An Analysis of Non-Suppression Management Strategies of Unplanned Wildland Fire in the Palisades Wilderness Study Area

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Preface

I started in the fire service in 2001 as a Volunteer firefighter with Jackson-Teton County Fire Department. Providing structure protection during the locally significant Green Knoll Fire sparked my interest in pursuing a career in federal fire management. In 2003, I worked as an employee of Teton County, Wyoming on a Type 4 forest service engine based in Jackson. My first federal position was with Teton Interagency Helitack in, 2004, as a Senior Firefighter and rappeler. After two seasons with Helitack, I accepted a permanent position with the Bridger-Teton National Forest as an Assistant Engine Captain on a Type 3 Interagency Engine in Moose, Wyoming. I am still serving as an Assistant Captain, and I am currently volunteering as a Station Captain with Jackson Hole Fire/EMS.

- Amy, Charlie, and Molly – For putting up with frequent and extended absences while attending TFM, and for their love and constant support during my neurotic episodes working on this project.
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Anthony A Rojo

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Executive Summary

Given current fire policy implementation guidelines, there is a conscientious effort on the part of line officers and fire management officers on the Bridger-Teton National Forest to manage unplanned wildland fires to accomplish multiple objectives. For example, in 2011, on the North Zone of the Bridger-Teton National Forest, three large fires were managed for multiple resource objectives concurrently for a combined total of approximately 18,000 acres. The Bridger-Teton National Forest has successfully managed fires in the Gros Ventre Wilderness since 2004, and the Teton and Bridger Wilderness Areas since 1970. However, all historic fires in the Palisades Wilderness Study Area have been suppressed. The reason for suppression is proximity to wildland urban interface, power-line infrastructure, and highway corridors that exist around and within its boundaries. Miller (2010) states suppressing lightning caused fires "removes one of the most important natural processes from fire-dependent ecosystems, and runs counter to the untrammeled characteristics for …wilderness." A transition from suppression to non-suppression strategies is desired for the Palisades Wilderness Study Area to align with The Wilderness Act (1964) in maintaining Wilderness character.

This study tests the hypothesis that 5 percent or less of fires managed using non-suppression strategies will burn into, or onto, surrounding values. FARSITE (Finney 2004), a fire growth simulator, was used to model natural ignitions in the Palisades Wilderness Study Area under multiple weather streams. These weather streams were developed to represent 50th, 70th, and 90th percentile Burning Index based weather scenarios.

A statistical analysis was performed to test the 5 percent impact threshold to a significance of 95 percent. Calculated scores for 50th percentile Burning Index showed that the null hypothesis (less than 5 percent of fires will impact surrounding values) should be accepted. For 70th percentile weather streams, the null hypothesis was also accepted. For 90th percentile Burning Index, the null hypothesis was rejected. This means that for fires burning under 90th percentile Burning Index weather conditions, more than 5 percent of fires can be expected to impact values surrounding the Palisades Wilderness Study Area.

This paper describes an analysis to provide Bridger-Teton National Forest line officers and fire management staff with information to assist implementation of non-suppression fire management strategies for naturally ignited fires consistent with the Bridger-Teton Land and Resource Management Plan (1990), Bridger-Teton Land and Resource Management Plan Revision of Fire Management Standards and Guidelines (2004), and the Wyoming Wilderness Act of 1984.

Recommendations include considering broader array of long term management alternatives for natural ignitions under most weather conditions. Areas in which fires have a high likelihood of impacting values surrounding the Palisades Wilderness Study Area have been identified. Recommendations for fire management in the "Identified Risk Areas" consist of utilizing partial

or full suppression strategies. Flexibility to manage fires, especially in the "Risk" areas, would be substantially improved if threats to wildland urban interface were reduced. The Teton to Snake Fuels Management Project (2010) is a current proposal that addresses threat areas and strategically locates fuels treatments to reduce the threat to values surrounding the analysis area. Implementation of fuels treatments in those areas would aid in allowing natural processes in the Palisades Wilderness Study Area.

Additionally, a perimeter for allowing natural ignitions to play their natural role, even under more favorable fire growth scenarios, was developed. This "feasibility" area should be explored to enhance the ability of decision makers and fire managers to continue being flexible in the use of a broad range fire management strategies.

Introduction

This project tests the hypothesis that 5 percent or less of naturally ignited fires in the Palisades Wilderness Study Area (WSA) will reach private property and highway corridors existing on the north, east, and south sides of the study area. This hypothesis is examined under three weather scenarios. The Burning Index (BI) was used to define weather streams for FARSITE (Fire Area Simulator, Finny 2004) modeling. Results were statistically analyzed using the "Statistic for Large-Sample Test Concerning Proportion" (Fruend and others 2007).

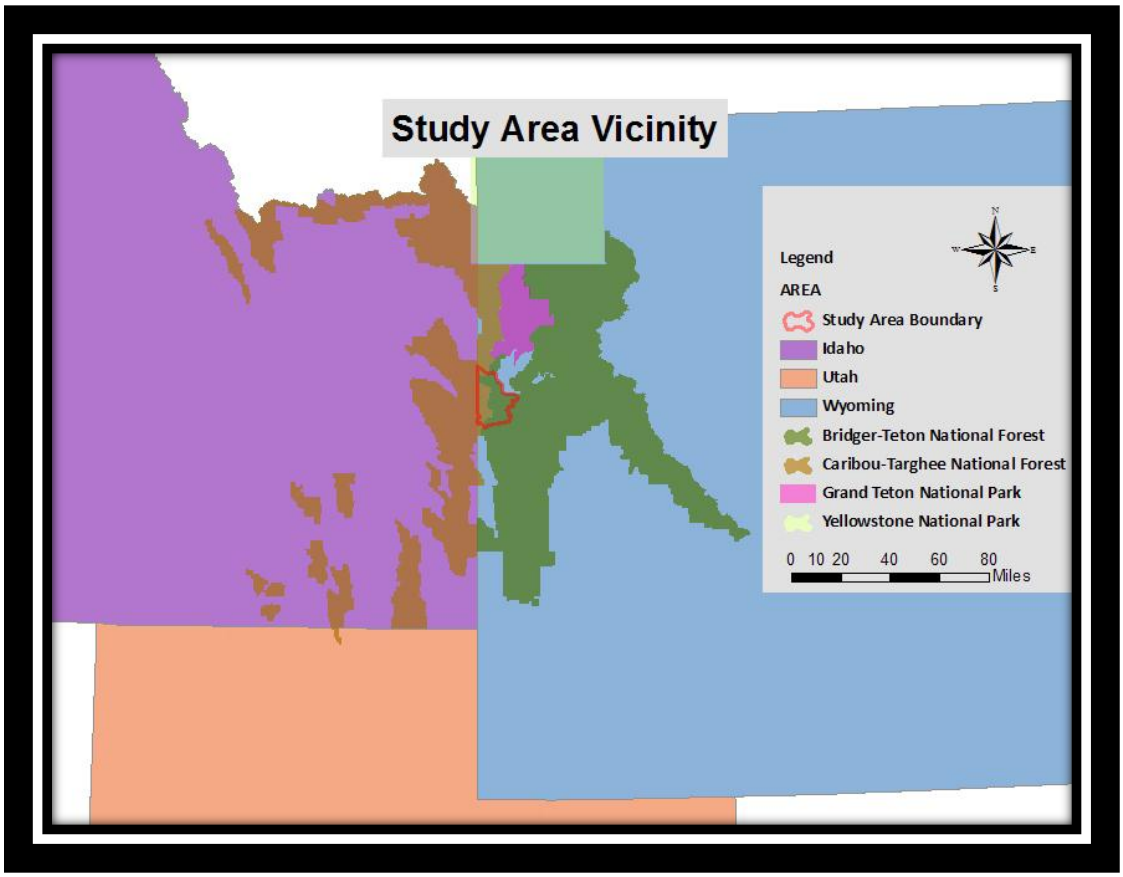
Actual historical fire ignitions were used in FARSITE and modeled under three different weather streams representing 50th, 70th, and 90th percentile BI. Burning Index combines Energy Release Component and Spread Potential, and takes into account wind which is highly influential on fire growth on the Bridger-Teton. By comparing environmental and climatological similarities of natural fire ignition occurrence to those in this study, managers may be able to better assess a future situation. This study intends to provide Bridger-Teton National Forest line officers and North Zone fire management staff with science based information for decisions on management strategies of naturally ignited fires in the Palisades WSA.

Background and Significance

The Bridger-Teton National Forest encompasses 3.4 million acres of National Forest System lands (USDA Forest Service 1990). It is located in western Wyoming and shares borders with Grand Teton and Yellowstone National Parks. To the west and east are the Caribou-Targhee National Forest and the Shoshone National Forest. The Bridger-Teton National Forest (BTNF) is split into three fire management zones. The West Zone is made up of the Kemmerer and Grey's River Ranger Districts, and the East Zone is comprised of the Pinedale and Big Piney Ranger Districts. The North Zone of the Bridger-Teton N.F. includes the Jackson and Buffalo Ranger Districts. Fire resources of the Bridger-Teton N.F. work under an interagency umbrella with Grand Teton N.P., and share initial attack resources, various fire staff positions, and a dispatch center.

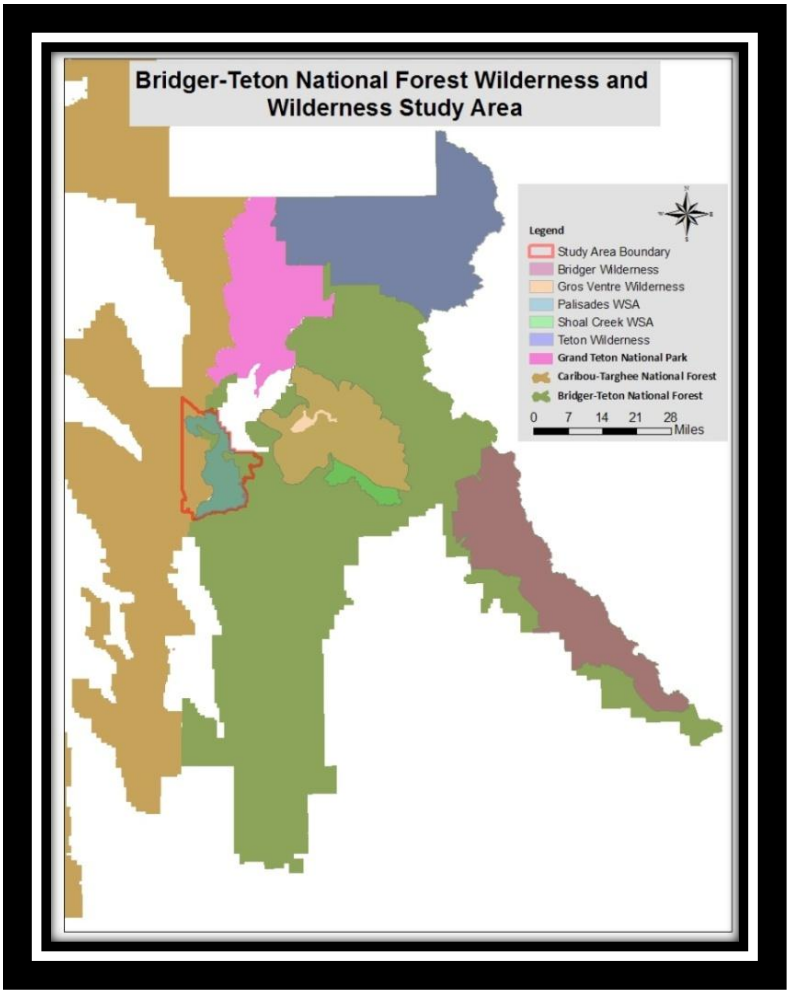
Figure 1 shows the Study Area boundary within Wyoming, Idaho, and the Bridger-Teton and Caribou-Targhee National Forests.

