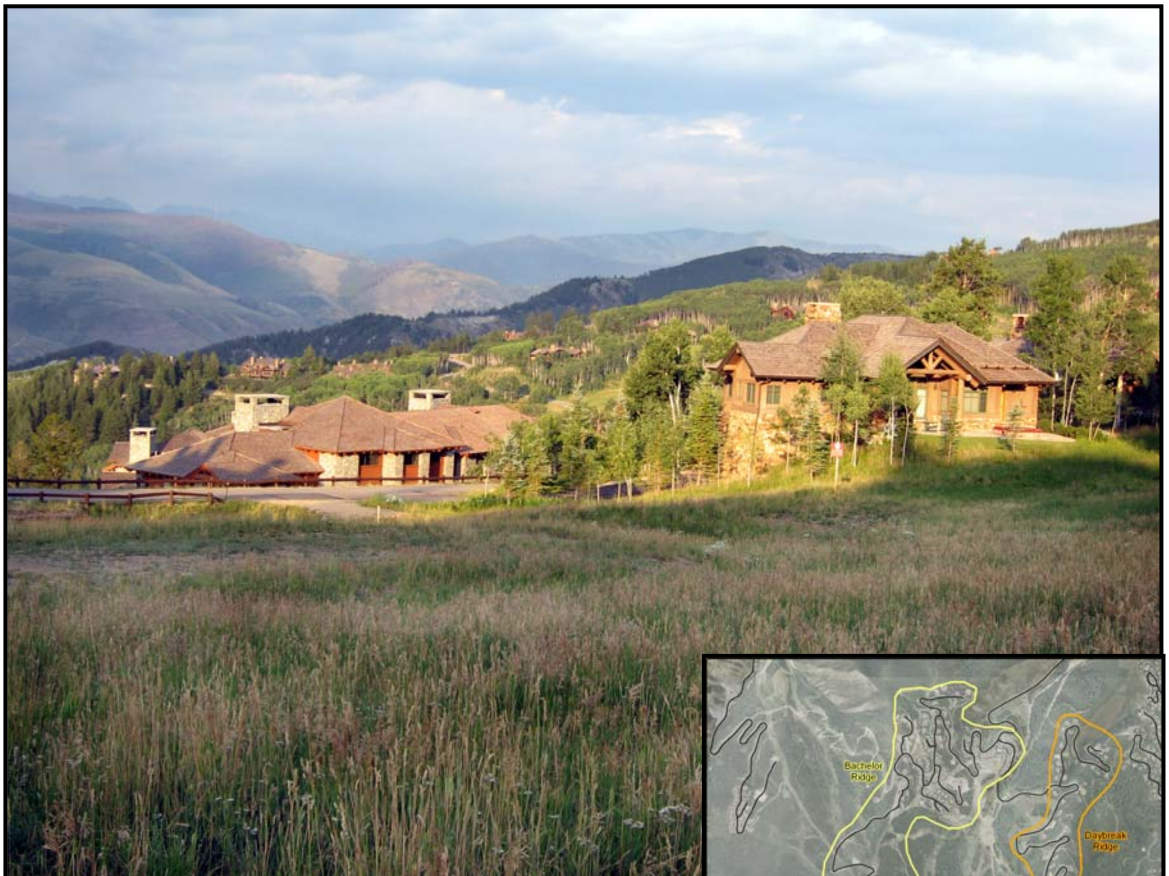
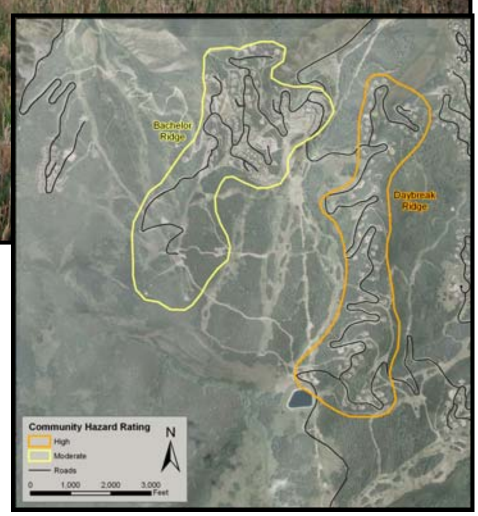
BACHELOR GULCH, COLORADO

Wildland Urban Interface
Community Wildfire Protection Plan





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PURPOSE

This document has the following primary purposes:

1. To provide a comprehensive, scientifically-based analysis of wildfire related hazards and risks in the Wildland Urban Interface (WUI) areas of the Bachelor Gulch Village community.
2. Using the results of the analysis, to generate recommendations designed to prevent and/or reduce the damage associated with wildfire to WUI values in the Bachelor Gulch study area.
3. To create a Community Wildfire Protection Plan (CWPP) document for Bachelor Gulch which conforms to the standards for CWPPs established by the Healthy Forest Restoration Act (HFRA).

INTRODUCTION

The Bachelor Gulch CWPP is the result of a community-wide planning effort including extensive field data gathering, compilation of existing documents and GIS data, scientifically based analyses and recommendations designed to reduce the threat of wildfire related damages to values at risk. This document incorporates new and existing information relating to wildfire which will be valuable to citizens, policy makers, and public agencies in and adjacent to the Bachelor Gulch community. Participants in this project include homeowners, the Bachelor Gulch Village Association, Eagle County, adjacent state and federal land managers and other stakeholders. This document meets the requirements of the federal Healthy Forest Restoration Act of 2003 for community fire planning.

The assessment portion of this document estimates the hazards and risks associated with wildland fire in proximity to WUI areas. This information, in conjunction with identification of the values at risk, defines "areas of concern" and allows for prioritization of mitigation efforts. From the analysis of this data, solutions and mitigation recommendations are offered that will aid homeowners, land managers and other interested parties in developing short-term and long-term fuels and fire management plans.

Wildfire hazard data is derived both from the Community Wildfire Hazard Rating system (WHR) and from the analysis of Fire Behavior Potential, which are extensive and/or technical in nature. Detailed findings and methodologies for these analyses are included in their entirety in appendices rather than the main report text. This approach is designed to make the plan more readable, while establishing a reference source for those interested in the technical elements of the Bachelor Gulch wildfire hazard and risk assessment.

For the purposes of this report the following definitions apply:

Risk is considered to be the likelihood of an ignition occurrence. This is primarily determined by the fire history of the area.

Hazard is the combination of the WHR ratings of the Wildland-Urban Interface (WUI) neighborhoods and the analysis of Fire Behavior Potential, as modeled from the fuels, weather, and topography of the study area. Hazard attempts to quantify the severity of undesirable fire outcomes to the values at risk.

Values at Risk are the intrinsic values identified by the citizens as being important to the way of life in the study area (e.g., life safety, property conservation, access to recreation, and wildlife habitat).

THE NATIONAL FIRE PLAN AND THE HEALTHY FOREST RESTORATION ACT

In the year 2000, more than eight million acres burned across the United States, marking one of the most devastating wildfire seasons in American history. One high-profile incident, the Cerro Grande fire at Los Alamos, NM, destroyed more than 235 structures and threatened the Department of Energy's nuclear research facility.

Two reports addressing federal wildland fire management were initiated after the 2000 fire season. The first report, prepared by a federal interagency group, was titled "Review and Update of the 1995 Federal Wildland Fire Management Policy" (2001). This report concluded, among other points, that the condition of America's forests had continued to deteriorate.

The second report, titled "Managing the Impacts of Wildfire on Communities and the Environment: A Report to the President in Response to the Wildfires of 2000", was issued by the Bureau of Land Management (BLM) and the United States Department of Agriculture Forest Service (USFS). It became known as the National Fire Plan (NFP). This report, and the ensuing congressional appropriations, ultimately required actions to:

- Respond to severe fires
- Reduce the impacts of fire on rural communities and the environment
- Ensure sufficient firefighting resources

Congress increased its specific appropriations to accomplish these goals. 2002 was another severe season: more than 1,200 homes were destroyed and over seven million acres burned. In response to public pressure, congress and the Bush administration continued to designate funds specifically for actionable items such as preparedness and suppression. That same year, the Bush administration announced the HFRA initiative, which enhanced measures to restore forest and rangeland health and reduce the risk of catastrophic wildfires. In 2003, that act was signed into law.

Through these watershed pieces of legislation, Congress continues to appropriate specific funding to address five main sub-categories: preparedness, suppression, reduction of hazardous fuels, burned-area rehabilitation, and state and local assistance to firefighters. The general concepts of the NFP blended well with the established need for community wildfire protection in the study area. The spirit of the NFP is reflected in the Bachelor Gulch CWPP.

This CWPP meets the requirements of HFRA by:

1. Identifying and prioritizing fuels reduction opportunities across the landscape (See the "Fuels Modification FMU" section on pages 40-46 of this document)

2. Addressing structural ignitability (see pages 36-39 and Appendix B)
3. Assessing community fire suppression capabilities (See the “Local Preparedness and Firefighting Capabilities FMU” section on pages 30-35)
4. Collaborating with stakeholders (See **Appendix E**)

GOALS AND OBJECTIVES

Goals for this project include the following:

1. Enhance life safety for residents and responders.
2. Mitigate undesirable fire outcomes to property and infrastructure.
3. Mitigate undesirable fire outcomes to the environment, watersheds, and quality of life.

In order to accomplish these goals, the following objectives have been identified:

1. Establish an approximate level of risk (the likelihood of a significant wildfire event in the study area).
2. Provide a scientific analysis of the fire behavior potential of the study area.
3. Group values at risk into “communities” that represent relatively similar hazard factors.
4. Identify and quantify factors that limit (mitigate) undesirable fire effects to the values at risk (hazard levels).
5. Recommend specific actions that will reduce hazards to the values at risk.

OTHER DESIRED OUTCOMES

1. To promote community awareness:

   Quantifying the community's hazards and risk from wildfire will facilitate public awareness and assist in creating public action to mitigate the defined hazards.
2. To improve wildfire prevention through education:

   Community awareness, combined with education, will help to reduce the risk of unplanned human ignitions.
3. To facilitate and prioritize appropriate hazardous fuel reductions:

   Organizing and prioritizing hazard mitigation actions into Fire Management Units (FMUs) will provide stakeholders with social and fire-management perspectives, allowing them to make better decisions about their future efforts.
4. To promote improved levels of response:

   The identification of areas of concern will improve the focus and accuracy of pre-planning, and facilitate the implementation of cross-boundary, multi-jurisdictional projects.

COLLABORATION: COMMUNITY/AGENCIES/FIRE SAFE COUNCILS

Representatives involved in the development of the Bachelor Gulch CWPP are included in the following table. Their names, organizations, and various roles and responsibilities are indicated in **Table 1**. For more information on the collaborative process that led to the development of this CWPP see **Appendix E** Bachelor Gulch CWPP Collaborative Effort.

Table 1. CWPP Development Team

Name	Organization	Roles / Responsibilities
Jim Funk, OEM Director	Bachelor Gulch Village Association	Local information and expertise, including community values. Development of community protection priorities. Implementation of fuels treatment project areas and methods.
Ron Cousineau, Assistant District Forester	Colorado State Forest Service	Provides input and expertise on planning and hazard mitigation. Provides information on existing and planned projects on adjacent state lands.
Eric Lovgren, Eagle County Wildfire Mitigation Specialist	Eagle County	Facilitation of planning process and approval of CWPP minimum standards. Provides input and expertise on forestry, fire and fuels, and FireWise concepts.
Chris White, CEO Marc McDonald, Project Manager Mark McLean, GIS Project Manager Rod Moraga, Fire Behavior Analyst and Managing Partner	Anchor Point Group LLC Consultants	Development of the CWPP document. Scientific analysis of fire behavior, community hazard and risk. Development of hazard mitigation actions and priorities. Establishment of fuels treatment project areas and methods.

STUDY AREA OVERVIEW

Bachelor Gulch is located south of Avon, Colorado approximately 100 miles west of Denver, Colorado. The Bachelor Gulch community is accessed via Highway 6. The area is considered to be in the Montane zone (6000-10,000 ft), of the western slope of the Central Rockies of Colorado.[1] The predominant vegetation in the study area is quaking aspen (Populus tremuloides) which varies in coverage from open-stand woodland to dense forest. Significant stands of conifers also occur throughout the study area. These stands are generally dominated by lodgepole pine (Pinus contorta) or Douglas fir (Pseudotsuga menziesii). Serviceberry, sage and other shrubs are common at lower elevations on the north and east sides of the study area especially on east facing slopes.

For this project the residential areas were divided into two communities. Each community represents certain dominant hazards from a wildfire perspective. Fuels, topography, structural flammability, availability of water for fire suppression, egress and navigational difficulties as well as other hazards both natural and manmade are considered in the overall hazard ranking of these neighborhoods. The methodology for this assessment uses the WHR community hazard rating system that was developed specifically to evaluate communities within the WUI for their relative wildfire hazard.[2] The WHR model combines physical infrastructure such as structure density and roads as well as fire behavior components like fuels and topography, with the field experience and knowledge of wildland fire experts. **Figure 1** shows the communities that define the WUI study area. For more information on the WHR methodology please see **Appendix B**.

As a reference for the rest of this document, please see **Figure 2** and **Figure 3,** which show the general topography of the area. These graphic representations of the landforms within the study area (elevation and slope) will be helpful in interpreting other map products in this report.

[1] Elevation limits for life zones were based on life zone ranges from: Jack Carter, "Trees and Shrubs of Colorado" (Boulder, CO: Johnson Books, 1988).

[2] C. White, "Community Wildfire Hazard Rating Form" *Wildfire Hazard Mitigation and Response Plan*, Colorado State Forest Service, Ft. Collins, CO, 1986.

Figure 1. Hazard Ranking of Communities in the Study Area

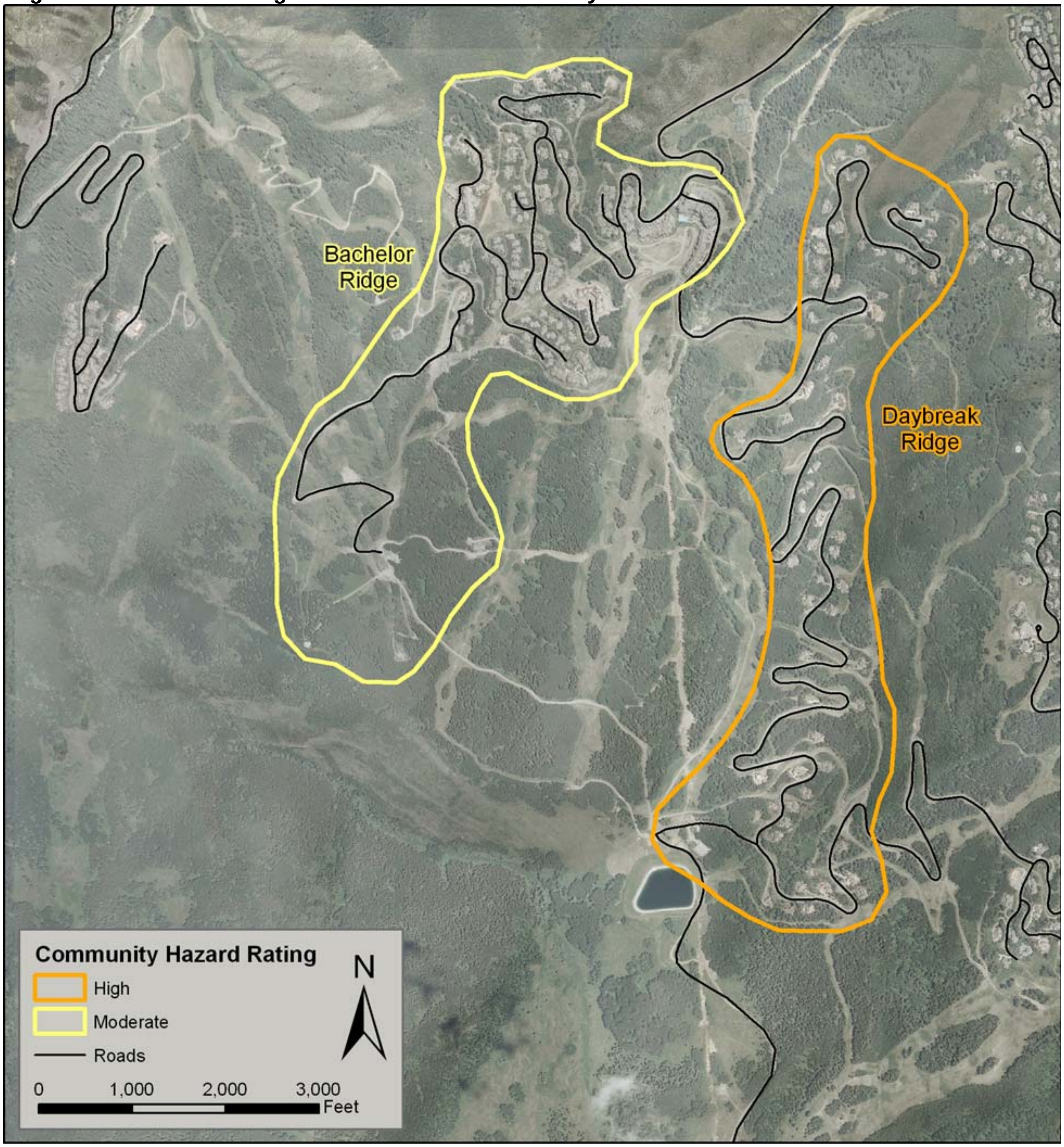


Figure 2. Slope

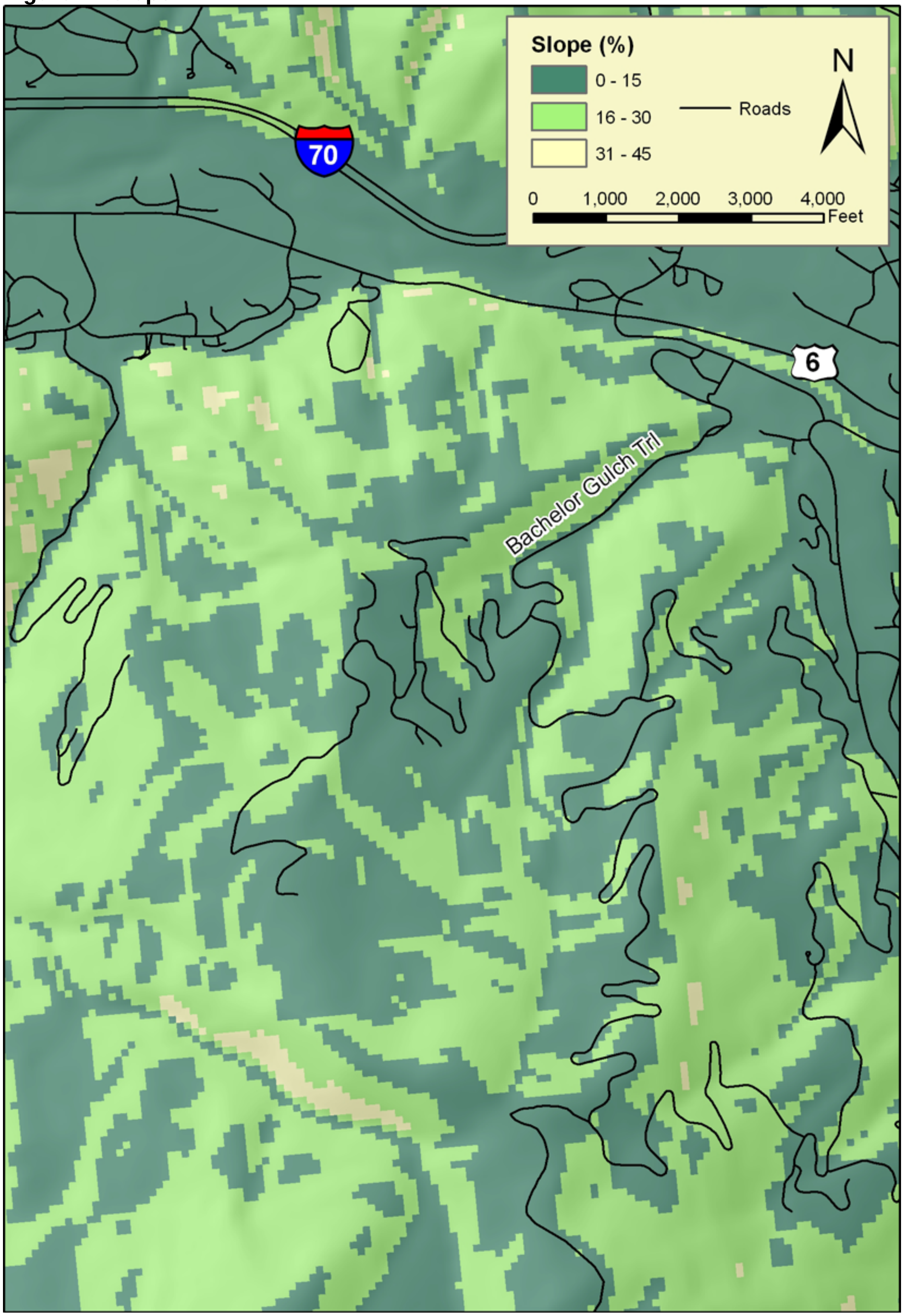
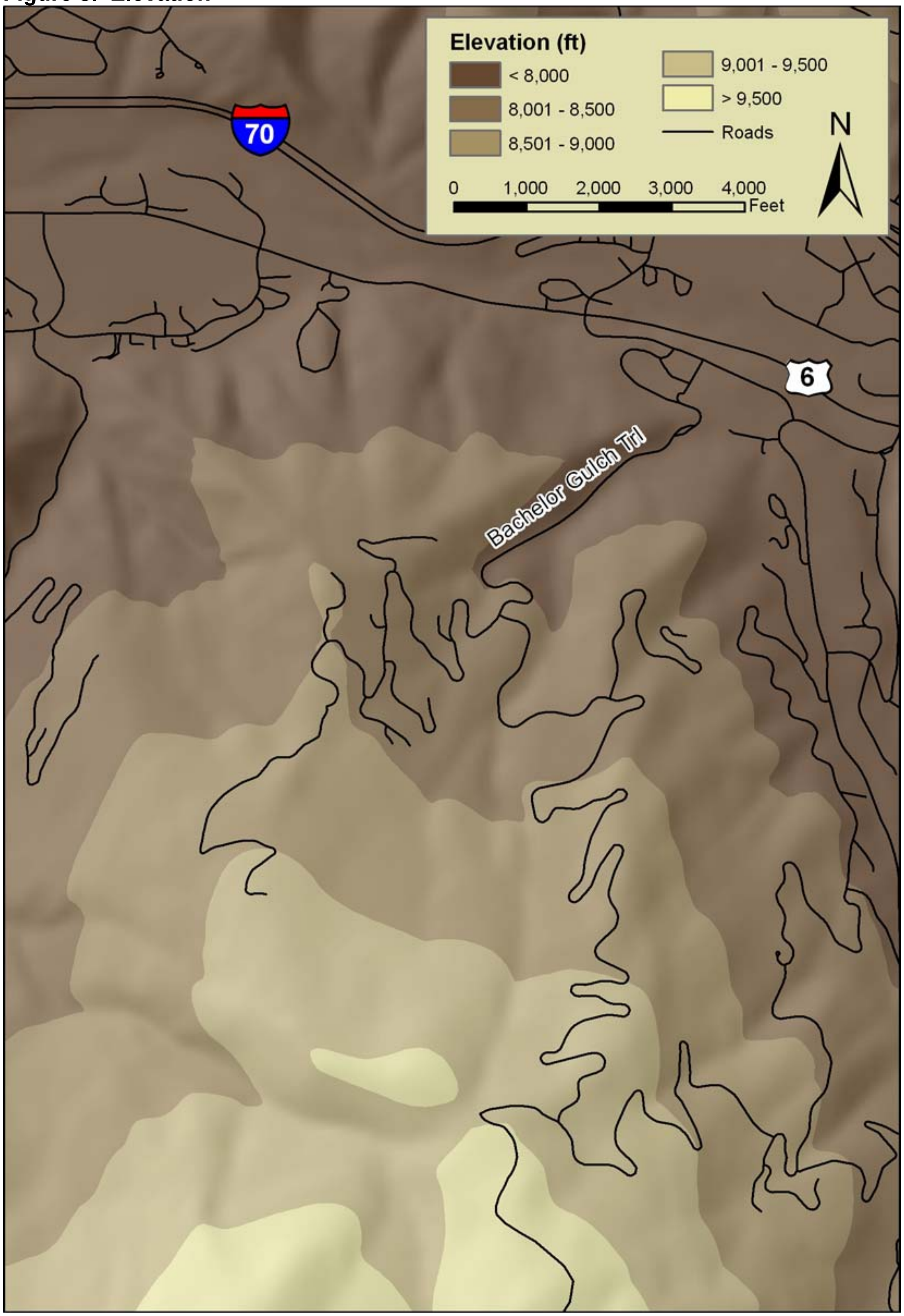


Figure 3. Elevation



VALUES

LIFE SAFETY AND HOMES

Population information specific to the Bachelor Gulch study area was not available for this report, but the Bachelor Gulch/Beaver Creek area contains an approximate year round-population of 250, and a significant number of second homes. Bachelor Gulch is located 10 miles west of Vail and south of Avon. The study area is a gated community with single family homes, town homes, high-rise hotels and condominium residences.

With tens of thousands of people moving to Colorado each year, building in the once inaccessible mountain areas has become a growing concern. Of the 63 counties in Colorado, Eagle County is the sixth-fastest growing with a population increase of 10.5% between 2000 and 2003.[3] 534 new building permits for single family homes were issued in 2006 and there were 169 permits for single family residences and 167 permits for multi-family structures issued from January to September in Eagle County.[4]

Most of Eagle County is vulnerable to some form of natural disturbance, and wildland fire is one of the most serious concerns. Recent national disaster events have focused increased attention at both local and state government levels on the need to mitigate such events where possible and to prepare to cope with them when unavoidable.

COMMERCE AND INFRASTRUCTURE

In 2005 Eagle County had a per capita personal income (PCPI) of $44,200. The 2005 PCPI reflected an increase of 5.8% from 2004. The 2004-2005 state change was 4.7% and the national change was 4.2%. The 1995-2005 average annual growth rate of PCPI was 4.4%. The average annual growth rate for the state was 4.5% and for the nation was 4.1%.

In 2005 Eagle County had a total personal income (TPI) of $2,107,633,000. The 2005 TPI reflected an increase of 9.2% from 2004. The 2004-2005 state change was 6.2% and the national change was 5.2%. The 1995-2005 average annual growth rate of TPI was 8.8%. The average annual growth rate for the state was 6.6% and for the nation was 5.2%.[5]

The earnings for people employed in Eagle County increased from $1,542,289,000 in 2004 to $1,721,599,000 in 2005, an increase of 11.6%. The 2004-2005 state change was 6.5% and the national change was 5.6%. The average annual growth rate from the 1995 estimate of $756,956,000 to the 2005 estimate was 8.6%. The average annual growth rate for the state was 7.1% and for the nation was 5.5%.[6]

[3] http://www.epodunk.com/top10/countyPop/coPop6.html
[4] http://socds.huduser.org/permits/index.html?
[5] http://www.bea.gov/bea/regional/bearfacts/action.cfm?fips=08037&areatype=08037&yearin=2005
[6] http://www.bea.gov/bea/regional/bearfacts/action.cfm

The Beaver Creek Ski area opened in 1980 and was host to World Ski Championships in 1989 and 1999. A combination of chairlifts, skiing and hiking trails create a village-to-village connection linking Bachelor Gulch Village to nearby Beaver Creek Village and Arrowhead Resort. Bachelor Gulch Village has a large percentage of ski-in ski-out properties. The ski resort, along with the infrastructure that supports it, is the major employer within the study area.

Another significant component of the local economy is the quality of life that attracts professionals to establish residences. Wildfire, therefore, has the potential to cause significant damage to the local economy.

RECREATION AND LIFE STYLE

Bachelor Gulch is the only totally on-mountain community in Eagle County and almost 85% of the homes have ski-in ski-out access to Beaver Creek Mountain.[7] Beaver Creek Mountain was originally designed to accommodate skiers of all ability levels, with a specific focus on winter recreation. That design proved timeless and today the mountain is enjoyed by a variety of winter and summer sports enthusiasts.

Residents who live in the study area have a keen appreciation for their natural environment. They like to be in the mountains, which create the context for their quality of life. Recreation and the natural beauty of the area are frequently quoted as reasons local residents have chosen to live in the study area.

ENVIRONMENTAL RESOURCES

Residents agree that the preservation of wildlife is important to the quality of life of the area. The White River National Forest provides critical habitat to several species of concern including Canada Lynx, Colorado River Cutthroat Trout, Boreal Toad, Leopard Frog, Townsend's Big-Eared Bat and others.

"Habitat effectiveness" is defined as the degree to which habitat is free of human disturbance and available for wildlife to use. Effective habitat is mostly undisturbed land area, which is buffered (at least 300 feet in essentially all situations) from regular motorized and non-motorized use of roads and trails (11 or more people or vehicle trips per week). [8] The USFS has made improving habitat effectiveness and ensuring the viability of these species one of their forest-wide objectives.[9] Wildfire, specifically severe wildfire, can have significant adverse effects on habitat effectiveness and species viability.

The Bachelor Gulch CWPP process is in concert with the guiding principles of environmental stewardship. Through public involvement, local support and a regional perspective, the fuels reduction elements described in this document can and should enhance and protect the values of the study area.

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[7] http://www.vailrealestate.com/relatedLinks.cfm

[8] Peak to Peak Community Indicators Project 2003 Presented by Peak to Peak Healthy Communities Project ©Copyright 2003 Peak to Peak Healthy Communities Project

[9] White River National Forest Land and Management Resource Plan-2002 Revision, Chapter 1, page 1-4, Objective 1c.

CURRENT RISK SITUATION

For the purpose of this report the following definitions apply:

Risk is considered to be the likelihood of an ignition occurrence. This is primarily determined by the fire history of the area.

Hazard is the combination of the wildfire hazard ratings of the Wildland Urban Interface (WUI) communities and fire behavior potential, as modeled from the fuels, weather and topography of the study area.

