AND INDIRECT EFFECTS OF THE NO ACTION ALTERNATIVE

Wildland Fire

There would not be fuel reduction activities under this “no action” alternative. The risk of crown fire and high intensity surface fire will increase over time. The mature lodgepole pine and subalpine fir forest types pose the greatest threat for future high intensity surface fires. Trees will continue to die from mountain pine beetle and the standing dead trees will eventually fall over and accumulate as surface fuels over the next several decades.

The Fire and Fuels Extension to the Forest Vegetation Simulator identifies fall down rates for dead trees such that 95 percent of 10-inch snags will fall down in 20 years, and 100 percent will be on the ground in 22 years. For a 20-inch snag, 95 percent will fall in 31 years, and 100 percent will fall in 100 years. These rates coincide with a study in burned lodgepole pine forests on the Bitterrroot National Forest in which Lyon (1984) found that 85 percent of the snags fell in the first 13 years post-fire, with smaller snags falling at a faster annual rate than larger snags. Over 90 percent of snags had fallen after 21 years (Lyon 1977, 1984).

The effect of all these down dead trees would be large accumulations of surface fuels greater than 25 tons/acre on approximately 6068 acres, or nearly 42 percent, of the project area resulting in greater fire intensities, greater potential spotting, and greater resistance to control (Brown, Reinhardt, and Kramer, 2001). Heavy down fuels also provide receptive fuels for firebrands and contribute to extreme fire behavior occurrence, which creates less safe firefighting conditions and increased difficulty for protecting values at risk and private property. A lack of breaks in fuel continuity would leave fewer strategic and tactical options for firefighters when and where wildland fires need to be extinguished.

Figure 3.6: Mountain Pine Beetle mortality from the 1930s results in heavy fuel loading in the Trail Creek Drainage on the Wisdom Ranger District of the Beaverhead-Deerlodge National Forest. Photo taken May 30, 2003 (Paddock 2003).

Crown fire hazard is a physical situation (fuels, weather, and topography) with potential for damage or injury caused by crown fires. The nature of crown fires—intense, fast-moving, and destructive—suggests that potential for damage is great whenever a crown fire occurs. Assessing the hazard posed by crown fires is a matter of identifying the physical situations that lead to their occurrence.

The potential for crown fire occurrence does not depend on any single element of the fuel complex, nor does it depend on any one element of the fire environment. Rather, crown fires result from certain combinations of fuels, weather, and topography that lead to the development and continued spread of crown fires (Scott and Reinhardt 2001). High fuel loadings contribute to high intensity surface fires and fires transitioning from surface fires to crown fires.

Over time, succession will advance in the absence of fire in sagebrush/grass communities. These forest openings will convert into tree cover, shrubs will deteriorate, and bunchgrasses will be reduced or eliminated. Over time, forest fuels would accumulate, and more fuel leads to increased fire intensities and resistance to control. As these openings are lost, opportunities for defensible space and anchor points are also lost, leading to a decrease in the ability to safely and efficiently suppress fire.

The purpose of the following stand and fire behavior characteristics is to compare the relative susceptibility of different stands to crown fire and higher intensity surface fires, and not to predict the behavior of an actual fire.

Stand Characteristics

The presence of dead and dying trees from the mountain pine beetle affects stand structure, which in turn affects both fire behavior and suppression operations. Table 3.15 below describes the future condition, under the No Action Alternative, of the vegetation types by strata described in the Vegetation Existing Condition. Douglas-fir pole stands would remain mostly Douglas-fir. Because the mountain pine beetle epidemic kills most of the large diameter lodgepole pine trees, the mature lodgepole pine stands will change from predominantly lodgepole to a mixture of young small diameter subalpine fir, lodgepole, and other species of trees. Lodgepole representation decreases in lodgepole pine pole stands as well, replaced by subalpine fir. Subalpine fir trees are more flammable because they contain pockets of pitch on the bole, and these stands are more prone to high intensity fires because lower limbs reach all the way to the ground. Stand composition of mature Douglas-fir and subalpine fir stands stays relatively constant.

Table 3.15: Stand characteristics for vegetation strata in 2028, under Alternative 1, the No Action Alternative (DF=Douglas-fir; LP=Lodgepole pine; AF=Subalpine fir; S=Spruce; O=Other)

		Douglas-fir pole	Mature Lodgepole Pine	Lodgepole Pine Pole	Mature Douglas-fir	Mature Subalpine Fir
	Stand #	41404424	41505528	41503308	41601105	41504427
	Year	2028	2028	2028	2028	2028
Stand Attributes	Species Mix	89% DF 7% LP 4% O	44% AF 33% LP 23% O	65% LP 16% AF 8% DF 11% O	97% DF 3% LP	94% AF 3% S 1% DF 2% O
	Fuel model	99% 8 1% 10	82% 12 18% 13	68% 10 32% 8	71% 10 29% 8	51% 10 49% 12
	BA (sq ft/ac)	78	67	148	148	201
	Trees/acre	345	680	1240	3909	6755
	Height (ft)	83	89	62.4	78.1	90.7
	Diameter	6.4	4.3	4.7	2.6	2.3
	Fuel loading (tons/acre)	9.7	58.3	19.4	15.9	30.7

As trees killed from the mountain pine beetle epidemic fall over and contribute to fuel loadings, fuel models will change from predominantly Fuel Model 8 with some Fuel Model 10, to Fuel Models 10, 11, 12, and 13. This is least noticeable in the Douglas-fir pole strata. Fire behavior in Fuel Models 11, 12, and 13 is characterized by more intense fires than in models 8 and 10. These fuel models are capable of generating firebrands and active flaming is sustained for long periods of time. Crowning out, spotting, and torching of individual trees is highly probable, especially in Fuel Model 13. Future fuel models associated with the No Action Alternative are associated with a higher resistance to control, longer residence times, and higher intensities. For a more detailed discussion on fuel models, refer to the Existing Condition.

Basal area and trees per acre decrease immediately following mountain pine beetle mortality and then begin to increase as regeneration occurs. This is most obvious in the mature lodgepole pine stands. Diameter in the mature lodgepole pine stands decreases significantly, indicating an overall loss in the number of large trees in those stands.

The mountain pine beetle will have a substantial effect on fuel loadings over time. By killing trees, beetles create snags, which eventually fall over and become down woody debris and add substantially to fire intensity, especially in droughty conditions. Fuel loading increases from 2003 to 2028. The year 2028 represents the point in time that the Forest Vegetation Simulator predicted the greatest fuel loading. Fuel loading in 2028 is highest in the mature lodgepole pine strata at 59 tons/acre, and lowest in the Douglas-fir pole strata at 10 tons/acre. Fuel loading increased in the mature Douglas-fir strata from 5 tons/acre in 2003 to 16 tons/acre in 2028, in the lodgepole pine pole strata from 5 tons/acre to 20 tons/acre, and in the mature subalpine fir strata from 18 tons/acre to 31 tons/acre. Fuel loading increased an average of 19

tons/acre from 2003 to 2028 as a result of mortality associated with the mountain beetle. Table 3.16 compares the change in fuel loading from 2003 to 2028.

Table 3.16: Comparison of fuel loading in tons per acre resulting primarily from Mountain Pine Beetle Mortality in 2003 and 2028, under the No Action Alternative

	Douglas-fir Pole	Mature Lodgepole Pine	Lodgepole Pine Pole	Mature Douglas-fir	Mature Subalpine Fir
2003	4.6	9.4	4.7	4.9	17.7
2028	9.7	58.3	19.4	15.9	30.7

Both standing dead trees (snags) and dead trees that have fallen over inhibit line construction and line holding operations. Standing snags pose safety concerns and have the potential to burn out and fall over suddenly, without warning. They often fall across control lines, and falling snags kill and/or injure fire fighters every year. Snags falling across fire lines can ignite fire across the line, compromising the integrity of control lines and posing a potential hazard to firefighters. Managers are often compelled to pull suppression forces off the fire when snag hazards are especially dangerous. Heavy amounts of down woody debris hamper line construction efforts by requiring a lot of chainsaw work.