FIGURE 1. Vicinity Map



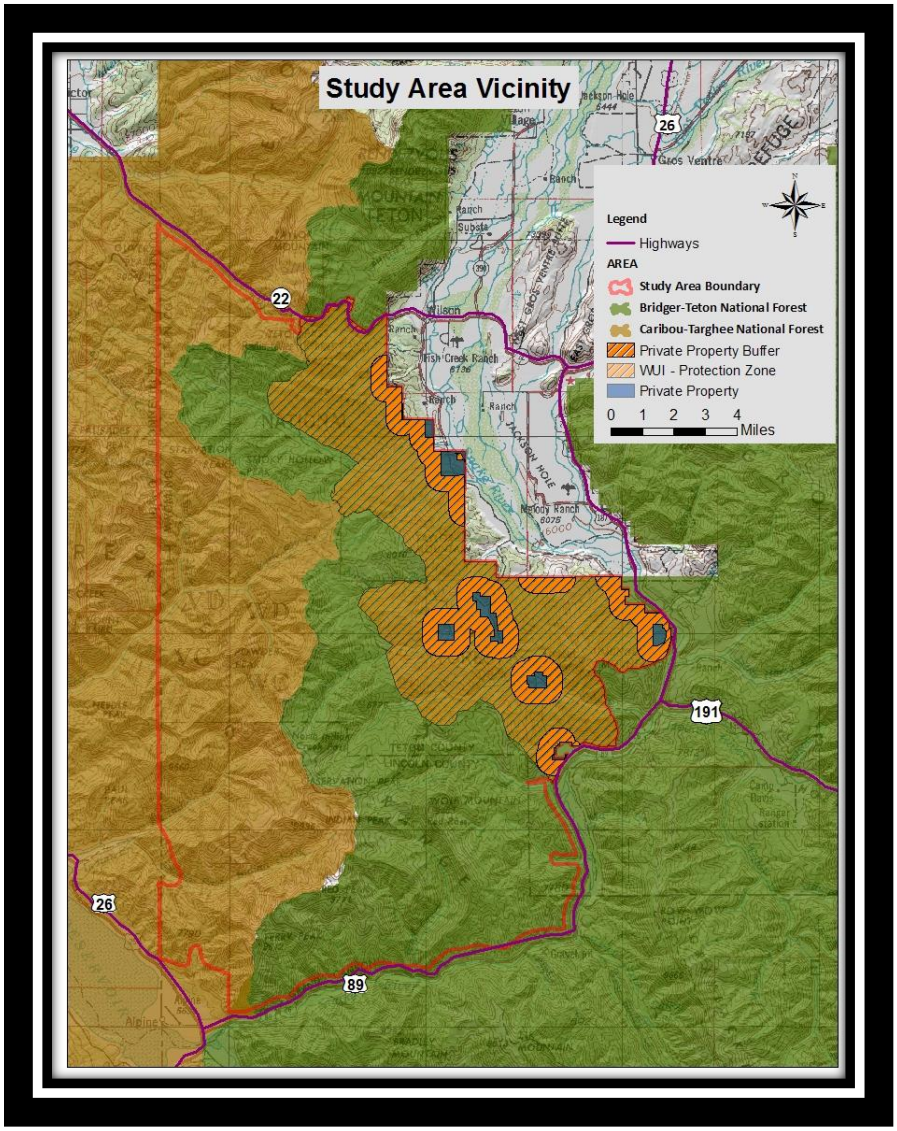
The Bridger-Teton National Forest contains three Wilderness Areas and two Wilderness Study Areas (Figure 2). The 428,087 acre Bridger Wilderness is located on the west slope of the Wind River Range on the Pinedale Ranger District. The Teton Wilderness is located on the north end of the Forest. It is bordered on the north by Yellowstone National Park, on the west by Grand Teton National Park and on the east by the Washakie Wilderness (Shoshone National Forest). The Teton Wilderness is 585,238 acres and is a part of the Buffalo Ranger District. The Gros Ventre Wilderness is 317,784 acres and lies on the east side of the Jackson Hole valley. It is part of the Jackson Ranger District. The Shoal Creek Wilderness Study Area, managed by the Big Piney Ranger District is 30,000 acres and lies along the southern edge of the Gros Ventre Wilderness Area. Finally, the Palisades Wilderness Study Area is made up of 135,840 acres and lies on both the Caribou-Targhee National Forest and the Bridger-Teton National Forest. It is jointly managed by both Forests.

FIGURE 2. Bridger-Teton Wilderness and WSA's



The study area (Figure 3) lies in the North Zone of the Bridger-Teton National Forest. It incorporates extents of the Palisades Wilderness Study Area that lie in Wyoming and portions of the Teton to Snake Fuels Management Project area. The analysis area is bounded on the south and east by the Snake River Canyon (Highway 89) and Private lands, on the north by Wyoming State Highway 22 (Teton Pass), and on the west by the Wyoming State line and the Caribou-Targhee National Forest. The analysis area is inclusive of a small portion of the Caribou-Targhee that is administered by the Bridger-Teton N.F. (U.S.D.A. Forest Service 2010), and together with the middle and southern units of the Teton to Snake Fuels Management Project area, represents over 156,000 acres.

FIGURE 3. Study Area



The Teton to Snake Fuels Management Project:

> "...would implement fuels management activities on national forest system (NFS) lands that comply with the 2005 Teton County Wildfire Protection Plan (Teton County 2005) and move the landscape toward the desired future condition outlined in the Bridger-Teton Land and Resource Management Plan (1990)." (U.S.D.A. Forest Service 2010)

Project objectives describe the need to treat fuels in wildland urban interface (WUI) areas to include mechanical thinning and prescribed fire, designed to reduce current fuel loading levels and enhance aspen stand regeneration. By reducing fuel loading in WUI areas around the Palisades WSA, risk to residences, firefighters, improvements, and infrastructure will be reduced. And, by reducing risk to values in the WUI, natural fire in the WSA can be managed with much more flexibility and fewer impacts on Wilderness character. This will aid in meeting the objectives 1 and 2 (2324.21) in the Forest Service Manual Direction for fire management in Wilderness and Wilderness Study Areas which permits lightning to play its natural ecological role, and to reduce risks of fire escaping Wilderness to an acceptable level.

The Teton to Snake Fuels Management Project is important to this study in its overlap with the Palisades WSA, its boundaries with private property, its common borders with the project analysis area, and the need to implement actions identified in the Proposed Action (See Appendix A for a map of Teton to Snake Fuels Management area and proposed actions). Additionally, the Teton to Snake project has generated questions surrounding what fuel characteristics are "natural." Comments from the Teton to Snake project record challenge the idea that suppression has impacted processes of ecological change and that suppression has not altered fuels characteristics and risk of large fire. By modeling historic fire ignitions, this analysis provides theoretical quantification of the impacts suppression may have had even if only a few fires spread as modeled (Appendix B).

The Palisades WSA was designated by Congress as part of the 1984 Wyoming Wilderness Act (USDA Forest Service 1990, amendment 3-C). Desired future conditions of the Palisades WSA put emphasis on natural processes and protection of wilderness character (U.S.D.A. Forest Service 2010). Of the 135,800 acres comprising the Palisades WSA, 82,584 lie in the Bridger-Teton National Forest. Elevations range from just over 6000 feet to almost 11,000 feet and represent diverse ecosystems ranging from high alpine rock formations and cliffs, to subalpine conifer stands and montane parklands, as well as aspen communities and shrub lands in the lower elevations.

A great variety of vegetation exists in this area. Coniferous forests consist of Lodgepole pine (*Pinus contorta)*, Subalpine fir (*Abies lasiocarpa*), Douglas-fir (*Pseudotsuga menziesii*), Englemann Spruce (*Picea engelmannii*), Limber pine (*Pinus flexilis*), and Whitebark pine (*Pinus*

albicaulis), among others. Deciduous forest is comprised mainly of quaking aspen (*Populus tremuloides*), with a small component of cottonwood (*Populus angustifolia*) usually in broad drainage bottoms. Shrublands in the analysis area are primarily classified as mountain big sagebrush (*Artemisia tridentata*).