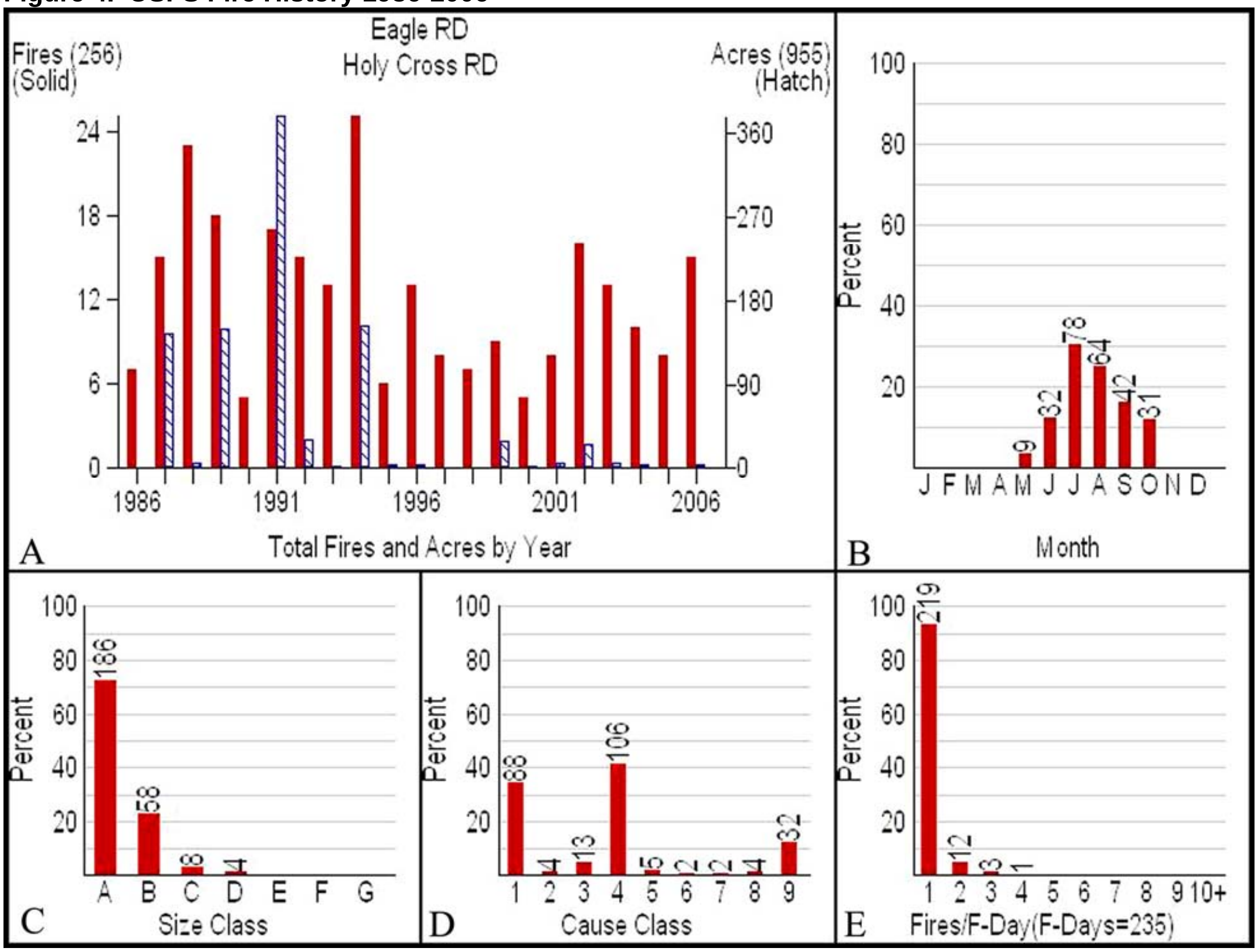
The majority of the study area is at a low to moderate risk for WUI fires. This assessment is based on an analysis of the following factors:

- Bachelor Gulch Village is not listed in the Federal Register as a community at high risk from wildfire (http://www.fireplan.gov/reports/351-358-en.pdf).
- The study area is shown on the Colorado State Forest Service WUI Hazard Assessment map to be an area of low to moderate Hazard Value (an aggregate of Hazard, Risk and Values Layers).
- The USDA Forest Service fire regime and condition class evaluation of forest stands in the study area shows that historic fire regimes have been moderately altered. Please see the "Fire Regime and Condition Class" section of this report for details.
- Eagle River Fire Department has maintained computerized records of historic fire responses within its district since 1998. According to their data, fire activity in the study area has not been significant as to size or frequency with all wildland fires being less than one acre in size. Two fires displaying crown runs were reported in the WUI areas of the fire district; one in Lake Creek and one in Bellyache Ridge. Causes of wildfires in the Bachelor Gulch/Beaver Creek area have been limited to consumer-grade fireworks, lightning and electrical power grid equipment failures.
- From 1972 to 2006 the Bureau of Land Management reported 6,001 fires in the Craig District; however, the United States Forest Service (USFS) reported only 256 fires from 1986-2006 in the Holy Cross and Eagle Ranger Districts of the White River National Forest (See below).

The nearest USFS lands, the Holy Cross and Eagle Ranger Districts, report moderate levels of fire activity (256 fires in 20 years for an average of just over 12 fires/year), however the nearest BLM district, Craig District, reports a very active history (6,001 fires over the last 34 years for an average of more than 175 fires per year). Fire occurrences for the Holy Cross and Eagle Ranger Districts of the White River National Forest were calculated from the USDA Forest Service Personal Computer Historical Archive for the twenty-year period from 1986-2006 (See **Figure 5** on **Page 14**). This calculation does not include any data from state, county or private lands. The data have been processed and graphed using the Fire Family Plus software program and are summarized below.

BLM reports are not available in a format that allows similar processing with Fire Family Plus, and the reasons for the great disparity between reported fire activity on BLM and USFS lands are not clear. From the available data, the only assumption that can be drawn is that the risk of a significant wildfire occurrence in the study area based solely on federal fire history is inclusive. Nonetheless, since the USFS lands include areas that are much closer in proximity to the study area than the BLM lands, they have been given greater weight in the overall risk analysis. An analysis of the USFS data is presented below.

Figure 4. USFS Fire History 1986-2006



Size Class (in acres)	**A** < ¼	**B** ¼ - 9	**C** 10 – 99	**D** 100-299	**E** 300-999	**F** 1000 - 4999	**G** 5000 +		
Causes	**1** Light-ning	**2** Equipment	**3** Smoking	**4** Campfire	**5** Burning Debris	**6** Railroad	**7** Arson	**8** Kids	**9** Misc

Figure 4a shows the number of fires (red bars) and the total acres burned (blue hatched bars) in the Holy Cross and Eagle Ranger Districts each year. While the number of annual fires ranges from four to 25, there is little year-to-year pattern to the variation. Acres burned spiked in 1987, 1989, 1991, and 1994, primarily due to a small number of large-fire events in those years, rather than an increase in the number of fires. The number of acres burned has remained small since 1994. It is interesting to note that in 2002 (the most severe fire year in this period for the

state of Colorado) the acreage burned was relatively small and the number of fires was significantly less than the peak years of 1988 and 1994.

Figure 4b shows the percentage and number of fires between 1986 and 2006 occurring in each month of the year. July and August had the greatest number of fires followed by September, June, and October. No reported fires occurred between the months of November and April, which reflects the climate conditions and high elevations in this area.

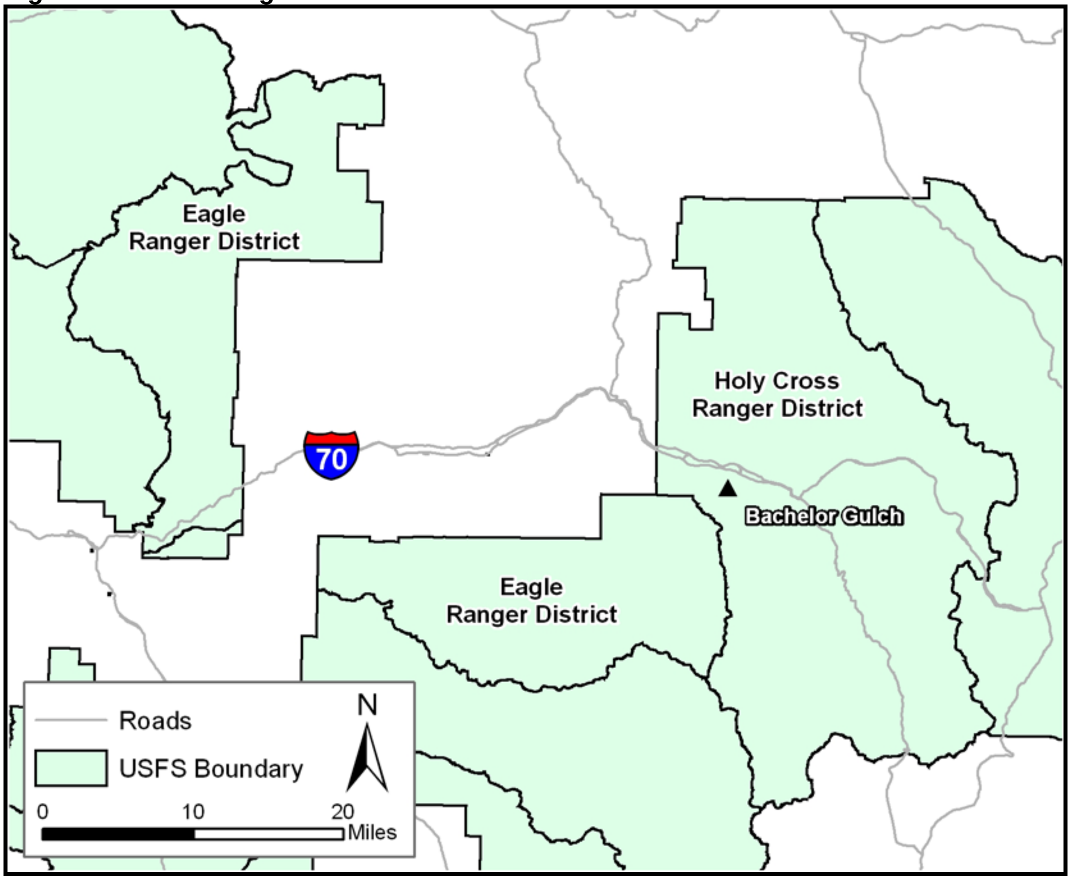
Figure 4c shows the size class distribution of fires. Approximately 95% of the reported fires (244 of 256) were less than 10 acres in size. This statistic reflects the widely held opinion that throughout the western US, the vast majority of fires are controlled during initial attack.

Figure 4d shows the number of fires caused by each factor. As shown in this graph, the most common cause for ignitions is campfires (41%); the next most common cause is lightning (34%). If we remove the miscellaneous cause category, human causes represent a significant majority of ignitions (61% human causes and 39% natural causes). However, even these figures, which show a clear predominance of human starts, are likely to be conservative. The reason for this is that the data is only for national forest areas lacking the concentrated development and other human-related risk factors present in the portions of the study area where private land is dominant.

Figure 4e shows the number of fire starts for each day that a fire start was recorded. Most fires (219) occurred on days that only had one fire start. Less than 1% of fire days had two fire starts and less than .2% of fire days were reported with three or more starts in the twenty-year period. The statistics suggest that multiple start days are a rare occurrence compared to fire days with a single ignition.

PLEASE NOTE: Residential development in the WUI is increasing in the study area. As the density of structures and the number of residents in the interface increases, potential ignition sources will multiply. Unless efforts are made to mitigate the increased likelihood of human ignition spreading to the surrounding wildland fuels, the probability of a large wildfire occurrence will increase.

Figure 5. USFS Ranger Districts

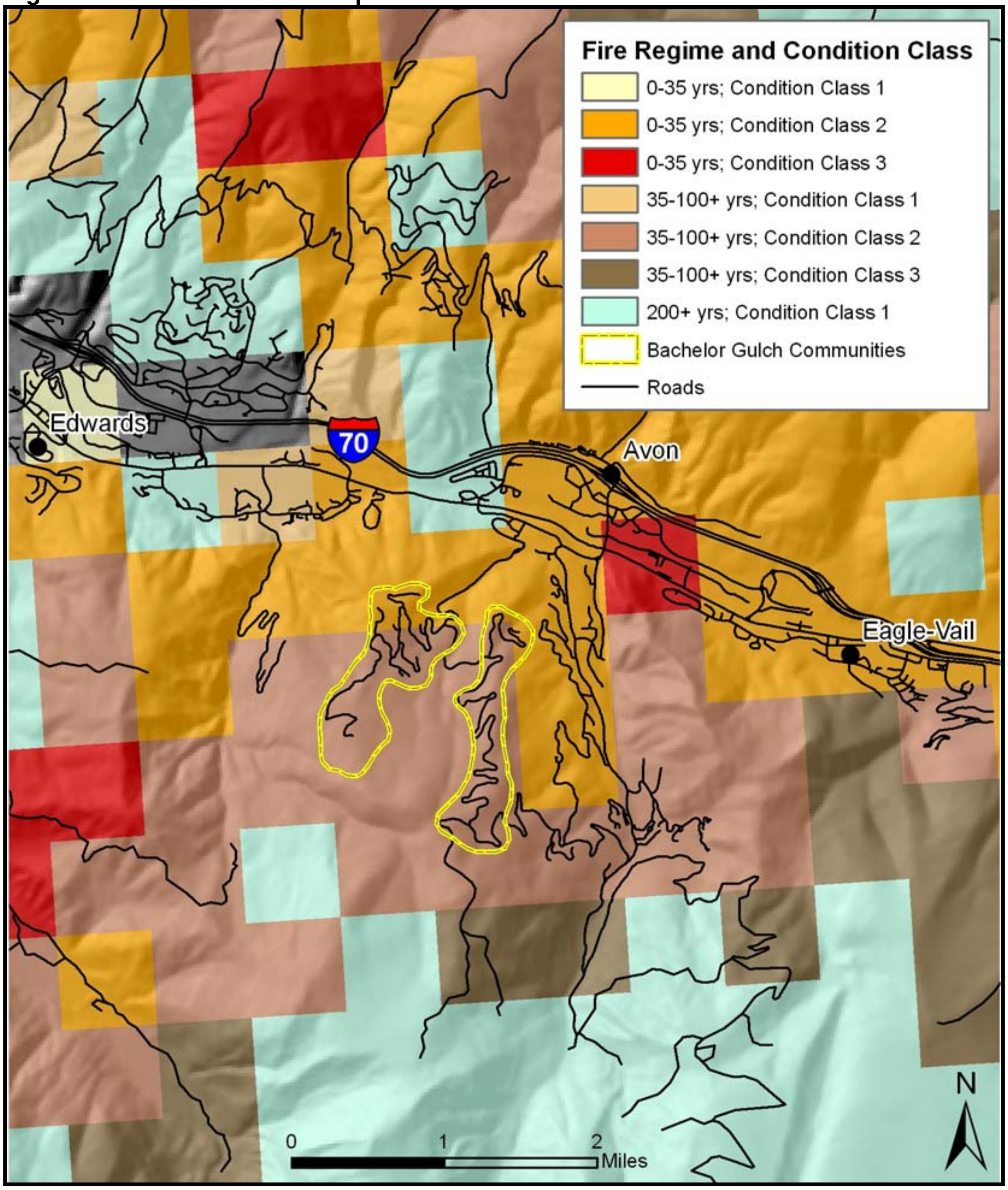


FIRE REGIME CONDITION CLASS

The Fire Regime Condition Class (FRCC) is a landscape evaluation of expected fire behavior as it relates to the departure from historic norms. The data used for this study is from a national level map. The minimum mapping unit for this data is 1 square kilometer. FRCC should not be confused with the BEHAVE or FlamMap fire behavior models, which provide the fire behavior potential analysis for expected flame length, rate of spread, and crown fire development. BEHAVE and FlamMap are detailed in the fire behavior section.

The FRCC is an expression of the departure of the current condition from the historical fire regime. It is used as a proxy for the probability of severe fire effects (e.g., the loss of key ecosystem components such as soil, vegetation structure, species; or alteration of key ecosystem processes such as nutrient cycles or hydrologic regimes). Consequently, FRCC is an index of hazards to the status of many components (e.g., water quality, fish status, wildlife habitats, etc.). **Figure 6** displays graphically the return interval and condition class of the study area.

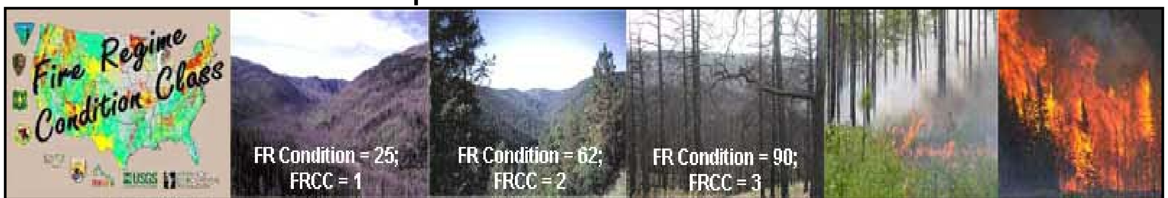
Figure 6. Condition Class Map



Deriving fire-regime condition class entails comparing current conditions to some estimate of the historical range that existed prior to substantial settlement by Euro-Americans. The departure of the current condition from the historical baseline serves as a proxy to likely ecosystem effects. In applying the condition class concept, it is assumed that historical fire regimes represent the conditions under which the ecosystem components within fire-adapted ecosystems evolved and have been maintained over time. Thus, if it is projected that fire intervals and/or fire severity have changed from the historical conditions, then one would expect fire size, intensity, and burn patterns to be subsequently altered if a fire occurred. Furthermore, it is assumed that if these basic fire characteristics have changed, then it is likely that there would be subsequent effects to those ecosystem components that had adapted to the historical fire regimes. As used here, the potential of ecosystem effects reflect the probability that key ecosystem components may be lost should a fire occur within the study area. Furthermore, a key ecosystem component can represent virtually any attribute of an ecosystem (for example, soil productivity, water quality, floral and faunal species, large-diameter trees, snags, etc.).[10]

The following categories of condition class are used to qualitatively rank the potential of effects to key ecosystem components:

Table 2. Condition Class Descriptions



Condition Class	Condition Class Description
1	Fire regimes are within their historical range and the risk of losing key ecosystem components as a result of wildfire is low. Vegetation attributes (species composition and structure) are intact and functioning within an historical range. Fire effects would be similar to those expected under historic fire regimes.
2	Fire regimes have been moderately altered from their historical range. The risk of losing key ecosystem components as a result of wildfire is moderate. Fire frequencies have changed by one or more fire-return intervals (either increased or decreased). Vegetation attributes have been moderately altered from their historical range. Consequently, wildfires would likely be larger, more intense, more severe, and have altered burn patterns than that expected under historic fire regimes.
3	Fire regimes have changed substantially from their historical range. The risk of losing key ecosystem components is high. Fire frequencies have changed by two or more fire-return intervals. Vegetation attributes have been significantly altered from their historical range. Consequently, wildfires would likely be larger, more intense, and have altered burn patterns from those expected under historic fire regimes.

The study area is dominantly classified under Condition Class 2. By definition, historic fire regimes have been moderately changed. Consequently, **Wildfires are likely to be larger, more severe and have altered burn patterns from those expected under historic fire regimes**.

10 Fire Regime Condition Class, website, http://www.frcc.gov/, July 2005.

FIRE BEHAVIOR POTENTIAL

From the fire behavior potential analysis carried out as a part of this study (see **Appendix A**), the fire behavior potential of the study area was mapped. These maps can be combined with the WHR and Values at Risk information to generate current and future "areas of concern," which are useful for prioritizing mitigation actions.

Figures 7, 9 and 11 show fire behavior potential maps for moderate burning conditions. They graphically display potential crown fire activity, flame length, and rate of spread. These maps were generated with FlamMap 2.0 fire behavior modeling software (see **Glossary**). Weather observations from the nearby Down Junction Remote Automated Weather Station (RAWS) site were averaged for a 20-year period (1986-2006) to derive relevant wind and fuel moisture variables for inclusion in FlamMap. The average conditions class (16^{th} to 89^{th} percentile) was calculated for each variable (1 hour, 10 hour, and 100 hour fuel moisture, woody fuel moisture, herbaceous fuel moisture, and wind speed) using the Fire Family Plus (see **Glossary**) computer software package. This weather condition class most closely represents an average fire season day.

The extreme conditions maps, **Figures 8, 10 and 12**, were calculated using ninety-seventh percentile weather data. This means that the weather conditions of the most severe fire weather days (sorted by Spread Component) in each season for the 20-year period were averaged together. It is reasonable to assume that similar conditions may exist for at least a similar period (three to five days) of the fire season during an average year. In fact, during extreme years such conditions may exist for significantly longer periods. Even these calculations may be conservative compared to observed fire behavior.

Weather conditions are extremely variable and not all combinations are accounted for. These outputs are best used for pre-planning and not as a stand-alone product for tactical planning. When this information is used for tactical planning, it is recommended that fire behavior calculations be done with actual weather observations during the fire event. For greatest accuracy, the most current Energy Release Component (ERC) values should be calculated and distributed during the fire season, for use as a guideline for fire behavior potential. For a more complete discussion of the fire behavior potential methodology, please see **Appendix A**.

FIRE BEHAVIOR MODELING LIMITATIONS AND INTERPRETATION

This evaluation is a prediction of likely fire behavior, given a standardized set of conditions and a single point-source ignition in every cell (each 10 x 10 meter area). It does not consider cumulative impacts of increased fire intensity over time and space. The model does not calculate the probability a wildfire will occur. It assumes an ignition occurrence for every cell. These calculations may be conservative (under-predict) compared to observed fire behavior.

This model can be conceptually overlaid with the Community Wildfire Hazard Ratings (WHR) or other values at risk identification to generate current and future "areas of concern," which are useful for prioritizing mitigation actions. This is sometimes referred to as a "values layer." One possibility is to overlay the fire behavior potential maps with the community hazard map **(Figure**

1) in order to make general evaluations of the effects of the predicted fire behavior in areas of high hazard value (that is, areas where there are concentrations of residences and other man-made values). However, one should remember that the minimum mapping unit used for fire behavior modeling is one acre; therefore, fine-scale fire behavior and effects are not considered in the model.

Weather conditions are extremely variable and not all combinations are accounted for. These outputs are best used for pre-planning and not as a stand-alone product for tactical planning. If this information is used for tactical planning, fire behavior calculations should be made with actual weather observations from the fire. For greatest accuracy, the most current Energy Release Component (ERC) values should be calculated and distributed during the fire season for use as a guideline for fire behavior potential. For a more complete discussion of the fire behavior potential methodology, please see **Appendix A**.

Flame Length

Figures 7 and 8 display flame length predictions for the two weather scenarios. Flame length is a proxy for fire intensity. It is important to note that flame length is considered to be the entire distance from the base of the flame to the tip, irrespective of angle—not simply the flame height above the ground. It is possible in high wind conditions to have very intense flames (high flame lengths) which are relatively close to the fuel bed. The legend boxes display flame length in ranges which are meaningful to firefighters. Flame lengths of four feet and less are deemed low enough intensity to be suitable for direct attack by hand crews, and therefore represent the best chances of direct extinguishment and control. Flame lengths of less than eight feet are suitable for direct attack by equipment such as bulldozers and tractor plows. Flame lengths of eight to 12 feet are usually attacked by indirect methods and aircraft. In conditions where flame lengths exceed 12 feet, the most effective tactics are fuel consumption ahead of the fire by burnouts or mechanical methods. Although indirect fire line and aerial attack are also used for fires with flame lengths of greater than 12 feet, as flame lengths increase, the effectiveness of these tactics decreases, and their use is generally designed to slow rates of spread and reduce fire intensity, especially in areas where values at risk are concentrated.

In the moderate fire weather scenario, the model predicts that fires in most of the populated portions of the WUI could be attacked directly by either hand crews or equipment. However, the combination of accessibility and higher flame lengths (up to 12 feet) will make operations more difficult in the steeper northern portions of both communities. It should also be noted that although flame lengths of four to 12 feet are predicted adjacent to Bachelor Gulch Trail, the primary access in and out of Bachelor Gulch Village, the road is positioned so that access is unlikely to be threatened by fires in these fuel beds.

Under the extreme fire weather scenario, flame lengths of greater than eight feet are predicted throughout the interface area except for the central portions of Daybreak Ridge and some small pockets in Bachelor Ridge. In these areas, the predicted flame lengths indicate that fires are likely to be too intense for direct attack by hand crews. Nonetheless, hand crews would be vital for structure preparation, triage, and the construction of indirect fire line. Under extreme weather and fuel moisture conditions, fire intensity in some areas of the northern portion of the study area could be a serious issue, and control may be difficult to establish and maintain.

Rate of Spread

Figures 9 and 10 show the predicted rates of spread for the moderate fire weather and extreme fire weather scenarios, respectively. Rates of spread are expressed in chains/hour (CPH). A chain is a unit of measure commonly used by loggers and firefighters. It is equal to 66 feet. Therefore, one mile equals 80 chains. Rates of fire spread are influenced primarily by wind, slope grade, fuel type/continuity, and fuel sheltering from the wind. Fire is the only force of nature which moves faster uphill than downhill. When all other factors are equal, fire moves twice as fast uphill on a slope of 30% than it does on flat terrain. In areas where high to extreme rates of spread are predicted (ROS of >40 CPH or ½ mile per hour) it is possible for fires to spread faster than humans can escape, creating extremely dangerous conditions for firefighters and evacuating residents. High rates of spread also make suppression efforts less effective and increase the tactical complexity of the incident.

In the moderate fire weather scenario, high rates of spread are predicted throughout the Bachelor Ridge community and in some of the northern portions of Daybreak Ridge. High rates of spread are also predicted along Bachelor Gulch Trail, indicating that both communities should be considered for evacuation early if fires are moving toward the Bachelor Ridge community from the north or northwest.

Extreme fire weather conditions do not create a substantial change in predicted rates of spread within the WUI areas, but the shrub fuels to the north of Bachelor Ridge are predicted to experience double to triple the rates of spread. Timing evacuation and suppression operations well ahead of the fire will be more critical for fires originating or moving through these fuels when extreme weather conditions exist.

Crown Fire Activity

The Crown Fire Activity maps (**Figures 11 and 12**) display the potential for fires to move from the surface into the canopy of trees and shrubs. The likelihood of progression from the surface into the aerial fuels is displayed in four categories. N/A refers to areas where surface fires are unlikely to develop due to the lack of combustible fuels. These would include any area such as rock, ice, snow fields, water, sand, or certain urban landscapes. The surface fire category covers areas where fires are expected to be limited to the surface fuels and lack the energy to initiate and sustain vertical development into the aerial fuels. Areas in which grass fuels without overstory plants are dominant fall into this category, regardless of the energy produced by the fire due to the lack of an aerial fuel bed. Areas covered by the torching category are expected to experience isolated combustion of the tree crowns in individual trees and groups of trees. In other words, individual or relatively small clusters of trees will be completely involved, but these fires lack the energy to initiate sustained horizontal movements (referred to as “runs” by fire fighters) through the crowns. The active crown fire category includes areas where sustained horizontal movements through tree crowns are expected. This category can be further subdivided into “dependent” or “independent” crown fires. Dependent crown fires rely on the presence of surface fires to support aerial burning. Independent crown fires develop when aerial burning is sustained, without the need for associated surface fire. Independent crown fires are rare and associated with the most extreme fire behavior conditions. Current fire behavior models do not have the ability to predict independent crown fire development. All crown fires, regardless of whether they are dependent or independent, represent extreme fire behavior conditions and are notoriously resistant to typical methods of suppression and control.

Under moderate burning conditions torching of individual trees and small patches is only expected to develop in isolated stands in the northern and southern portions of the study area, most of which are located away from homes; however since wood roofs are dominant in both communities, any ember cast generated by torching of trees near homes should be carefully monitored.

Under extreme burning conditions torching is expected to develop in some of the northern portions of Bachelor Ridge and throughout the southern portion of Daybreak Ridge. Some small pockets of active crown fires are predicted to develop in these areas, but these pockets are generally small, and should only pose a threat to homes in the southern portion of Daybreak Ridge. Structure defense in this area will be complicated by the dominance of wood shake roofs.

Spotting Potential

There is little chance of embers and spots from aspen stands. The lodgepole pine stands within the study area could generate embers and spotting, but the resulting embers would need to land in a receptive fuel bed. Where aspen surround homes in the study area there would be little chance of an ignition. Many homes also have landscaping and grass lawns which are not likely to be receptive to ignition. The primary concerns would be embers landing onto wood shake roofs and homes surrounded by lodgepole pine stands. Due to the active safety patrol schedule and nearby fire response, a fire should be detected quickly before it has a chance to extend to other structures or vegetative fuels. Additionally, a substantial water supply system is available to control any spot fires that may develop due to ember cast.