Fire Behavior

Future condition of predominant vegetation types by strata and associated fire behavior are displayed in Table 3.17 below. The following characteristics were pulled from the FFE model runs to compare alternatives.

Table3.17: Fire Behavior for vegetation strata in 2028, under Alternative 1, the No Action Alternative

		Douglas-fir pole	Mature Lodgepole Pine	Lodgepole Pine Pole	Mature Douglas-fir	Mature Subalpine Fir
	Stand #	41404424	41505528	41503308	41601105	41504427
	Year	2028	2028	2028	2028	2028
Fire Behavior	Flame Length					
	severe	1	20.1	42	75	100.3
	moderate	0.5	4.4	1.6	1.8	4.1
	Type of fire					
	severe	surface	passive	passive	active	active
	moderate	surface	passive	surface	surface	surface
	Canopy Bulk Density (kg/m3)	0.045	0.043	0.113	0.276	0.508
	Canopy Base Height (ft)	6	4	3	5	5
	Torching Index (mph)	57	0	0	14	0
	Crowning Index (mph)	41	43	20	9	0
	Crown Fire Hazard Rating	Low	Moderate	High	High	High

FFE runs for severe fires in 2028 showed 20 foot flame lengths or greater in all but the Douglas-fir pole stands, in which case the flame lengths did not change from 2003 to 2028. The most notable results, however, are the mature lodgepole pine and subalpine fir stands under moderate fire weather conditions, producing flame lengths greater than four feet. As stated on p. 3.19, flame lengths greater than four feet increase the potential for "extreme" fire behavior, prevent firefighters from initiating direct attack on a fire, greatly reduce firefighter safety, and contribute to long range spotting.

Figures 3.7 and 3.8 (below), and Table 3.17 (above), display how FFE simulates fire type based on moderate and severe fire weather conditions shown in Table 3.10. Fires burned as a surface fire in all forested areas under moderate fire weather conditions in 2003. After 25 years of growth and mortality, 52 percent of this forested area will burn as a passive fire type. In contrast, under severe fire weather conditions, 98 percent of the forested area burns as a surface fire in 2003 and after 25 years of growth, 79 percent of the area burns as a passive fire and 15 percent burns as an active crown fire. This is an overall increase in the amount of acres that will burn with intensities too high for direct attack from 2003 to 2028. These comparisons illustrate the substantial change in fire potential as these forests grow and change over time. The amount of passive and active fire is greatest in stands with enough surface and ladder fuels to facilitate flames reaching the crown canopy. Under severe fire weather conditions, wind speeds are high enough to cause surface and passive fires to become active crown fires.

Canopy bulk density decreased in Douglas-fir pole, mature lodgepole pine, and lodgepole pine pole strata due to mountain pine beetle mortality when compared to 2003 when lodgepole pine trees were still alive and had full crowns contributing to canopy bulk density. Only Douglas-fir pole and mature lodgepole pine stands have canopy bulk densities below Graham and others' (1999) recommendation of less than 0.0791 kg/m3 to reduce the potential for a crown fire moving through the crowns. In mature Douglas-fir and subalpine fir stands, there is a dramatic increase in canopy bulk density, the main influence of crown fire behavior. In these stands, canopy bulk densities are 0.276 and 0.508 kg/m3.

Two indices are used to assess crown fire hazard—the torching index and crowning index. These indices, discussed in depth in on pages 3.12, 3.18, 3.20 – 3.22, were used to rate different forest stands by their relative susceptibility to crown fire and to compare the effectiveness of crown fire mitigation treatments. The potential for fires to move from the surface to the crowns of trees is expressed by torching index and is generally function of canopy base height and surface fuel loading. Torching index increases from 35 mph to 57 mph in the Douglas-fir pole strata. This means that the wind value needed to move a fire from the surface to the tree crowns increases and the potential for torching, therefore, decreases. In mature lodgepole pine, mature subalpine fir, and lodgepole pine pole stands, torching index dropped to 0 mph, implying that fires can move from the surface to the tree crowns with no wind at all. In these stands the potential for crown fire initiation is high. The mature subalpine fir stands remain in a high crown fire hazard rating category. Mature Douglas-fir stands change from moderate crown fire hazard to high crown fire hazard, and lodgepole pine remains at a moderate crown fire hazard. Subalpine fir, Douglas-fir, and lodgepole pine stands encompass 4824 acres of the project area. In addition to creating woody debris, the killing of overstory trees creates openings in the canopy allowing the establishment and/or growth of understory trees. Overtime, this leads to the development of two- and multi-story stands, which adds to the potential for crown fire initiation by decreasing the canopy base height. A stand may have a high potential for crown fire initiation but a low potential for crown fires to sustain because the crowning index is high. Such is the case with mountain pine beetle killed lodgepole pine stands in the short term (less than 50 years). Because the large trees have died and allowed regeneration to occur, crown fire initiation may be probable, but lower canopy bulk densities and a younger stand will likely not sustain crown fires. Table 3.18

and Figures 3.7 and 3.8 (below) illustrate the changes in these values and the resulting change in crown fire hazard rating.

Figures 3.7, and 3.8: These figures illustrate the changes in torching and crowning index for all strata from 2003 to 2008 and then to 2028, under the No Action Alternative

Figure 3.7: A comparison of windspeed needed to initiate fire moving from the surface into the crowns in 2003, 2008, and 2028 under the No Action Alternative

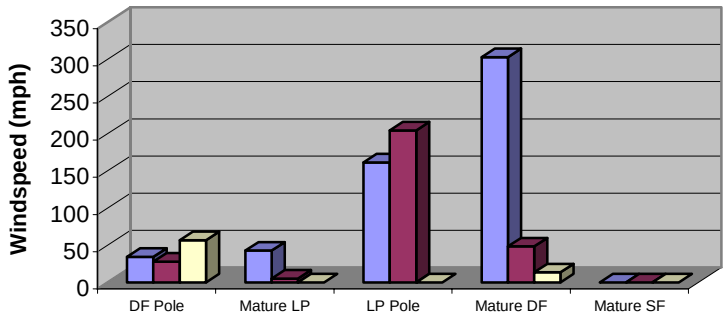


Figure 3.8: A comparison of windspeed needed to initiate fire moving from the surface into the crowns in 2003, 2008, and 2028 under the No Action Alternative

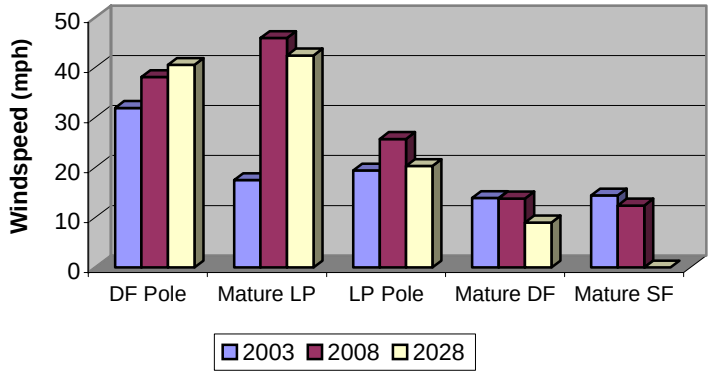


Table 3.18: Changes in crown fire hazard rating for all strata from 2003 to 2008 and then to 2028, under the No Action Alternative

	2003	2008	2028
Douglas-fir Pole	Low	Low	Low
Mature Lodgepole Pine	Moderate	Moderate	Moderate
Lodgepole Pine Pole	Moderate	Low	High
Mature Douglas-fir	Moderate	Moderate	High
Mature Subalpine Fir	High	High	High

When the mountain pine beetle kills lodgepole pine, tree needles die and persist for several years. This situation creates conditions that are conducive to surface to crown fire transition and canopy fire spread. In a healthy stand, during normal summer fuel moisture conditions, foliar moisture content averages around 100 percent (Rothermel 1991). However, when a tree is killed, its needles die and respond to climate like a one-hour fuel. It is common for one-hour fuel moistures to drop to four and five percent during hot periods with low relative humidity (summer and fall). As a result, while the dead needles still persist on the twigs, the tree is much more susceptible to torching than when it's in a green state or the needles have fallen to the ground. Personal observations by the district silviculturist since this epidemic began in 1999 indicate red needles will persist on the tree for four years before falling off (Hodge 2003). However, not all trees are infected in the same year, so it is reasonable to expect that there will be red-needled trees in the analysis area for the next 10 years as the infestation progresses. The needles gradually fall from the tree and become incorporated with the surface duff layer, adding to the surface fuel load but becoming compacted over time. The duff layer will facilitate slow fire spread but does not contribute significantly to surface fire intensity in short needle forest types.