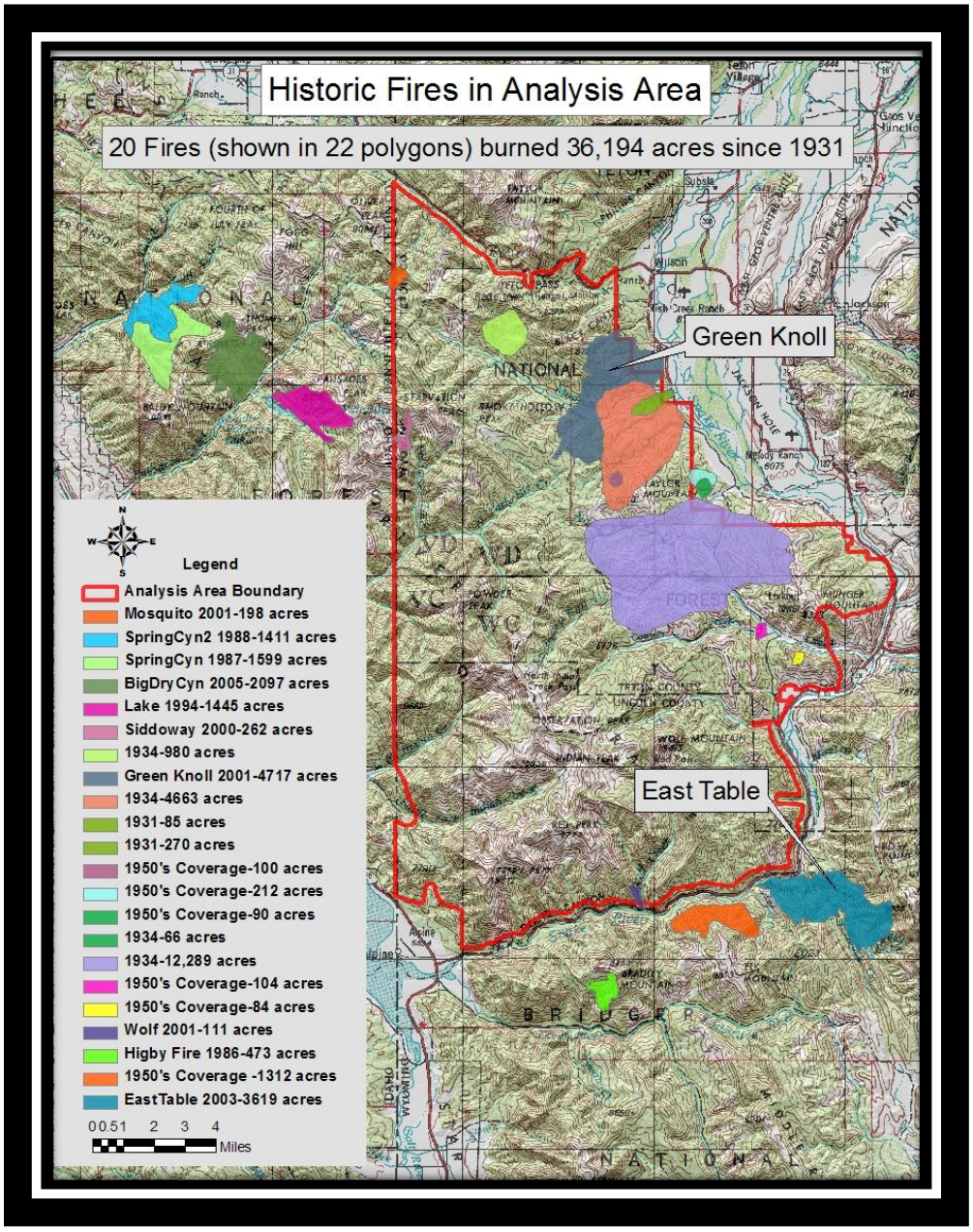
This diversity in vegetation provides habitat for a correspondingly high number of fauna. The analysis area is suitable for elk (*Cervus canadensis*), moose (*Alces alces*), mule deer (*Odocoileus hemionus*), big horn sheep (*Ovis canadensis*), lynx (*Lynx canadensis*), beaver (*Castor canadensis*), bear (*Ursus Americanus* and *Ursus arctos horribilis*), grey wolf (*Canis lupus*), wolverine (*Gulo gulo*), mountain goats (*Oreamnos Americanus*), cutthroat trout (*Oncorhynchus clarkii*), several owl species, bald eagle (*Haliaeetus leucocephalus)*, coopers hawks (*Accipiter cooperii*), sharp-shinned hawks (*Accipiter striatus*) and Northern goshawk (*Accipiter gentilis*).

The presence of fires on the landscape surrounding the study area has been documented since before the turn of the 20th Century. T.S. Brandegee (1899), in an 1897 U.S.G.S. survey for timber reserves states:

> "It is only occasionally that tracts of timber of merchantable size are found, and areas containing notable quantities of merchantable forests are few and limited.
>
> This condition appears to be due simply and solely to fires which have swept over the country so completely and persistently that scarcely any part has been entirely exempt from them, while nearly all portions have been burned again and again within a generation…"

Indeed, extensive areas of the Jackson Hole valley burned in the 1800's with large fires burning around the early 1840's, mid 1850's, and late 1870'-mid 1880's (Loope and others 1973). More recently, large fires burned in portions of the study area during the 1930's (Loope and others 1973). However, the only significant fire to occur in the study area since the 1930's was the Green Knoll fire which burned 4717 acres in 2001. Figure 4 shows large fires in and around the study area since the 1930's.

FIGURE 4. Historic Fires



These historical fire perimeters illustrate that fires tend to move to the east and grow large in this area, even under full suppression strategies (i.e. the Green Knoll, and East Table fire).

In addition to protecting and enhancing flora and fauna, the Bridger-Teton National Forest is mandated by the Forest's Fire Plan Amendment (2004) to protecting values from fires coming out of the wilderness area. According to the Teton County, Wyoming Community Wildfire Protection Plan (CWPP) (2005) there are 50,178 acres of Wildland Urban Interface identified as

being in or adjacent to the Teton to Snake Fuels Management Project area. The Proposed Action divided the WUI into two classifications; the defense zone which extends one-quarter mile from private property boundaries, and the threat zone which includes the remaining area within the wildland urban interface. The defense zone for this study was extended to one-half mile around private lands to account for observed spotting distances which have potential to impact private property. Extending the defense zone buffer also adds a margin of safety for managing future fires which have potential to burn onto private property.

Two WUI areas identified in the Teton County CWPP (2005) describe the hazard level as "High to Extreme." Subdivisions within these areas include Crescent H Ranch, Aspen Cove, Indian Paintbrush, Heck of a Hill, Cameron Road, Elliot Cemetery, Trail Creek Ranch and Wooded Hills. Subdivisions listed as moderate to high hazard include Fall Creek Ranch, Red Top Meadows, Trails End Ranch, and Hidden Hills Ranch. All of these wildland urban interface areas lie along the eastern side of the analysis area and are threatened by fires driven by south/southwest winds characteristic of the study area. On the east side of the analysis area there is a protection zone defined by the Fire Management Plan (2011), and mirrored by the CWPP (2005). This WUI will be referred to in this study as the "protection zone."

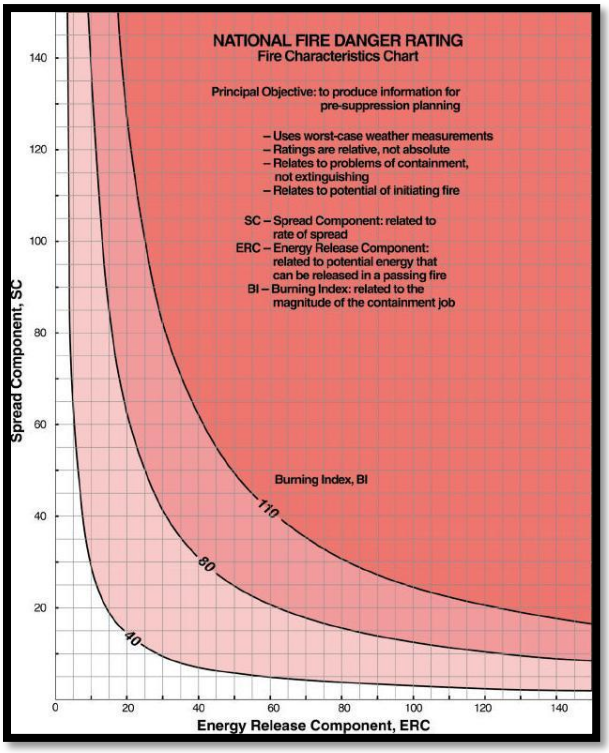
Highway corridors are identified as values for several reasons. First, they serve as boundaries for the analysis area. Second, the highways serve as power-line routes through the Jackson Hole valley, and to communities and infrastructure in Jackson Hole. Third, these routes serve as important commuter, tourist, and commerce travel routes to the Jackson Hole area. Closure of these highways for even a short duration would have significant financial and economic impacts for area residents and businesses. Finally, tourism would be greatly impacted as access routes to and from the Jackson area are very limited.

Weather in the study area varies greatly. Summers, while short, can be warm and dry, with daytime highs typically in the mid 80's and nighttime lows in the mid to low 40's (as recorded by the Grand Teton Remote Automated Weather Station.) It is not uncommon for valley temperatures to reach into the 90's at mid-day, and for temperatures to drop below freezing in early and late summer in the upper elevations. Daytime high temperatures are generally several degrees lower in the higher elevations. Yearly variations in precipitation vary considerably as well, with most of the yearly precipitation occurring as snow during winter months. The climate can be characterized as "dry continental" (U.S.D.A. Forest Service 2010).

Energy Release Component (ERC) is commonly used to assess fire hazard. Indeed, in a fire behavior report for the Bridger-Teton, Helmbrecht (2010) states that 80 percent of fires larger than 100 acres started when ERC was above 90th percentile and 60 percent of fires larger than 200 acres started when the ERC was above 95th percentile. However, many fires on the Bridger-Teton that are resistant to control or have exhibited large growth also correlate to Burning Index. ERC represents the potential heat release, and is driven largely by fuel moistures. Figure 5 illustrates how Burning Index is comprised of Spread Component (SC) ***and*** Energy Release

Component (ERC) (Andrews and others 1982). Wind speed, slope and fine fuel moisture are used to compute SC, and create high variation from day to day (Andrews, P.L. and others 1982). Thus, the BI exhibits large variation in daily values as well (Schlobohm and others 2002).

FIGURE 5. BI Chart



In discussions with North Zone Fire Managers, it was decided to use Burning Index to create weather stream categories for this analysis. Burning Index (BI) captures a critical element of fire spread in this area; namely wind. Typical fires on the Bridger-Teton National Forest spread through torching, spotting, and short run wind-driven crown fires. Although spotting was not used in the analysis, the wind component of Burning Index is important in producing fire growth similar to that typically observed in the surrounding areas. Wind helps to simulate conditions closer to "worst case" for the study area.

The Green Knoll (2001) and more recent Red Rock (2011) fires illustrate the benefit of using BI as an indicator of large fire growth. The Green Knoll fire was one of the largest in the area, and grew to 4717 acres despite full suppression strategies. It started on a day below the 90th percentile ERC and remained below the 90th percentile during much of its growth. The days when ERC was below 90th percentile were characterized by record high BI. During the time when ERC was comparatively low and BI was very high, the fire made some of its largest runs and showed high resistance to control efforts (Appendix C). This phenomenon was observed

again in 2011 on the Red Rock fire which burned 9800 acres. During the main growth period between August 22nd and September 6th, the ERC remained below 70th percentile, while the BI was well above 70th percentile (Appendix D).