Figure 7. Flame Length Predictions (Moderate Weather Conditions)

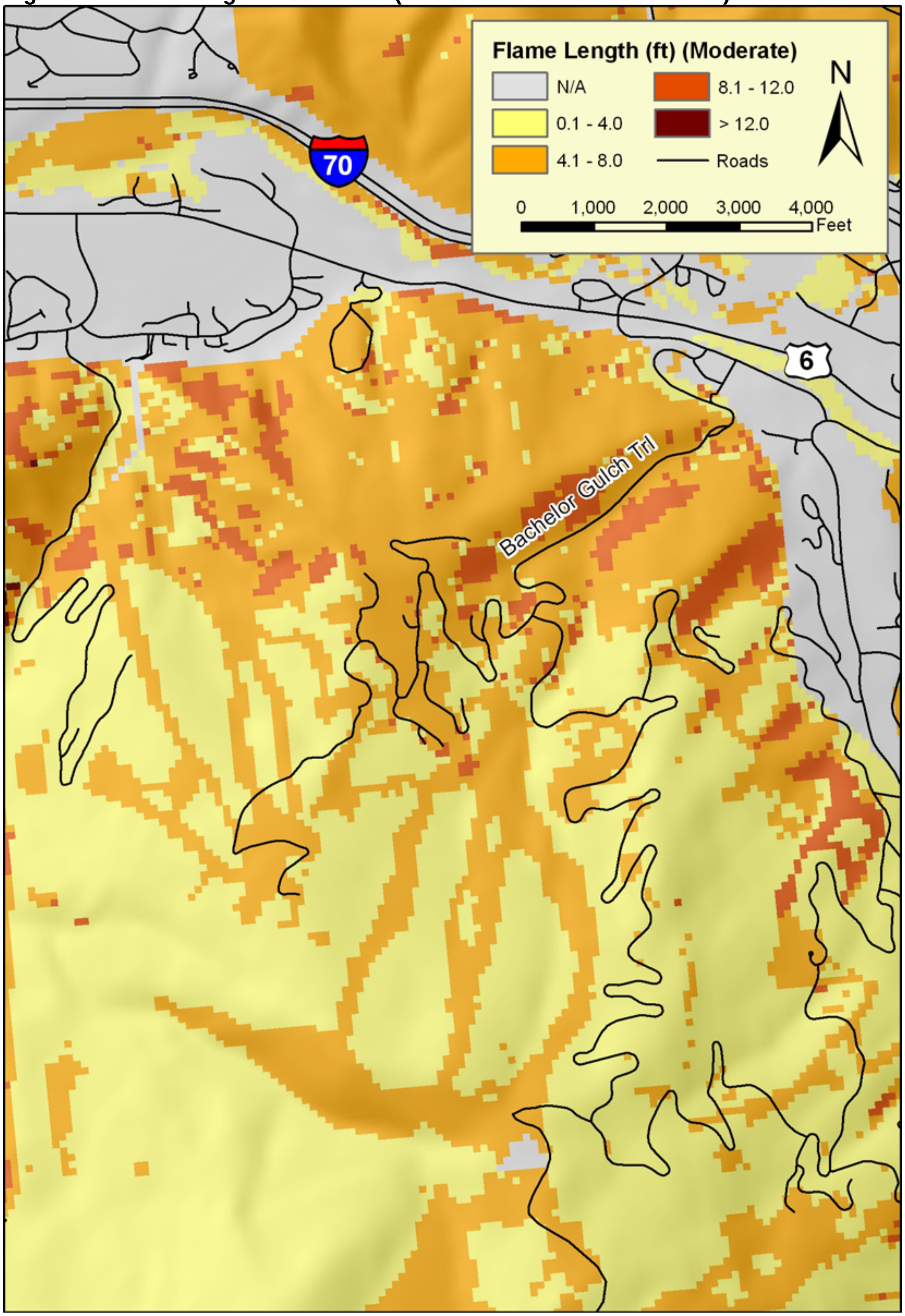


Figure 8. Flame Length Predictions (Extreme Weather Conditions)

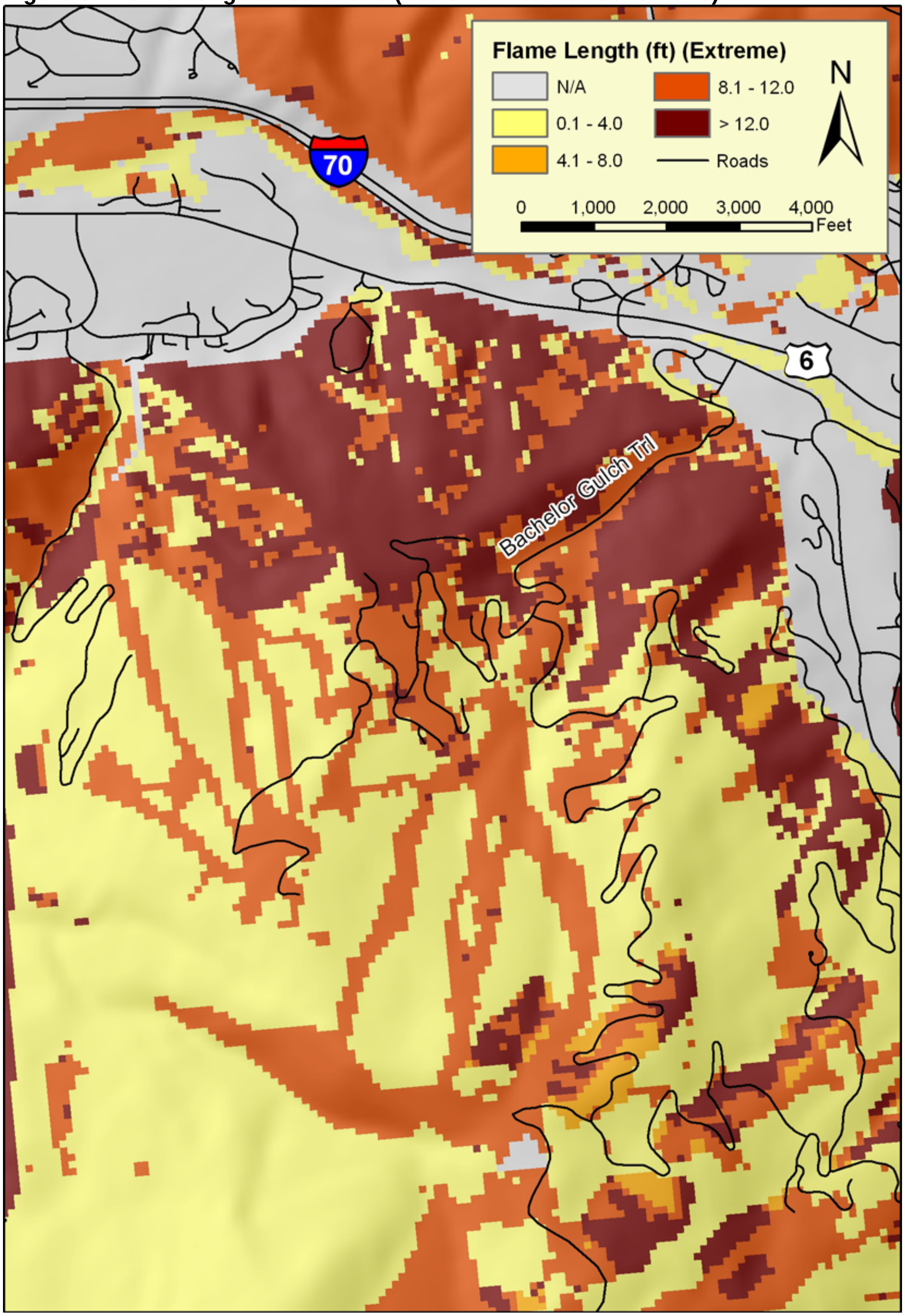


Figure 9. Rate of Spread Predictions (Moderate Weather Conditions)

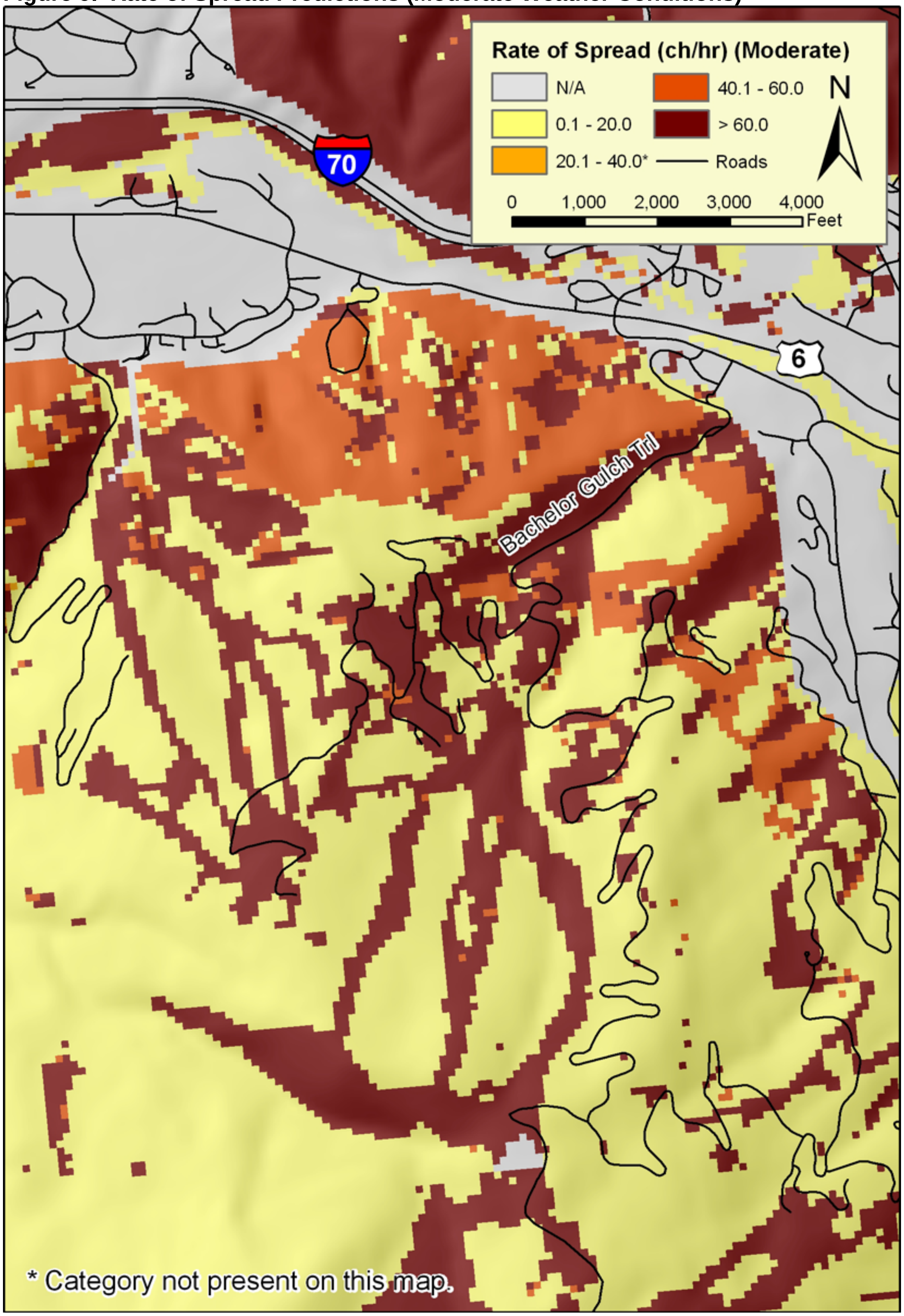


Figure 10. Rate of Spread Predictions (Extreme Weather Conditions)

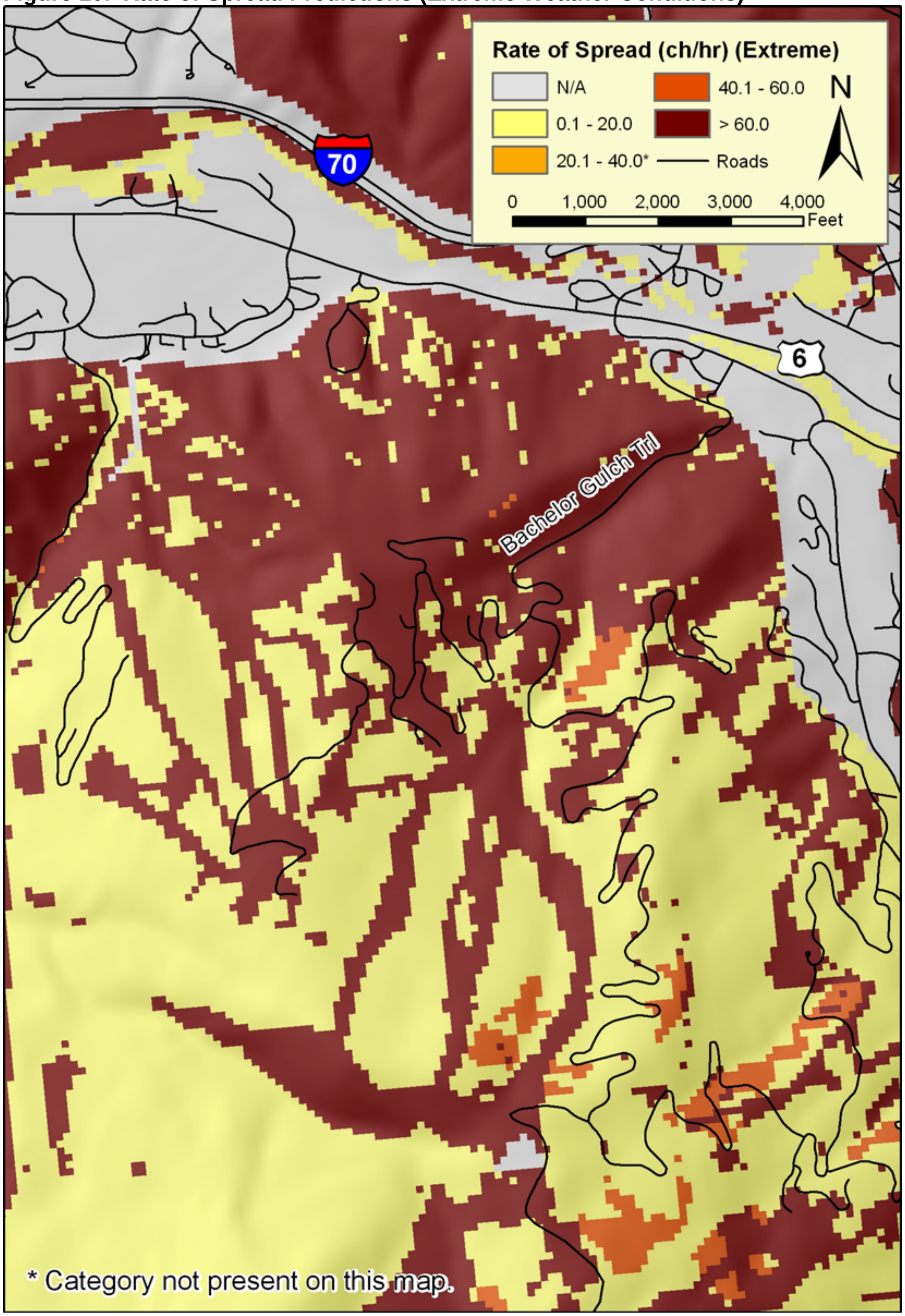


Figure 11. Crown Fire Activity Predictions (Moderate Weather Conditions)

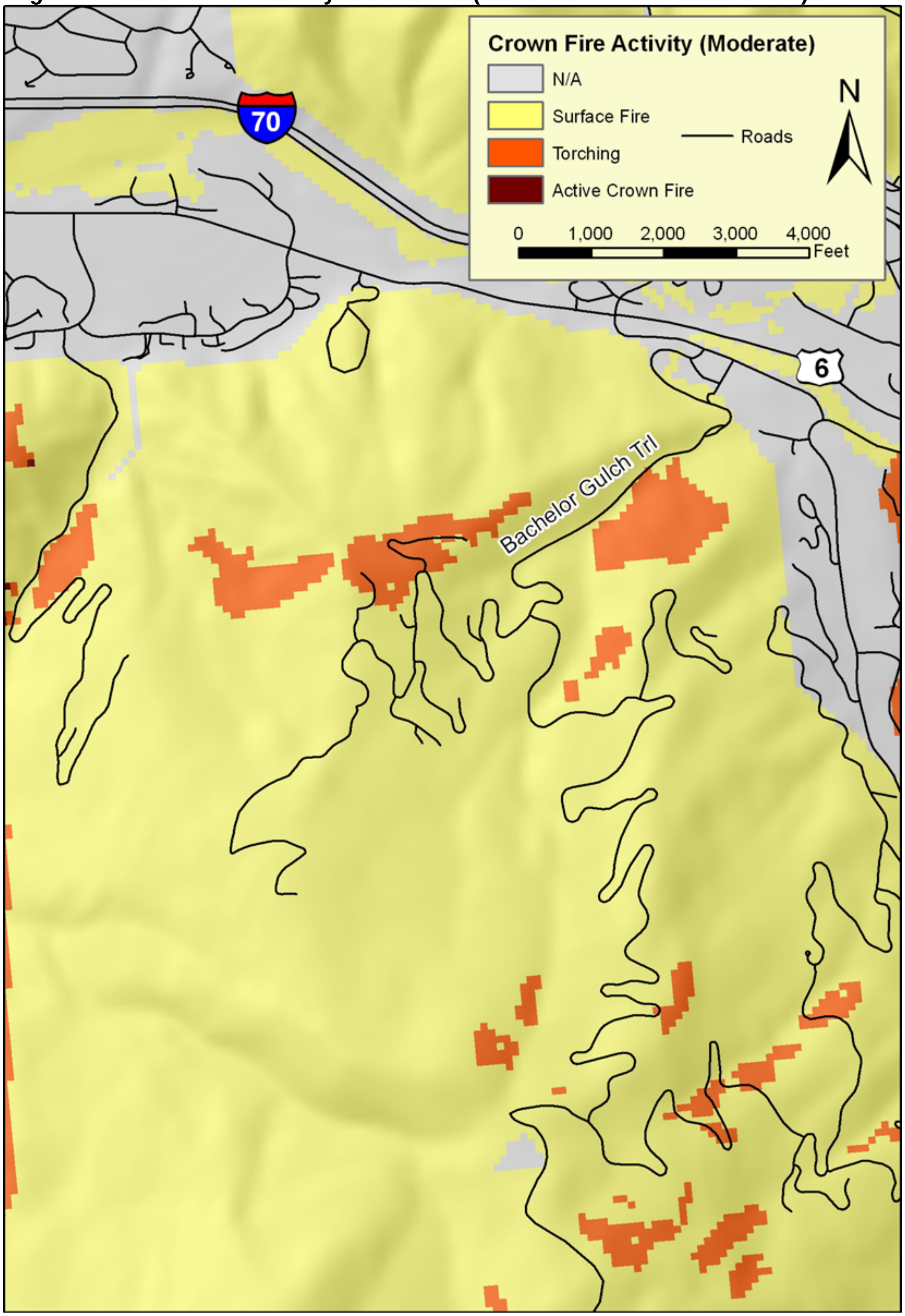
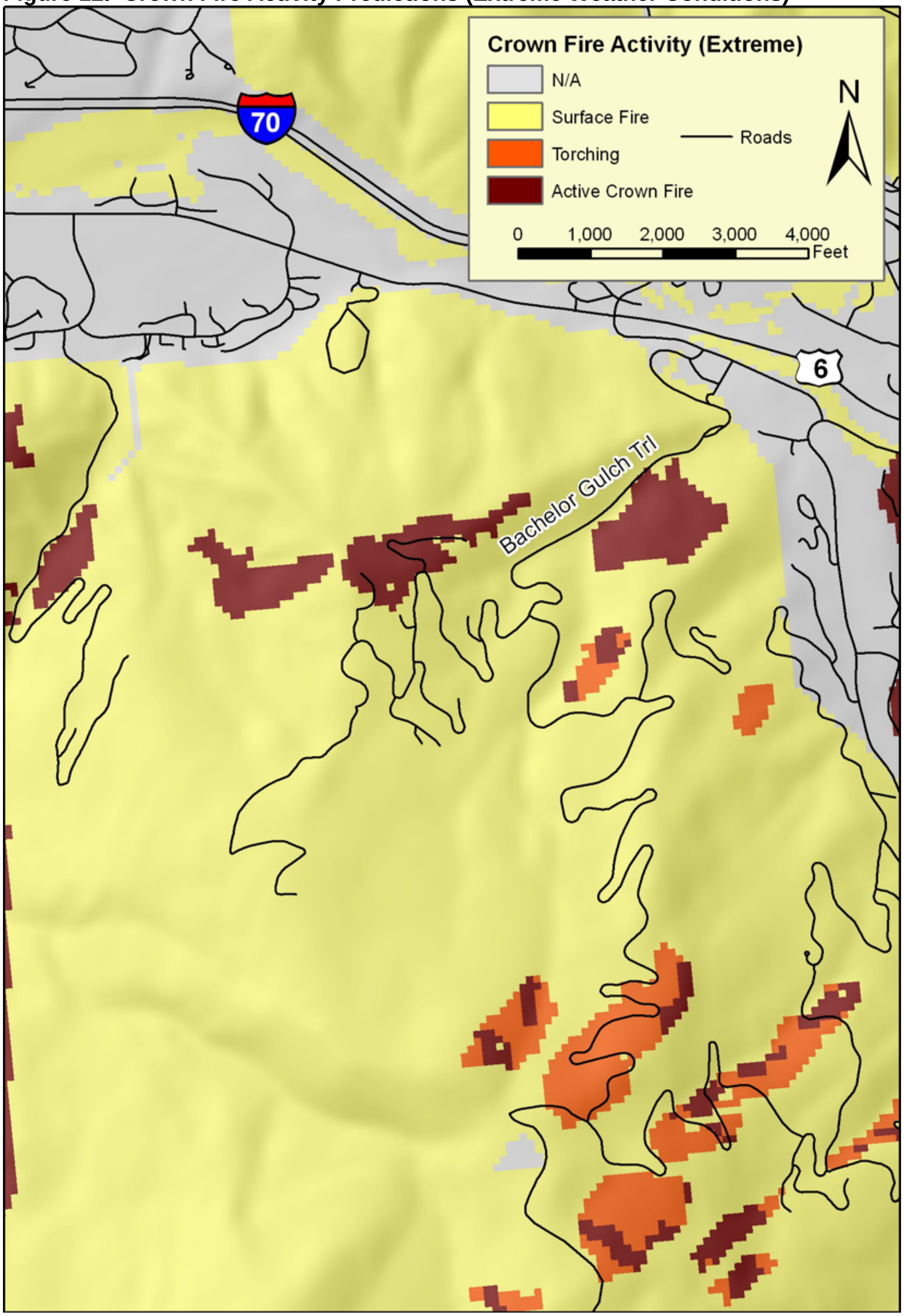


Figure 12. Crown Fire Activity Predictions (Extreme Weather Conditions)



SOLUTIONS AND MITIGATION

ESTABLISHING AND PRIORITIZING FIRE MANAGEMENT UNITS (FMUS)

An efficient method of prioritizing work efforts is to create Fire Management Units (FMUs). FMUs should be created prior to planning or initiating fuels management projects and other mitigation. There are unique vegetation and/or mitigation management activities recommended for each unit. Units may be functional or geographic. The local land management and fire management agencies (ideally with the input of the citizen's advisory council) must determine priority actions. The following FMUs have been identified for the study area; a situational analysis and recommendations are provided for each. FMUs are NOT ranked by priority, however priority recommendations have been provided for specific tactical mitigation actions, where appropriate, within FMUs.

- Access and Evacuation FMU
- Public Education FMU
- Local Preparedness and Firefighting Capabilities FMU
- Home Mitigation FMU
- Fuels Modification Projects FMU
- Water Supply FMU

ACCESS AND EVACUATION FMU

Addressing

Throughout the study area streets are generally well marked, however some street signs, especially along Daybreak Ridge, are made of wood and are mounted on wood poles; these signs would most likely be consumed by intense fires. Most homes have an address marker at the structure, but in some of the communities the length of the driveway and/or position of the home makes it difficult or impossible to see the address marker from the street. Some of these homes do not have an additional address marker at the street and of those that do, many of the markers are not reflective and/or not of a consistent type or location. This situation was noted in the both communities, but was especially prevalent in Bachelor Ridge above Tall Timbers.

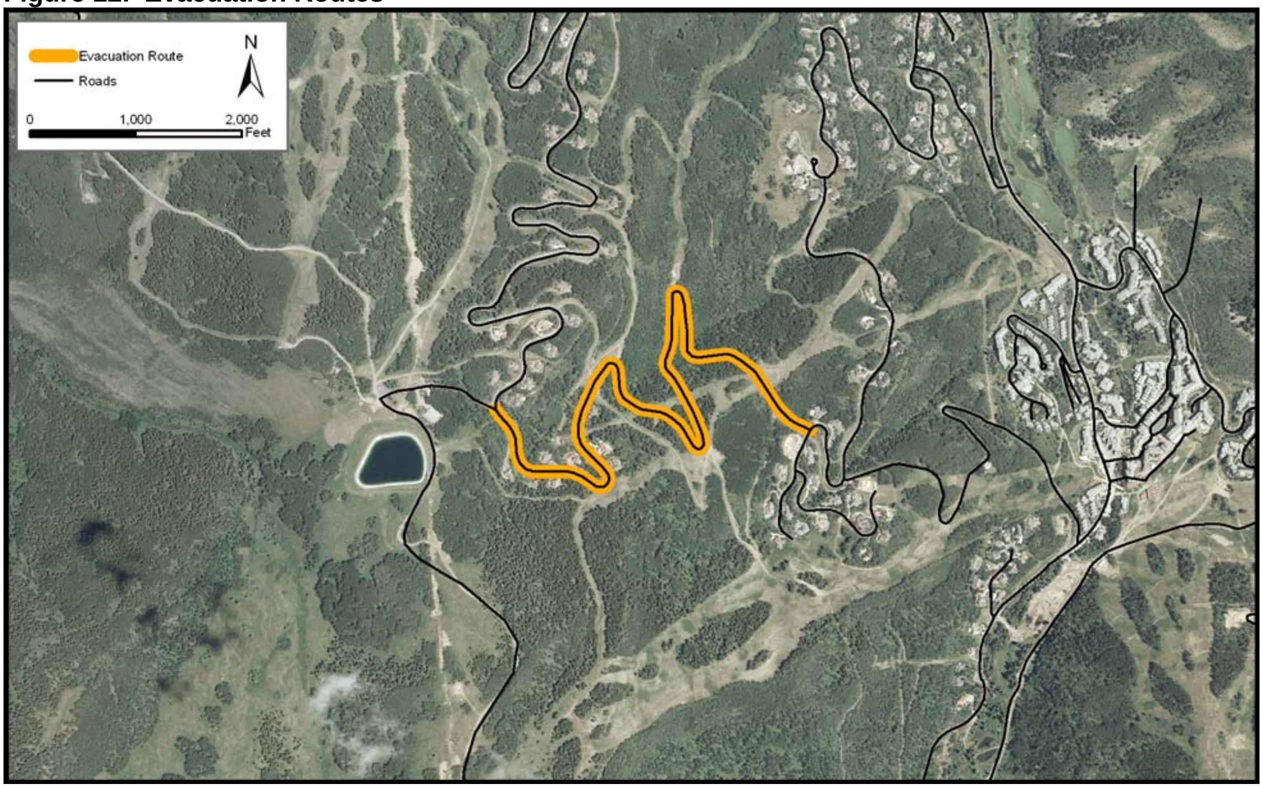
Reflective or illuminated street signs and address markers visible from the access road are a critical operational need. The time saved, especially at night and in difficult conditions, is absolutely crucial for ensuring effective suppression efforts. Knowing at a glance the difference between a road and a driveway (and which houses are on the driveway) cuts down on errors and time wasted interpreting maps. This is especially true for volunteer operators who do not have the opportunity to train on access issues as often as career firefighters. Recommendations for address markers can be found in **Appendix D**.

Evacuation Routes

Throughout Bachelor Gulch, access to the communities is generally very good. Of some concern, however, is the southern end of Daybreak Ridge, which is a long way from the highway on primarily winding two-lane roads. There is a service road that could serve as alternative evacuation route from the southern end of Daybreak Ridge to the Strawberry Park community in Beaver Creek. This route is highlighted in the overview of the area shown in **Figure 12**.

Daybreak Ridge to Strawberry Park: ***Priority level: High*** It is possible to escape from Bachelor Gulch to US 6 or I 70 by using an existing service road that connects from Daybreak Ridge Road to the Strawberry Park community in Beaver Creek. This road is asphalt and is passable by all vehicles including passenger cars; however it currently has a gate that blocks access at the upper (western) end. This gate should be replaced or refitted for fire department access and this road included in the fire department pre-plan as a firefighter access point as well as a potential escape route. This road is of adequate width and generally has good clearance, but thinning should be conducted to shaded fuelbreak standards wherever predominately conifer stands are below the road, especially where the road crosses the major drainage. The priority level is high because a relatively small amount of work will greatly improve the usefulness of this route.

Figure 12. Evacuation Routes



ACCESS ROUTE RECOMMENDATIONS

- In order to reduce potential conflicts between evacuating citizens and incoming responders, there should be nearby evacuation centers for citizens, and staging areas for fire resources. Evacuation centers should include heated buildings with facilities large enough to handle the population. Schools and churches are usually ideal for this purpose. Fire staging areas should contain large safety zones, a good view in the direction of the fire, easy access and turnarounds for large apparatus, a significant fuel break between the fire and the escape route, topography conducive to radio communications, and access to water. Golf courses and large irrigated greenbelts may make good safety zones for firefighting forces. Local responders are encouraged to preplan the use of potential staging areas with local officials and property owners. ***Priority level: High***
- Create an evacuation plan for the WUI communities of the study area. Evacuation planning in the study area will require a substantial effort including the resort company, property owners, the fire department, law enforcement and the Eagle County OEM staff. Eagle County has identified some evacuation centers, but more work needs to be done in planning for a community-wide evacuation. The Eagle River Fire Department has suggested that one possibility would be to move residents to a shelter-in-place area within the resort village and then to evacuation centers beyond the resort should it become necessary. ***Priority level: High***
- Utilize a reverse 911 system or call lists to warn residents when an evacuation may be necessary. Notification should also be carried out by using any existing disaster notification systems. ***Priority level: High***
- Supplement or replace any existing wood street signs mounted on wood poles with lighted or reflective metal signs on non-combustible mountings. ***Priority level: High***
- Perform response drills to determine the timing and effectiveness of escape routes and fire resource staging areas. ***Priority level: Moderate***
- See *Access Route Fuels Modification Recommendations* in the *Fuels Modification Projects FMU* section of this report.

PUBLIC EDUCATION FMU

Bachelor Gulch, like the rest of the Vail valley, is experiencing ongoing development. Increasing property values and the associated rise in the number of non-resident owners has resulted in a varied understanding among property owners of the intrinsic hazards associated with building in WUI areas. An approach to wildfire education that emphasizes safety and hazard mitigation at the individual property level should be undertaken, in addition to community and emergency services efforts at risk reduction. Combining community values such as quality of life, property values, ecosystem protection, and wildlife habitat preservation with the hazard reduction message will increase the receptiveness of the public.

A definitive shift to shared responsibility must be actively promoted. Homeowners must be made aware that fire suppression resources cannot be the only line of defense against wildland fires.

Landowners and homeowners must take responsibility as key players in mitigation efforts. The Bachelor Gulch Village Association should be the focal point for educating at-risk homeowners and working with them to reduce the hazards on their property.

RECOMMENDATIONS

- Use these web sites for a list of public education materials, and for general homeowner education:
    - http://www.fs.fed.us/fire/links/links_prevention.html
    - http://www.nwcg.gov/pms/pubs/pubs.htm
    - http://www.firewise.org
    - http://csfs.colostate.edu/protecthomeandforest.
    - http://www.eaglecounty.us/commDev/wildfireInfo.cfm Eagle County has also developed and distributes an educational CD/DVD that covers a wide a variety of wildfire information topics.

- Encourage homeowner's groups and mortgage lenders to eliminate covenants and deed restrictions requiring the retention of dangerous vegetation and/or the use of flammable building materials (such as wood-shake roofs). Request that these groups promote the development of defensible space and Firewise plantings.

- Provide citizens with the findings of this study including:
    - Levels of risk and hazard.
    - Values of fuels reduction programs.
    - Consequences of inaction for planned and unplanned ignitions in the community.

- Create a Wildland Urban Interface (WUI) citizen advisory council to provide peer-level communications for the community. Too often government agency advice can be construed as self-serving. Consequently, there is poor internalization of information by the citizens. The council should be used to:
    - Include the concerns of the residents in the prioritization of mitigation actions.
    - Select demonstration sites.
    - Assist with grant applications and awards.

LOCAL PREPAREDNESS AND FIRE FIGHTING CAPABILITIES FMU

Fire suppression services for Bachelor Gulch are provided by the Eagle River Fire Protection District (ERFPD), see **Figure 13**. Mutual aid is available from the Greater Eagle, Vail, and Gypsum Fire Departments.