Fire Effects

Table 3.19: Fire Effects for strata in 2028 under the No Action Alternative, should a fire burn under severe and/or moderate fire weather conditions (see Table 3.10 for weather and fuel conditions associated with these fire types).

		Douglas-fir pole	Mature Lodgepole Pine	Lodgepole Pine Pole	Mature Douglas-fir	Mature Subalpine Fir
	Stand #	41404424	41505528	41503308	41601105	41504427
	Year	2028	2028	2028	2028	2028
Fire Effects	Mortality (%BA)					
	severe	16	99	99	100	100
	moderate	16	56	68	37	57
	Smoke (T/A < 2.5)					
	severe	0.17	0.63	0.37	0.35	0.71
	moderate	0.10	0.41	0.21	0.18	0.39
	Fuel Consumed (>3"), tons/acre					
	severe	3.4	39.52	9.59	6.7	21.8
	moderate	1.1	35	3.9	3.5	15.6
	Fuel Remaining (>3"), tons/acre					
	severe	6.4	18.8	9.81	9.2	8.9
	moderate	7.6	23	15.5	12.4	15.1

For the following measures, the Fire and Fuels Extension to the Forest Vegetation Simulator (FVS-FFS) was used to simulate a fire under both moderate and severe weather conditions as they would occur in

2008 (see Table 3.10 on p. 3.23 for details) and 2028 under the No Action Alternative. Under severe fire weather conditions, a fire remains as a surface fire, and the percent of fire-killed mortality in the Douglas-fir pole stands actually decreases from 2003 to 2008 (from 24% to 16%) and then remains at 16 percent into 2028. In contrast, in the mature Douglas-fir stands, a fire increases in intensity from a surface fire in 2003 and 2008 to an active crown fire in 2028, and the percent of the basal area killed increases from 40 percent to 100 percent under severe fire weather conditions. Mortality increases over time in the mature lodgepole pine and lodgepole pine pole stands as well. The amount of fuel consumed and fuel remaining on a site after a fire has important consequences for soil, water, and wildlife resources. Table 3.19 above shows these values under severe and moderate conditions.

Fire Size

The FARSITE model was used to spatially and temporally simulate the spread and behavior of fires in the analysis area. Table 3.20 below illustrates some possible fire sizes should a fire occur in the analysis area in 2028 (refer to Table 3.11 for potential 2003 acres). The model is described on pages 3.11, 3.25, 3.26, and for the purposes of this analysis, the model ran for a 5-day period and acreages were computed. The model estimated an average increase of 5157 acres from 2003 to 2028.

Increased fuel loading, understory regeneration, and continuous fuel loading contribute to this increase in acreage. The model also does not account for fire suppression, which would take place in actual circumstances.

Table 3.20: Possible acreages, from the FARSITE model, of a fire occurring in the analysis area over a 5-day period in 2028, under the no action alternative (based on actual fire starts from Appendix B, Map 11 Fire Occurrence)

Fire starting near:	2028 acres
Herman Gulch	5414
Basin Creek Reservoir	8031
Roadless Area	2988

The Mussigbrod Fire in 2000, the Sheep Creek Fire in 2002, and the Blackwall Fire in 2003 are actual fires that burned in areas very similar to the Basin Creek area. These fires occurred in areas where the mountain pine beetle had reached epidemic proportions in the 1930s. The Mussigbrod Fire burned approximately 40,000 acres, the Sheep Creek Fire burned 2,000 acres, and the Blackwall Fire burned over 3,500 acres.

DIRECT AND INDIRECT EFFECTS COMMON TO ALL ACTION ALTERNATIVES

Fuel Reduction and Thinning

Wildland fire is a natural ongoing process, and its time and location can never be precisely predicted by fire behavior science. Life, resources, and property are always at risk during a large wildland fire event. None of the alternatives have an influence on the time and place a natural fire may start. Human caused fire is also unpredictable, but can be prevented in many cases with education and law enforcement. The alternatives examined, however, will influence the size and intensity of a wildfire and the ability of suppression forces to

safely and effectively control a wildland fire within the project area. As stated on page 3.2, any wildland fire within the analysis area would require a suppression response as directed by the Deerlodge Forest Plan to control, confine or contain fires, using rapid initial attack actions.

Of the three contributing factors to fire behavior (fuels, weather, and topography), fire managers influence only fuels. Managers can modify both live and dead fuels, their amount, and their arrangement. Fuels management modifies fire behavior, ameliorates fire effects and reduces fire suppression costs and danger (DeBano 1998), and treatments that reduce fuel loads have been shown to decrease fire behavior (Buckley 1992). Fuel management includes reducing the loading of available fuels (either mechanically or with prescribed fire), converting fuels to those with a lower flammability, reducing stand layering, reducing canopy bulk density, or isolating or breaking up large continuous bodies of fuels (DeBano 1998). A reduction in surface fuels can limit fireline intensity (Brown and Davis 1979) and can help to lower fire severity (Ryan and Noste 1985). Van Wagtendonk (1996) found in fire simulations that a reduction in fuel loads decreased subsequent fire behavior, increased fireline control possibilities and decreased fire suppression costs. Efficient fireline construction rates are also enhanced where fuel reduction has occurred, which decreases resistance to control (Agee et al 2000). Increased fireline control leads to enhanced firefighter safety. Refer to Figures 3.9, 3.10, and 3.11. Figures 3.9 and 3.10 depict unmanaged, burned stands on the 1990 Gird Point and 1961 Sleeping Child wildfires. Figure 3.11 depicts a managed, burned stand on the Gird Point wildfire. From a fire suppression perspective, it is easier to contain a fire in a stand with fuel features exhibited in Figure 3.11, rather than in Figures 3.9 and 3.10 under equal weather conditions.

Figure 3.9: 2001 photo of unmanaged burned stand inside 1990 Gird Point Wildland Fire area.

Figure 3.10: 2001 photo of unmanaged burned stand inside 1961 Sleeping Child Wildland Fire area.

Figure 3.11: 2001 photo of a managed burned stand inside 1990 Gird Point Wildland Fire area.

Fuels management—including reducing the loading and continuity of available fuels—is a realistic management goal. Breaking up fuel continuity can change the behavior of a fire entering or starting in an area to allow suppression forces a higher probability of successfully attacking a wildland fire (Agee et.al. 2000, Green 1977). Areas with significantly less fuel may also be used as anchor points for both wildland fire control and prescribed fires (Agee et al 2000). Breaks in fuel continuity in the forest lands could reduce the extent and severity of future fires by reducing intensities to acceptable levels in areas where social, ecological, and economic considerations warrant. Readily available anchor points and reduced fire intensities enhance firefighter safety.

Fires were generally large and intense in 2000 and 2002, and would not allow for direct attack by wildland firefighters. Rather, incident managers chose aerial and indirect attack to fight the heads of fires. In response to the fires of 2000, the General Accounting Office mandated federal land management agencies to develop a cohesive strategy to address fuel accumulation and the threat of catastrophic wildfires. This increase in fuel treatment activities caused increased debate regarding the purpose and intentions of fuel

treatments. The fire seasons of 2000 and 2002 provided an opportunity for fire and fuel managers to evaluate the effectiveness of previous fuels treatments.