The suppression of fires in the Palisades WSA, while dictated by risk to life and property, is threatening ecological processes and may increase fuel continuity. Fires of all sizes and burning under various weather conditions, contribute to natural breaks in fuels, vegetative mosaics, and age class diversity. While unplanned fires are being managed to achieve multiple objectives in Wilderness areas of the Bridger-Teton National Forest, the Palisades WSA presents special challenges to decision makers and land managers. The Jackson District Ranger is uncertain under which conditions fires can be managed to accomplish resource objectives while still managing risk to neighboring communities and sub-divisions in the area. By looking at how historical fire ignitions would have burned under various Burning Index weather scenarios, this project is intended to assist the District Ranger and Fire Management Officers to make informed decisions in this critical area.

As new fires burn in the Palisades WSA or as fuels conditions change over broad areas, the results of this study will no longer be accurate. While the results of this study are temporally limited, fire management's goal is to maintain the natural role of fire within the Palisades WSA will help return an agent of natural change to the landscape. This will also keep the WSA eligible for being designated Wilderness as required by the Wyoming Wilderness Act (1984). There are unquantifiable risks and unforeseen circumstances when attempting to balance natural processes in proximity to communities and infrastructure that have inherent and monetary value. Ironically, the more fire is allowed to play its natural role, more natural breaks in fuel continuity may result in reduced risk to those same values we have tried to protect through suppression.

Scope & Limitations

This study provides information to aid line officers and fire management officers make decisions to effectively manage naturally ignited fires in the Palisades WSA with regard to the values in and surrounding the 156,000 acre analysis area.

Multiple fire ignitions are simulated in FARSITE for this study. Each of these fires was modeled on the current landscape. Any fires burning in the analysis area will change the fuels characteristics, and subsequent fires in the area will not burn as modeled. Other disturbances which impact the fuels in the area, such as beetle kill, blow down, or landslides, will impact this analysis and its usefulness in the future for decision support.

With all future fire ignitions in the Palisades Wilderness Study Area, fuel conditions, time of year, weather forecasts, resource availability, and other current fires will influence the decisions with respect to whether or not fires will be suppressed or managed long term for multiple objectives. The North Zone Fire Management Officer developed estimates of the percentage of fires which might be managed on the zone through non-suppression strategies (Johnston, personal communication 2011; Helmbrecht 2011). Even these percentages (Appendix E) will be subject to information and resources at the time of a future fire, and not strictly observed. The results and recommendations of this paper do not take into account these and other circumstances that necessarily impact management decisions.

This analysis is focused from a Jackson Ranger District perspective. This study does have relevance, however, for long-term managed fires which may spread to the west impacting the Caribou-Targhee National Forest, and fires moving east from the Caribou-Targhee onto the Bridger-Teton. Coordination between decision makers of these units will be necessary to agree upon management actions. Those decisions are beyond the scope of this analysis.

Decision Makers Problem Statement

The Jackson District Ranger has expressed uncertainty that 5 percent or less of unsuppressed, long duration fires starting in the Palisades Wilderness Study Area will impact values adjacent to the WSA.

Management Goal

The Bridger-Teton National Forest strives to manage wildland fuels and fire in Wilderness and Wilderness Study Areas by transitioning from full suppression to use of natural fire as directed by the Bridger-Teton Land and Resource Management Plan Revision of Fire Management Standards and Guidelines (2004) which states: "Fire management emphasizes preservation of Wilderness values and allows natural processes of ecological change to operate freely."

Project Objective

The objective of this analysis is to test the hypothesis that 5 percent or less of unsuppressed fires that start in the Palisades Wilderness Study Area will impact values surrounding the analysis area. A confidence level of 95 percent, $\boldsymbol{\alpha = 0.05}$, was used to assess statistical success.

Methods

The primary tools used for this analysis were FARSITE (Finney 2004) version 4.1.055, ArcGIS 9.3 –ArcInfo (ESRI 2009), and FireFamily Plus 4.1 Beta (2009).

FARSITE was used to model fire growth and spread of 108 ignitions within the boundaries of the Palisades WSA.

The analysis requires seven steps:

1. Defining the analysis area
2. Selecting the ignition data
3. Selecting the weather stream
4. Compiling fuels data
5. Calibrating of FARSITE inputs
6. FARSITE modeling
7. Conducting statistical analysis of impact fires

Analysis Area

The analysis area for this project includes the Palisades WSA, and the middle and south units of the Teton to Snake Fuels Management Project area. The Jackson District Ranger expressed a willingness to implement non-suppression strategies for fires moving from Wilderness into the protection zone, but to suppress fires that start in the protection zone. A one-half mile buffer was created around private property to serve as the impact threshold for to private lands.

The north end of the analysis area is defined by Wyoming State Highway 22 which runs east to west. This highway follows a large natural drainage on the east and west sides of Teton Pass. The highway corridor also has a high voltage power line used to supply the Jackson Hole area and is maintained by the Bonneville Power Administration. Fires coming into contact with the highway, or moving across it, were counted as impacting that value, as interruption of highway traffic or electrical power by a fire event would not be acceptable.

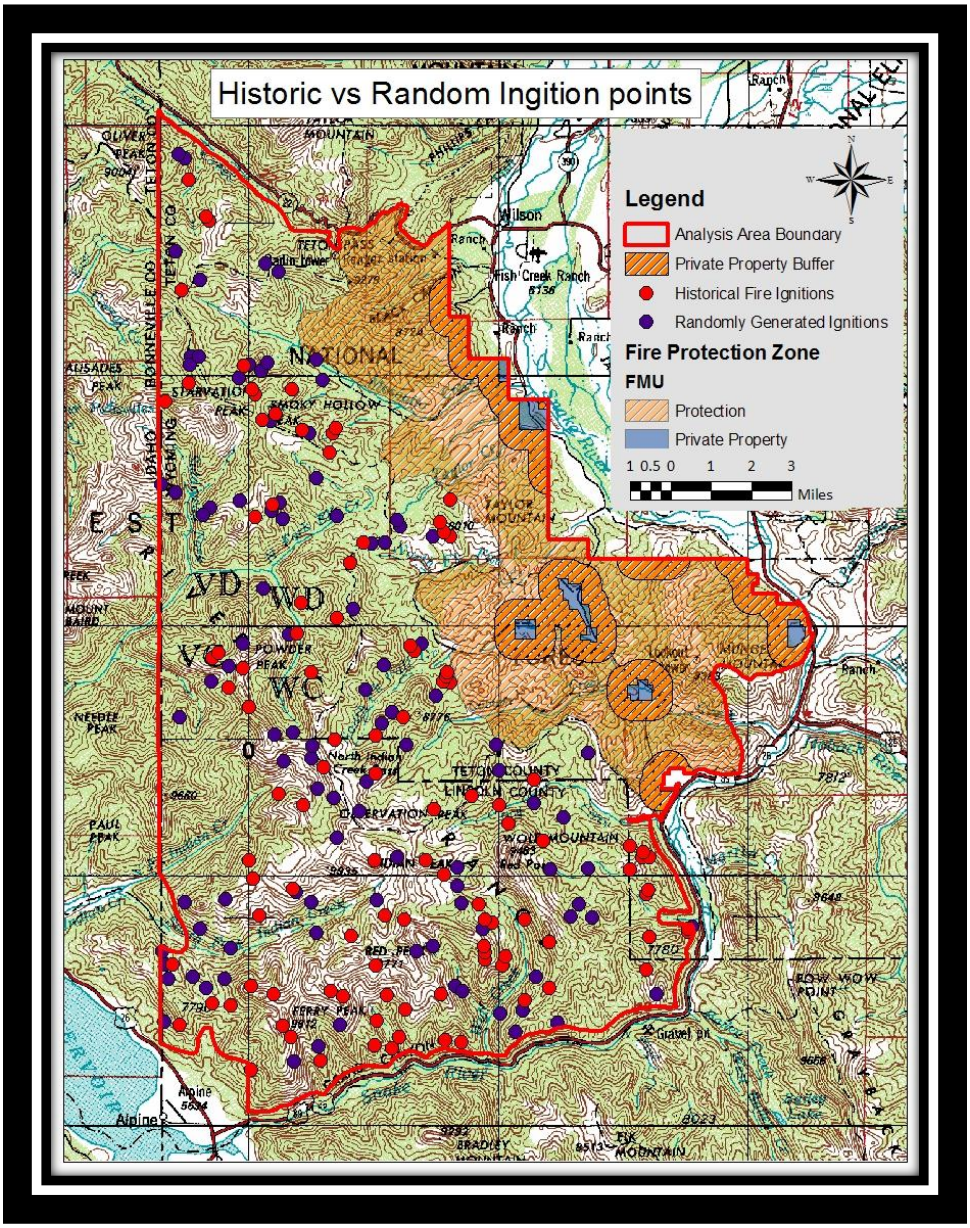
Similarly, the south end of the analysis area is defined by the Snake River Canyon and Highway 89, which runs east to west through the canyon. The Snake River corridor in this area is designated as a Wild and Scenic River, and as such, natural fire is allowed. However, the Wyoming Department of Transportation would be averse to allowing fire to interrupt transportation values.

Ignition Data

Consideration was given to generating random points for this analysis. However, it was decided that historical lightning fire ignition points would be used. Using historical fire occurrence in the form of geospatial ignition patterns for use in risk modeling has been used in Large Fire Simulator (FSim) modeling (Scott and others 2012, Helmbrecht 2011). Ignitions (108) were compiled from fire records from the Bridger-Teton and Caribou-Targhee National Forests. These ignitions represent lightning starts over the period from 1971 to 2010. This period represents the most complete fire history data for which records were available at the time of compilation. Due to the number and distribution of the fire locations, it was determined that there was more than adequate spatial and sample representation. Fires generated by random points or grid overlay also risk putting ignitions in areas not likely to be impacted by lightning or unlikely to support an actual fire. Also, by using historical ignition data, answers to other questions concerning fire suppression impacts in the analysis area may be inferred.

Forty-three fire ignitions located within the protection zone (WUI) on the east side of the analysis area were eliminated. It is important to note that seventeen of the fire ignitions excluded from this analysis were located in the Palisades WSA where it overlaps with the Teton County CWPP (2005) protection zone. The Jackson District Ranger has always chosen suppression of fires that start in the protection zone. There were no exclusions based on proximity to the protection zone within the Palisades WSA, or along the highway corridors. The following map (Figure 6) shows 100 Random ignition points created using Hawths tools (Beyer 2004) in purple and historic fire ignitions in red. Visual inspections show a high degree of common spatial coverage, with both models showing some gaps and some clumping of start locations.