The Eagle River Fire Department (ERFD) employs more than 50 full-time staff and 22 resident/intern firefighters. All ERFD firefighters are certified to State of Colorado FF1 or higher. Most of the paid staff are certified to Colorado FF2. Company Officers are certified to Fire Officer 1 and 2, HazMat Operations or higher and National Wildfire Coordinating Group (NWCG) S130/190 (basic wildland firefighter) levels. ERFD has 10 employees with advanced wildland firefighter certifications (Squad Boss) and four Engine Boss qualified personnel. Two chief officers participate in the regional Incident Management Team. Public Safety Officers

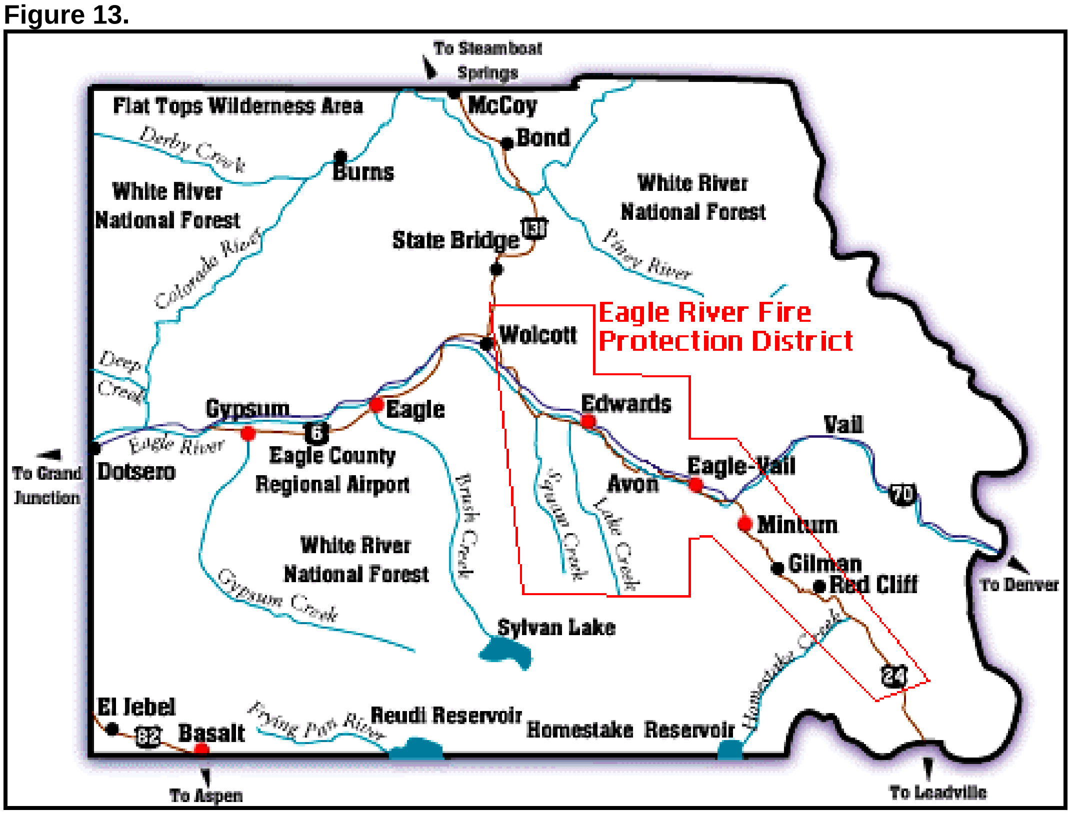
(PSOs) patrol Bachelor Gulch, and respond with the on-duty crew. Some PSOs are cross-trained in wildland firefighting.

ERFD operates nine fire stations and 15 pieces of fire apparatus. Six of the fire stations are staffed 24 hours a day by a crew of two to four including the Lieutenant, Engineer and firefighters. One Battalion Chief commands each shift, overseen by the Deputy Chief od Operations. The primary response to incidents in Bachelor Gulch is from the ERFD stations seven and eight in Avon. [11]

The distribution of ERFD apparatus changes seasonally, however Engine 131 and Engine 113 are always available at station 11 (located at the Beaver Creek base area). ERFD operates three wildland engines that have complete tool caches and a wildland tool cache is also maintained at Station 7 in Avon.

The concern among ERFD officers is that wildfire hazards and risks are increasing. Multi-acre fires will demand a substantial commitment of resources. There is the potential that suppression of simultaneous fires resulting from lightning, or possibly other causes, may burn unchecked until sufficient resources are obtained and deployed. ERFD chief officers believe the limits of local capability could be reached or exceeded in any multi-acre fire burning in 100-hour fuels, multiple ignitions exceeding two acres and/or fires requiring operations extending beyond two operational periods (24 hours). Such an event may requirement the deployment of a Type III Incident Management Team, assuming one is available.

Figure 13.



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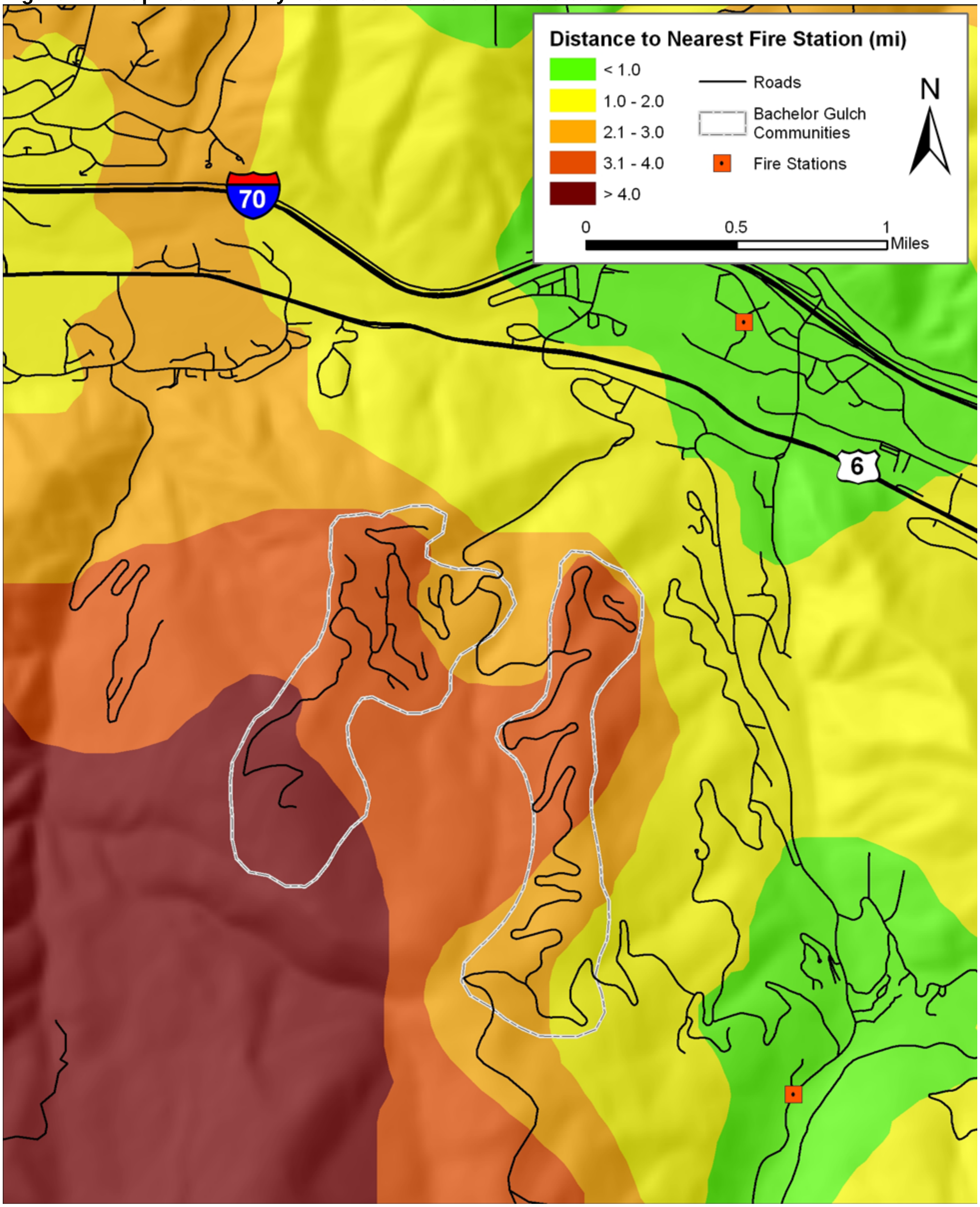
11 http://www.erfpd.org/index.asp

Figure 14. Map - Community Distances to Nearest Fire Stations



Distances to the nearest fire stations were calculated in ArcGIS and take into account the driving distance to a given area, rather than merely the "flight distance." **Figure 14** shows the driving distances from the nearest fire station to the communities of the study area.

None of the communities in the study area are greater than five miles from a fire station. However, for the purposes of this report, this is not an Insurance Services Office (ISO) issue, but one of defining response distance to potential fire ignitions. The distance analysis calculates *drivable distance, not drive time*. However, the distance is an important factor in rating community hazards. Response times will vary greatly over the same distance due to road conditions, steepness, curvature of roads, and evacuation traffic. Most fire service leaders agree that response time is composed of a number of distinct elements: call processing time (the time it takes for dispatchers to ascertain the location and nature of the emergency and initiate the appropriate response), turnout or staffing time (the time it takes for personnel to respond to the dispatch, board apparatus, and begin traveling to the scene), and travel time (the actual time it takes to travel from the station to the scene).

The National Fire Protection Agency (NFPA) has established time objectives for fire response:

NFPA 1710 requires:

1. Turnout time of one minute.
2. Four minutes or less for the arrival of the first arriving engine company at a fire suppression incident and/or eight minutes or less for the deployment of a full first alarm assignment at a fire suppression incident.[12]

If turnout time of one minute is met, and average driving speed is 30 MPH, then the engine company will be able to drive two miles in the four minutes established by NFPA 1710. Therefore, communities with mean distances greater than two miles from a fire station were given a weighted increase in their hazard rating.

RECOMMENDATIONS

- Training:
  - Provide continuing education for firefighters including:
    - □ Continue to require NWCG S-130/190 for all department members. It is recommended this requirement be extended to include all auto-aid agencies.
    - □ Continue to require annual wildland fire refresher and "pack testing" (physical standards test) for all department members. It is recommended this requirement be extended to include all auto-aid agencies.
    - □ S-215 Fire Operations in the Urban Interface for all firefighters.
    - □ S-290 Intermediate Fire Behavior for all officers.
    - □ I-200 and I-300 – Basic and Intermediate ICS for all officers.

  Priority level: High

  - Continue training of Public Safety Officers with the goal of having all PSOs trained to basic wildland firefighting standards. ***Priority level: High***

[12] http://72.14.253.104/search?q=cache:u8XMw9ZRQUYJ:www.pcpages.com/fireman02169/1710.pdf+NFpa+1710&hl=en&ct=clnk&cd=1&gl=us , Section **5.2.3.1.1,** page 11.

- Equipment:

  - ☐ Continue to ensure all firefighters have wildland Personal Protective Equipment (PPE). ***Priority level: High***
    - (See NFPA Standard 1977 for requirements).
  - ☐ ERFD currently provides gear bags for both wildland and bunker gear to be placed on engines responding to fire calls. This helps ensure that firefighters have both bunker gear and wildland PPE available when the fire situation changes. It is recommendation that auto-aid agencies carry the same equipment on their apparatus. ***Priority level: High***
  - ☐ Consider locating one type VI (4WD) engine at Station 11 from May to October. ***Priority level: Moderate***
  - ☐ Provide and maintain a ten-person wildland fire cache at Station 11 in addition to any tools on the apparatus. The contents of the cache should be sufficient to outfit two squads for handline construction and direct fire attack. Recommended equipment would include:
    - Four cutting tools such as pulaskis or super pulaskis
    - Six scraping tools such as shovels or combis
    - Four smothering tools such as flappers
    - Four backpack pumps with spare parts
    - Two complete sawyer's kits including chainsaw, gas, oil, sigs, chaps, sawyer's hard hat, ear protection, files, file guides, spare chains and a spare parts kit
    - MREs and water cubies sufficient for 48 hours

  Priority level: Moderate

- Communications:

  - ☐ Surveys of GEFD officers indicated that their primary communications system operates in the 800 MHz band, which is becoming more common for urban fire departments. Systems such as these offer high audio quality, but are easily blocked by terrain features. VHF radios operating in 150 MHz band are still the principle radios for many wildland fire resources and have generally better reception than 800 MHz systems in complex terrain. Although the surveys indicate there is a backup communication system to the primary 800 MHz system, its specifications were not reported. ERFD has provided their firefighters with Nextel units to supplement the existing radio system. According to ERFD this has solved many of the communication problems.

- Compatibility with other local resources such as USFS, BLM, CSFS and auto-aid agencies should be a high priority. Federal land managers (USFS, BLM) will continue to operate on the existing VHF band. In order to have universal communication on wildland fires, responders will be required to maintain VHF radio equipment which will still have the current problem areas. The suggestions that follow will need to be evaluated for cost/benefit effectiveness by the fire department before implementation. Due to the restrictions of terrain, it is unlikely more powerful base stations or portable radios will make any impact on VHF communication problems. Some areas may see slight improvements in base station reception by increasing the height above average terrain of the base station antenna. However, the best solution is to increase the number of VHF repeaters in the problem areas. If landowners are a barrier to fixed repeater sites, another solution is to construct one or more mobile repeaters in engines or command vehicles. Mobile repeaters allow the vehicle to be positioned for optimum communication for each incident. Repeaters are expensive; however grants and other sources of funding could be pursued in order to solve this operational problem. If it is not possible to obtain a repeater frequency, which is likely, satellite phones may be a reasonable additional tool for incident communication ***Priority level: Moderate to Low*** (depending on cost effectiveness).

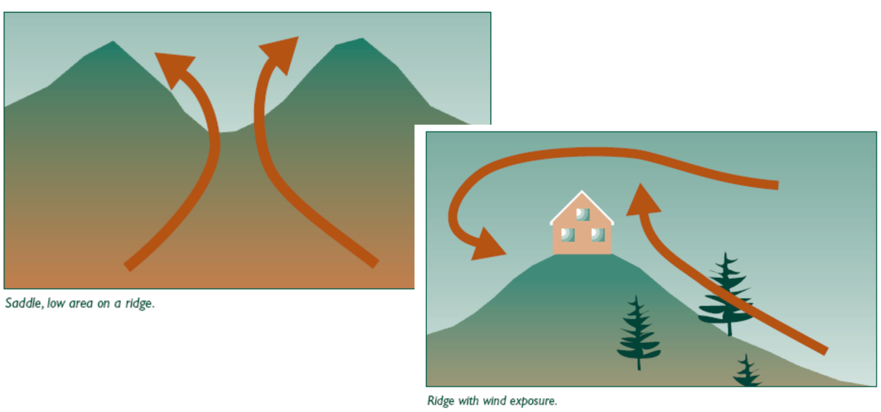
HOME MITIGATION FMU

Community responsibility for self-protection from wildfire is essential. Educating homeowners is the first step in promoting shared responsibility. Part of the educational process is defining the hazard and risks both at the community and parcel levels. Defensible space planning, maintenance, ignition-resistant construction, and preventative landscaping techniques are critical to the mitigation of the loss of life and property during wildfire events.

Many of the homes in Bachelor Gulch Village are constructed with heavy timber or full log construction and non-combustible roofing. These building elements are considered ignition-resistant. Others have cedar siding and/or cedar shake roofing, considered to be combustible and not ignition-resistant. All residential structures including multi-family units and hotels, such as the Ritz-Carlton, are equipped with interior sprinkler systems, greatly reducing the potential for structure ignition and spread of fire to surrounding vegetation. These and other factors contribute a lower hazard rating than might be expected for similar residences located in similar fuels (see **Table 3**).

Some homes in Bachelor Gulch have fire resistant landscaping with irrigation creating defensible fuel profiles; however there are many homes, especially in the Daybreak Ridge community, with flammable native and/or ornamental vegetation too close to the structure. Other than ember ignition to cedar roofing, the construction features of most structures do not contribute to the propagation of fire. However, the most important element for the improvement of life safety and property preservation is for every home in the study area to have compliant, effective defensible space. This is especially important for homes with wood roofs and homes located on steep slopes, in chimneys, saddles, or near any other topographic feature that contributes to fire intensity (see **Figure 15**).

Figure 15. Saddle & Ridge Top Development[13]



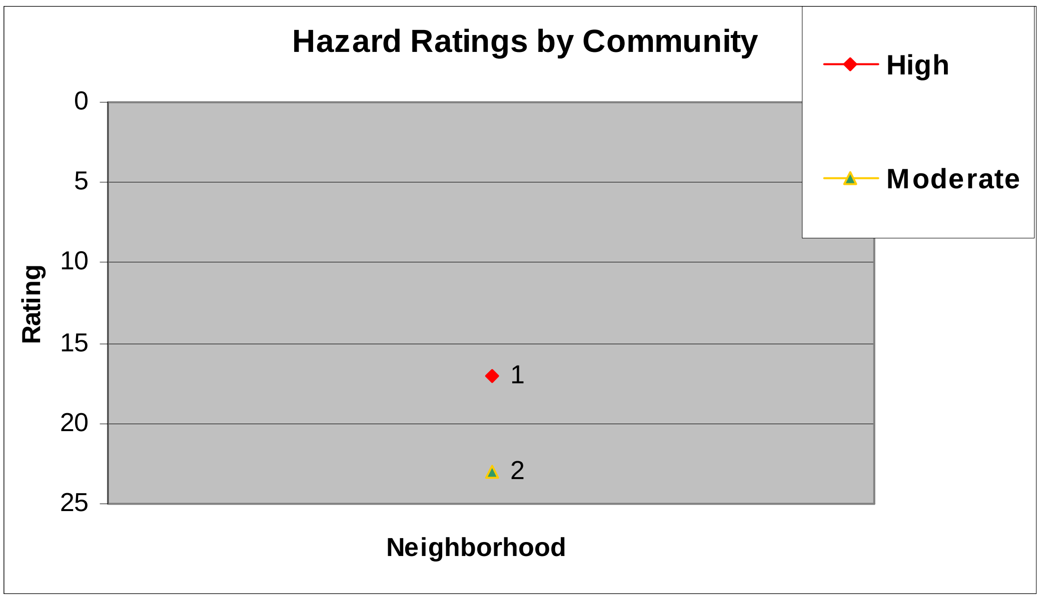
When designing defensible space treatments, there is no question that any type of dense/flammable vegetation should be removed from around a home in order to reduce the risk of structural ignition during a wildfire. The question is, how much should be removed? The basic rule is to eliminate all flammable materials (fire-prone vegetation, wood stacks, wood decking, patio furniture, umbrellas, etc.) from within 30 feet of the home. For structures near wildland

[13] *FireWise Construction*, Peter Slack, Boulder Colorado

open space, an additional 70 feet should be modified in such a way as to remove all dead wood from shrubbery, thin and trim trees and shrubs into "umbrella" like forms (lower limbs removed), and prevent the growth of weedy grasses (see **Figure 16**). Steep slopes and/or the presence of dangerous topographic features as described above may require the defensible space distances to be increased.

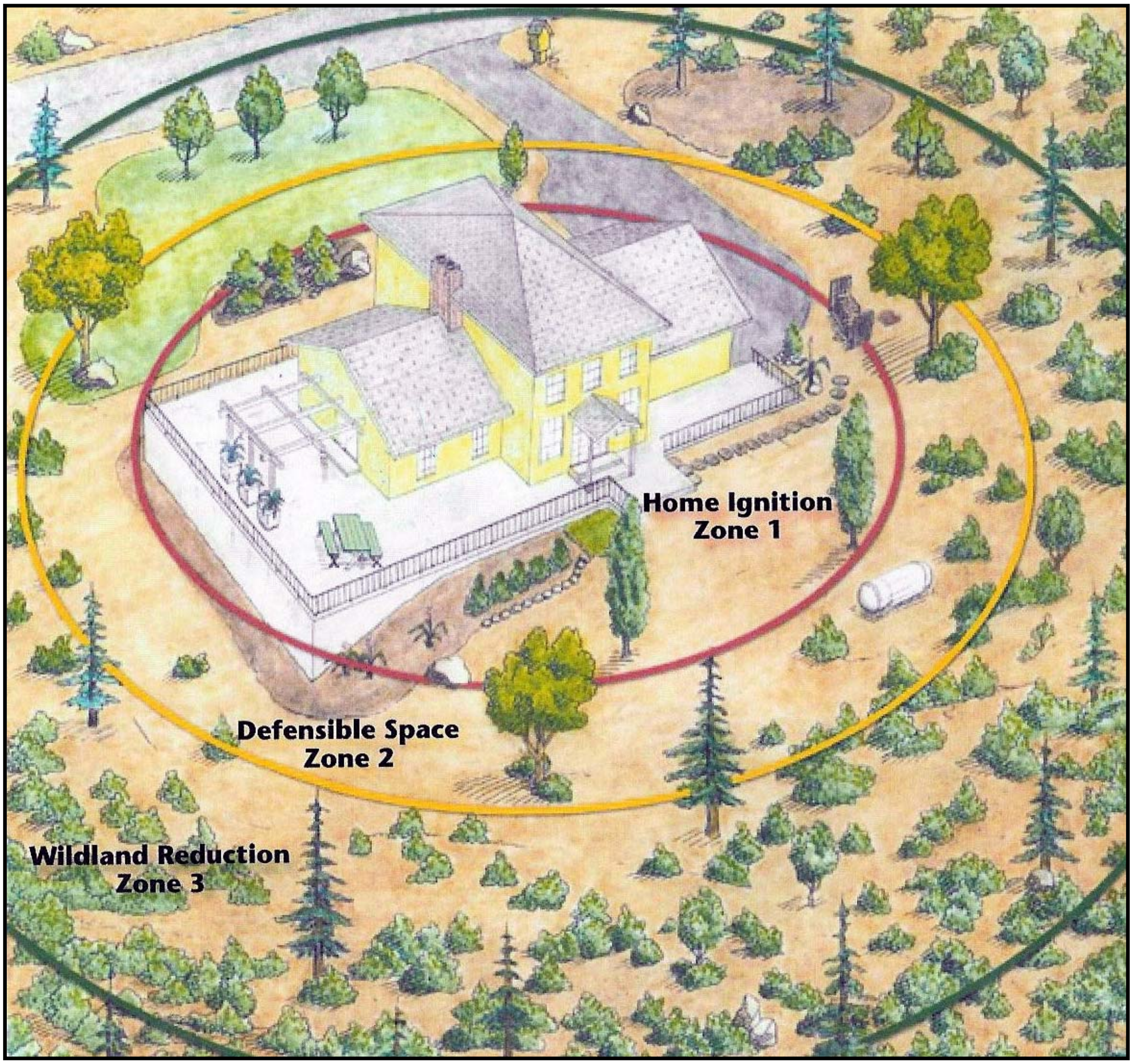
The term “clearance” leads some people to believe all vegetation must be removed down to bare soil. This is not the case. Removing all vegetation unnecessarily compromises large amounts of forested terrain, increases erosion, and will encourage the growth of weeds in the now disturbed soil. These weeds are considered “flashy fuels,” which actually increase fire risk because they ignite so easily. Defensible space must be ecologically sound, aesthetically pleasing and relatively easy to maintain. Only then will the non-prescriptive use of fuels reduction around homes become commonplace.

Table 3. Hazard Ratings by Community



1. Daybreak Ridge	**2. Bachelor Ridge**

Figure 16: Defensible Space Zones (not to scale)[14]



[14] *A Homeowner's Guide to Fire Safe Landscaping* (2005) www.FireSafeCouncil.org

RECOMMENDATIONS

- Complete a parcel-level wildfire hazard analysis for the homes in the study area. Completing this process will facilitate the following important fire management practices:
  - Establish a baseline hazard assessment for individual homes in all the communities
  - Education of the community through the presentation of the parcel level Hazard-Risk Analysis at neighborhood public meetings
  - Identification of defensible space needs and other effective mitigation techniques
  - Identification and facilitation of "cross-boundary" projects
  - Community achievement of national FIREWISE status
  - Development of a Pre-Attack/Operational Plan for the study area. A pre-attack plan assists fire agencies in developing strategies and tactics that will mitigate incidents when they occur

  Priority level: High

- Add reflective or illuminated address signs at the driveway entrance to all homes that do not already have an address marker that is easily visible from the street (See **Appendix D** for recommendations). ***Priority level: High***

- Use the structure triage methodology provided in **Appendix C** to identify homes not likely to be defendable. ***Priority level: High***

LANDSCAPE SCALE FUELS MODIFICATIONS FMU

One of the most effective forms of landscape scale fuels modification is the fuelbreak (sometimes referred to as “shaded fuelbreak”). A fuelbreak is an easily accessible strip of land of varying width, depending on fuel and terrain, in which fuel density is reduced, thus improving fire control opportunities. Vegetation is thinned removing diseased, fire-weakened and most standing dead trees. Thinning should select for the more fire resistant species. Ladder fuels, such as low limbs and heavy regeneration are removed from the remaining stand. Brush, dead and down materials, logging slash and other heavy ground fuels, are removed and disposed of to create an open park-like appearance. The use of fuelbreaks under normal burning conditions can limit uncontrolled spread of fires and aid firefighters in slowing the spread rate. Under extreme burning conditions where spotting occurs for miles ahead of the main fire and probability of ignition is high, even the best fuelbreaks are not effective. That being said, however, fuelbreaks have proven to be effective in limiting the spread of crown fires in Colorado.[15] Factors to be considered when determining the need for fuelbreaks in mountain subdivisions include:

- The presence and density of hazardous fuels
- Slope
- Other hazardous topographic features
- Crowning potential
- Ignition sources

With the exception of aspen, all of Colorado’s major timber types represent a significant risk of wildfire. Increasing slope causes fires to move from the surface fuels to crowns more easily due to preheating. A slope of 30% causes the fire spread rate to double compared with the same fuels and conditions on flat ground. Chimneys, saddles and deep ravines are all known to accelerate fire spread and influence intensity. Communities with homes located on or above such features as well as homes located on summits and ridge tops would be good candidates for fuel breaks. Crown fire activity values for the study area were generated by the FlamMap model and classified into three standard ranges (surface fire only, passive crown fire and active crown fire). In areas where active crown fire activity is likely to exist, fuelbreaks should be considered. If there are known likely ignition sources (such as railroads and recreation areas that allow campfires) that are present in areas where there is a threat of fire being channeled into communities, fuelbreaks should be considered.

Fuelbreaks should always be connected to a good anchor point like a rock outcropping, river, lake, or road. The classic location for fuelbreaks is along the tops of ridges to stop fires from backing down the other side or spotting into the next drainage. This is sometimes not practical from a WUI standpoint as the structures firefighters are trying to protect are usually located at the tops of ridges or mid-slope. Mid-slope positioning is considered the least desirable for fuelbreaks; however it may be easiest to achieve as an extension of defensible space work or an extension of existing roads and escape routes. One tactic would be to create fuelbreaks on slopes below homes located mid-slope and on ridge tops so that the area of continuous fuels between the defensible space of homes and the fuelbreak is less than ten acres. Another tactic that is commonly used is to position fuelbreaks along the bottom of slopes. In most of the study area this would require the cooperation of many individual landowners. In some areas the only

[15] Frank C. Dennis, “Fuelbreak Guidelines for Forested Subdivisions” (Colorado State Forest Service, Colorado State University, 1983), p. 3.

way to separate residences from fuels is to locate the fuelbreak mid-slope above homes. This would provide some protection from backing fires and rolling materials. It may also be effective to locate fuelbreaks mid-slope below homes, where this is possible, to break the continuity of fuels into the smaller units mentioned above, even though this position is considered the least desirable from a fire suppression point of view.

Fuelbreaks are often easiest to locate along existing roadbeds. The minimum recommended fuelbreak width is usually 200 feet. As spread rate and intensity increases with slope angle, the size of the fuel break should also be increased with an emphasis on the downhill side of the roadbed or centerline employed. The formulas for slope angles of 30% and greater are as follows: below road distance = 100' + (1.5 x slope %), above road distance = 100' – slope % (see **Table 4**). Fuelbreaks that pass through hazardous topographic features should have these distances increased by 50%.[16] Since fuelbreaks can have an undesirable effect on the esthetics of the area, crown separation should be emphasized over stand density levels. That is to say that isolating groupings rather than cutting for precise stem spacing will help to mitigate the visual impact of the fuelbreak. Irregular cutting patterns that reduce canopy and leave behind islands with wide openings are effective in shrub models.

Another issue in mechanical thinning is the removal of cut materials. It is important to note that in Colorado's dry climate slash decomposes very slowly. One consequence of failing to remove slash is to add to the surface fuel loading, perhaps making the area more hazardous than before treatment. It is imperative that all materials be disposed of by piling and burning, chipping, physical removal from the area, or lopping and scattering. Of all of these methods lopping and scattering is the cheapest, but also the least effective since it adds to the surface fuel load.

It is also important to note that fuelbreaks must be maintained to be effective. Thinning usually accelerates the process of regenerative growth. The effectiveness of the fuelbreak may be lost in as little as three to four years if ladder fuels and regeneration are not controlled. Fuelbreaks should not be constructed without a maintenance plan.

One of the most difficult issues in establishing and maintaining fuelbreaks is securing cooperation and participation of landowners. Fuels reduction projects recommended here and in the "Access and Evacuation FMU" section may require the approval of several public land management agencies as well as private landowners. These entities include the Colorado State Forest Service, the United States Forest Service, Eagle County and possibly others.

[16] Frank C. Dennis, "Fuelbreak Guidelines for Forested Subdivisions" (Colorado State Forest Service, Colorado State University, 1983), p. 11.

Table 4. Recommended Treatment Distances For Mid-Slope Roads

% Slope	Distance Above Road	Distance Below Road
30	70 feet	145 feet
35	65 feet	153 feet
40	60 feet	160 feet
45	55 feet	168 feet
50	50 feet	175 feet

CURRENT AND COMPLETED PROJECTS

Representatives of Eagle County were contacted regarding planned and existing projects in the study area. There are currently no landscape scale fuels mitigation projects in progress or in planning for the Bachelor Gulch study area. Most of the fuels removal in Bachelor Gulch has been conducted in conjunction with private development. A forest management plan is currently being developed for Bachelor Gulch. Once this plan is approved, the Bachelor Gulch Village Association will spearhead hazardous vegetation removal in Bachelor Gulch.