Historically, studies comparing the effects of wildland fire on treated and untreated stands were rare and inconclusive. Omi et. al. (2002) speculates possible reasons for this research void: 1.) The question of treatment effectiveness is uninteresting in that the answer seems obvious or fuel treatment has only recently become controversial, 2.) Assessment of fuel treatment effects on fire behavior are not possible due to incomplete record-keeping as to exact treatment boundaries or other potential past management activities, and 3.) Fire behavior can often be related to one of the other contributing variables such as topography or weather.

Recent research, however, suggests that thinning will reduce fire intensity and severity by reducing the risk of crown fires. Crown fires depend on surface fire flame length (related to the fuel loading on the surface), canopy base height, live fuel moisture, and canopy bulk density (Reinhardt and Scott 2001; Graham et. al. 1999). A fire burning in the surface fuels with a flame length exceeding 5 feet, combined with a canopy base height of 10 feet and live fuel moistures of 75 percent, will ignite fuels in the canopy (Graham et. al. 1999). Whether or not the canopy will sustain a crown fire depends on canopy bulk density and continued rate of spread. As canopy bulk density increases, lower wind speeds are required to maintain a crown fire, and the potential is greater for an active crown fire to establish (Reinhardt and Scott, 2001; Graham et. al. 1999).

Two important characteristics of crown fire may be altered through thinning: canopy base height and canopy bulk density, discussed at length on pages 3.18 to 3.25. If activity generated slash is treated, surface fire flame length will also be decreased. Live fuel moisture is largely a function of climate, and can generally not be modified by land managers. Canopy base height relates to the lower live limbs and branches of a stand, the smaller trees and vegetation in the understory, and their role as ladder fuels. Increasing the canopy base height decreases the ability of a fire to move from surface fuels into the canopy, thereby lowering the potential for crown fire initiation. The primary influence of crown fire behavior in the tree crowns is canopy bulk density. Thinning will generally lower canopy bulk densities, and Graham et. al. (1999) suggests that canopy bulk densities lower than 0.006 pound per cubic foot (0.0791 kg/m^3) are relatively protected from crown fires. Graham et. al. (1999) state, “Fire intensity in thinned stands is greatly reduced if thinning is accompanied by reducing the surface fuels created by the cuttings.”

Crowns of trees removed during treatments may contribute to surface fuel loadings and may have a large impact on fire behavior if left untreated. Graham et. al. (1999) point out that logging slash has been responsible for extreme fire behavior in the past and contributed to the fires in the Inland and Pacific Northwest forests in the late 1800s and early 1900s. Thinning also has the potential to exacerbate ground and surface fire behavior by increasing surface wind exposure and increasing solar radiation, thereby lowering fuel moisture and increasing fine fuels (Graham et.al. 1999; Pollet and Omi 2000). However, these fires would occur as ground and surface fires, which can often be suppressed using direct attack. In order for fuel treatments such as thinning to be effective, activity generated slash needs to be eliminated to reduce surface fuel loading.

Omi et.al. (2000) studied the severity of four wildfires that burned into fuel treatments, which included prescribed fire treatments and mechanical treatments over the 10 years previous to the wildland fire. The studies occurred in four forest types: slash pine and longleaf pine in Missouri; white fir, Douglas-fir and sugar pine in California; ponderosa pine, pinyon pine and juniper in New Mexico; and ponderosa pine, lodgepole pine, and Douglas-fir in Colorado. Their results “unanimously indicate that treated stands

experience lower fire severity than untreated stands that burn under similar weather and topographic conditions" (Omi et. al. 2000).

A case study of the Hayman Fire in Park County, Colorado, in 2002, by Finney et. al. (undated) found mixed results under extreme drought conditions. They looked at the effects of previous wildfires, prescribed burns, and mechanical treatments on fire severity and progress. One recent wildfire prevented the Hayman fire from progressing, "even as a heading fire under the most extreme weather conditions" (Finney et. al. undated). The fire burned through a recent timber harvest unit and killed most of the trees, but remained as a surface fire; the surrounding, untreated area burned as a crown fire. Two previous prescribed burns acting together temporarily prevented a crown fire run. However, during the fires largest runs, and under the most extreme fire weather conditions fuel treatments generally had little effect on fire progress or fire severity. Most studies indicated that under extreme fire weather conditions, fuel treatment units were often overwhelmed and became ineffective (Pollet and Omi 2000; Graham et. al. 1999; Finney et. al. undated). Finney et. al. (undated) also found that in the case of the Hayman Fire, relatively recent fuel treatments were more effective than older units in slowing fire and decreasing fire severity, indicating that treatments may only be effective a short time into the future.

In these particular cases, fuel treatments did not work under extreme conditions, but empirical evidence on the Wisdom Ranger District, under severe fire and weather conditions on the Mussigbrod Complex in 2000 and the Sheep Creek Fire in 2002, suggests that clearcuts remained unburned even when active crown fire burned the entire area surrounding them (Hutton 2001). Even clearcuts as old as 35 years and as tall as 30 feet would not burn. Figure 3.12 was taken recently after the Mussigbrod Complex and illustrates that clearcuts often acted as fire breaks during that extreme fire season. Crews could often use past clearcuts for safety zones when fire activity increased. Pollet and Omi (2000) found, in their study of the effects of fuel treatments on wildfire severity, that fuel treatments moderated fire severity and allowed for safer, more effective fire suppression efforts. They also found that treating strategically located stands is beneficial in decreasing wildfire severity across a large area. These examples often work.

Figure 3.12: Overlooking the Mussigbrod Complex, on the Wisdom Ranger District shortly after it burned in the 2000 fire season.Finney et. al. (undated) determined that often times, smaller treatment units were less effective than larger units in changing fire progress and severity. Fuel treatments do not necessarily stop a fire's progress, but they will change fire behavior and effects. The Rodeo-Chediski Fire burned more than 48,000 acres on almost 20 percent of the Lakeside Ranger District in Arizona during the summer of 2002 and District Ranger Ed Collins stated, "Most places where we were able to thin and burn in the last ten

years still have green trees" (Keller 2002). Fire moving into treated areas dropped from tree crowns to the ground and became a surface fire, allowing firefighters options for suppression (Keller 2002). Most studies have only been conducted under extremely droughty conditions because in moderate conditions, initial suppression actions are often successful.

The above-cited literature indicates that if the goal of a landowner/manager is to decrease fire related mortality and severity when a fire occurs; there are several variables they need to address. One is to create conditions that minimize the potential for a fire to move from the surface fuels into the tree crowns by reducing the amount of downed woody material. Another variable is to thin the crowns of trees, thereby decreasing the ability of a fire moving in the crowns to continue forward spread through the crowns.

Prescribed Fire

There is a risk of escaped prescribed fire for all action alternatives. All action alternatives propose prescribed fire in the form of broadcast burns and slash disposal. Alternatives 3 and 4 propose the most broadcast burning which is at the highest risk for escape. Alternatives 4 and 5 have the highest overall risk because these alternatives propose the more burning overall. Risk of escape would be mitigated with prescribed fire burn plans, which set parameters for fuel moisture, air temperature, humidity, wind speed and direction, flame length, fire behavior, and air quality. These plans also identify the resources needed to carry out the prescribed burn and define a contingency plan with needed contingency resources, should a fire escape its control boundaries. The seasonal timing of the prescribed burning would have the most effect on the risk of escape. Because burning reduces fuel loading, the potential for a future wildfire escaping initial attack is minimized and the long-term effects of wildfire are reduced with the action alternatives.