FIGURE 6. Comparing Historic and Random Ignitions



Weather

Weather data files from Grand Teton RAWS were used to compute Burning Index for this study. The Grand Teton RAWS proximity to the study area, comprehensive weather data, and its wind representations made this station desirable for use. The Hoback RAWS, while also in proximity to the study area, did not have wind data that was representative of the Palisades WSA, likely due to terrain influences close to the RAWS site. The Pine Creek RAWS, located to the west of

the study on the Caribou-Targhee N.F., was also excluded because of incomplete weather data. Weather for the Grand Teton RAWS was downloaded from the Western Regional Climate Center into Fire Family Plus and input into FARSITE in .fw9 format.

Using Fire Family Plus, theoretical weather streams were generated by gathering historical weather from days which met the BI criteria for 50th, 70th, and 90th percentile. Days with precipitation were excluded, and the remaining day's temperatures and humidity were averaged to produce a homogenous weather stream for each of the BI categories which are summarized in Table 1.

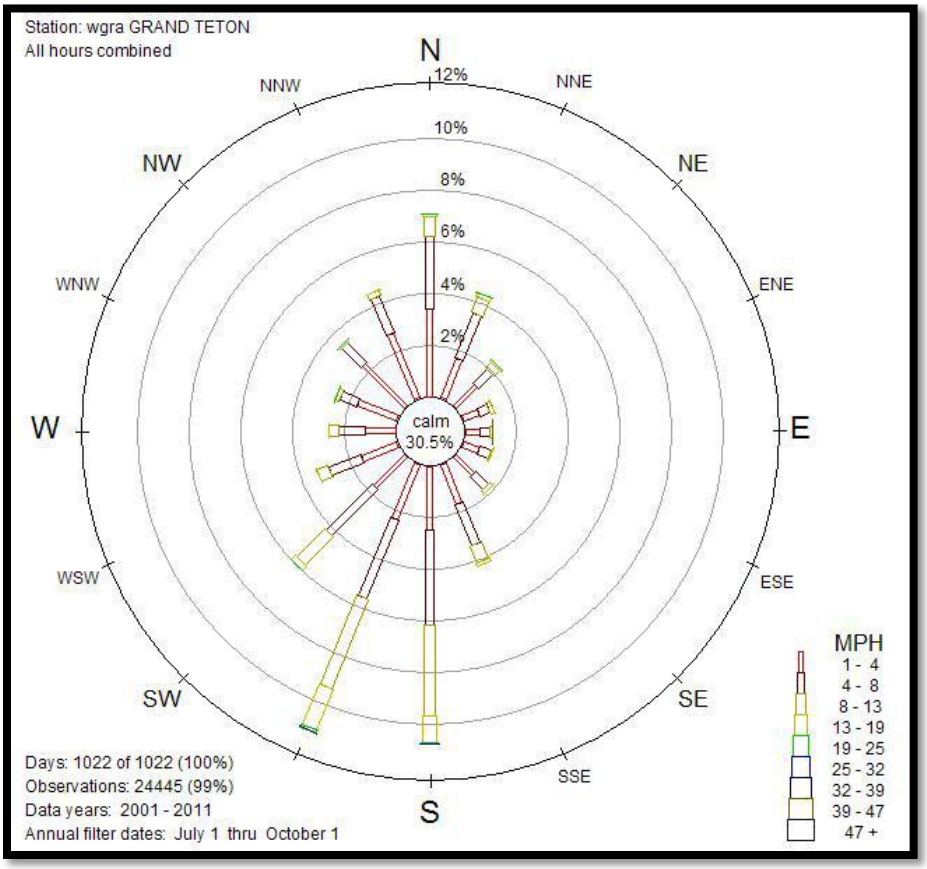
TABLE 1 : Percentile Weather Values

50th Percentile Weather				
Low Temp	High Temp	High RH	Low RH	*Avg. Wind Speed
39	78	76	16	4.9
70th Percentile Weather				
Low Temp	High Temp	High RH	Low RH	*Avg. Wind Speed
41	81	71	15	5.4
90th Percentile Weather				
Low Temp	High Temp	High RH	Low RH	*Avg. Wind Speed
42	82	69	16	6.5

*Hourly wind speeds were used in all FARSITE runs. Avg. Wind Speed is average of all winds during the 0900-2200 hour burn period file used in FARSITE modeling runs.

Because of the tendency for BI to exhibit large daily variation, the compilation of weather for two weeks at the same BI lends itself to a more extreme case and will be prone to larger fires over that temporal period than would historical weather. This is especially true of the 90th percentile weather data. Wind readings from the corresponding days were used to develop wind files for the BI categories of 50th, 70th, and 90th percentile. Wind files retained hourly data format and averages are displayed in Table 1 above. Figure 7 shows the wind rose from Grand Teton RAWS. The south and southwest wind component are the directions of concern for line officers and fire management officers in the analysis area because of the potential to push fires toward developed areas. For this analysis winds were generalized to a southwest component (225 degrees) for comparative purposes between BI categories.

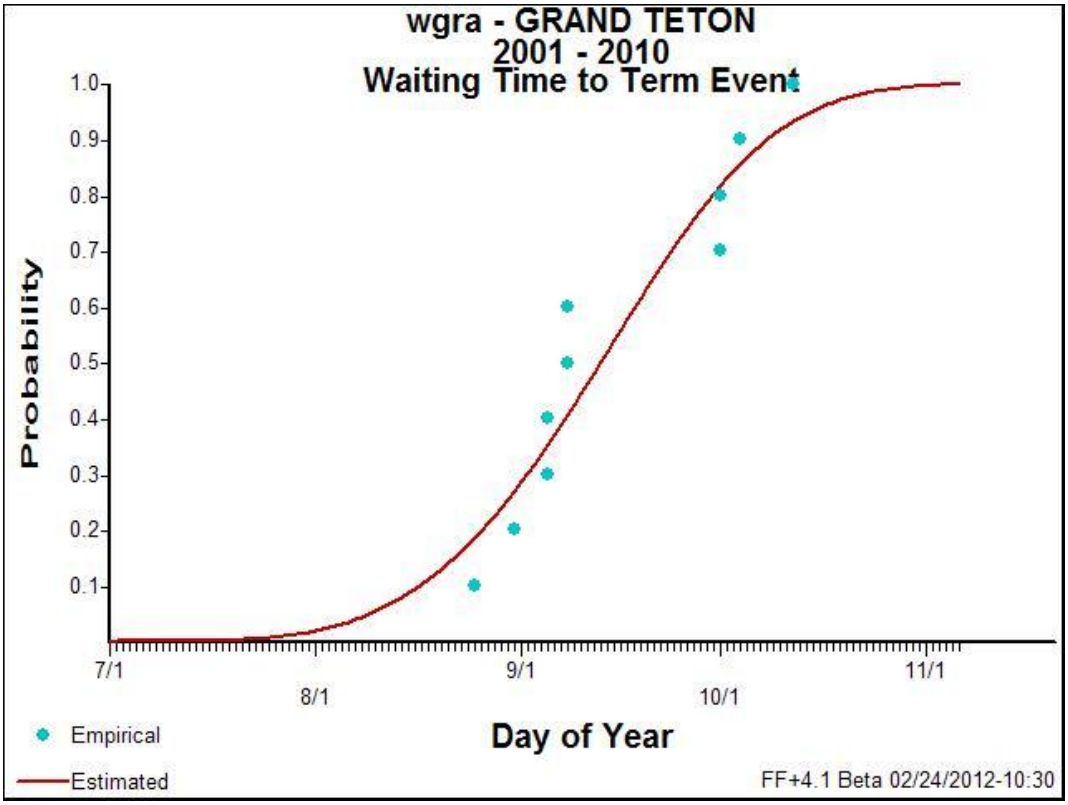
FIGURE 7. Grand Teton Wind Rose



Fire history records and the Bridger-Teton National Forest Fire Management Plan (2011) show over 80% of fires occur during the months of July, August, and September. October sees the next highest percentage of fires, although October fires are usually limited in size due to their proximity to season ending precipitation events. There is a high occurrence of hunter caused fires during October, but few natural ignitions. Since this study only considered natural fire ignitions for non-suppression management strategies, the fires in October were disregarded.

Using the Term Event function in Fire Family Plus, a season slowing event (Figure 8) was calculated for the years of 2001 to 2010. It was determined that a season slowing event on or before the end of Sept would allow subsequent drying, but after the end of September chance for larger fire growth was greatly reduced. The definition of a season slowing event was one-half inch of precipitation in a three day period. This historical period shows a 90 percent chance of a season slowing event by about October 2nd. The term event analysis supports the use of July, August and September weather data for the study.

FIGURE 8. Term Event



Fuels

Updated and locally calibrated LANDFIRE data were used in the Landscape (LCP) files utilized in FARSITE. These calibrations included removing much of the over-represented TU5 and converted recently burned areas to TU1. Changes to the LCP in 2010 updated canopy base heights (CBH) and canopy bulk density (CBD) to better reflect current conditions. Figure 9 displays fuels distribution in the LCP, and Figure 10 shows fuels composition in the analysis area.