FUELS MODIFICATION RECOMMENDATIONS

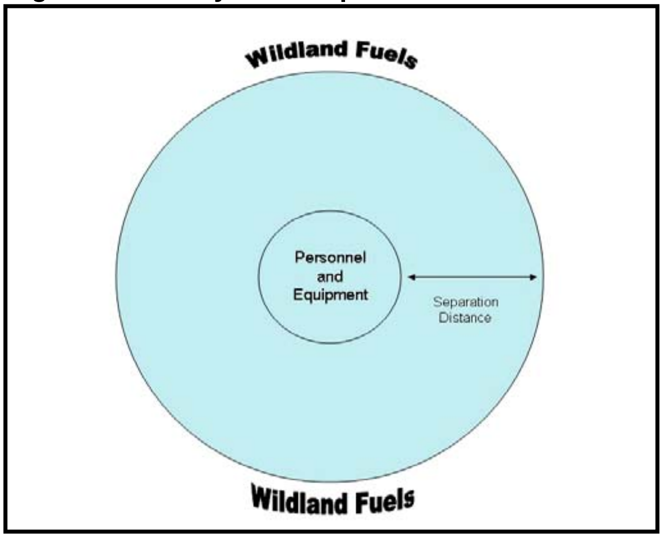
These recommendations have been designed to take advantage of prevailing wind patterns in this area (winds from the west and southwest) and cannot account for all weather conditions and circumstances.

Recommendations are listed by priority level. However, recommendations within each priority level are of relatively equal importance and no further sorting is necessary. The prioritization of recommendations was driven principally by life safety concerns. Conservation of property and operability were considered as secondary factors. Only treatments affecting values inside the boundaries of the study area have been included. Obviously, fire does not respect administrative boundaries, so cooperative efforts with adjoining land owners/managers and other stakeholders are highly recommended. Many of the recommendations in this report will require the cooperation of private landowners, and in some cases, land managers from public agencies. Negotiations and public education efforts should begin as soon as possible to secure a consensus for future fuels reduction projects on the landscape scale.

These recommendations are not a replacement for defensible space or other recommendations in this report. It is important to understand that defensible space for all homes is a critical element in reducing hazards to life and property. It is critical that land owners and managers understand the importance of defensible space for all structures in close proximity to flammable vegetation. These recommendations will only achieve maximum effectiveness in conjunction with defensible space treatments. An overview of recommended treatment areas is shown in **Figure 18**.

A. **Daybreak Ridge Safety Zone (Approx. 2.9 Acres)** ***Priority level: High*** There is an existing large clearing located near a pond on McCoy Park Road approximately 1,000 feet the intersection with Daybreak Ridge Road. The existing clearing should be maintained to be free of flammable vegetation (other than light grasses to prevent erosion and provide a natural appearance) for a separation distance (firefighter to the outer edge of the treatment area) of at least four times the flame lengths predicted by the extreme weather fire behavior scenario (See **Figure 17**). The connection between the road and the safety zone should be maintained to the same standards.

Figure 17. Safety Zone Separation Distance



B. **McCoy Park Road Fuel Treatment (Approx. 3.3 Acres)** ***Priority level: High*** This project is designed to provide safer access from Daybreak Ridge to the safety zone on McCoy Park Road. The project area extends from the junction of Daybreak Ridge to the safety zone on McCoy Park Road (See Project A). Thinning and limbing to shaded fuelbreak standards in order to reduce ladder fuels and interrupt the crown continuity of fuels is recommended for a distance of at least three times the flame lengths predicted by the extreme weather scenario fire behavior model from the centerline of the road to each side. The project area should be inspected on an annual basis and maintained as necessary to reduce the potential for re-growth.

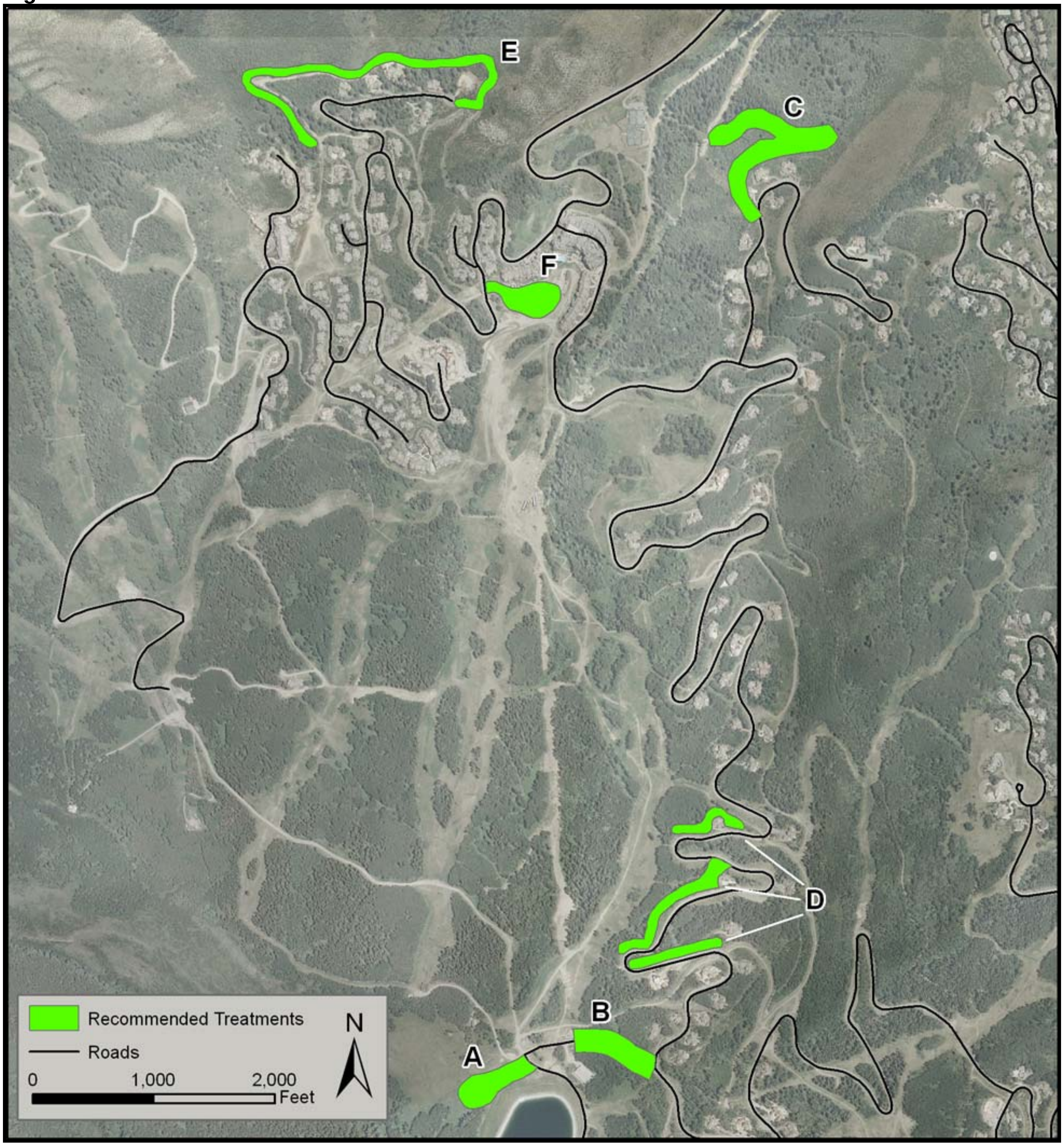
C. **Elk Horn Ridge Service Road Fuel Treatments (Approx. 7.6 Acres)** ***Priority level: High*** This project is designed to interrupt the fuels continuity on the steep slopes below homes at the end of Elk Horn Road. Thinning and limbing to shaded fuelbreak standards in order to reduce ladder fuels and interrupt the crown continuity of fuels is recommended for a distance of at least 50 feet from the center line of the two dirt service roads running from the end of Elk Horn Road downhill to the north and west.

D. **Daybreak Ridge Fuel Treatments (Approx. 5.6 Acres)** ***Priority level: High*** This project is designed to interrupt the fuels continuity on the steep slopes below homes located on Daybreak Ridge Road and promote forest health. Patch cutting in lodgepole pine stands is recommended for a distance of at least 100 feet downhill from Daybreak Ridge Road. Thinning and removal of materials should be conducted as necessary to isolate homes from down-slope conifer fuels and remove beetle infested trees. The Bachelor Gulch Forest Management Plan (currently being written) will determine the final acreages and priority of these cuts.

E. **Tall Timber Fuel Treatment (Approx. 6.0 Acres)** ***Priority level: High*** This project is designed to interrupt the fuels continuity on the steep slopes below homes located on Tall Timber Trail. Thinning and limbing to shaded fuelbreak standards in order to reduce ladder fuels and interrupt the crown continuity of fuels is recommended for a distance of at least 100 feet from the center line of the dirt service road paralleling Tall Timber Trail to the north below the homes.

F. **Ritz-Carlton Safety Zone (Approx. 2.8 Acres)** ***Priority level: Moderate*** There is an existing large clearing located south of the Ritz-Carlton hotel and accessed from Bachelor Gulch Trail. The existing clearing should be maintained to be free of flammable vegetation (other than light grasses to prevent erosion and provide a natural appearance) for a separation distance (firefighter to the outer edge of the treatment area) of at least four times the flame lengths predicted by the extreme weather fire behavior scenario (See **Figure 17**). The connection between the road and the safety zone should be maintained to the same standards.

Figure 18.



OTHER FUELS RECOMMENDATIONS

- Both Aspen and lodgepole pine stands can be kept healthy and fire resistant by using sound forestry practices. Maintaining these stands with a scheduled thinning and limbing program would reduce potential for fire growth. A forest management plan is currently being prepared to define proper forestry practice and to assure sustainability of the local ecosystems.
- In 2006, mountain pine beetle was detected in lodgepole stands in the study area. Tree mortality due to mountain pine beetle infestation is becoming an increasing problem in the entire Vail Valley. An ongoing beetle inventory should be conducted on an annual basis until the current epidemic subsides. In addition to the fuels treatments recommended in this report, cross-boundary discussions designed to facilitate cooperation between public and private landowners in removing dead and diseased trees and treating for beetles are recommended.
- Begin talks with the USFS on grants that Bachelor Gulch Village could receive and the Forest Service use to mitigate the public lands surrounding the study area.

WATER SUPPLY FMU

As in most of the mountainous areas of Colorado, water in the study area is a critical fire suppression issue. Bachelor Gulch has a well maintained and adequate network of hydrants. Vail Resorts also keeps snowlines charged during the summer months to assist in fire suppression. There are no homes located an excessive distance from a reliable water source in the study area.

RECOMMENDATIONS

- ***Priority level: Moderate*** A program of periodic hydrant testing and inspection should be instituted to check the function and condition of hydrants throughout the study area. Hydrants should be tested at least once every two years.

GLOSSARY

The following definitions apply to terms used in the Bachelor Gulch Fire Protection District Community Wildfire Protection Plan.

1 hour Timelag fuels: Grasses, litter and duff; <1/4 inch in diameter

10 hour Timelag fuels: Twigs and small stems; ¼ inch to 1 inch in diameter

100 hour Timelag fuels: Branches; 1 to 3 inches in diameter

1000 hour Timelag fuels: Large stems and branches; >3 inches in diameter

Active Crown Fire: This is a crown fire in which the entire fuel complex – all fuel strata – become involved, but the crowning phase remains dependent on heat released from the surface fuel strata for continued spread (also called a Running Crown Fire or Continuous Crown Fire).

ArcGIS 9.x: This is Geographic Information System (GIS) software that is designed to handle mapping data in a way that can be analyzed, queried, and displayed. ArcGIS is in its ninth major revision and is published by the Environmental Systems Research Institute (ESRI).

Crown Fire (Crowning): The movement of fire through the crowns of trees or shrubs, which may or may not be independent of the surface fire.

Defensible Space: An area around a structure where fuels and vegetation are modified cleared or reduced to slow the spread of wildfire toward or from the structure. The design and distance of the defensible space is based on fuels, topography, and the design/materials used in the construction of the structure.

Energy Release Component: An index of how hot a fire could burn. ERC is directly related to the 24-hour, potential worst case, total available energy within the flaming front at the head of a fire.

Extended Defensible Space (also known as Zone 3): This is a defensible space area where treatment is continued beyond the minimum boundary. This zone focuses on forest management with fuels reduction being a secondary consideration.

Fine Fuels: Fuels that are less than ¼ inch in diameter such as grass, leaves, draped pine needles, fern, tree moss, and some kinds of slash which, when dry, ignite readily and are consumed rapidly.

Fire Behavior Potential: The expected severity of a wildland fire expressed as the rate of spread, the level of crown fire activity, and flame length. This is derived from fire behavior modeling programs using the following inputs: fuels, canopy cover, historical weather averages, elevation, slope, and aspect.

Fire Danger: In this document we do not use this as a technical term due to various and nebulous meanings that have been historically applied.

Fire Hazard: Given an ignition, the likelihood and severity of Fire Outcomes (Fire Effects) that result in damage to people, property, and/or the environment. The hazard rating is derived from the Community Assessment and the Fire Behavior Potential.

Fire Mitigation: Any action designed to decrease the likelihood of an ignition, reduce Fire Behavior Potential, or to protect property from the impact of undesirable Fire Outcomes.

Fire Outcomes (aka Fire Effects): This is a description of the expected effects of a wildfire on people, property and/or the environment based on the Fire Behavior Potential and physical presence of Values-at-Risk. Outcomes can be desirable as well as undesirable.

Fire Risk: The probability that an ignition will occur in an area with potential for damaging effects to people, property, and/or the environment. Risk is based primarily on historical ignitions data.

Flagged Addressing: A term describing the placement of multiple addresses on a single sign, servicing multiple structures located on a common access.

FlamMap: A software package created by the Joint Fire Sciences Program, Rocky Mountain Research Station. The software uses mapped environmental data such as Elevation, Aspect, Slope, and Fuel Model, along with fuel moisture and wind information, to generate predicted fire behavior characteristics such as Flame Length, Crown Fire Activity, and Spread Rate.

Flame Length: The distance between the flame tip and the midpoint of the flame depth at the base of the flame (generally the ground surface)—an indicator of fire intensity.

FMU (Fire Management Unit): A method of categorizing and prioritizing fire mitigation work efforts. Units can be defined by function (e.g., public education efforts) or geography (e.g., fuel reduction projects in a given area).

Fuelbreak: A natural or constructed discontinuity in a fuel profile used to isolate, stop, or reduce the spread of fire. Fuelbreaks may also make retardant lines more effective and serve as control lines for fire suppression actions. Fuelbreaks in the WUI are designed to limit the spread and intensity of crown fire activity.

ICP (Incident Command Post): The base camp and command center from which fire suppression operations are directed.

ISO (Insurance Standards Office): A leading source of risk (as defined by the insurance industry) information to insurance companies. ISO provides fire risk information in the form of ratings used by insurance companies to price fire insurance products to property owners.

Jackpot Fuels: a large concentration of fuels in a given area such as a slash pile.

Passive Crown Fire: a crown fire in which individual or small groups of trees torch out (candle), but solid flaming in the canopy fuels cannot be maintained except for short periods.

Shelter-in-Place Areas: A method of protecting the public from an advancing wildfire involving instructing people to remain inside their homes or public buildings until the danger passes. This concept is new to wildfire in the United States, but not to hazardous materials incident response where time, hazards, and sheer logistics often make evacuation impossible. This concept is the dominant modality for public protection from wildfires in Australia where fast-moving, short-duration fires in light fuels make evacuation impractical. The success of this tactic depends on a detailed preplan that takes into account the construction type and materials of the building used, topography, depth and type of the fuel profile, as well as current and expected weather and fire behavior. For a more complete discussion of the application and limitations of Shelter-in-place concepts see the "Addressing, Evacuation, and Shelter-In-Place FMU" section in the main report.

Slash: Debris left after logging, pruning, thinning, or brush cutting; includes logs, chips, bark, branches, stumps, and broken understory trees or brush.

Spotting: Refers to the behavior of a fire producing sparks or embers that are carried by the wind and start new fires beyond the zone of direct ignition by the main fire.

Structural Triage: The process of identifying, sorting, and committing resources to a specific structure.

Surface Fire: This is a fire that burns in the surface litter, debris, and small vegetation on the ground.

Timelag: Time needed under specified conditions for a fuel particle to lose about 63% of the difference between its initial moisture content and its equilibrium moisture content.

Values-at-Risk: People, property, ecological elements, and other human and intrinsic values within the project area. Values at Risk are identified by inhabitants as important to the way of life of the study area and are susceptible specifically to damage from undesirable fire outcomes.

WHR (Community Wildfire Hazard Rating. AKA Community Assessment): A sixty-point scale analysis designed to identify factors that increase the potential for and/or severity of undesirable fire outcomes in WUI communities.

WUI (Wildland Urban Interface): The line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels. This is sometimes referred to as Urban Wildland Interface, or UWI.

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Standard for Protection of Life and Property from Wildfire, NFPA 1144(02) (Formerly *NFPA 299*) National Fire Protection Association, Quincy, MA, 2002.

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Wildland/Urban Interface Fire Policy Action Report, Western Governor's Association, Feb. 1996.

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Fire Regime Condition Class, http://www.frcc.gov/, July 2005.

FRAMES -- Fire Research and Management Exchange System, http://www.frames.gov/tools/, January 2005.

Interagency Wildland Fire Communications Group – Rocky Mountain Area, http://www.rockymountainwildlandfire.info/grants.htm, January 2005.

NFPA 1710 summary, http://www.iaff.org/academy/content/online/modules/1710/summary.htm

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Standard for Protection of Life and Property from Wildfire, NFPA 1144, http://www.normas.com/NFPA/PAGES/NFPA-1144(02).html, January 2005.

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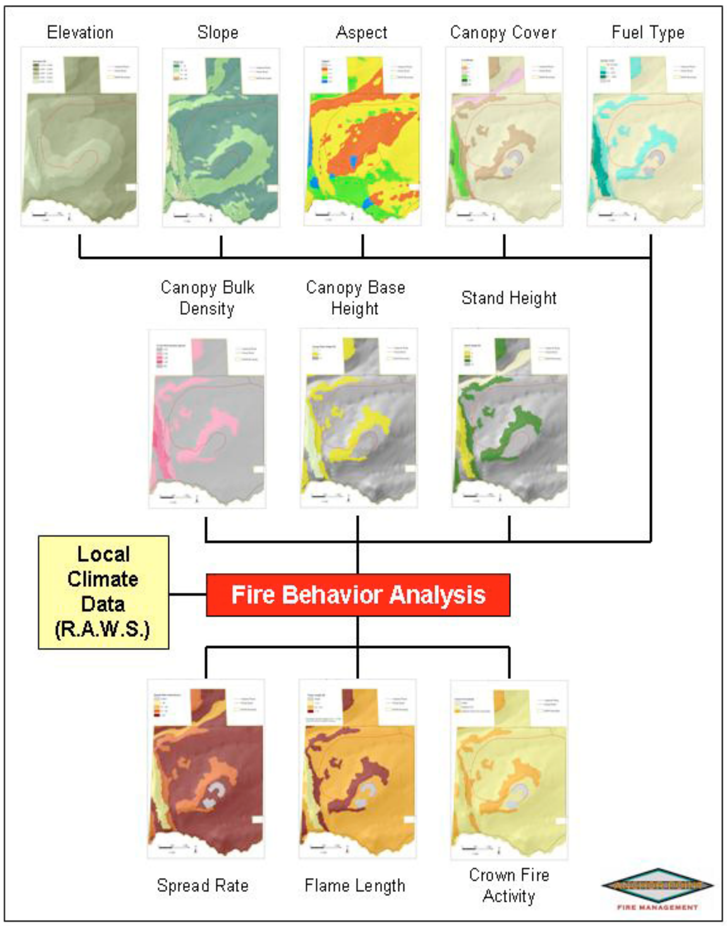
APPENDIX A

FIRE BEHAVIOR POTENTIAL ANALYSIS METHODOLOGY

PURPOSE

The purpose of this document is to describe the methodology used to evaluate the threat represented by physical hazards—such as fuels, weather, and topography—to Values at Risk in the study area, by modeling their effects on fire behavior potential.

Figure 1. Flow Chart



The fire behavior potential analysis reports graphically the probable range of spread rate, flame length, and crown fire potential for the analysis area, based upon a set of inputs significant to fire behavior. The model inputs include aspect, slope, elevation, canopy cover, fuel type, canopy bulk density, canopy base height, stand height, and climate data. The model outputs are determined using FlamMap[1], which combines surface fire predictions with the potential for crown fire development. Calculations for surface fire predictions (rate of spread and flame length) are based on the USDA Forest Service's BEHAVE[2] model.

BEHAVE

The BEHAVE fire behavior prediction and fuel modeling system was employed to determine surface fire behavior estimates for this study. BEHAVE is a nationally recognized set of calculations used to estimate a surface fire's intensity and rate of spread, given certain conditions of topography, fuels, and weather. The BEHAVE modeling system has been used for a variety of applications, including prediction of an ongoing fire, prescribed fire planning, fuel hazard assessment, initial attack dispatch, and fire prevention planning and training. Predictions of wildland fire behavior are made for a single point in time and space, given simple user-defined fuels, weather, and topography. Requested values depend on the modeling choices made by the user.

Assumptions of BEHAVE:

- Fire is predicted at the flaming front
- Fire is free burning
- Behavior is heavily weighted towards the fine fuels
- Continuous and uniform fuels
- Surface fires

FLAMMAP

Anchor Point uses FlamMap to evaluate the potential fire conditions in the fire behavior study area. The Bachelor Gulch study area encompasses 1,031 acres. The study area for the fire behavior analysis covers approximately 3,206 acres. This area includes the study area and a half-mile buffer in all directions. The use of this buffer provides the user with an analysis of potential fire behavior on adjacent lands. From both a planning and tactical perspective, it is important to evaluate exposures beyond the area of interest. The study area is broken down into grid cells of 10-meters per side (10M). Using existing vector and raster spatial data and field data, ArcGIS spatial analysis capabilities are used to calculate model inputs for each 10M cell. These values are input into FlamMap, along with reference weather and fuel moisture (long-term weather observations statistically calculated from the Dowd Junction Remote Automated Weather Station information). The outputs of FlamMap include the estimated Rate of Spread (ROS) (from BEHAVE), Flame Length (FL) (from BEHAVE) and Crown Fire Activity for a fire in that 10M cell. The model computes these values for each cell in the study area independently, so the data in each cell is unaffected by adjacent cells.

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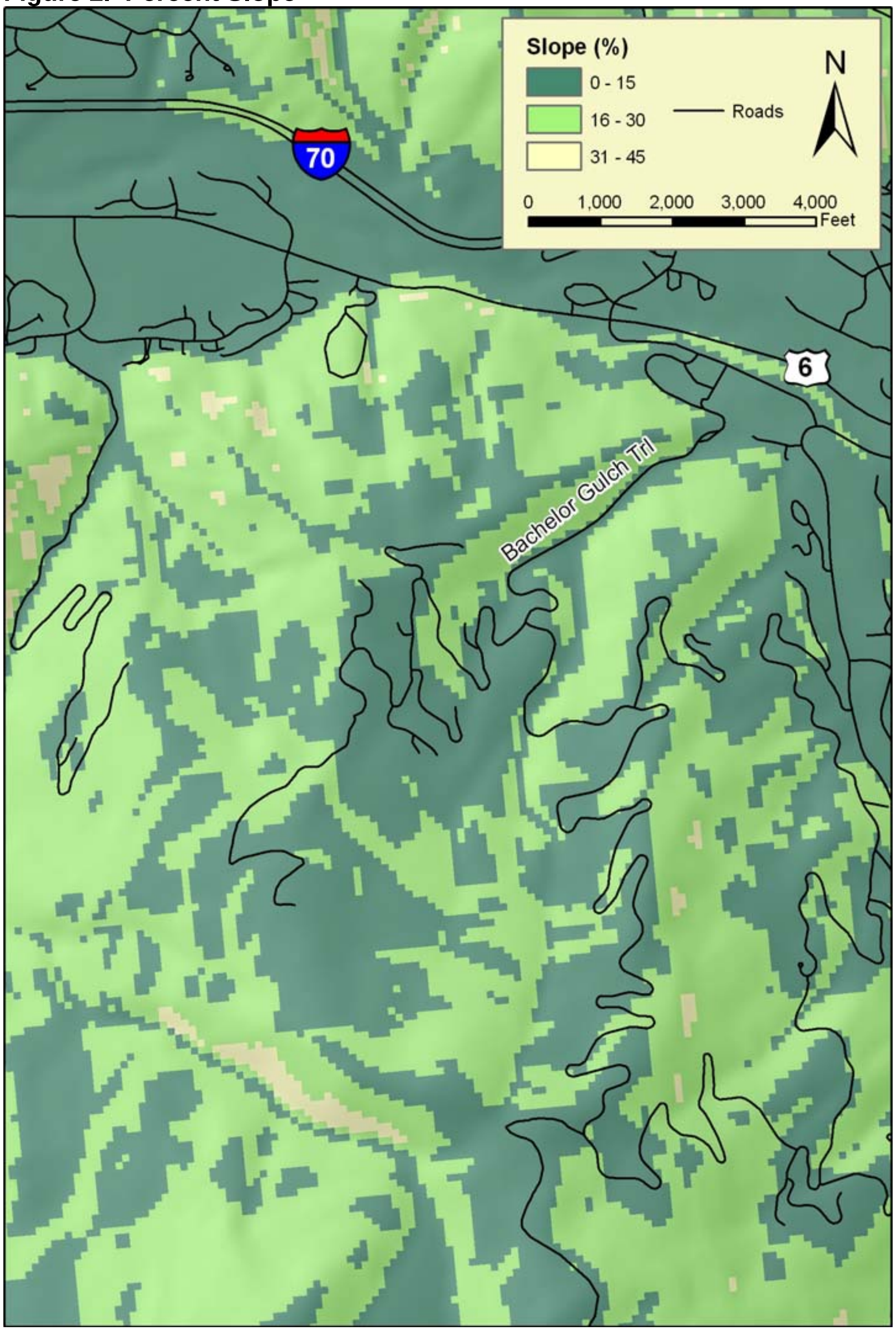
[1] Mark Finney, Stuart Brittain and Rob Seli., The Joint Fire Sciences Program of the Rocky Mountain Research Station (USDA Forest Service, Missoula, Montana), the Bureau of Land Management and Systems for Environmental Management (Missoula, Montana).

[2] Patricia L. Andrews, producer and designer, Collin D. Bevins, programmer and designer, The Joint Fire Sciences Program of the Rocky Mountain Research Station (USDA Forest Service, Missoula, Montana) and Systems for Environmental Management (Missoula, Montana).

FIRE BEHAVIOR INPUTS

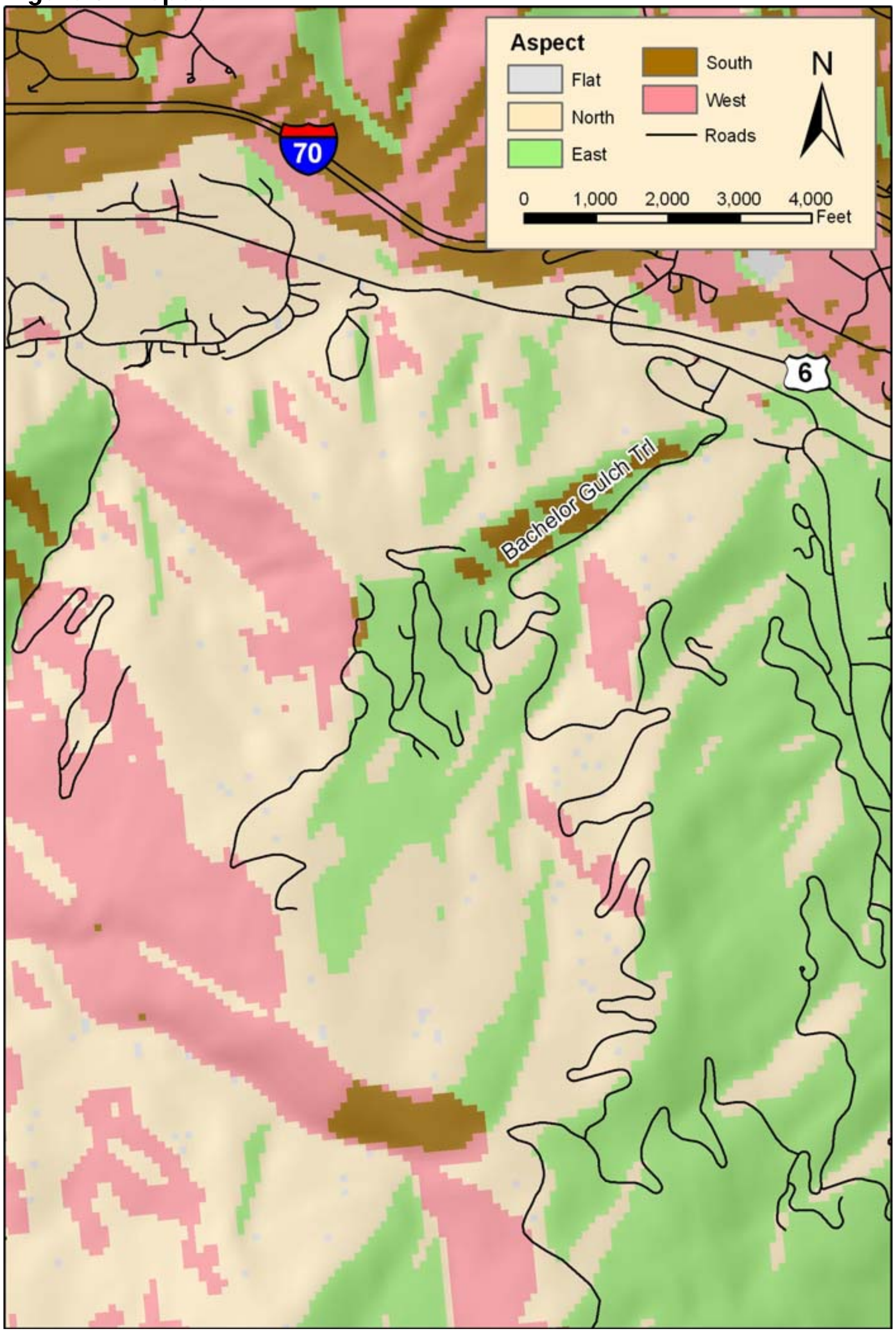
The major factors influencing fire behavior are fuels (type and coverage), weather, and topography (aspect, slope and elevation). The following pages contain a brief explanation of each.

Figure 2. Percent Slope



Slopes are shown here as percent (rise/run x100). Steeper slopes intensify fire behavior and thus will contribute to a higher wildfire hazard rating. Rates of spread for a slope of 30% are typically double those of flat terrain, when all other influences are equal.