Fire Risk in the Wildland Urban Interface

Wildland fire threatens structures in three ways: direct exposure from flames, radiated heat, and airborne firebrands. The proposed treatments are meant to decrease the probability of wildland fire threatening structures in the immediate area of the project from all three means. Creating "defensible space" implies that the vegetation in the area between a structure and an oncoming wildland fire has been modified to reduce the wildland fire threat and to provide an opportunity for firefighters to effectively and safely defend the structure. Fuels can be treated in a relatively small area immediately adjacent to structures to reduce exposure to flames and radiant heat. Evidence suggests that fuel reduction within 40 meters of a structure can substantially reduce ignitions from direct exposure to flames or their radiant heat (Cohen 1995 and Alexander et. al. 1998). Experience has shown that firefighters are more likely to take risks when structures are threatened (Hvizdak 2003). Although Cohen's research advocates that the fuel profile only needs treatment within 40 meters of residences, it is reasonable to assume that fuels reduction and thinning outside of this perimeter will decrease fire intensity, thereby increasing firefighter safety and the ability of firefighters to protect structures. Proposed treatments reduce the likelihood of firebrands being lofted downwind from fires and onto private land and structures. In 1994, the Kootenai National Forest experienced a fire in the wildland-urban interface in an area that had previous been treated with thinning and underburning. The fire behavior changed from a crown fire to a surface fire when it entered the treated stand, and possibly saved half a dozen homes (Hvizdak 2003).

Structures at risk in the analysis area are on private and National Forest land; this project only proposes treatment on National Forest lands. Many landowners have already treated their property, and some are

currently in the process of creating defensible space. Approximately 210 acres of private land on Roosevelt Drive and 65 acres in China Basin have been or will be treated. Slash has been or will be removed, and fuels on those acres are generally below 15 tons/acre. Landowners hold this responsibility and none of the alternatives, including Alternative1: The No Action Alternative, propose treatment on private land. However, the Forest Service, in cooperation with Silver Bow County, has held public meetings regarding the protection and evacuation of private land and the State, County and Butte Ranger District currently provide brochures and information describing methods and mitigation measures for reducing wildfire hazard on private land.

Reducing the fuel loadings, fuel continuity, and the availability of ladder fuels keeps fire confined to the ground, reduces fire intensity, and reduces firebrands, all of which increase the ability to control fires and improve firefighter safety. Reducing the threat of ignition from firebrands requires reducing fuels both near and at some distance from the structure. Ignitions may result from firebrands originating as far away as 1 kilometer or more (Cohen 2000). Threat from firebrands, however, becomes greater the closer the fire moves to structures. The Basin Creek Project proposes to treat fuels adjacent to private property along the National Forest Boundary.

Effects to Stand Characteristics

As discussed on pages 3.12 to 3.14, stands in the analysis area were grouped in strata. Using the Forest Vegetation Simulator (FVS), treatments were applied to each of the strata and ran into the future to identify the conditions that will likely exist in 2008 and 2028. Changes to stand characteristics resulting from fuels reduction and thinning are direct effects. For the purposes of this analysis, the effects these changes have on fire behavior will be viewed as indirect effects, since the time and place a fire occurs is unpredictable. Subalpine fir stands were not analyzed in the alternative effects analysis because these stands were not treated under any of the action alternatives.

Douglas-fir Pole

Lodgepole pine will be removed from these stands and then the stand will be thinned from below to a basal area between 40 and 80 sq ft/ac. Following treatment in these stands, there is an increase in Douglas-fir, ponderosa pine and other species, and a decrease in lodgepole pine in the Douglas-fir Pole strata. Table 3.21 above describes the future conditions under the action alternatives. Fuel model remains mostly Fuel Model 8, with 20 percent of the area changing to a Fuel Model 2 (refer to Table 3.5 for fuel model descriptions). Fires in Fuel Model 2 are generally surface fires and are carried primarily through the fine herbaceous fuels, and fires in Fuel Model 8 are mostly slow-burning ground fires with low flame lengths. Basal area and trees per acre decrease following treatment, especially in those units that jackpot burning occurs. Basal area drops from 83 ft^2/acre in 2003, to 62 ft^2/acre in 2008 in unburned units, and 54 ft^2/acre in 2008 in burned units. By 2028, basal area increases to 71 ft^2/acre in unburned units as a result of existing tree diameter growth and the occurrence of regeneration.

Table 3.21: Effects to Stand Characteristics for vegetation strata in 2008 and 2028, following treatment in the action alternatives (Alternatives 2, 3, 4, and 5)

		Douglas-fir Pole				Mature Lodgepole Pine		Lodgepole Pine Pole		Mature Douglas-fir			
	Stand #	41404424				41505528		41503308		41601105			
	Year	2008	w/burn	2028	w/burn	2008	2028	2008	2028	2008	w/burn	2028	w/burn
Stand Attributes	Species Mix	88% DF 4% LP 3% PP 5% O	89% DF 5% LP 3% PP 3% O	87% DF 6% LP 3% PP 4% O	89% DF 5% LP 1% PP 5% O	21% LP 29% DF 15% AF 35% O	20 % LP 30% DF 15 % AF 35% O	99% LP 1% DF	99% LP 1% DF	88% DF 6% LP 6% O	90% DF 8% LP 2% O	88% DF 10% LP 2% O	89% DF 9% LP 2% O
	Fuel model	80% 8 20% 2	69% 8 31% 2	94% 8 6% 2	83% 8 17% 2	60% 11 40%8	60% 11 40% 8	100% 8	100% 8	70% 8 23% 10 7% 2	70% 8 30% 2	100% 8	83% 8 17% 2
	BA (sq ft/ac)	62	54	71	63	0	9	84	100	63	50	73	59
	Trees/acre	224	202	346	323	520	867	373	352	231	199	342	307
	Height (ft)	71.5	68.3	82.8	77.4	1.2	18	55.6	65.6	65.8	64.5	77	76
	Diameter	7.1	7	6.1	6	0.1	1.4	6.4	7.2	7.1	6.8	6.2	5.9
	Fuel loading (tons/acre)	10-15	10-15	10-15	10-15	10-15	10-15	10-15	10-15	10-15	10-15	10-15	10-15

Mature Lodgepole Pine

Most of the lodgepole pine will be removed from these stands, and Douglas-fir will remain where they occur. These stands will experience a decrease in the amount of lodgepole pine and an increase in the amount of Douglas-fir. Subalpine fir representation remains relatively constant. The **fuel model** changes from mostly Fuel Model 8 (97 percent) with some Fuel Model 10 (3 percent) to Fuel Model 11 (60 percent) and Fuel Model 8 (40 percent) (see **Table 3.5** for fuel model descriptions). Fuel Model 8, characterized by slow moving surface fires, combined with Fuel Model 11, characterized by slow moving, more intense fires burning in jackpot concentration of down woody debris, is an overall decrease in fire intensity and rate of spread from the Fuel Model 8 and 10 combination seen in the existing condition. The number of **trees per acre** will increase from 551 trees/acre in 2003 to 867 trees/acre in 2028, but the average diameter in the stand will decrease from 8 inches to 1.4 inches, indicating these stands will change from stands with large mature trees to stands containing young, small diameter regeneration with a few large “reserve” Douglas-fir trees in the overstory.

Lodgepole Pine Pole

These stands will be thinned to a basal area between 80 and 120 sq ft/ac. Species composition will remain relatively constant in these stands. **Fuel model** also remains constant (Fuel Model 8) under this action alternative. The number of **trees per acre** decreases from 1088 trees/acre in 2003 to 352 trees/acre in 2028, but the average diameter increases from 5.7 inches to 7.2 inches, indicating a more open stand with larger trees.

Mature Douglas-fir

Most of the lodgepole pine will be removed and the remaining Douglas-fir will be thinned from below to a to a basal area between 40 and 80 sq ft/ac, retaining trees in a clumpy distribution where possible.Lodgepole pine representation increases approximately 6 percent in these stands from 2003 to 2028, but this stratum is still dominated by large diameter Douglas-fir trees after treatment. The **fuel model** remains unchanged over time in unburned treated stands, but the representation by Fuel Model 2 increases in treated stands where jackpot burning occurs in conjunction with thinning (see **Table 3.5** for fuel model descriptions). Small diameter Douglas-fir trees are removed, decreasing the number of **trees per acre** from 4126 trees/acre in 2003 to 342 trees/acre in unburned stands in 2028 and 307 trees/acre in burned stands in 2028. Average diameter is increased significantly, from 2.5 inches in 2003 to 6.2 inches in 2028, implying the post treatment stand condition to be a much more open stand with fewer small trees in the understory.