FIGURE 9. FARSITE Fuels

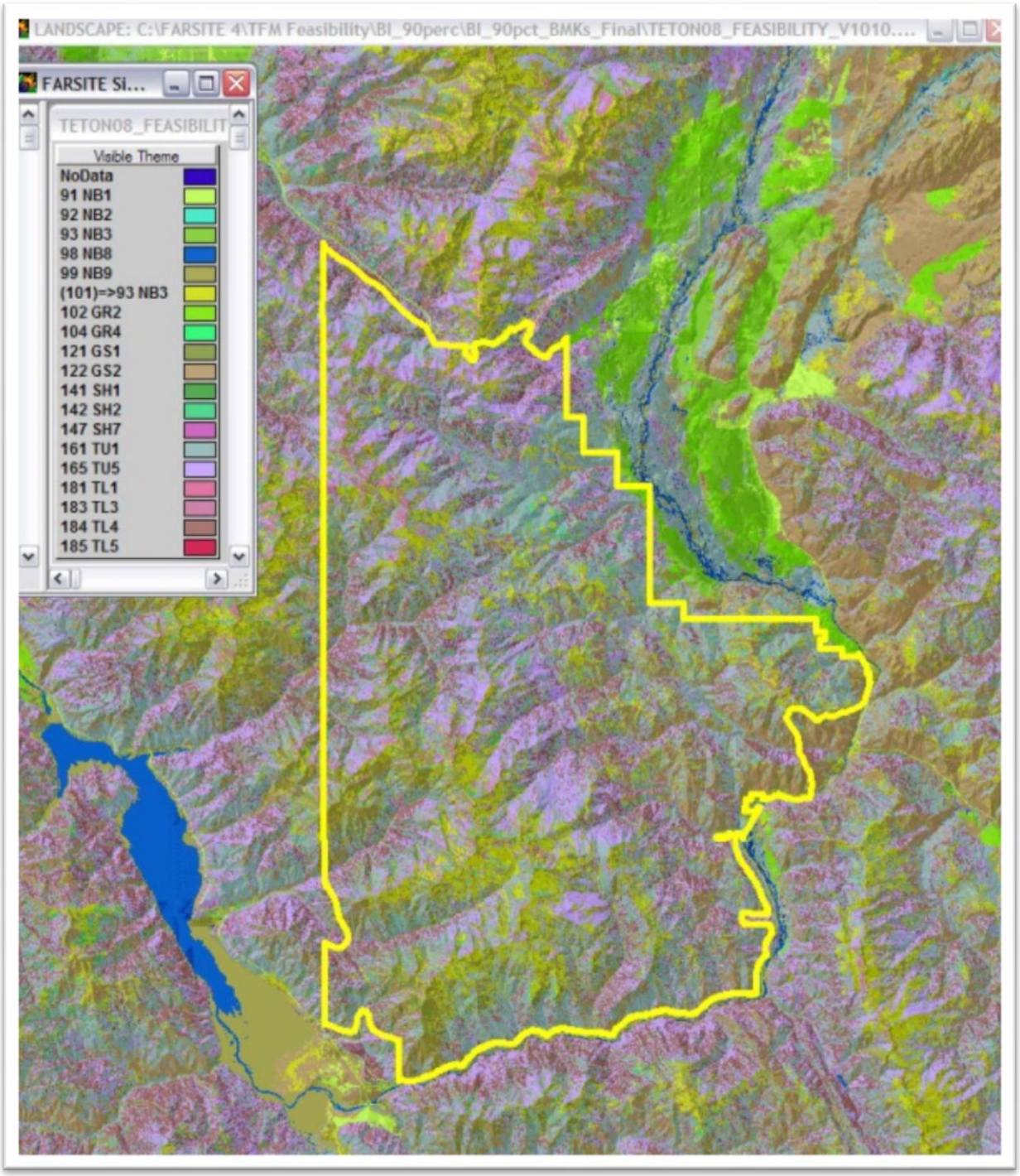
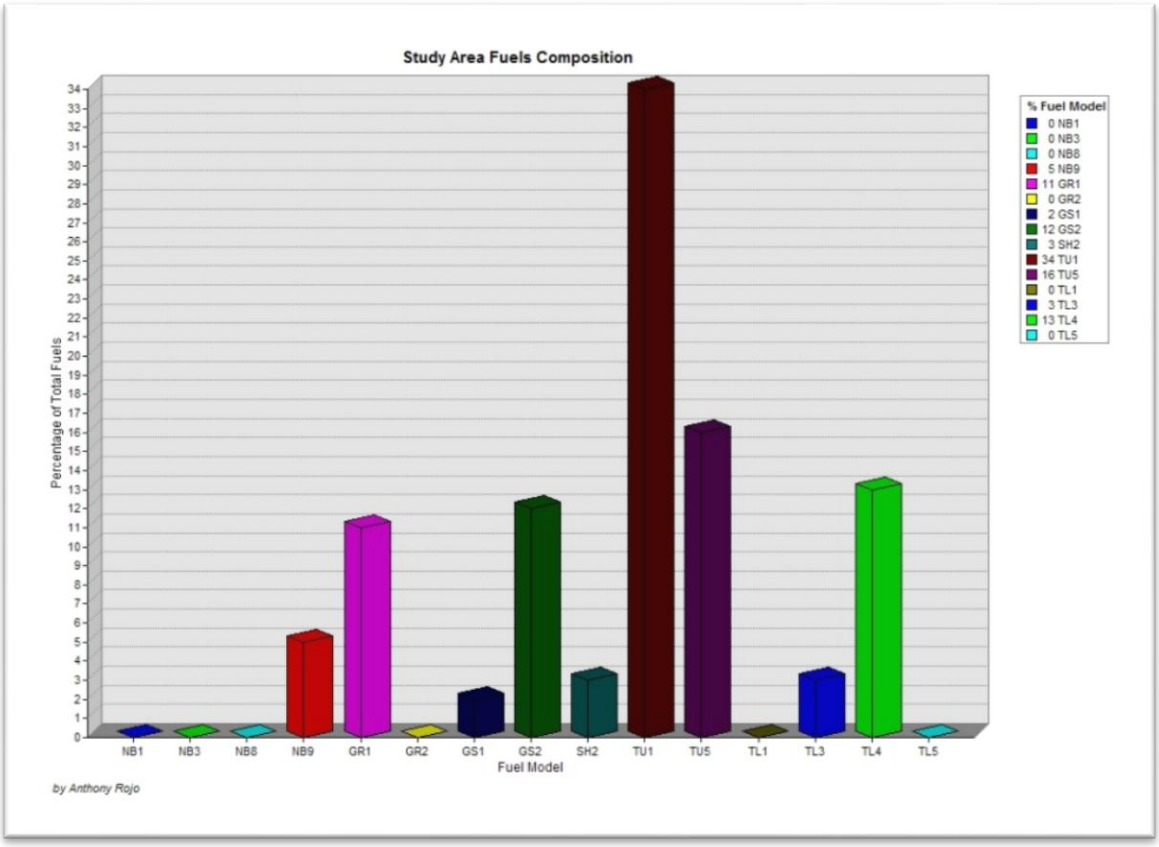


FIGURE 10. Study Area Fuels Composition



Short, sparse dry climate grass (GR1) and moderate load, dry climate grass-shrub (GS2) are well represented in the analysis area (Scott and others 2005). While the Jackson Hole valley area has experienced some large sage and grass fires (i.e. Row Fire, 1994; Blacktail Butte Fire, 2003) these fuel types generally do not contribute to fire spread in the higher elevations represented in the analysis area. These fuel models will typically only burn when they are adjacent to timber fuel models and are impacted by the radiant heat from the timber. It was decided to convert these grass and grass/shrub fuel models to non-burnable agricultural (NB3) (Scott and others 2005) in the 50th and 70th percentile FARSITE modeling to avoid over predicting fire spread. GR1 was converted to NB3 for all FARSITE runs as it is generally too sparse to contribute to fire growth even under more severe fire weather conditions at higher elevations. Pictures below of the Red Rock fire (2011) in Figure 11, and the Green Knoll fire (2001) in Figure 12, illustrate how fuel type changes affect fire spread in the terrain, and at elevations, typical of the analysis area.

FIGURE 11. Red Rock Fire.

FIGURE 12. Green Knoll Fire

Note: Grass/Shrub fuels do not carry fire beyond the extent of forest fuels.

Fuel moistures vary through the years and seasons. Based on Scott and Burgan's (2005) dynamic fuel model process and level of curing, live herbaceous and live woody fuel moistures were developed for the weather categories to represent mostly uncured fuels for the 50th percentile category, about 25 percent cured for the 70th percentile category, and almost 50 percent cured for the 90th percentile category (Appendix F) . Scott and others (2005) recommend working backwards from field observed levels of curing. Live herbaceous fuel moistures observations from local fuel moisture graphs (Steffens, personal communication, December 2011) show values as low as 78 percent. This aligns well with fuel moistures used for this analysis.

FARSITE Calibration

Multiple test runs were performed in FARSITE for calibration. Two fires were chosen for the calibration runs. The Bull fire of 2010 burned 5,429 acres in an area about 10 miles east of the study area. The Red Rock fire was located about 25 miles to the north-east and burned about 9800 acres. These fires were both long duration events with few management actions that affected the final perimeters or acreage. The Bull and Red Rock fires were also similar in fuel types and elevation to those modeled in FARSITE for this analysis.

Using actual ignition points, historical weather and modified wind data (Grand Teton RAWS wind directions were not aligned to drainage features dominating the calibration fire sites; winds were modified for calibration to align more consistently with the fire site locations), FARSITE modeling runs were set up using calibrated LANDFIRE landscape files created for the Bridger-Teton National Forest. Modifications to the landscape file's CBH, and CBD (Helmbrecht 2010) reduce the tendency toward crown fire when using FARSITE, and better represent the way fire spreads in fuels across the Bridger-Teton National Forest where torching and spotting tend to carry fire more than continuous ground fuels or crown fire. In this way, the FARSITE runs could be compared to the actual progression and final perimeters of the fires. The decision was made to disable the spotting feature in FARSITE as it contributes considerably to the duration of the run. These modifications allowed fire to spread in similar patterns to those observed on the actual fires used for calibration. An example of the calibration runs is exhibited in Appendix G.

The calibration of FARSITE becomes problematic for long term events. While the nature of FARSITE to over-predict fire spread (Finney 1998) is tempered by the updated landscape files, there is still a significant amount of over-prediction, as the model maintains an active fire perimeter for the duration of the event. In "real life" many areas of the perimeter burn themselves out and/or cease to contribute to fire growth over time. This is particularly true for lighter fuels such as the grass and shrub models. Simulation time also poses a problem for modeling long term events. This is inevitable as the number of calculations FARSITE must

perform increases as the fire perimeter increases. To limit the complex calculations FARSITE must compute, Mitch Burgard (personal communication, November 2011) recommended "averaging out the effects of spotting on long duration fires through the use of surface spread…" This was accomplished by using fuel model conversions and fuels adjustments to mimic the spread of fires that actually spread via spotting. Limiting FARSITE run duration to 14 days also eased computer modeling simulation run times.

Calibration runs for the Bull and Red Rock fires showed good correlation to total acres burned. Fire perimeters were more accurate during the first part of the simulation, and tended to deviate for the latter part of the simulation. This is probably due to the differences between the modeled fuel types being "homogenous" for each computerized representation whereas actual fuels on the ground show more variation.

FARSITE Modeling

FARSITE requires landscape data in the form of a landscape file (LCP) which includes raster data layers of elevation, slope, aspect, fuel models, and canopy cover. Landscape data was locally calibrated in a workshop held in November of 2009 with collaboration with the Bridger-Teton N.F., Grand Teton N.P., and representatives from the LANDFIRE program and Missoula Fire Sciences Lab (Helmbrecht 2010). Weather and wind data were developed from RAWS data collected and processed using Fire Family Plus. Fuels adjustments and conversions were developed in the calibration runs done on the Red Rock and Bull fires. Each of the 108 ignitions was modeled under all three weather streams and fuels adjustments.

FARSITE runs were completed using the following parameters:

- Time step 3 hours
- Visible time step 1 day
- Perimeter resolution 60 meters (default)
- Distance resolution 30 meters (default)
- Burn period set from 0900 hours to 2200 hours

Crown fire was enabled as was the Scott and Reinhart (2001) method for all BI percentile categories. Canopy characteristics were set to defaults, changing tree type to Subalpine Fir with medium tolerance in the 50th, and 70th percentile categories and low tolerance in the 90th percentile category. Export and Output files for ARCVIEW shape files and time of arrival (TOA) raster files were selected for each run. Ignition files were generated in ArcGIS using

historical fire points buffered to 10 meters, as FARSITE runs better with a shape file, rather than a point ignition (Williamson, personal communication, November 2011).