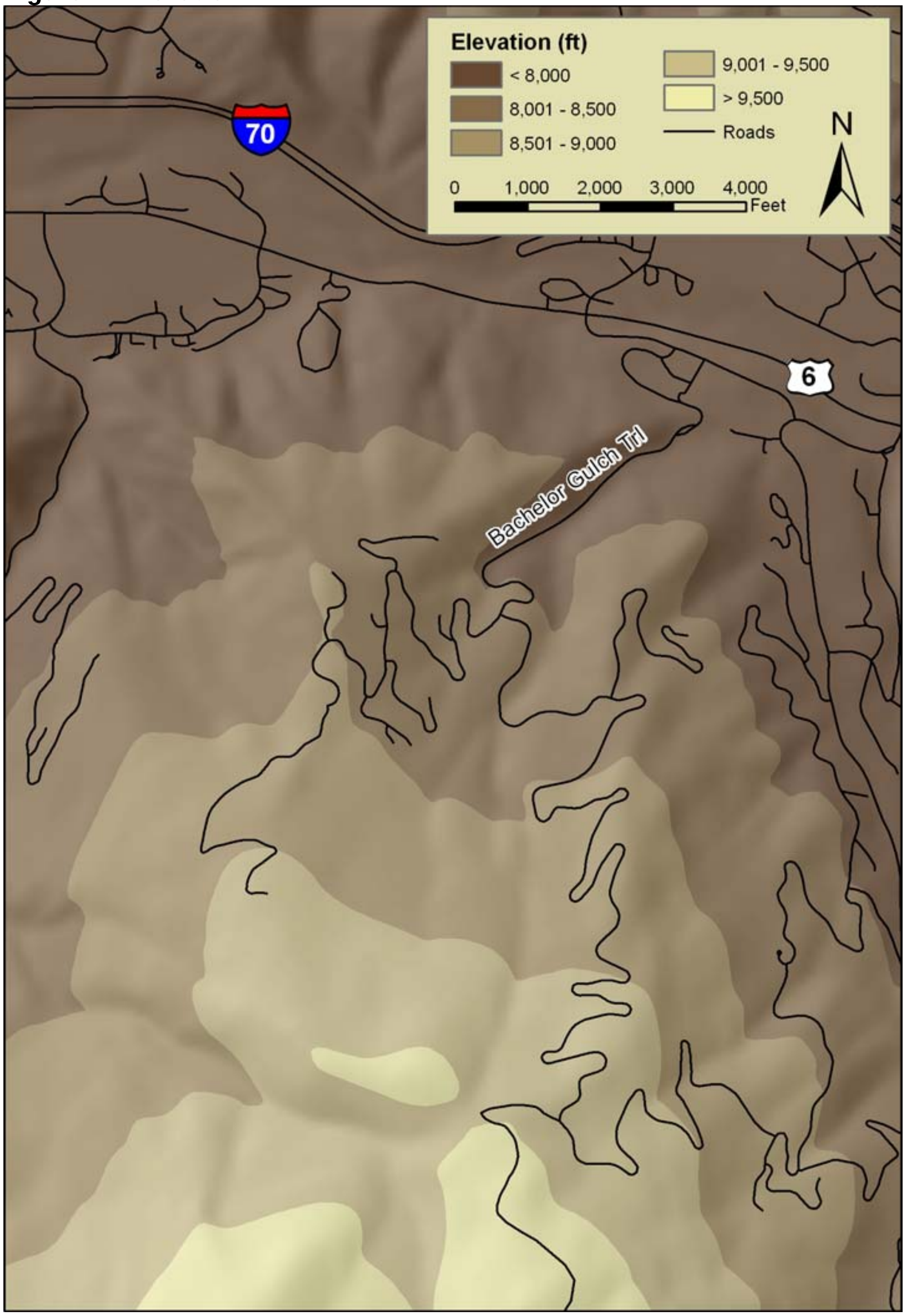
Figure 3. Aspect



Aspects are shown as degrees from north ranging from 0 to 360 according to their orientation. Aspects are influential in the type and quantity of vegetative fuels. Fuels on south facing slopes tend to be drier and more lightly loaded than fuels on north facing slopes, when all other influences are equal. Aspect also has an influence on plant species dominance.

Classification	North	East	South	West
Range	315-45	45-135	135-225	225-315

Figure 4. Elevation



Elevations within the study area range from approximately 7,500′ to over 9,500′. As elevation increases, environmental conditions, fuel species, and characteristics change.

FUEL MODELS AND FIRE BEHAVIOR

Fire behavior fuel models are a set of numbers that describe fuels in terms that a fire behavior model, in this case FlamMap, can use. There are seven characteristics used to categorize fuel models.

- Fuel Loading
- Size and Shape
- Compactness
- Horizontal Continuity
- Vertical Arrangement
- Moisture Content
- Chemical Content

Each of the major fuel types present in the study area are described below in terms of the characteristics that coincide with that fuel model. Fuel model descriptions are taken from Anderson's *Aids to Determining Fuel Models for Estimating Fire Behavior*[3], a national standard guide to fuel modeling, unless otherwise noted.

Vegetation for the project area may or may not be specifically listed in the description.

Plant species are only an aid to help visualize the characteristics of the model. The photos are taken from the project area and show where the local vegetation fits in. A table showing a range of surface fire behavior under moderate burning conditions based on the **BEHAVE** system is also included.

The study area is represented primarily by five fuel models (FM): FM 1, 5, 6, 8, 10, and 40. Other fuel models exist, but not in quantities sufficient to significantly influence fire behavior in the Wildland Urban Interface. Fuel models 97, 98, and 99 in the map legend indicate areas of insignificant combustibility such as water, rock, sand, etc. Fuel model 40 is a custom fuel model to describe standing dead stands of conifers with the needles still on (standing red-needle trees).

Quaking aspen stands dominate the landscape. Aspens are very fire resistant—so much so that they are designated as safety zones on wildfires. Aspen stands can burn under extreme conditions, but even then usually only the area nearest some other, more flammable fuel type that is crowning. Once the fire gets into the stand, the heat is quickly dissipated due to the green leaf canopy and the lack of ladder fuels. Once leaves drop there is little possibility for fire to carry into the overstory. Further, the understory brush and forbs are typically moist and difficult to burn. A low intensity surface fire is possible but should not be difficult to extinguish. Some of the aspen stands have a sparse grass and shrub understory.

There are also stringers of Lodgepole pine (Pinus contorta) in the resort. This fuel type is resistant to fire in most of its life stages. Typically, there are few ladder or ground fuels and fires smolder in the duff. Only when very young or during its decline, when there are ladder fuels from other tree species and considerable dead and down material, is it very susceptible to high intensity fire. **Figure 5** displays the fuel types graphically for the study area.

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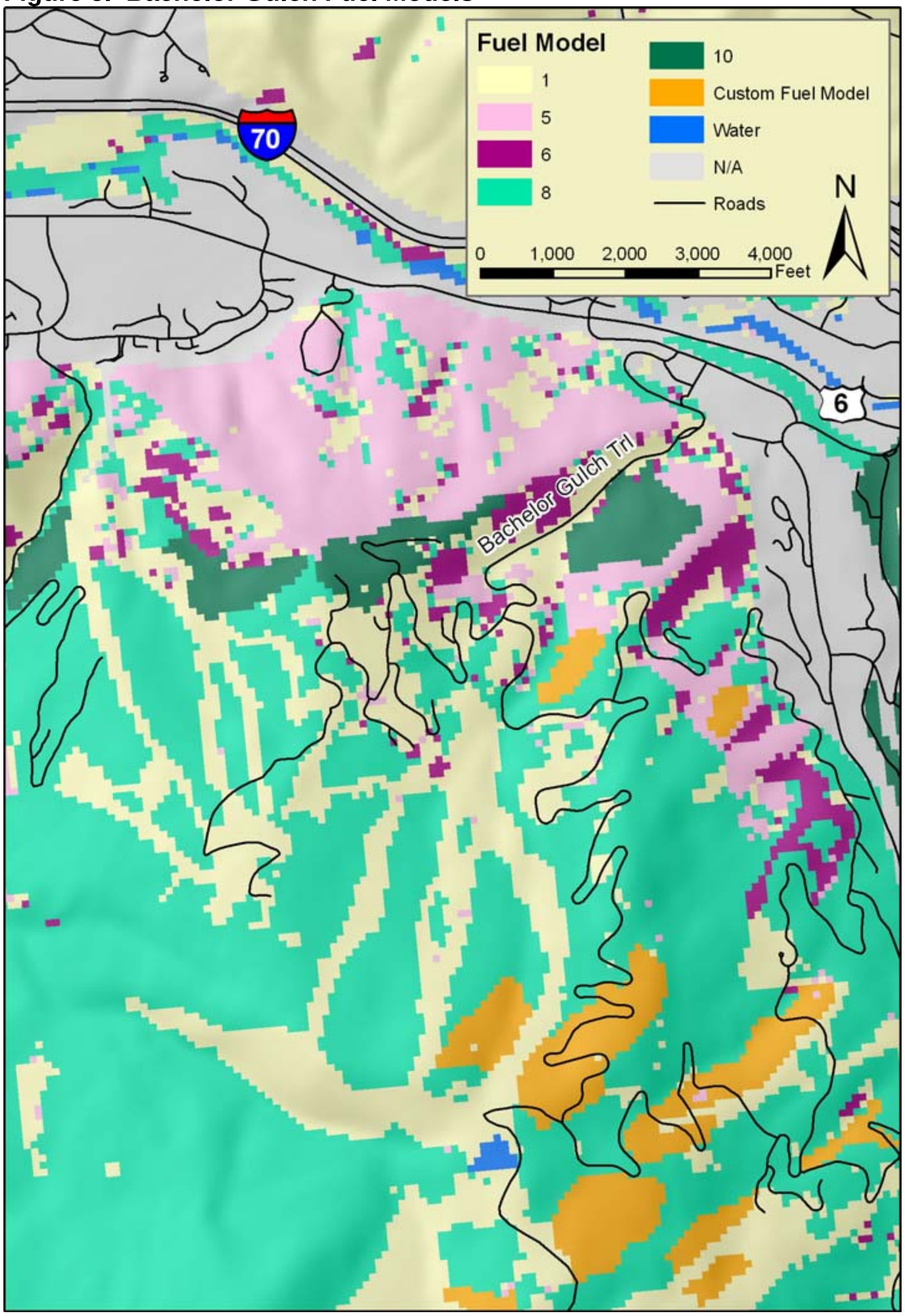
[3] Anderson, Hal E., *Aids to Determining Fuel Models for Estimating Fire Behavior*, National Wildfire Coordinating Group, NFES 1574, April 1982.

Figure 5. Bachelor Gulch Fuel Models



FUEL MODEL 1

Figure 6. Short Grasses

Characteristics

Grasslands and savanna are represented along with stubble, grass-tundra, and grass-shrub combinations.

Common Types/Species

Annual and perennial grasses are included in this fuel model.

Fire Behavior

Fire spread is governed by the fine, very porous, and continuous herbaceous fuels that have cured or are nearly cured. Fires in this fuel model are surface fires that move rapidly through the cured grass and associated material. Very little shrub or timber is present—generally less than one third of the area.

FUEL MODEL 1

Rate of spread in chains/hour
(1 chain=66 ft) (80 chains/HR = 1 MPH)

Fine Dead Fuel moisture %	Mid-flame Wind Speed					
	2.0	4.0	6.0	8.0	10.0	12.0
2.0	28.8	92.9	203.6	362.4	570.1	665.6
4.0	22.0	71.1	155.7	277.0	345.1	345.1
6.0	19.4	62.4	136.8	243.4	270.1	270.1
8.0	16.7	53.9	118.1	198.7	198.7	198.7
10.0	11.0	35.6	64.8	64.8	64.8	64.8

10-hr fuel = 9%, 100-hr fuel = 12%, slope = 10%

Flame Length in Feet

Fine Dead Fuel moisture %	Mid-flame Wind Speed					
	2.0	4.0	6.0	8.0	10.0	12.0
2.0	3.0	5.1	7.3	9.6	11.8	12.7
4.0	2.4	4.1	5.9	7.8	8.6	8.6
6.0	2.2	3.8	5.5	7.1	7.5	7.5
8.0	2.0	3.4	4.9	6.3	6.3	6.3
10.0	1.4	2.4	3.2	3.2	3.2	3.2

FUEL MODEL 5

Figure 7. Young Shrub Stands with Primarily Live Fuels

Characteristics

This model consists of continuous stands of low brush. Generally, heights do not exceed six feet. The stands will have a grass or scattered grass understory. Usually shrubs are short and almost totally cover the area.

Common Types/Species

Young, green stands with no dead wood would qualify: laurel, vine maple, alder, or even chaparral, manzanita, or chamise. Mountain grasses are also associated with this type.

Fire Behavior

The fires are generally not very intense because surface fuel loads are light, the shrubs are young with little dead material, and the foliage contains little volatile material. Fire is generally carried in the surface fuels that are made up of litter cast by the shrubs and the grasses or forbs in the understory. Cured leaves retained on shrubs can cause greater intensities.

FUEL MODEL 5

Rate of spread in chains/hour
(1 chain=66 ft) (80 chains/HR = 1 MPH)

Fine Dead Fuel moisture %	Mid-flame Wind Speed					
	2.0	4.0	6.0	8.0	10.0	12.0
2.0	9.4	21.8	37.1	54.6	73.8	94.7
4.0	8.3	19.3	32.7	48.1	65.1	83.5
6.0	6.8	15.9	27.0	39.8	53.8	69.0
8.0	3.9	9.1	15.5	22.8	30.9	39.6
10.0	2.7	6.3	10.6	15.6	21.2	21.4
12.0	2.6	6.0	10.2	15.0	19.7	19.7

10-hr fuel 9%, 100 = 12%, woody fuel moisture = 102%, slope 10%

Flame Length in Feet

Fine Dead Fuel moisture %	Mid-flame Wind Speed					
	2.0	4.0	6.0	8.0	10.0	12.0
2.0	4.2	6.2	8.0	9.5	10.9	12.3
4.0	3.8	5.6	7.1	8.5	9.8	11.0
6.0	3.2	4.7	6.0	7.2	8.2	9.2
8.0	1.9	2.8	3.6	4.3	5.0	5.6
10.0	1.4	2.0	2.6	3.1	3.5	3.5
12.0	1.3	1.9	2.5	3.0	3.4	3.4

FUEL MODEL 6

Figure 8. Shrub Stands

Characteristics

The shrubs are older but not as tall as the shrub types of model 4, nor do they contain as much fuel as model 4. A broad range of shrub conditions is covered by this model.

Common Types/Species

Fuel situations to be considered include intermediate stands of chamise, chaparral, oak brush, low pocosin, Alaskan spruce taiga, and shrub tundra. Even hardwood slash that has cured can be considered. Pinyon-juniper shrub lands may be represented but may over predict rate of spread except at high winds, like 20 mi/h (32 km/h) at the 20-foot level.

Fire Behavior

Fires carry through the shrub layer where the foliage is more flammable than fuel model 5, but this requires moderate winds, greater than 8 mi/h (13 km/h) at mid-flame height. Fire will drop to the ground at low wind speeds or at openings in the stand.

FUEL MODEL 6

Rate of spread in chains/hour
(1 chain=66 ft) (80 chains/HR = 1 MPH)

Fine Dead Fuel moisture %	Mid-flame Wind Speed 2.0	4.0	6.0	8.0	10.0	12.0
2.0	16.6	37.1	61.7	89.2	119.2	151.3
4.0	13.5	30.3	50.3	72.7	97.2	123.4
6.0	11.5	25.7	42.6	61.7	82.4	104.6
8.0	10.1	22.6	37.5	54.3	72.6	92.1
10.0	9.2	20.5	34.1	49.3	65.9	83.6
12.0	8.5	19.0	31.6	45.6	61.0	77.4

10-hr fuel 9%, 100 = 12%, woody fuel moisture = 102%, slope 10%

Flame Length in Feet

Fine Dead Fuel moisture %	Mid-flame Wind Speed 2.0	4.0	6.0	8.0	10.0	12.0
2.0	4.9	7.0	8.9	10.5	12.0	13.4
4.0	4.2	6.0	7.6	9.0	10.3	11.5
6.0	3.7	5.4	6.8	8.0	9.2	10.2
8.0	3.4	4.9	6.2	7.4	8.4	9.4
10.0	3.2	4.6	5.8	6.9	7.9	8.8
12.0	3.1	4.4	5.6	6.6	7.6	8.5

FUEL MODEL 8

Figure 8. Aspen Stands

Characteristics

Hardwoods that have leafed out support fire in the compact litter layer. This layer is mainly needles, leaves, and occasionally twigs because little undergrowth is present in the stand. Amounts of needle and woody litter are also low.

Common Types/Species

Closed canopy stands of short-needle conifers or hardwoods. Representative conifer types are white pine, lodgepole pine, spruce, fir, and larch.

Fire Behavior

Fires in this fuel model are slow burning and low intensity, burning in surface fuels. Fuels are mainly needles and woody litter. Heavier fuel loadings from old dead and down trees or branches can cause flare-ups. Heavier fuel loads have the potential to develop crown fires in extreme burning conditions.

FUEL MODEL 8

Rate of spread in chains/hour
(1 chain=66 ft) (80 chains/HR = 1 MPH)

Fine Dead Fuel moisture %	Mid-flame Wind Speed 2.0	4.0	6.0	8.0	10.0	12.0
2.0	1.1	2.3	3.8	5.6	7.7	9.7
4.0	0.9	1.8	3.1	4.6	6.2	6.6
6.0	0.7	1.5	2.6	3.8	4.8	4.8
8.0	0.6	1.3	2.3	3.3	3.7	3.7
10.0	0.6	1.2	2.0	3.0	3.1	3.1
12.0	0.5	1.1	1.8	2.7	2.7	2.7

10-hr fuel = 9%, 100-hr fuel = 12%, woody fuel moisture = 102%, slope = 10%

Flame Length in Feet

Fine Dead Fuel moisture %	Mid-flame Wind Speed 2.0	4.0	6.0	8.0	10.0	12.0
2.0	0.9	1.3	1.6	1.9	2.2	2.5
4.0	0.8	1.1	1.4	1.7	1.9	2.0
6.0	0.7	1.0	1.2	1.5	1.6	1.6
8.0	0.6	0.9	1.1	1.3	1.4	1.4
10.0	0.6	0.8	1.0	1.2	1.3	1.3
12.0	0.5	0.8	1.0	1.2	1.2	1.2

FUEL MODEL 10

Figure 9. Decadent Mixed Conifer Stands

Characteristics

This model is represented by dense stands of over-mature ponderosa pine, lodgepole pine, mixed-conifer, and continuous stands of Douglas-fir. In all stand types, heavy down material is present. There is also a large amount of dead, down, woody fuels. Reproduction may be present, acting as ladder fuels. This model includes stands of budworm-killed Douglas-fir, closed stands of ponderosa pine with large amounts of ladder and surface fuels, and stands of lodgepole pine with heavy loadings of downed trees. This model can occur from the foothills through the sub-alpine zone.

Common Types/Species

Many types of vegetation can occur in this model, but primary species are Spruce/fir, ponderosa pine and lodgepole pine.

Fire Behavior

Fire intensities can be moderate to extreme. Fire moves through dead, down woody material. Torching and spotting are more frequent. Crown fires are quite possible.

FUEL MODEL 10

Rate of spread in chains/hour
(1 chain=66 ft) (80 chains/HR = 1 MPH)

Fine Dead Fuel moisture %	Mid-flame Wind Speed 2.0	4.0	6.0	8.0	10.0	12.0
2.0	3.7	7.9	13.3	19.5	26.4	33.9
4.0	3.2	7.0	11.8	17.3	23.4	30.1
6.0	2.9	6.4	10.7	15.7	21.2	27.3
8.0	2.7	5.9	9.9	14.6	19.8	25.4
10.0	2.6	5.6	9.4	13.8	18.7	24.0
12.0	2.5	5.4	9.0	13.2	17.8	22.9

10-hr fuel = 9%, 100 = 12%, woody fuel moisture = 102%, slope 10%

Flame Length in Feet

Fine Dead Fuel moisture %	Mid-flame Wind Speed 2.0	4.0	6.0	8.0	10.0	12.0
2.0	3.8	5.4	6.8	8.1	9.3	10.5
4.0	3.4	4.8	6.1	7.3	8.4	9.5
6.0	3.1	4.5	5.7	6.8	7.8	8.7
8.0	3.0	4.2	5.4	6.4	7.4	8.3
10.0	2.8	4.1	5.1	6.1	7.1	7.9
12.0	2.8	3.9	5.0	5.9	6.8	7.7

FUEL MODEL 40

Figure 11. MPB infected lodgepole stands

Characteristics

This custom model was created to capture Mountain Pine Beetle infested lodgepole pine stands. The model has most of the characteristics of FM 8 with some modifications to better represent the affects of MPB on the stand. The 1 hour fuels are increased to account for needle fall as is the fuel bed depth. The Canopy Bulk Density has been reduced to better represent the loss of red needles. This is an attempt to model an average condition. In reality, some trees lose needles quicker and some hold on to them longer. Trees are also in different stages of decline depending on when they were infected.

Common Types/Species

Primary species is lodgepole pine.

Fire Behavior

Fire intensities can be moderate to extreme. Surface fires will have larger flame lengths and rates of spread with the continuous red needle layer. Transition from surface fire to torching and crowning is more likely as the needles on the trees are dead and more receptive. Some needles stay on the tree for several years and continue to create high potential for crown fire. Trees that have dropped some of the needles are more prone to torching than crowning.

FUEL MODEL 40

Rate of spread in chains/hour
(1 chain=66 ft) (80 chains/HR = 1 MPH)

Fine Dead Fuel moisture %	Mid-flame Wind Speed 2.0	4.0	6.0	8.0	10.0	12.0
2.0	4.3	9.7	16.6	24.9	34.2	44.5
4.0	3.5	7.9	13.5	20.2	27.7	36.1
6.0	2.9	6.6	11.3	16.9	23.2	30.2
8.0	2.5	5.7	9.8	14.6	20.1	26.2
10.0	2.3	5.1	8.7	13	17.9	23.3
12.0	2.1	4.6	8	11.9	16.4	21.3

10-hr fuel = 9%, 100 = 12%, woody fuel moisture = 102%, slope 10%

Flame Length in Feet

Fine Dead Fuel moisture %	Mid-flame Wind Speed 2.0	4.0	6.0	8.0	10.0	12.0
2.0	2.7	3.9	5	6	7	7.9
4.0	2.3	3.4	4.3	5.2	6	6.8
6.0	2	2.9	3.8	4.5	5.3	5.9
8.0	1.8	2.7	3.4	4.1	4.7	5.4
10.0	1.7	2.5	3.2	3.8	4.4	5
12.0	1.6	2.3	3	3.6	4.2	4.7

REFERENCE WEATHER USED IN THE FIRE BEHAVIOR POTENTIAL EVALUATION

The weather inputs for FlamMap were created by using weather data collected at the Dowd Junction Remote Automated Weather Station (RAWS).

Dowd Junction Site Information

Latitude (dd mm ss)	39 ° 38' 0 " N
Longitude (dd mm ss)	106 ° 27 ' 29 " W
Elevation (ft.)	8,998

Weather observations for a twenty-year period (1986-2006) were used to calculate these conditions. The moderate conditions class (16th to 89th percentile) was calculated for each variable (1 hour, 10 hour, and 100 hour fuel moisture, woody fuel moisture, herbaceous fuel moisture, and wind speed) using Fire Family Plus. This weather conditions class most closely represents an average fire season day.

The extreme conditions class was calculated using 97th percentile weather data. In other words, the weather conditions on the most severe fire weather days (sorted by Spread Component) in each season for the twenty-year period were used for this analysis. It is reasonable to assume that similar conditions may exist on at least three to five days of the fire season during an average year. In fact, during extreme years such conditions may exist for significantly longer periods. Even these calculations may be conservative compared to observed fire behavior. The following values were used in **FlamMap**:

Moderate Weather Conditions	
Variable	**Value**
20 ft Wind speed up slope	20 mph
Herbaceous fuel moisture	47%
Woody fuel moisture	102%
100-hr fuel moisture	12%
10-hr fuel moisture	9%
1-hr fuel moisture	6%

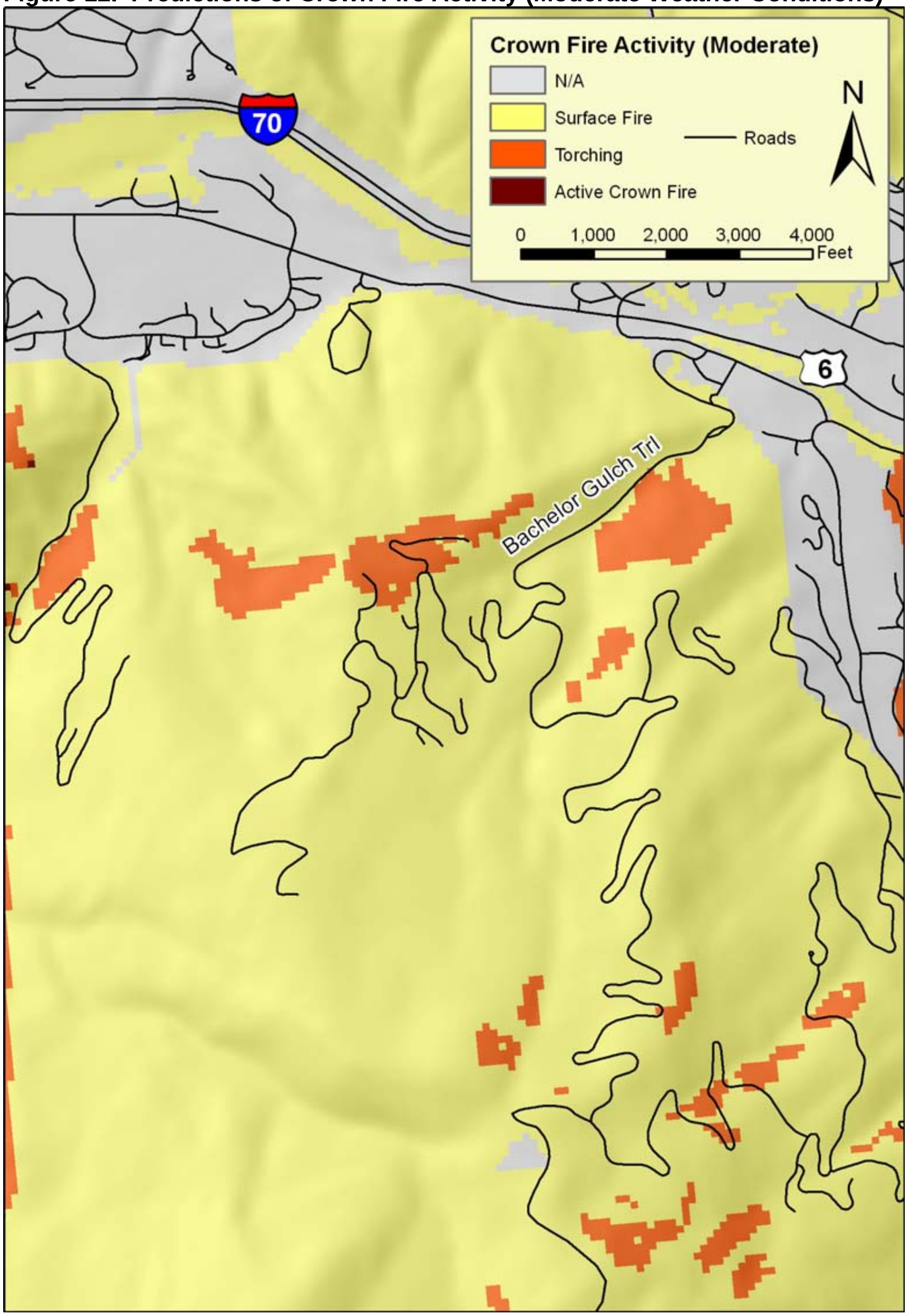
Extreme Weather Conditions	
Variable	**Value**
20 ft Wind speed up slope	32 mph
Herbaceous fuel moisture	30%
Woody fuel moisture	78%
100-hr fuel moisture	8%
10-hr fuel moisture	4%
1-hr fuel moisture	3%

(Note: Strong winds at 20 ft will feel significantly less noticeable on the skin at ground level. For example, a "gentle breeze" on the skin may constitute an 11 MPH 20-foot wind, adding one of the components necessary for extreme weather conditions.)

FIRE BEHAVIOR ANALYSIS OUTPUTS

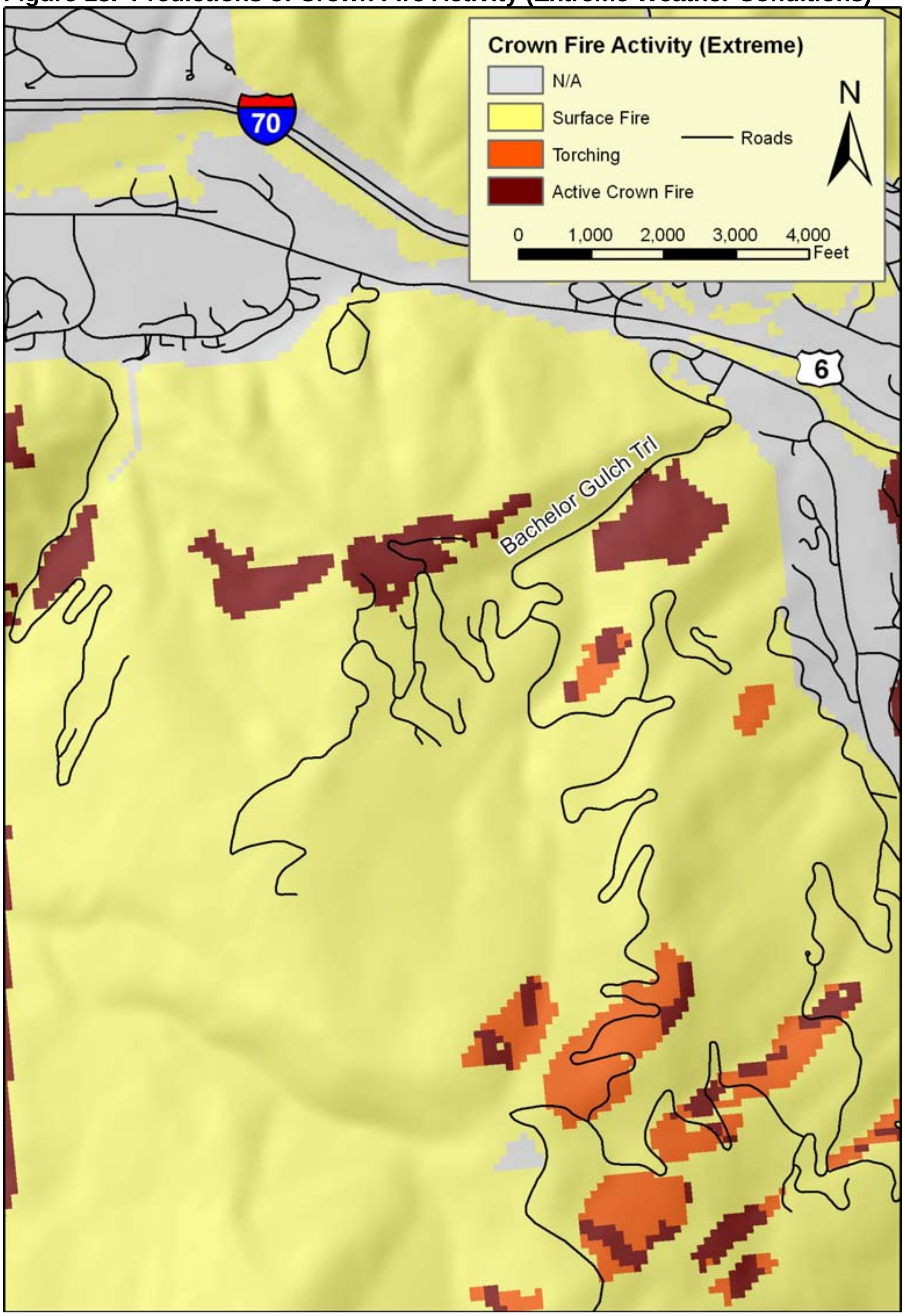
Crown fire activity, rate of spread, and flame length are derived from the fire behavior predictions. The following maps graphically display the outputs of **FlamMap** for both moderate and extreme weather conditions.