Effects to Fire Behavior

Alternative development was focused specifically on reducing hazardous fuels in the wildland/urban interface and in the Basin Creek drainage area to decrease the probability of crown fires, lower the spread and intensity of future surface fires, and increase the probability of safely defending life and property from fire. Treatments were designed to affect stand structure, which in turn affects fire behavior. Treatments were unique to each vegetative strata, and the features of each treatment are described in Chapter 2. Using FVS and the FFE, treatments were modeled and the future condition of fire behavior is displayed in following discussion. The values were pulled from the FVS and FFE model runs to compare alternatives. In the case of fire behavior, comparisons will not only be made with the existing conditions in 2003 and 2008, but also with the no action alternative in 2028, as discussed above.

Douglas-fir Pole

After treatment, Douglas-fir pole stands will experience an overall increase in **flame length** from 1 foot in 2003 to 2 feet in 2008 and up to 3.7 feet in 2028. Flame lengths potentially increase as a result of a more open canopy allowing for a higher midflame windspeed. These stands have higher flame lengths in 2028 under the action alternatives than under a no action alternative. Under all the alternatives, including the no action alternative, flame lengths in the Douglas-fir strata never exceed four feet, which allows the option of direct attack under most circumstances. Fires in the Douglas-fir pole strata remain as **surface fires** during severe and moderate fire weather conditions under all alternatives.

Canopy bulk densities in this stratum do not exceed Graham's recommendation of 0.0791 kg/m^3. Currently, the canopy bulk density is 0.062 kg/m^3. Removing lodgepole pine trees and thinning Douglas-fir trees decreases the canopy bulk density to 0.044 kg/m^3. This occurs under the no action alternative, as well, as a result of mountain pine beetle mortality, when the crown bulk density drops to 0.045 kg/m^3.

Although the **crown fire hazard rating** remains "Low" throughout time under all alternatives, treating these stands in 2003 increases the **canopy base height** from four feet in 2003 to 25 feet in 2008 and 26 feet in 2028. This essentially raises the **torching index**, or the windspeed required to move a surface fire into tree crowns, from 35 mph to 130 mph. The **crowning index** is also raised in 2008, following treatment, from 32 mph to 41 mph. Such high numbers in these indices imply that it becomes highly unlikely that a crown fire will initiate or be sustained in Douglas-fir stands under the action alternatives.

Table 3.22: Fire Behavior for vegetative strata in 2028, under all action alternatives.

		Douglas-fir Pole				Mature Lodgepole Pine		Lodgepole Pine Pole		Mature Douglas-fir			
	Stand #	41404424				41505528		41503308		41601105			
	Year	2008	w/burn	2028	w/burn	2008	2028	2008	2028	2008	w/burn	2028	w/burn
Fire Behavior	Flame Length												
	severe	2	2.7	1.3	3.7	4.2	6.6	1	0.9	2.4	3.7	1	1.9
	moderate	0.8	1	0.6	0.8	1.5	1.2	0.5	0.5	1.1	1.1	0.5	0.8
	Type of fire												
	severe	surface	surface	surface	passive	surface	passive	surface	surface	surface	surface	surface	surface
	moderate	surface	surface	surface	surface	surface	passive	surface	surface	surface	surface	surface	surface
	Canopy Bulk Density (kg/m3)	0.044	0.038	0.039	0.033	0	0.042	0.054	0.063	0.086	0.066	0.068	0.052
	Canopy Base Height (ft)	25	26	4	4	0	1	30	36	32	32	33	33
	Torching Index (mph)	130	96	26	18	n/a	0	329	436	172	120	335	183
	Crowning Index (mph)	41	46	45	50	n/a	43	35	32	25	30	30	37
	Crown Fire Hazard Rating	Low	Low	Low	Low	Low	Mod	Low	Low	Low	Low	Low	Low

Mature Lodgepole Pine

FFE runs for severe fires in 2028 showed 6.6 foot **flamelengths** in mature lodgepole pine stands in the action alternatives. In 2003, FFE predicted flamelengths of only 1 foot and in 2008, under the no action alternative and after the mountain pine beetle simulation, FFE reported 8.8 foot flamelengths. Flamelengths under *severe* fire weather conditions after treatment in 2028 are similar to the no action alternative flamelengths under *moderate* conditions. The model also predicts a change in fire type from **passive fire** under the no action alternative in 2008 to a **surface fire** under the action alternatives in that same year. In 2028, FFE predicts passive fires under severe and moderate conditions in the action alternatives.

Because all of the large diameter lodgepole pine will be removed from these units, leaving only small diameter lodgepole and large and small diameter Douglas-fir (which only occur in small quantities) following

treatment, these units will be composed primarily of lodgepole pine regeneration. Although in 2028 the FFE model predicts flamelengths above the identified trigger point for ceasing direct attack (4 feet), burning in a passive fire type with a low torching index under the action alternatives, local experience has shown that lodgepole pine regeneration stands will not burn. The Mussigbrod Fire, the Sheep Creek Fire (Beaverhead-Deerlodge National Forest), and the North Fork Fire (Kootenai National Forest) burned in extreme drought years under severe fire weather conditions. All three fires dropped from the crowns to the ground in lodgepole pine regeneration units and even stopped burning in some cases (Hutton 2002, Hvizdak 2003, Paddock 2003). Figures 3.13 and 3.14 show how fires burned up to but not into lodgepole pine regeneration units.

Canopy bulk density, canopy base height, torching index, and crowning index are not applicable in this strata in 2008 because the stands are made up of 1-5 year old seedling trees, which do not contribute to FFE's calculations of these measures. These seedling stands, therefore, have a crown fire hazard rating of "Low." In 2028, these units will be made up of sapling size trees and will have canopy bulk density of 0.042 kg/m3, and a canopy base height of one foot. Because the canopy base height is so low, FFE estimates the torching index to be 0 mph, implying it would take no wind at all to move a fire from the surface to the crowns. These stands retain a crown fire hazard rating of moderate in 2028. The following discussion describes why the model is over-predicting fire behavior in this stratum, for this area.

Figures 3.13 and 3.14: These photos were taken of the Mussigbrod Fire in 2000 (left) and the North Fork Fire in 1994 (right—complements of Ron Hvizdak 2003) and verify the effect regeneration units can have on fire behavior, even under extreme fire weather conditions.

Lodgepole Pine Pole

After thinning occurs in lodgepole pine pole stands, FFE predicts **flamelengths** under one foot and **surface fire** types in 2008 and 2028 under both moderate and severe conditions, which is close to the existing condition. Under the no action alternative, these stands have a predicted flamelength of 42 feet and a passive fire type when fire weather conditions are severe. When conditions are moderate, fire behavior in these strata is similar in all the alternatives in 2003, 2008, and 2028. **Canopy bulk density** drops from 0.119 kg/m3 to 0.054 kg/m3 immediately following treatment in 2008 and then increases to 0.063 kg/m3 in 2028 after 20 years of growth. **Canopy base height** increases after treatment, as do **torching** and **crowning index**. As a result, these stands experience a drop in **crown fire hazard rating** from "Moderate" to "Low."

Mature Douglas-fir

Flamelengths in mature Douglas-fir stands increase an average of 1.1 feet, but fires remain as **surface fires** after removing lodgepole pine and thinning the remaining Douglas-fir trees. In those areas where jackpot burning will occur, canopy bulk density decreases dramatically from 0.173 kg/m3 to 0.066 kg/m3 in 2008; canopy bulk density decreases even more by 2028, when it will be 0.052 kg/m3. Where burning does not occur, this value still drops to 0.086 kg/m3 in 2008, followed by 0.068 kg/m3 in 2028. **Figure 3.15** below illustrates the change in canopy bulk density over time under this action alternative.