Output perimeters were imported into ArcMap 9.3. These perimeters were then placed on a map of the analysis area showing the private land boundaries and highway corridors. If any part of the fires reached any of identified values, they were considered as having impacted that value.

Statistical Analysis

This analysis tests the null hypothesis that 5 percent or less of naturally ignited fire will impact WUI defense zone buffers or Highways surrounding the Palisades WSA and Teton to Snake Fuels Management Project area. The alternative hypothesis is that more than 5 percent of fires will impact WUI defense zone buffers or Highways. This will be tested at the 95 percent confidence level where $\alpha = 0.05$. To test the null hypothesis that 5 percent or less of naturally ignited fires will impact values, $p_o = \leq .05$ is used in a z test for large-samples using the continuity correction (Freund and others 2007). "x" is the binomial distribution or number of successes, defined by the number of fires that did impact the private property buffer or highways adjacent to the study area. "Since x is a discrete random variable, many statisticians prefer to make the continuity correction that represents x by the interval from $x - \frac{1}{2}$ to $x + \frac{1}{2}$ …" (Freund 2007).

$$z = \frac{x \pm \frac{1}{2} - np_o}{\sqrt{np_o(1 - p_o)}}$$

The normal approximation to the binomial distribution should be used only when *np* and *n*(1-*p*) are both greater than 5; where "*n*" is the sample size and "*p*" is the probability of success.

$np > 5$ and,

$n(1-p) > 5$ (Fuend, J.E. 2007.)

Since: $np = 108*0.05 = 5.4$ and,

$n(1-p) = 108(1-0.05) = 107.95$;

The statistical requirement for use of the normal approximation to the binomial distribution was satisfied and used for proportions with large sample size for all of the BI categories.

The z score cut-off for 95 percent confidence is 1.645, otherwise known as the fence. In other words, 95 percent of z values fall to the left of the fence, and 5 percent of z values lie to the right

of the fence (see *results* section.) If the calculated z is determined to be less than 1.645 (the z value for 95 percent confidence) the null hypothesis must be accepted. If the calculated z is more than 1.645 the null hypothesis must be rejected. The z scores are plotted on normal curves in Figures 15, 17, and 19.

Assumptions

FARSITE uses Rothermel's (1972) spread model, Van Wagner's (1977) crown fire initiation model, Rothermel's (1991) crown fire spread model, and Nelson's (2000) dead fuel moisture models, and is subject to all their limitations and assumptions . Additionally, the following limitations must be acknowledged when using FARSITE (NWCG 2009):

- When using the Scott and Burgan (2005) fuel models, mistakes or incorrect assumptions with live fuel moisture transfer can result in faulty model outputs.
- Fires are assumed to burn as ellipses under uniform conditions.
- Fire behavior calculations at vertices are assumed independent of each other.
- Weather is difficult to predict and data are only as good as the inputs.
- Fire growth predictions tend to worsen with time because errors compound.

Problems encountered during calibration runs focused around producing ground-based fire growth which demonstrated growth patterns similar to what was observed during real fire events. Conflict with over prediction in grass and shrub fuels and under-prediction in timber fuels seemed to be at odds. The subtle changes to fuel moistures and adjustments in fuel conversions, along with a healthy dose of advice (Burgard, personal communication) served to overcome these problems, but no true "rules" were generated with regard to fuel moistures. The fuel moistures and conversions used in the analysis were compared to fire sizes fire staff experts would expect given the weather inputs. Fire sizes were also compared to historical fire sizes in the immediate and surrounding areas and found to be compatible. Appendix H depicts a representative fire from the 70th percentile BI category, and how the fire follows fuel type and terrain influences similar to what has been observed on actual fires in the area.

FARSITE modeling was set up for a two week period. This duration was based on the assumption that fire growth in FARSITE over a two week period would give a good indication of whether a fire would begin to impact surrounding values in that time period. Although the weather stream used is unrealistic for a given two week period, these conditions could be experienced over the duration of a long-term fire incident. Large fires on the Bridger-Teton tend to exhibit fire perimeter growth for about a week or less. Fires actively growing for longer than a week are relatively rare, although some fire may smolder for weeks before conditions are right for significant growth, as demonstrated by the Bearpaw Bay Fire in 2009. It is assumed that the fire perimeter outputs from FARSITE are erroneous, at least in terms of accuracy for a "real life"

ignition. These perimeters are to be utilized primarily for comparative and general planning purposes. Given the complexities and inability to validate FARSITE outputs (Finney 2000), differing weather scenarios were utilized to enhance variation. Tendencies toward over-prediction fill the role of measuring "worst case" scenarios, which is of interest for the Jackson District Ranger. Tendencies toward under-prediction are balanced by the more severe 90th percentile BI weather.

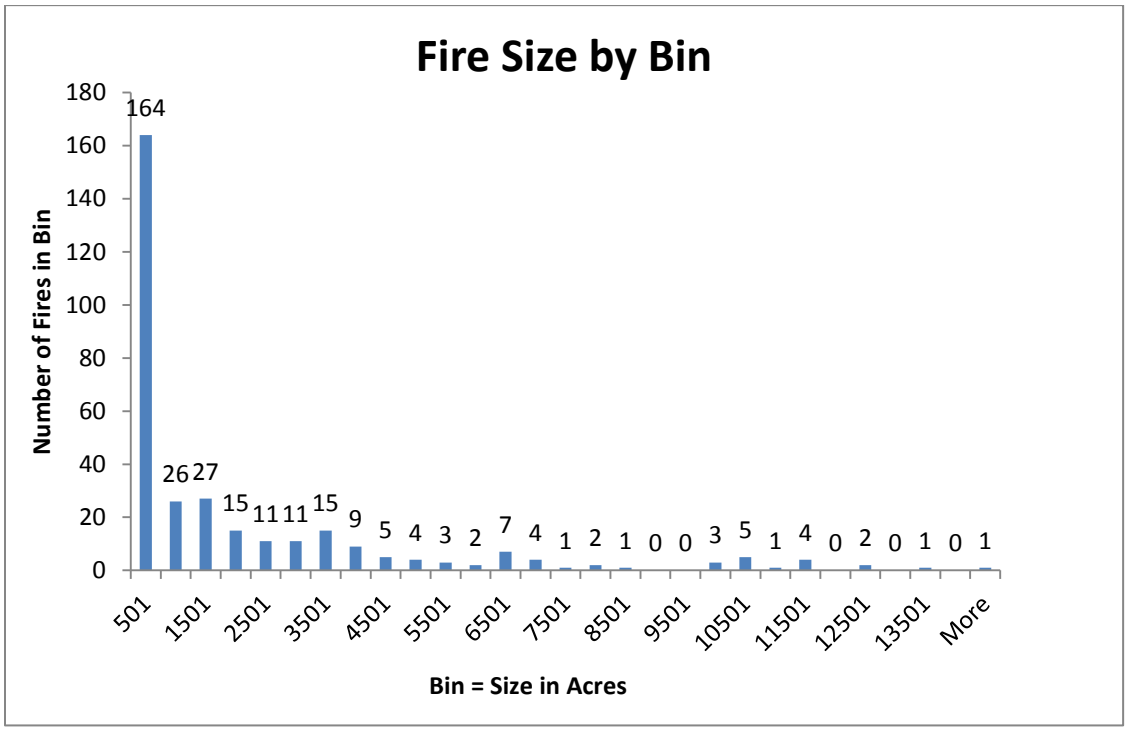
Since BI is a highly variable measure and can fluctuate daily, the use of BI to generate weather streams for use in FARSITE makes it prone to overestimation of fire perimeters. This is especially true in the 90th percentile range where winds are held consistently high through the 14 day FARSITE simulations. Winds in the study area are generally not sustained for more than 3-4 days using a 12mph average. In fact, for the time period between 2001 and 2010, winds averaging 6.5 mph, and 90th percentile BI over a 4 day period accounted for only 5.7 percent of days (Appendix I). Using 90th percentile winds over a longer period will result in fire spread resembling a higher ERC or a longer duration fire event. Hence, BI is a good choice for use in this study. By definition, 10 percent of days in July, August, and September will showing 90th percentile BI. However, they are usually spread out through the season. Therefore BI is assumed to generate a better "worst case" scenario for this analysis.

In the gathering of weather data, all data from a July 1- October 1 was utilized if it met the criteria for the specific BI being generated. Live fuel moistures were used to set the BI categories further apart. As shown in Table 1, the weather was remarkably similar, with the wind being the most variable component. The use of different live fuel moisture sets with the BI categories added diversity to allow the results to be applicable to the variety of weather which may be seen in any given fire season, and to allow this study to be pertinent to long-duration fire management.

Results

The objective of this study is to test the hypothesis that 5 percent or less of the fires starting in the Palisades WSA would impact values surrounding the WSA. The results for each BI category tested follow these general findings. Total number of fires modeled (324) for all BI categories and resulting fire size are summarized in Figure 13.