Figure 12. Predictions of Crown Fire Activity (Moderate Weather Conditions)



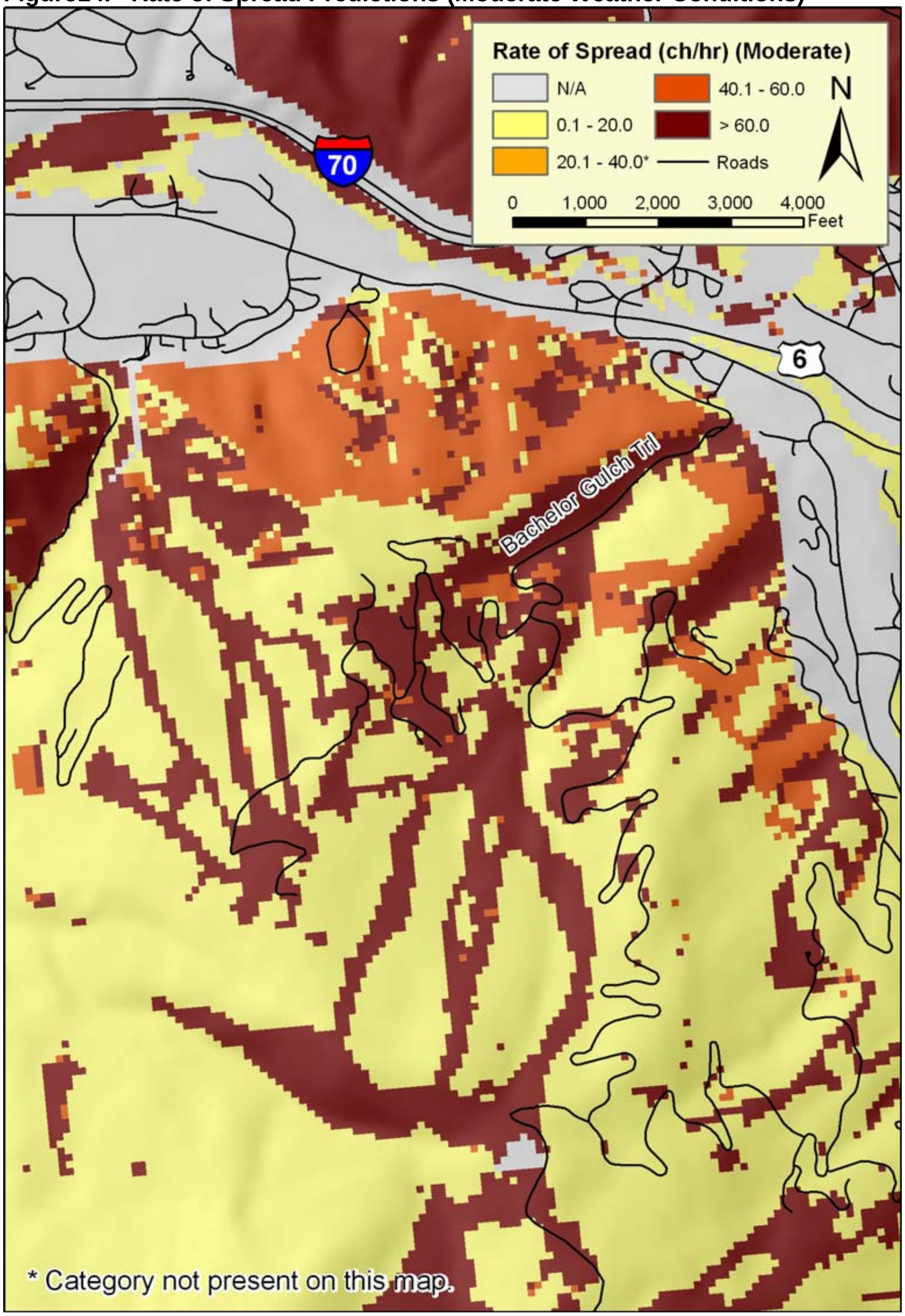
Crown fire activity values are generated by the **FlamMap** model and classified into four categories based on standard ranges: Active, Passive, Surface, and Not Applicable. In the surface fire category, little or no tree torching will be expected. During passive crown fire activity, isolated torching of trees or groups of trees will be observed and canopy runs will be limited to short distances. During active crown fire activity, sustained runs through the canopy will be observed that may be independent of surface fire activity.

Figure 13. Predictions of Crown Fire Activity (Extreme Weather Conditions)



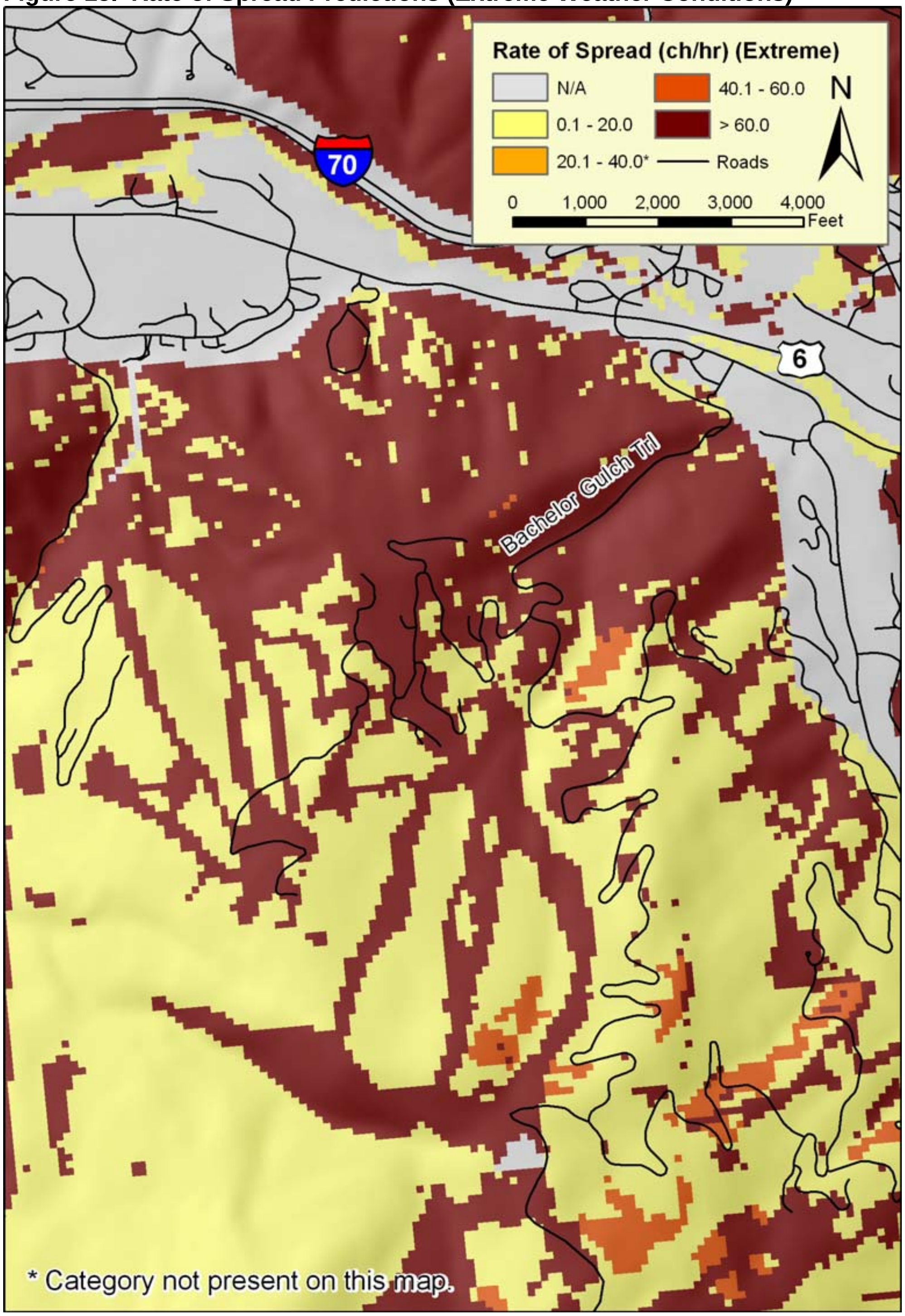
Spread rate values are generated by the **FlamMap** model and classified into four categories based on standard ranges: 0-20 ch/h (chains/hour), 20.1-40 ch/h, 40.1-60 ch/h, and greater than 60 ch/h. A chain is a logging measurement that is equal to 66 feet. One mile equals 80 chains. 1 ch/h equals approximately 1 foot/minute or 80 chains per hour equals 1 mile per hour.

Figure14. Rate of Spread Predictions (Moderate Weather Conditions)



Rate of spread in chains/hour (1 chain=66 ft) (80 chains/HR = 1 MPH)

Figure 15. Rate of Spread Predictions (Extreme Weather Conditions)



Rate of spread in chains/hour (1 chain=66 ft) (80 chains/HR = 1 MPH)

Flame length values are generated by the **FlamMap** model and classified in the four categories based on standard ranges: 0-4 feet, 4.1-8 feet, 8.1-12 feet and 12.1-60 feet. Flame lengths of 4 feet and less are acceptable for direct attack by hand crews. Flame lengths of 8 feet and less are suitable for direct attack by machinery. With flame lengths of greater than 8 feet, indirect attack and aerial attack are the preferred methods.

Figure 16. Flame Length Predictions (Moderate Weather Conditions)

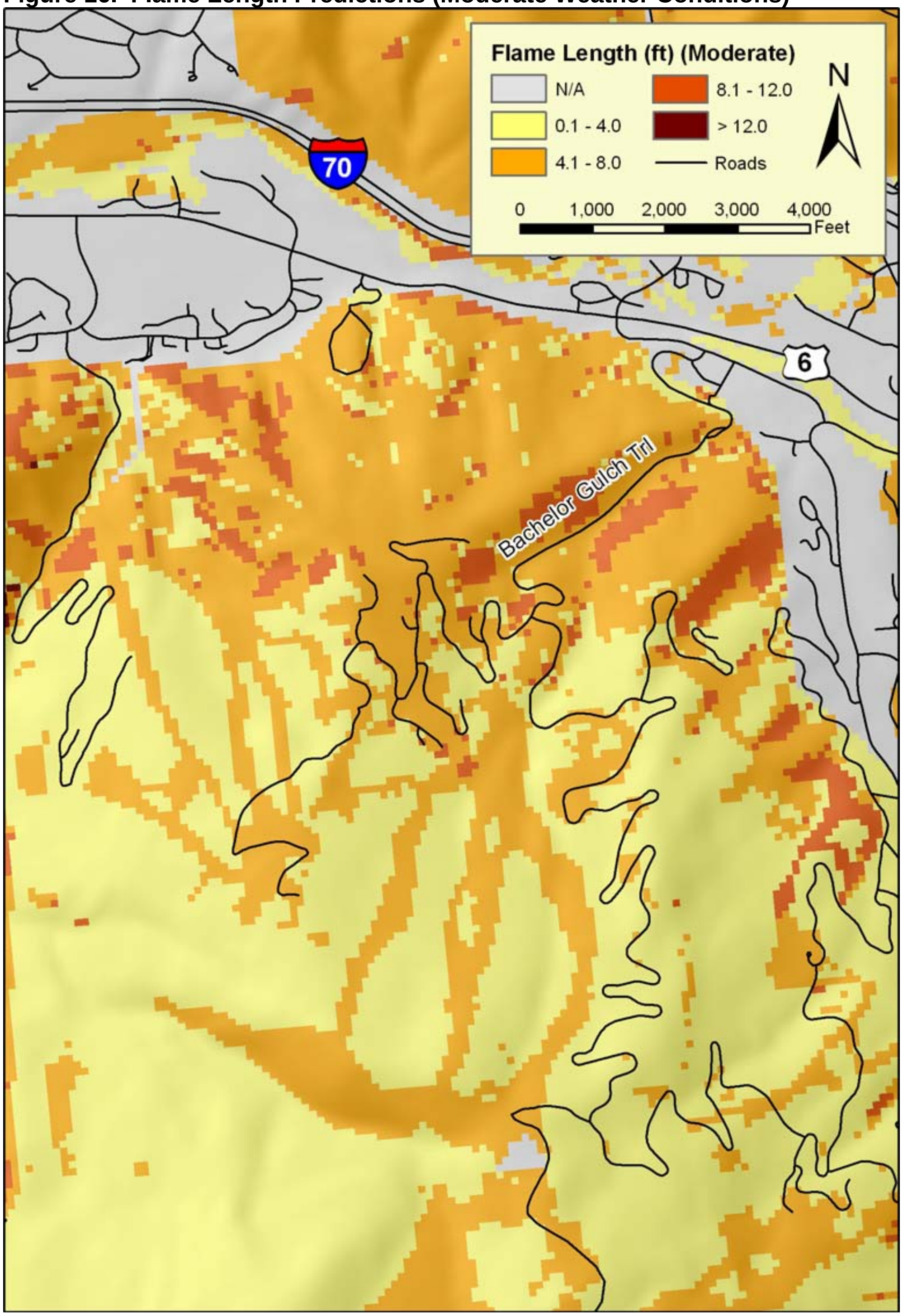
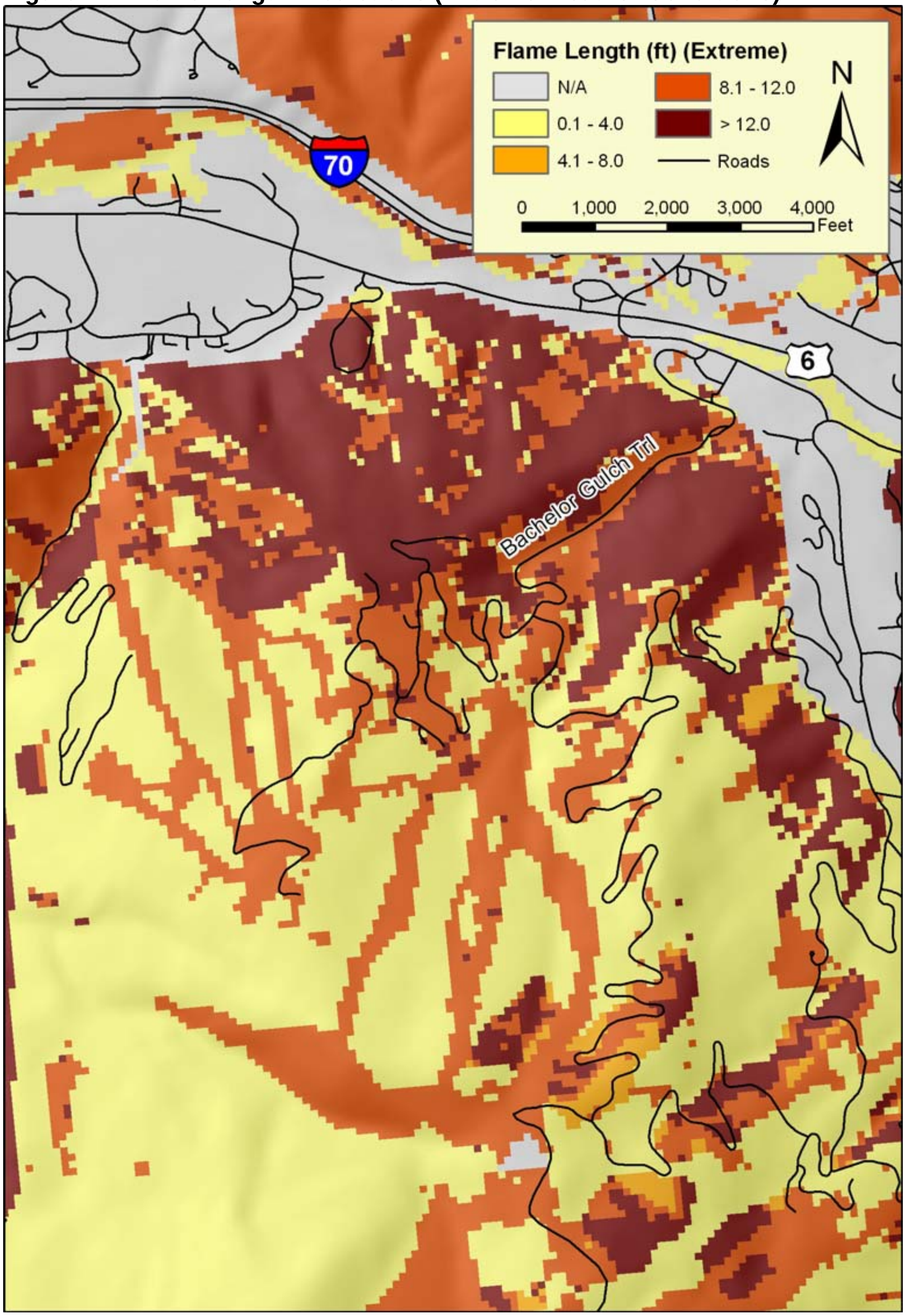


Figure 17. Flame Length Predictions (Extreme Weather Conditions)



FIRE BEHAVIOR MODELING LIMITATIONS AND INTERPRETATION

This evaluation is a prediction of likely fire behavior, given a standardized set of conditions and a single point-source ignition in every cell (each 10 x 10 meter area). It does not consider cumulative impacts of increased fire intensity over time and space. The model does not calculate the probability a wildfire will occur. It assumes an ignition occurrence for every cell. These calculations may be conservative (under predict) compared to observed fire behavior.

This model can be conceptually overlaid with the Community Wildfire Hazard Ratings (WHR) or other Values at Risk to generate current and future "areas of concern," which are useful for prioritizing mitigation actions. This is sometimes referred to as a "values layer." One possibility is to overlay the fire behavior potential maps with the community hazard map to make general evaluations of the effects of the predicted fire behavior in areas of high hazard value (areas where there are concentrations of residences and other man-made values). However, one should remember that the minimum mapping unit used for fire behavior modeling is one acre. Therefore, fine scale fire behavior and effects are not considered in the model. Additionally, weather conditions are extremely variable and not all combinations are accounted for. The fire behavior prediction maps are best used for pre-planning and not as a stand-alone product for tactical planning. If this information is used for tactical planning, fire behavior calculations should be done with actual weather observations during the fire event. For greatest accuracy, the most current Energy Release Component (ERC) values should be calculated and distributed during the fire season to be used as a guideline for fire behavior potential. Please see **Appendix B** for a further discussion of the WHR methodology.

Flame Length

Figures 16 and 17 display the flame length predictions for the two weather scenarios. Flame length is a proxy for fire intensity. It is important to note flame length is considered the entire distance from the base of the flame to the tip irrespective of angle and not simply the flame height above the ground. It is possible in high wind conditions to have very intense flames (high flame lengths) which are relatively close to the fuel bed. The legend boxes display flame length in ranges which are meaningful to firefighters. Flame lengths of four feet and less are deemed low enough intensity to be suitable for direct attack by hand crews, and therefore represent the best chances of direct extinguishment and control. Flame lengths of less than eight feet are suitable for direct attack by equipment such as bulldozers and tractor plows. Flame lengths of eight to 12 feet are usually attacked by indirect methods and aircraft. In conditions where flame lengths exceed 12 feet, the most effective tactics are fuel consumption ahead of the fire by burnouts or mechanical methods. Although indirect fire line and aerial attack are also used for fires with flame lengths of greater than 12 feet, as flame lengths increase the effectiveness of these tactics decreases, and their use is generally designed to slow rates of spread and reduce fire intensity, especially in areas where values at risk are concentrated.

In the moderate fire weather scenario, the model predicts that fires in most of the populated portions of the WUI could be attacked directly by either hand crews or equipment. However, the combination of accessibility and higher flame lengths (up to 12 feet) will make operations more difficult in the steeper northern portions of both communities. It should also be noted that although flame lengths of four to 12 feet are predicted adjacent to Bachelor Gulch Trail, the primary access in and out of Bachelor Gulch Village, the road is positioned so that access is unlikely to be threatened by fires in these fuel beds.

Under the extreme fire weather scenario, flame lengths of greater than eight feet are predicted throughout the interface area except for the central portions of Daybreak Ridge and some small pockets in Bachelor Ridge. In these areas, the predicted flame lengths indicate that fires are likely to be too intense for direct attack by hand crews. Nonetheless, hand crews would be vital for structure preparation, triage, and the construction of indirect fire line. Under extreme weather and fuel moisture conditions, fire intensity in some areas of the northern portion of the study area could be a serious issue, and control may be difficult to establish and maintain.

Rate of Spread

Figures 14 and 15 show the predicted rates of spread for the moderate fire weather and extreme fire weather scenarios respectively. Rates of spread are expressed in chains/hour (CPH). A chain is a unit of measure commonly used by loggers and firefighters. It is equal to 66 feet; therefore, one mile equals 80 chains. Rates of fire spread are influenced primarily by wind, slope steepness, fuel type/continuity and fuel sheltering from the wind. Fire is the only force of nature which moves faster uphill than downhill. When all other factors are equal, fire moves twice as fast uphill on a slope of 30% than it does on flat terrain. In areas where high to extreme rates of spread are predicted (ROS of >40 CPH or ½ mile per hour), it is possible for fires to spread faster than humans can escape, creating extremely dangerous conditions for firefighters and evacuating residents. High rates of spread also make suppression efforts less effective and increase the tactical complexity of the incident.

In the moderate fire weather scenario, high rates of spread are predicted throughout the Bachelor Ridge community and in some of the northern portions of Daybreak Ridge. High rates of spread are also predicted along Bachelor Gulch Trail indicating both communities should be considered for evacuation early if fires are moving toward the Bachelor Ridge community from the north or northwest.

Extreme fire weather conditions do not create a substantial change in predicted rates of spread within the WUI areas, although the shrub fuels to the north of Bachelor Ridge are predicted to experience double to triple the rates of spread. Timing evacuation and suppression operations well ahead of the fire will be more critical for fires originating or moving through these fuels when extreme weather conditions exist.

Crown Fire Activity

The Crown Fire Activity maps (**Figures 12 and 13**) display the potential for fires to move from the surface into the canopy of trees and shrubs. The likelihood of progression from the surface into the aerial fuels is displayed in four categories. N/A refers to areas where surface fires are unlikely to develop due to the lack of combustible fuels. These would include any areas with a non-combustible fuel bed such as rock, ice, snow fields, water, sand, or certain urban landscapes. The surface fire category covers areas where fires are expected to be limited to the surface fuels, and thus lack the energy to initiate and sustain vertical development into the aerial fuels. Areas where grass fuels without overstory plants are dominant fall into this category, regardless of the energy produced by the fire, due to the lack of an aerial fuel bed. Areas covered by the torching category are expected to experience isolated combustion of the tree crowns in individual trees and groups of trees. In other words, individual or relatively small clusters of trees will be completely involved, but these fires lack the energy to initiate sustained horizontal movements (referred to as “runs” by firefighters) through the crowns. The active crown fire category includes areas where sustained horizontal movements through tree crowns are expected. This category can be further subdivided into “dependent” or “independent” crown fires. Dependent crown fires rely on the presence of surface fires to support aerial burning. Independent crown fires develop when aerial burning is sustained without the need for associated surface fire. Independent crown fires are rare and are associated with the most extreme fire behavior conditions. Current fire behavior models cannot predict independent crown fire development. All crown fires, regardless of whether they are dependent or independent, represent extreme fire behavior conditions and are notoriously resistant to all methods of suppression and control.

Under moderate burning conditions, torching of individual trees and small patches is only expected to develop in isolated stands in the northern and southern portions of the study area, most of which are located away from homes. However, since wood roofs are dominant in both communities, any ember cast generated by torching of trees near homes should be carefully monitored.

Under extreme burning conditions, torching is expected to develop in some of the northern portions of Bachelor Ridge and throughout the southern portion of Daybreak Ridge. Some small pockets of active crown fires are predicted to develop in these areas, but these pockets are generally small, and only pose a threat to homes in the southern portion of Daybreak Ridge. Structure defense in this area will be complicated by the dominance of wood shake roofs.

Spotting Potential

There is little chance of embers and spots from aspen stands. The lodgepole pine stands within the study area could generate embers and spotting, but the resulting embers would need to land in a receptive fuel bed. Where aspen surround homes in the study area, there would be little chance of an ignition. Many homes have landscaping and grass lawns which are not likely to be receptive to ignition. The primary concerns would be embers landing on wood shake roofs and homes located in lodgepole pine stands. Due to the active safety patrol schedule and nearby fire response, a fire should be detected quickly, before it has a chance to extend to other structures or vegetative fuels. Additionally, a substantial water supply system is available to control any spot fires that might develop due to ember cast.

APPENDIX B

BACHELOR GULCH, COLORADO CWPP
NEIGHBORHOOD IGNITABILITY ANALYSIS AND RECOMMENDATIONS

PURPOSE

The purpose of this appendix is to examine in greater detail the communities in the study area. Of the two WUI communities in Bachelor Gulch, one was found to represent a high hazard and one a moderate hazard. For easy reference, the map of communities presented in the main text has been reproduced here as **Figure 1**. **Figure 2** displays this grouping graphically.

Figure 1.

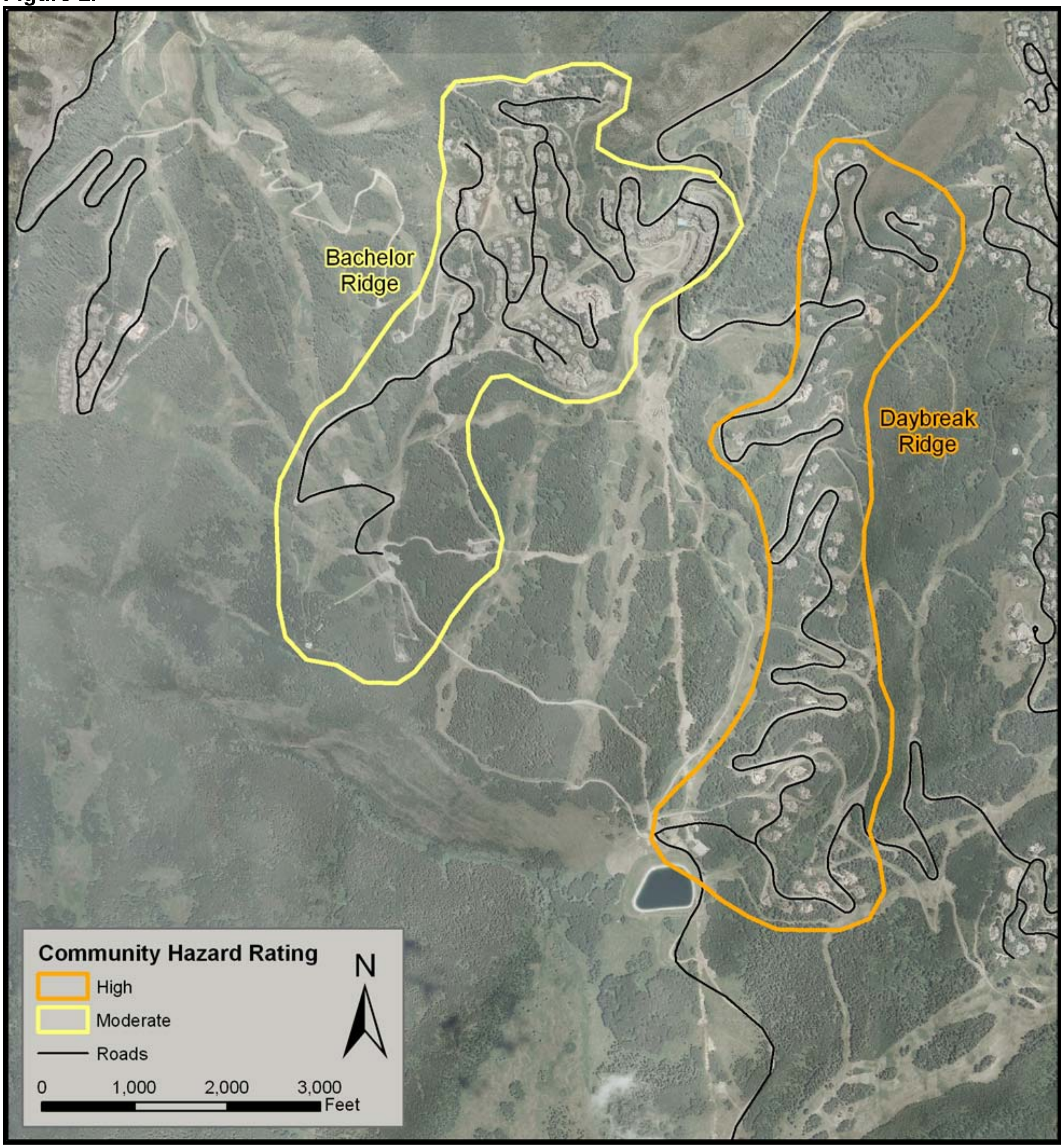
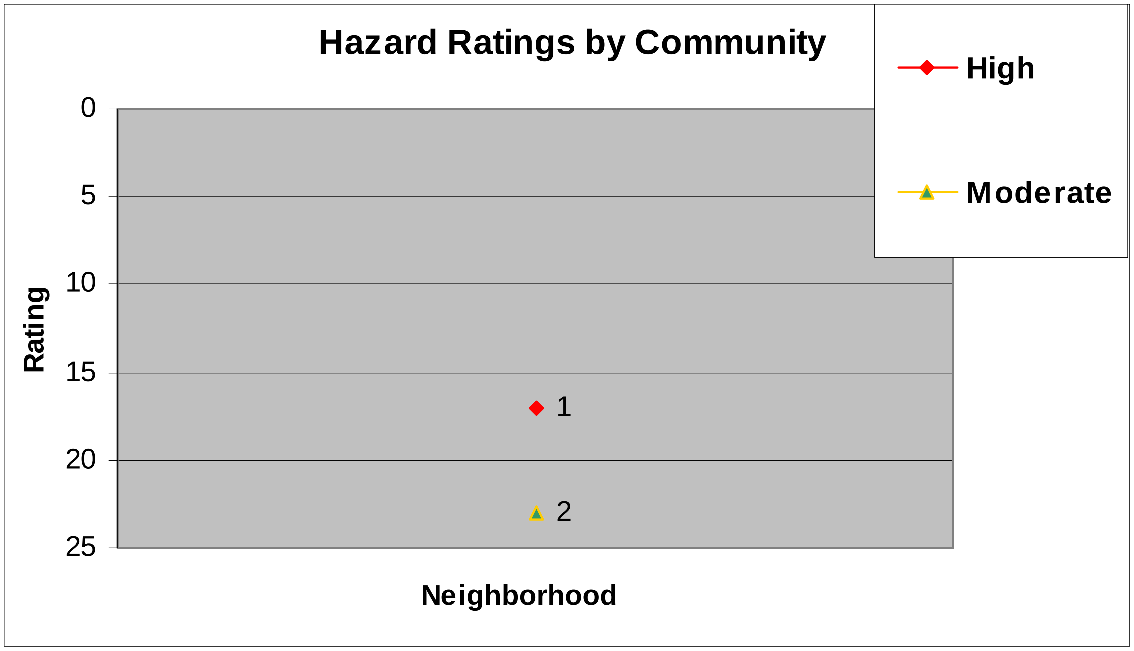


Figure 2.