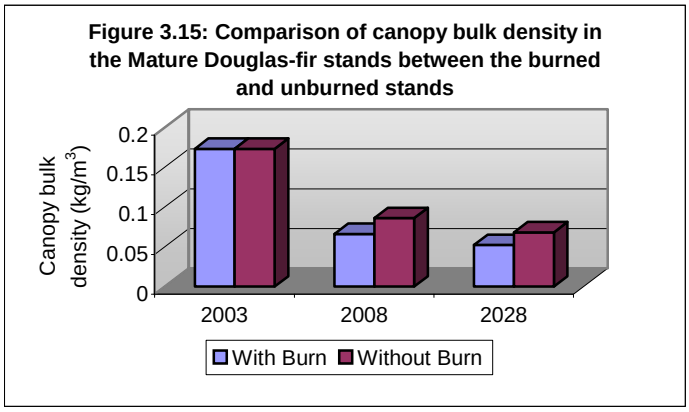


Figure 3.15: Change in canopy bulk density over time in the mature Douglas-fir strata over time

Canopy base height increases overtime from 22 feet in 2003 to 32 feet in 2008 and 33 feet in 2028. Torching index remains high (although torching index is higher in 2003, neither wind speeds of 172 or 303 mph are likely to occur), and in 2008 crowning index increases from 14 mph in 2003 to 25 mph in unburned stands and to 30 mph in burned stands. By 2028 crowning index is 30 mph in unburned stands and 37 mph in burned stands. The crown fire hazard rating drops from "Moderate" in these stands in 2003 to "Low" in both 2008 and 2028.

Sagebrush/grass

Conifers will be reduced in these openings. Rate of spread will increase as fine fuels increase, but flamelength and intensity will decrease. These areas will provide defensible space and anchor points, which allow for safe and efficient fire suppression efforts.

Fire Effects

The FFE model was used to simulate a fire under both severe and moderate conditions, as they would occur in 2008 and 2028. Many of these effects have important consequences for soil, water, wildlife, and air resources and those discussions occur elsewhere in this chapter. Fire killed mortality and fuel remaining may have impacts on post-fire fuel loadings and may contribute to fire behavior in the future. Mortality from simulated fires is discussed by vegetative strata below. Smoke production is discussed in the air quality chapter.

Table 3.23: Fire Effects for strata in 2028 under the Action Alternative (Alternative 2, 3, 4 and 5), should a fire burn under severe and/or moderate fire weather conditions.

		Douglas-fir Pole				Mature Lodgepole Pine		Lodgepole Pine Pole		Mature Douglas-fir			
	Stand #	41404424				41505528		41503308		41601105			
	Year	2008	w/burn	2028	w/burn	2008	2028	2008	2028	2008	w/burn	2028	w/burn
Fire Effects	Mortality (%BA)												
	severe	11	11	10	19	100	99	65	63	20	19	17	17
	moderate	11	11	10	10	100	82	65	63	20	19	17	17
	Smoke (T/A < 2.5)												
	severe	0.15	0.09	0.13	0.1	0.03	0.04	0.19	0.18	0.17	0.12	0.15	0.12
	moderate	0.08	0.05	0.07	0.06	0.02	0.03	0.09	0.09	0.09	0.06	0.08	0.07
	Fuel Consumed (>3"), tons/acre												
	severe	1.16	0.44	1.06	0.75	0.02	0.05	1.8	1.46	1.58	1.03	1.37	1.22
	moderate	0.98	0.36	0.88	0.62	0.01	0.04	1.35	1.21	1.37	0.86	1.1	1.01
	Fuel Remaining (>3"), tons/acre												
	severe	3.24	2.06	3.24	3.35	1.68	3.45	2.9	2.694	3.582	3.87	4.13	4.88
	moderate	3.42	2.14	3.42	3.48	1.69	3.46	3.15	2.19	3.73	4.04	4.4	5.09

Douglas-fir Pole

Mortality from a fire occurring in 2008 and 2028, after treatment, is less than mortality from a fire occurring in the existing forest conditions. The percentage of fire killed trees decreases more than 10 percent except in those stands that were jackpot burned in 2003. In this situation, mortality only decreases by 5 percent.

The **fuel remaining** on site after a fire occurring in 2008 and 2028 increases from approximately 1 ton/acre in 2003 to approximately 3 ton/acre in 2008 and 2028, indicating fires in these stands will likely not be as severe under the action alternative. It is important to note here, too, that more fuel remains after the simulated fire, **but** there is less fuel when the fire would occur.

Mature Lodgepole Pine

In this case, the FFE model predicts **mortality** from a potential fire will be greater after treatment than before. However, as previously discussed, experience has shown that the model over predicts fire behavior in lodgepole regeneration in this area. Regeneration units will likely not sustain even a surface fire. **Fuel remaining** on site after a fire decreases from 2003 to 2028, but the amount of fuel before the fire is greater in 2003, so it correlates that more fuel would remain on site afterwards.

Lodgepole Pine Pole

Fire related **mortality** decreases an average of 5 percent from 2003 to 2028 under the action alternatives. **Fuel remaining** on site after a fire decreases in these stands over time after treatment but fuel loadings is lower after treatment so less initial fuel is available.

Mature Douglas-fir

Mortality is reduced by nearly 20 percent in these stands in 2008 and 2028, and fuel remaining on site after a fire increases by as much as 4 tons/acre by 2028.

Direct and Indirect Effects of Alternatives 2, 3, and 5

Treatment of Slash

There is a short-term increase in fire hazard following treatment and prior to slash disposal when fuels remain in the units and on the ground. Slash will be whole tree yarded to the landing and piled and burned. In Douglas-fir units, remaining debris will be jackpot burned, leaving 10-15 tons/acre on site for soil nutrient cycling and to mitigate erosion. In lodgepole pine units, remaining debris will be machine or handpiled and burned, leaving 10-15 tons/acre as well. This amount is below the recommendation by Brown et al (2001) to reduce fire hazard and increase the ability to safely and efficiently suppress fires. Fuel loadings within 200 feet of the forest boundary may be less than this recommendation; these areas will be handpiled and burned to provide added protection next to private residences.

Direct and Indirect Effects of Alternative 4

Treatment of Slash

There is a short-term increase in fire hazard following treatment and prior to slash disposal when fuels remain on the ground in the units. This hazard is more prominent in this alternative than the other action alternatives because, in addition to other slash, treetops remain in the units yarded by helicopter. Instead of whole tree yarding as in the other action alternatives, trees will be cut to length and then aerially yarded to a landing, where they will be removed. Any debris associated with the landing will be machine piled and burned. Slash remaining in the units will be treated using a combination of machine piling, where feasible, and handpiling. Fuel loading will be reduced to 10-15 tons/acre to reduce fire hazard (Brown 2001). Fuel loadings within 200 feet of the forest boundary may be less than this recommendation to provide added protection. Piles will be burned. Jackpot burning may be used in Douglas-fir stands in areas where it is feasible outside the intermix community and where the risk of escaped prescribed fire is low.

DIRECT AND INDIRECT EFFECTS OF ALTERNATIVES 2-5

These alternatives all propose to treat the same number of acres adjacent to the private boundary by removing hazardous fuels in high and moderate risk stands, thereby decreasing the risk of fire moving from the intermix community into the watershed and vice versa. The treatments in the watershed and on the slope below the homes in Roosevelt Drive differ in the number of acres treated by indices of measure. Table 3.24 and Figure 3.16 compare how these indices differ by alternative.