1. Daybreak Ridge	**2. Bachelor Ridge**

GENERAL RECOMMENDATIONS

A combination of adequate access, ignition-resistant construction, and fuels management will help create a safe environment for emergency service personnel, and provide reasonable protection to structures from a wildfire. These techniques should also significantly reduce the chances of a structure fire becoming an ignition source to the surrounding wildlands.

In addition to the suggested mitigations listed for the individual communities, several general measures can be taken to improve fire safety. The following recommendations should be noted and practiced by anyone living in the Wildland-Urban Interface:

1. Be aware of the current fire danger in the area.

2. Clean roof and gutters at least twice a year, especially during cure-up in autumn.

3. Stack firewood uphill or on a side contour, at least 30 feet away from, and not directly above structures.

4. Don't store combustibles or firewood under decks.

5. Maintain and clean spark arresters on chimneys.

6. When possible, maintain an irrigated greenbelt around the home.

7. Connect, and have available, a minimum of 100 feet of garden hose.

8. Post reflective lot and/or house numbers so that they are clearly visible from the main road. Reflective numbers should also be visible on the structure itself.

9. Trees along driveways should be limbed and thinned as necessary to maintain a minimum 13’6” vertical clearance for emergency vehicle access.

10. Maintain your defensible space constantly.
    - Mow grass and weeds to a low height.
    - Remove any branches overhanging the roof or chimney.
    - Remove all trash, debris, and cuttings from the defensible space.

Note
All communities rated as high hazard or greater were recommended for a parcel-level analysis. In the moderate level communities a parcel-level analysis was recommended only if the evaluator found that a significant number of homes had no, or ineffective, defensible space or a significant number of hazards near homes was detected. In short, the recommendation was made if the evaluator felt information gathered by a parcel-level analysis could be used to generate a noticeable improvement in the community's defensibility.

TECHNICAL TERMS

The following definitions apply to terms used in the "Description" of this appendix.

Defensible Space: An area around a structure where fuels and vegetation are modified, cleared, or reduced to slow the spread of wildfire toward or from the structure. The design and extent of the defensible space is based on fuels, topography, and the design and materials of the structure.

Extended Defensible Space (also known as Zone 3): In this defensible space zone treatment is continued beyond the recommended minimum boundary for defensible space. This zone focuses on forest management with fuels reduction being a secondary function.

Shelter-in-Place Areas: There are several ways to protect the public from an advancing wildfire. One of these methods is evacuation, and involves relocation of the threatened population to a safer area. Another is to instruct people to remain inside their homes or public buildings until the danger passes. This concept is new to wildfire in the United States, but not to hazardous materials incident response, where time, hazards, and sheer logistics often make evacuation impossible. This concept is the dominant modality for public protection from wildfires in Australia, where fast moving, non-persistent fires in light fuels make evacuation impractical. The success of this tactic depends on a detailed pre-plan that takes into account the construction type and materials of the building used, topography, depth and type of the fuel profile, as well as current and expected weather and fire behavior. For a more complete discussion of the application and limitations of shelter-in-place concepts see the "Addressing, Evacuation, and Sheltering-In-Place FMU" section in the main report.

Citizen Safety Zone: An area that can be used for protection by residents in the event that the main evacuation route is compromised. The area should be maintained, cleared of fuels, and large enough for all residents of the area to survive an advancing wildfire without special equipment or training.

Fuelbreak: A natural or constructed discontinuity in a fuel profile used to segregate, stop, or reduce the spread of fire. As a practical matter, fuelbreaks in the WUI are most effective against crown fires.

COMMUNITY ASSESSMENT METHODOLOGY

The community level methodology for this assessment uses a Community Wildfire Hazard Rating (WHR) that was developed specifically to evaluate communities within the Wildland Urban Interface (WUI) for their relative wildfire hazard.[1] The WHR model combines physical infrastructure such as structure density and roads, and fire behavior components like fuels and topography, with the field experience and knowledge of wildland fire experts. It has been proven and refined by use in rating over 1,400 neighborhoods throughout the United States.

Many knowledgeable and experienced fire management professionals were queried about specific environmental and infrastructure factors, and wildfire behavior and hazards. Weightings within the model were established through these queries. The model was designed to be applicable throughout the western United States.

The model was developed from the perspective of performing structural triage on a threatened community in the path of an advancing wildfire with moderate fire behavior. The WHR survey and fuel model ground truthing are accomplished by field surveyors with WUI fire experience. The rating system assigns up to a maximum of 60 points based on seven categories: average lot size, slope, primary aspect, average fuel type, fuel continuity, dominant construction type and surface fuel loading. The higher the community scores, the lower its wildfire hazard. For example, a community with an average lot size of less than one acre and slopes of greater than 30% would receive zero points for those factors, whereas a community with an average lot size of five acres and slopes of less than 15% would receive 16 points for the same factors. Additional hazards are then subtracted from the subtotal of points earned in the seven categories to give a final numeric value. The final value is then used to group communities into one of five hazard ratings: Extreme, Very High, High, Moderate, or Low.

It is important to note that not all groupings occur in every geographic region. There are some areas with no low hazard communities, just as there are some areas with no extreme communities. The rankings are also related to what is customary for the area. For example, a high hazard area on the plains of Kansas may not look like a high hazard area in the Sierra Nevada. The system creates a relative ranking of community hazards in relation to the other communities in the study area. It is designed to be used by experienced wildland firefighters who have a familiarity with structural triage operations and fire behavior in the interface.

[1] C. White, “Community Wildfire Hazard Rating Form” *Wildfire Hazard Mitigation and Response Plan*, Colorado State Forest Service, Ft. Collins, CO, 1986.

COMMUNITIES

1. Daybreak Ridge

Figure 3.

Hazard Rating:	High
Does the neighborhood have dual access roads?	Yes, but gated and locked
Are there road grades > 8%?	Yes
Are all access roads of adequate width?	No
Average lot size:	1-5 Acres
Fuel models found in the neighborhood:	1, 8, 10
Water supply:	Hydrants
Hazards:	Steep slopes, ravines, natural chimneys, inadequate roads, wood roofs

Description: This is a community of large homes on moderate-size to large lots. Wood siding with rock wainscoting is the most common construction type. Most homes are well built and maintained. The most common roof type is wood shake. Few homes have conforming defensible space and many have flammable vegetation growing right up to the structure. Most homes have some sort of address marker, but not all are reflective or easy to locate. Road surfaces are generally good, but roads are narrow in some areas with no shoulder. There are few pullouts and turnarounds suitable for fire apparatus. There is a secondary access from this community to the Strawberry Park community in Beaver Creek, but this access is gated and sometimes locked. Like all of Bachelor Gulch, Daybreak Ridge has a network of hydrants. Dominant fuels are moderate to heavy loads of aspen and lodgepole pine, some insect-killed, broken by significant grassy areas including ski runs and lift lines. The general topography is steep and complex.

DAYBREAK RIDGE RECOMMENDATIONS

- A parcel-level analysis is recommended.
- Adequate defensible space is recommended for all homes (see the “Home Mitigation FMU” in the main report for details).
- Extended defensible space is recommended for some homes due to position, fuels and terrain.
- Discourage the use of combustible materials for decks, siding and roofs, especially where homes are upslope from heavy fuels. Replace all shake roofs with non-combustible types such as metal or composite shingle.
- Open areas below decks and projections should be enclosed or screened to prevent the ingress of embers and kept clean of flammable materials, especially where such openings are located on slopes above heavy fuels.
- Clean leaf and needle litter from roofs and gutters and away from foundations.
- Discourage the planting of flammable ornamentals, such as conifers, within 30 feet of homes. Encourage the use of fire- and drought-tolerant plants for ornamental plantings especially within 30 feet of homes (see the “Home Mitigation FMU” in the main report).
- Flammable vegetation should be thinned away from access roads and driveways. This is especially important for narrow driveways and road segments.
- Consider preplanning the construction access from Strawberry Park as an alternate escape route and equipping the gate with firefighter access such as a Knox Box or code-activated opener (see the “Access and Evacuation FMU” in the main report).
- Consider preplanning the large clearing located near the pond on McCoy Road as a safety zone for firefighters. Thinning of pockets of heavy fuel along McCoy Road between the safety zone and the intersection with Daybreak Ridge Road should be conducted to improve access safety to this safety zone (see the “Landscape Scale Fuels Modification FMU” in the main report).
- Consider fuelbreaks in conifer fuel beds downhill of homes located on Elk Horn Road and Daybreak Ridge Road (see the “Landscape Scale Fuels Modification FMU” in the main report).
- Wherever possible, on driveways and private roads longer than 300 feet, add pullouts for emergency apparatus. Turnarounds should be constructed at the end of all driveways and dead-end roads.
- Add reflective addressing to all driveways and homes.

2. Bachelor Ridge

Figure 4.

Hazard Rating:	Moderate
Does the neighborhood have dual access roads?	No
Are there road grades > 8%?	No
Are all access roads of adequate width?	Yes
Average lot size:	1-5 Acres
Fuel models found in the neighborhood:	1, 5, 6, 8, 10
Water supply:	Hydrants
Hazards:	Ravines, some steep slopes, wood roofs

Description: This community is a mix of large to moderate-size homes and high-density buildings such as condos and lodges. Although some homes are on large lots, lot sizes are generally smaller, and home density is greater than in the Daybreak Ridge community. Most homes are log or heavy timber siding, many with rock wainscoting. The dominant roof type is wood shake, although there are some ignition-resistant roofs. Many homes need conforming defensible space. Roads and street markers are generally good, but there is only one way in and out of this community. Most homes have address markers, but some are hard to locate and many are non-reflective. Address markers are good below Tall Timbers and become inconsistent in the area above. Like all of Bachelor Gulch, Bachelor Ridge has a network of hydrants. Dominant fuels are moderate to heavy loads of aspen and lodgepole pine, some insect-killed, broken by significant grassy areas including ski runs and lift lines. The general topography is moderate but complicated by ravines and ridges.

BACHELOR RIDGE RECOMMENDATIONS

- Adequate defensible space is recommended for all homes (see “Home Mitigation FMU” in the main report for details).
- Extended defensible space is recommended for homes located in dangerous topography (above ravines and natural chimneys, mid-slope on steep slopes, on ridge tops or summits) with heavy fuel loads near or below the home.
- Discourage the use of combustible materials for decks, siding and roofs, especially where homes are upslope from fuels. Replace all shake roofs with non-combustible types such as metal or composite shingle.
- Open areas below decks and projections should be enclosed or screened to prevent the ingress of embers and kept clean of flammable materials, especially where such openings are located on slopes above fuels.
- Clean leaf and needle litter from roofs and gutters and away from foundations.
- Discourage the planting of flammable ornamentals, such as conifers, within 30 feet of homes. Encourage the use of fire- and drought-tolerant plants for ornamental plantings, especially within 30 feet of homes (see the “Home Mitigation FMU” in the main report).
- Flammable vegetation should be thinned away from access roads and driveways. This is especially important for narrow driveways and road segments.
- Consider a fuelbreak in conifer fuelbeds downhill of homes located on Tall Timbers Trail (see the “Landscape Scale Fuels Modification FMU” in the main report).
- Consider preplanning the large clearing located south of the Ritz-Carlton as a safety zone for firefighters (see the “Landscape Scale Fuels Modification FMU” in the main report). .
- Wherever possible, on driveways and private roads longer than 300 feet, add pullouts for emergency apparatus. Turnarounds should be constructed at the end of all driveways and dead-end roads.
- Add reflective addressing to all driveways and homes.

APPENDIX C

BACHELOR GULCH, COLORADO CWPP
STRUCTURAL TRIAGE AND PREPARATION

Size Up Considerations

- What is the current and expected weather?
- Are fuels heavy, moderate, or light? What is the arrangement and continuity of fuels?
- Note any hazardous topography.
- What have fires in this area done before?
- What is the fire's current and expected behavior?
  - What is the rate and direction of spread?
  - What is the potential for spotting and firebrands?
  - Will topographical features or expected weather changes affect the rate of spread?
- What are the number and density of structures threatened?
- What are the available resources?
- Will you have to evacuate people or animals?
  - Are there residents who will not evacuate?
- How hazardous is the structure?
  - What is the roofing material?
  - Are the gutters full of litter?
  - Are there open eves and unscreened vents?
  - Does the structure have wooden decking?
  - Is there defensible space?
  - Are there large windows with flammable drapes or curtains?
  - What is the size and location of propane tanks and/or fuel storage tanks?

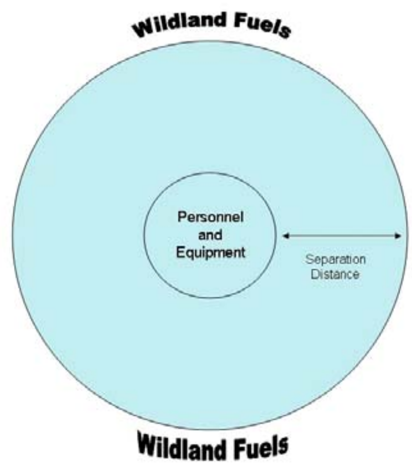
Fire Fighter Safety

- What are the routes of egress and ingress?
  - What is the largest engine that can access the structure safely?
  - Are the roads two-way or one-way?
  - Are there road grades steeper than 8%?
  - Are the road surfaces all-weather?
  - Are there load-limited bridges?
- Are there anchor points for line construction?
- Are there adequate safety zones?
- What are the escape routes?
- Are there special hazards such as hazardous materials, explosives, high-voltage lines, or above- ground fuel tanks?
- Are communications adequate?

Safety Zone Guidelines
• Avoid locations that are downwind from the fire.
• Avoid locations that are in chimneys, saddles, or narrow canyons.
• Avoid locations that require a steep uphill escape route.
• Take advantage of heat barriers such as lee side of ridges, large rocks, or solid structures.
• Burn out safety zones prior to flame front approach.
• For radiant heat only, the distance separation between the firefighter and the flames must be at least four times the maximum flame height. This distance must be maintained on all sides, if the fire has ability to burn completely around the safety zone. **Convective heat from wind and/or terrain influences will increase this distance requirement.**

CALCULATIONS ASSUME NO SLOPE AND NO WIND

Flame Height	Distance Separation (firefighter to flame)	Area in Acres
10 feet	40 feet	1/10 acre
20 feet	80 feet	1/2 acre
50 feet	200 feet	3 acres
75 feet	300 feet	7 acres
100 feet	400 feet	12 acres
200 feet	800 feet	50 acres
(1 acre = 208 feet x 208 feet, or the approximate size of a football field)		



Distance Separation is the radius from the center of the safety zone to the nearest fuels. When fuels are present that will allow the fire to burn on all sides of the safety zone, this distance must be doubled in order maintain effective separation in front, to the sides, and behind the firefighters. Area in Acres is calculated to allow for distance separation on all sides for a three person engine crew. One acre is approximately the size of a football field or exactly 208 feet x 208 feet.[1]

The size of safety zones recommended above are the minimum separation distances for a three-person engine crew and take into account only radiant heat transfer. Convective heat transfer (hot gases blown by winds and funneled by terrain features) is not considered in the model. The suitability of any area for use as a safety zone must be determined on a case-by-case basis using the current and expected fire behavior and adjusted as appropriate for the expected number of resources.

Structural Triage Categories *(Sort structures into three categories):*
1. Stand Alone or Not Threatened
2. Defendable
3. Not Defendable

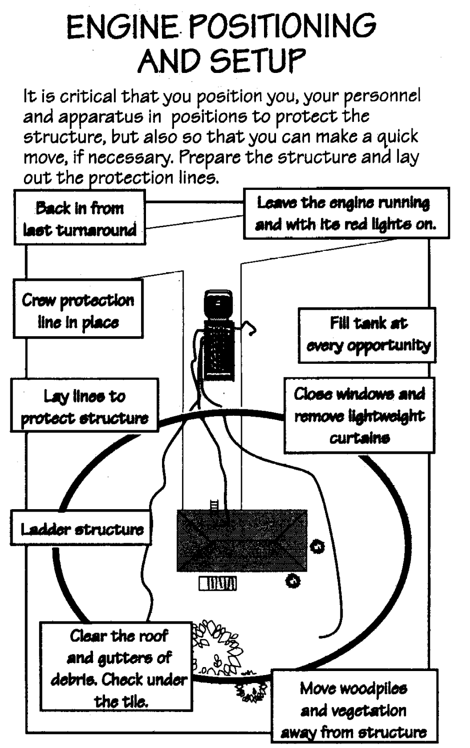
[1] http://www.nwcg.gov/pms/pubs/nfes1077/nfes1077.pdf

- Factors that may make an attempt to save a structure too dangerous or hopeless:
  - o The fire is making sustained runs in live fuels and there is little or no defensible space
  - o Spot fires are too numerous to control with existing resources
  - o Water supply will be exhausted before the threat has passed
  - o The roof is more than ¼ involved in flames
  - o There is fire inside the structure
  - o Rapid egress from the area is dangerous or may be delayed

Apparatus Placement Considerations

Common Ignition Points (remember, in windy conditions, firebrands can enter almost any opening)

- Flammable roof coverings and debris
- Unscreened vents, windows, or holes
- Open doors, windows, or crawl spaces
- Wooden decks, lawn furniture, stacked wood, and trash piles
- Openings under porches or patio covers



[2]

[2] Teie,William C.,1995, Firefighter's Guide, Urban/Wildland Situations. Deer Valley Press

APPENDIX D

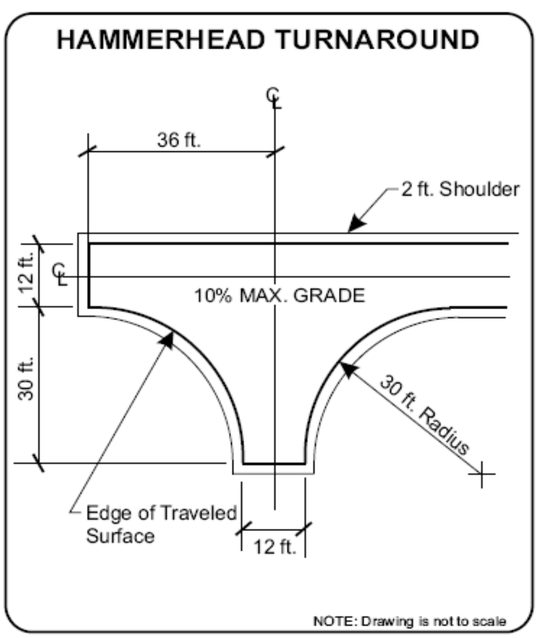
RECOMMENDED ACCESS GUIDELINES

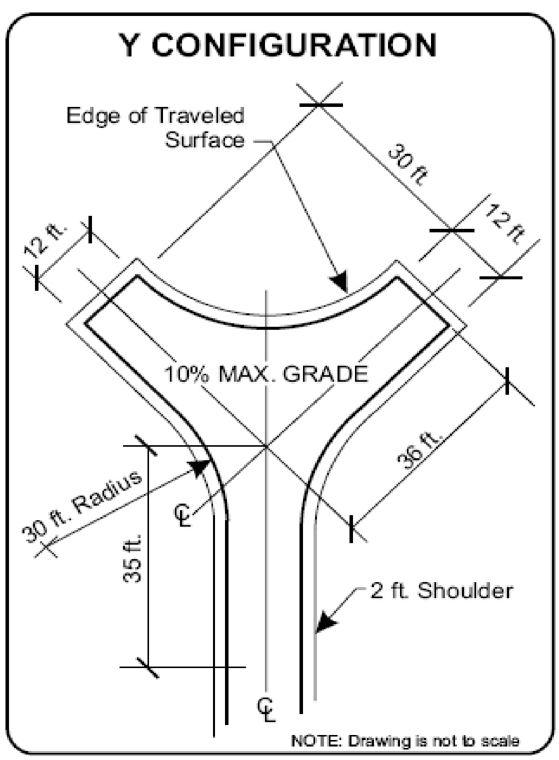
Introduction
This appendix has been designed with public education in mind, and is intended to help familiarize homeowners, contractors, and developers with the general principles of the access and water supply needs of firefighters. The recommendations in this section are based on proven practices. However, they are not meant to be a substitute for locally adopted codes.

Emergency response personnel do their best to respond to calls in a timely manner, often while negotiating difficult terrain. Planning for access by emergency equipment allows for a more efficient response, improving safety for residents and their families, as well as that of the firefighters and emergency medical technicians that will arrive on scene. This is especially important in rural areas, where response times may be considerably longer than in cities.

Access Guidelines
<u>Driveway Turnarounds</u>
Turnarounds unobstructed by parked vehicles should be located at the end of every driveway. They should be designed to allow for the safe reversal of direction by emergency equipment. The “Y” and “Hammerhead” turnarounds shown below are preferred because they provide the necessary access, while minimizing disturbance to the site.

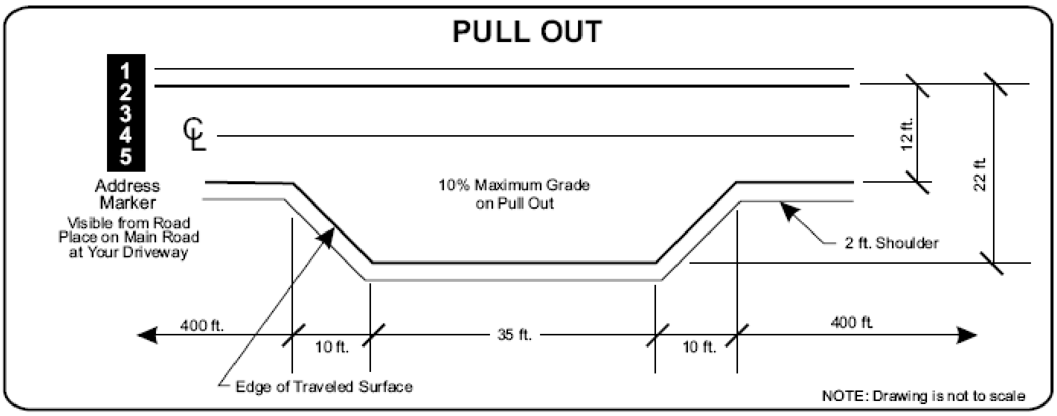
<u>Driveway Width and Height</u>
Driveways should have an unobstructed vertical clearance of 13 feet 6 inches. Trees may need to be limbed and utility lines relocated, to provide the necessary clearance. Driveways should have a 12 foot-wide drivable surface and 14 feet of horizontal clearance.





Driveway Pullouts

Driveway pullouts should be designed with sufficient length and width to allow emergency vehicles to pass one another during emergency operations. These features should be placed at 400-foot intervals along driveways and private access roads (community driveways). The location of pullouts may be modified slightly to accommodate physical barriers such as rock outcroppings, wetlands, and other natural or manmade features.



Address Markers

Every building should have a permanently posted, reflective address marker mounted on a non-combustible pole. The sign should be placed and maintained at each driveway entrance. Care should be taken to ensure that the location will not become obscured by vegetation, snow, or other features, whether natural or manmade. It is critical that the location and markings be adequate for easy night-time viewing. It is preferable to locate markers in a consistent manner within each community. A good guideline for this practice is to place the markers five feet above ground level on the right side of every driveway. Where access to multiple homes is provided by a single driveway, all addresses accessed via that driveway should be clearly listed on the driveway marker. Where multi-access driveways split, each fork should indicate all residences accessed by that fork, and the proper direction of travel to arrive at a given address. It is not adequate simply to mark addresses on a common pole in the center of the fork. Further, residential homes should have an additional reflective address marker permanently attached to the home, in clear view of the driveway or access road. Homes that are marked by lot number while under construction should have the lot number removed and a permanent address marker posted before granting a certificate of occupancy.

Bridge Load Limits

Bridge load limits should be posted with a permanently mounted, reflective marker at both entrances to the bridge. Care should be taken to ensure that these markers will not become obscured by vegetation, snow, or other features, whether natural or manmade. It is critical that the location of the markings and the markings themselves be adequate for easy night-time viewing.

Appendix E

Bachelor Gulch Collaborative Effort

The Need for a CWPP

In response to the Healthy Forest Restoration Act (HFRA), and in an effort to create incentives, Congress directed interface communities to prepare a Community Wildfire Protection Plan (CWPP). Once completed, a CWPP provides statutory incentives for the US Forest Service (USFS) to consider the priorities of local communities as they develop and implement forest management and hazardous fuel reduction projects. In the case of the Bachelor Gulch Village Association, the need for a community-based hazard and risk assessment (HRA) was born from an internal need, not a federal directive.

CWPPs can take a variety of forms, based on the needs of the people involved in their development. CWPPs may address issues such as wildfire response, hazard mitigation, community preparedness, structure protection, or all of the above.

The minimum requirements for a CWPP are:

- Collaboration between local and state government representatives, in consultation with federal agencies and other interested parties.
- Prioritized fuel reduction in identified areas, as well as recommendations for the type and methods of treatments
- Recommendations and treatment measures for homeowners and communities to reduce the ignitability of those structures in the project area.

Project Funding and Coordination

Bachelor Gulch used internal budgets to complete a community-wide hazard and risk assessment and the resultant CWPP.

Future community education and private landowner assistance will be coordinated through the Bachelor Gulch Village Association. The association will continue to identify funding for the implementation of mitigation projects.

Inter-Agency Collaboration

Roles and Responsibilities

To be successful, wildfire mitigation in the interface must be a community-based, collaborative effort. Stakeholders and, primarily Bachelor Gulch Village Association, will have the greatest responsibility for implementing the recommended mitigation projects. The CSFS and the USFS will be valuable participants in addressing cross-boundary projects throughout the area. Nearly all of the recommendations from this report affect private land or access roads to private land. There are also mitigation recommendations for individual structures which are the responsibility of the homeowner. Homeowners will, however, need a point of contact, most likely a member of Bachelor Gulch Village Association, to help them implement these recommendations. The best defensible space will be created with oversight and expert advice from the fire district and or government forestry personnel. One-on-one dialog will continue to build the relationship with community members. This level of involvement will allow agencies to keep track of the progress and update this plan to reflect the latest modifications at the community level.

The Collaborative Process

"The initial step in developing a CWPP should be the formation of an operating group with representation from local government, local fire authorities, and the state agency responsible for forest management … Once convened; members of the core team should engage local representatives … to begin sharing perspectives, priorities, and other information relevant to the planning process.[1]"

Numerous federal, State, local, and private agencies (stakeholders) participated in the Bachelor Gulch Resort CWPP. These stakeholders included:

- Bachelor Gulch Village Association
- Vail Resorts
- Eagle River Fire
- Eagle County Sheriff's Office
- Eagle County
- The United States Forest Service
- The Colorado State Forest Service
- Anchor Point Group

The true collaborative process was initiated thru a number of stakeholder meetings held within Eagle County. A CWPP meeting was held in September 2007. The purpose of the meeting was to bring all past, current, and future efforts and needs to the table. The primary focus was on the identification and delineation of communities, areas of concern, and values at risk. Best practices and anticipated "roadblocks" were identified.

Funding CWPP Recommendations

There are many sources of funds available for implementing the recommendations within the CWPP. Some available grants and websites where more information can be found are provided below.

- Agency: Homeland Security, Office for Domestic Preparedness

- Purpose: to assist local, state, regional, or national organizations in addressing fire prevention and safety. The emphasis for these grants is the prevention of fire-related injuries to children.
- More information: http://www.firegrantsupport.com/

- Agency: Federal Emergency Management Agency (FEMA)
  - Purpose: to improve firefighting operations, purchase firefighting vehicles, equipment, and personal protective equipment, fund fire prevention programs, and establish wellness and fitness programs.
  - More information: http://usfa.fema.gov/dhtml/inside-usfa/grants.cfm

- Agency: National Volunteer Fire Council
  - Purpose: to support volunteer fire departments
  - More information: http://www.nvfc.org/federalfunding.html

- Agency: Community Facilities Grant Program
  - Purpose: to help rural communities. Funding is provided for fire stations
  - More information: www.rurdev.usda.gov/rhs/

- Agency: Firehouse.com
  - Purpose: emergency services grants
  - More information: www.firehouse.com/funding/grants.html

- Agency: Cooperative Forestry Assistance
  - Purpose: to assist in the advancement of forest resources management, the control of insects and diseases affecting trees and forests, the improvement and maintenance of fish and wildlife habitat, and the planning and conduct of urban and community forestry programs
  - More information: www.usfa.fema.gov/dhtml/inside-usfa/cfda10664.html

- Agency: Forest Service, Economic Action Programs
  - Purpose: Economic Action Programs that work with local communities to identify, develop, and expand economic opportunities related to traditionally underutilized wood products and to expand the utilization of wood removed through hazardous fuel reduction treatments.
  - More information: www.fireplan.gov/community_assist.cfm

- Agency: FEMA
  - Purpose: Assistance to Firefighters Grant Program
  - More information: www.usfa.fema.gov/dhtml/inside-usfa/apply.cfm and www.nvfc.org/federalfunding.html