Table 3.24: Indices of Measure by Alternative

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Acres where future fuel loads are reduced to 10-15 tons/acre	0	1102	2541	4272	3013
Acres where crown fire hazard attains a “Low” rating	0	633	1107	1993	1536
Acres of colonized sage/grass parks where conifer encroachment has been reduced	0	181	311	361	342

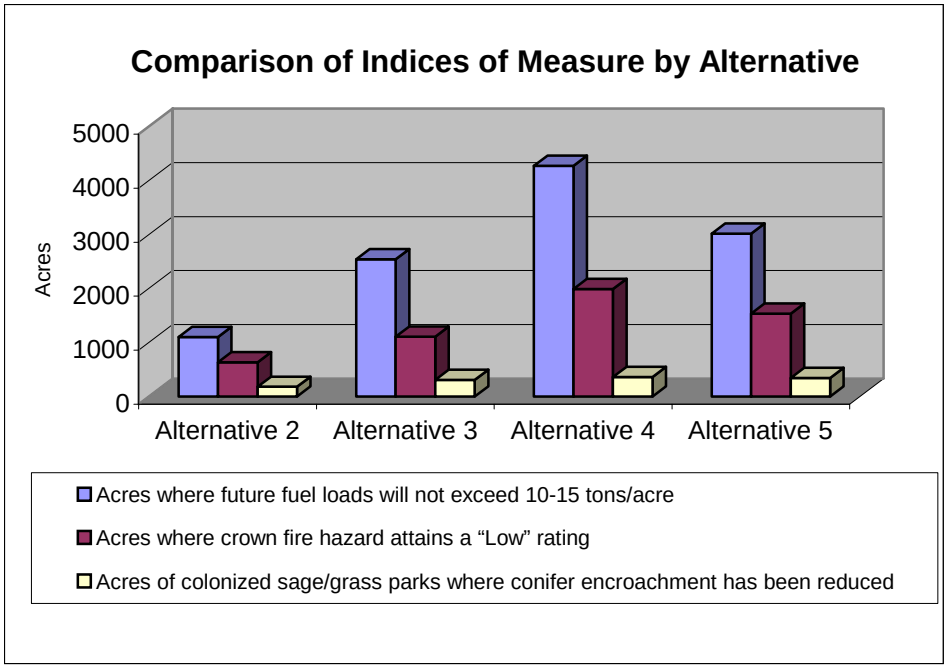


Figure 3.16: Comparison of Indices of Measure by Alternative

These alternatives reduce future fuel loading to 10-15 tons/acre in the project area and even more along the forest boundary, they increase the space between tree canopies thereby reducing the number of acres at a high risk to crown fire, and they decrease the number of acres of conifer colonized sage/grass parks. These actions enhance the safety of firefighters engaged in fire suppression, increase public safety, and decrease the opportunity for fires to move from the intermix community into the watershed and vice versa.

Alternative 4 treats the greatest number of acres followed by Alternative 5, affording the greatest reduction in fuel loadings and fire hazard in the intermix community and throughout the watershed under these alternatives. A wildfire would be less severe and of lower intensity than under current conditions or the no action alternative. Loss or damage to private property and resource values in and adjacent to the project area and Basin Creek Watershed in the event of a wildland fire would be minimized and suppression efforts would be reduced the most under these alternatives.

Alternative 3 treats a moderate number of acres, decreasing the severity and intensity in the event of wildland fire in this alternative when compared to the current conditions or the no action alternative. This alternative was designed specifically to minimize the risk to private property and resource values adjacent to the intermix community and on the slope below the homes on Roosevelt Drive. This alternative indirectly addresses the Basin Creek Watershed by reducing the potential for fires to move from the intermix community into the watershed, and vice versa.

Alternative 2 treats the least amount of acres. This alternative treats only the portion of the project area adjacent to the intermix community and therefore reduces the fire hazard in the watershed the least. This alternative reduces the risk to private property and reduces the risk of fires starting on private property from moving into the Basin Creek Watershed.

CUMULATIVE EFFECTS

This discussion represents effects from past, present and reasonably foreseeable projects that affect fire and fuels. The cumulative effects analysis area map can be found in Appendix B, Map 13. These boundaries were selected based on breaks in topography, major fuel type changes such as grassland/timber edge or major highways. Timber sales, prescribed fires and fuels reduction projects would all serve to reduce fuel loadings and disrupt fuel continuity of large fuels. Continuing fire suppression and the mountain pine beetle epidemic has and will continue to allow fuels to increase in loads and continuity. The risk of fires in untreated areas outside the analysis area remains unchanged. One hundred years of fire suppression have altered fire regimes and extended historic fire return intervals. Weed treatments and grazing affect the availability of fine fuels, and have little if any effect on large fuel loads.

Past, Present, and Reasonably Foreseeable Actions

Timber Harvest

The past timber harvest during the late 1800s and early 1900s has had a marked effect on the area in terms of current fire behavior and is discussed at length under existing condition.

Recent Forest Service timber harvest covers 92 acres in the cumulative effects area, see Map 13 in Appendix B. The slash from the Thompson Park hazard tree removal has all been chipped and scattered handpiles will be burned in the fall of 2003. These treatments will decrease the fire hazard in Thompson Park and the potential for a human caused fire in the corridor along Highway 2. Slash in the Wood Creek helicopter sale is currently a hazard and will be piled and burned in the fall of 2003. All of these projects will contribute to public and firefighter safety from snag hazards as well as creating stand conditions that will mimic treated mature lodgepole pine fire behavior proposed in this project.

The Lime Kiln Timber Sale proposed to harvest 366 acres and has not yet been implemented. The current mountain pine beetle epidemic is infesting this area and may facilitate another look at this project. However, no details have been discussed at this time. Any additional treatment around Roosevelt Drive, especially on the east side, would contribute to public and firefighter safety as well as help to reduce future fuel loads adjacent to those homes.

Timber harvest on lands not administered by the Forest Service includes 53 acres bordering public land between China and Herman Gulch. The area will be salvaged logged in 2004 to remove dead and dying lodgepole pine. Slash will be piled and burned. This State section lies adjacent to our proposed treatment units and will provide added fire protection to the forest boundary and local residents.

Logging on private grounds has and is occurring around residences in Roosevelt Drive, Herman Gulch, Basin Creek, and along the forest boundary on the north end of the analysis area. It is estimated that 285 acres have been treated. Landowners have piled and burned their slash to meet Montana State requirements for slash disposal. It is anticipated that they will continue to do so. Permittees for recreation residences in Basin Creek and Herman Gulch are required to remove hazard trees associated with the mountain pine beetle from their lots, thereby reducing future fire

and snag hazard. The logging in Basin Creek has removed all of the lodgepole pine and left scattered Douglas-fir. Fire behavior in these areas will be similar to the treated mature lodgepole pine stands proposed for this project.

Fire hazard increases temporarily during logging operations from equipment and red slash. However, contractors must comply with fire protection measures such as water and fire tools on site.

Access/Improvements

Increased access, building and recreation site improvements have the possibility of increasing use in and around areas with heavy mountain pine beetle mortality. More use leads to a greater chance of human caused fires.

The construction of approximately 16 miles of trail along the Continental Divide will improve access for fire suppression while increasing use and the possibility of human caused fires. Slash generated from construction of the trail will be lopped and scattered.

The Bear Gulch Trail reconstruction may increase motorized traffic into the project area. Use on this trail increases the probability of a human caused fire especially over time as dead lodgepole pine fall over creating heavy fuel loads. This trail also provides access to firefighters using ATV's.

A powerline runs across a portion of the project area (See Appendix B, Cumulative Effects Map 13). The line has a 33 foot right of way that is cleared of all shrubs and trees for 4 miles and could act as a barrier to fire spread under certain conditions.

Grazing

Cattle grazing allotments are located in the project area. Grazing reduces fine fuels and can have an effect on the rate of spread of fires. Nonuse on this allotment in 1999-2001, and rest in 2002, has resulted in fine fuel accumulation. However, range administration records show only light use when pastures were grazed.

Prescribed Fire

The only burning in the project area has been associated with slash disposal for the timber sales mentioned above. Burning effects include consumption of woody debris, duff reduction and seed bed preparation for natural regeneration. Smoke production is discussed under air quality.