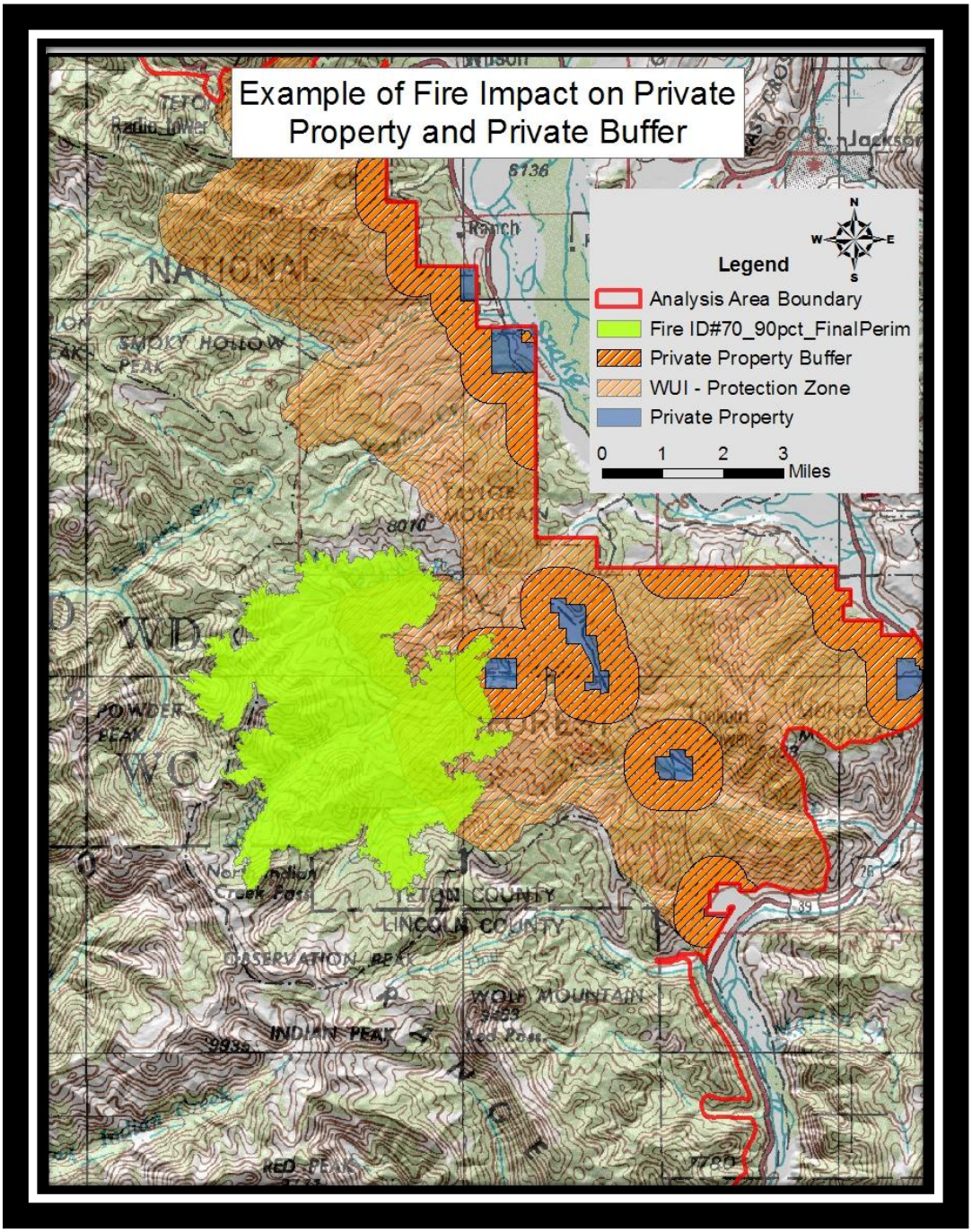
FIGURE 13. Summary of Fire Sizes



Thirteen of the 108 fires modeled did not grow, regardless of the weather stream utilized. This represents 12 percent of the total fires and indicates those fire ignitions occurred in fuel layer pixels where there were unburnable or unavailable fuels.

Impact was defined as any part of the fire perimeter contacting or proceeding past any part of the private land buffer or highway. Several fires moved into the WUI protection zone and remained in the WSA. Since these fires did not impact private property buffers or highways, they were not counted as impacting values. Figure 14 shows an example of an "impact" on private property and its associated buffer. This particular fire is modeled under 90th percentile BI and impacted the Trails End Ranch. The ignition point is the Coburn Creek fire which was suppressed at 0.1 acres.

FIGURE 14. Example Impact Fire



50th Percentile BI

Under 50th percentile weather stream data, fires burned an average of 498 acres. The total burned area for 108 fires modeled was 53, 830 acres, and 3 of the fires impacted values around the study area (2.77%). Results for FARSITE runs on 108 ignitions in the Palisades Wilderness Study Area are show below in Figure 16 as depicted in ArcGIS.

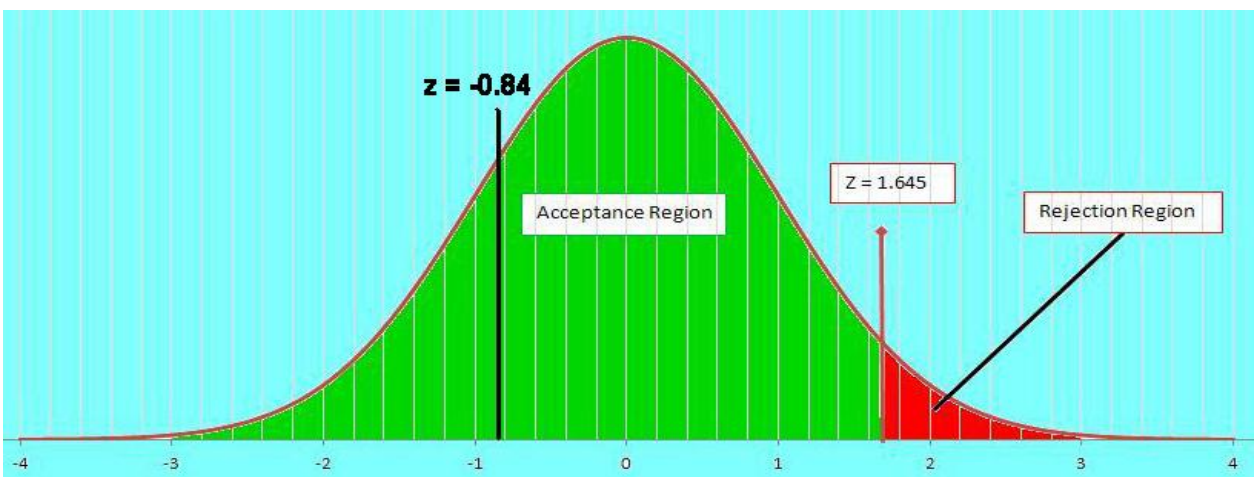
Geospatial Analysis under 50th percentile BI weather streams showed 3 fires impacting surrounding values. Therefore:

$\mathbf{H_O}$: $p \leq 0.05$	$\boldsymbol{n} = 108$	$\boldsymbol{\alpha} = 0.05$
$\mathbf{H_A}$: $p > 0.05$	$\boldsymbol{x} = 3$	$\boldsymbol{p} = 0.05$

$$z = \frac{x \pm \frac{1}{2} - np_o}{\sqrt{np_o(1-p_o)}} = \qquad z = \frac{3+\frac{1}{2}-108(0.05)}{\sqrt{108*0.05(1-0.05)}} = \mathbf{-0.84}$$

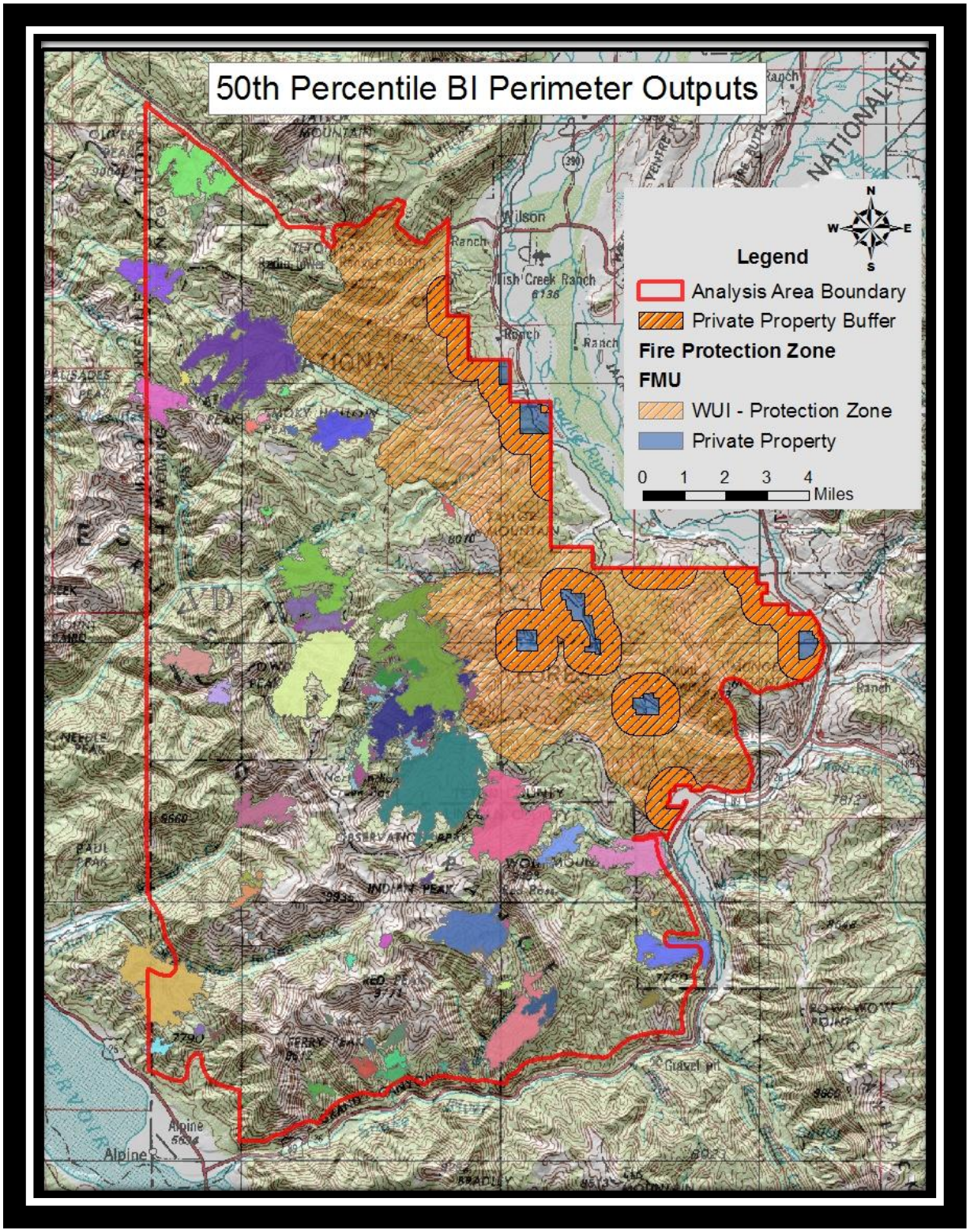
Addition ("+") is used because x (fire impacts) < np_O (sample size * probability $\mathbf{H_O}$) = 3 < 108(0.05) = 3 < 5.4; (Freund 2007).

FIGURE 15. *z*-score 50% BI



The null hypothesis $\mathbf{H_O}$: $p \leq 0.05$ must be accepted for the 50th percentile Figure 15.

FIGURE 16. FARSITE 50% BI Perimeters



70th Percentile BI

Under 70th percentile weather stream data, fires burned an average of about 1100 acres. The total burned area for 108 fires modeled was 118,682 acres, and 7 of the fires impacted values around the study area (6.48%). The resulting map of fire perimeters as illustrated in ArcGIS follows in Figure 18.

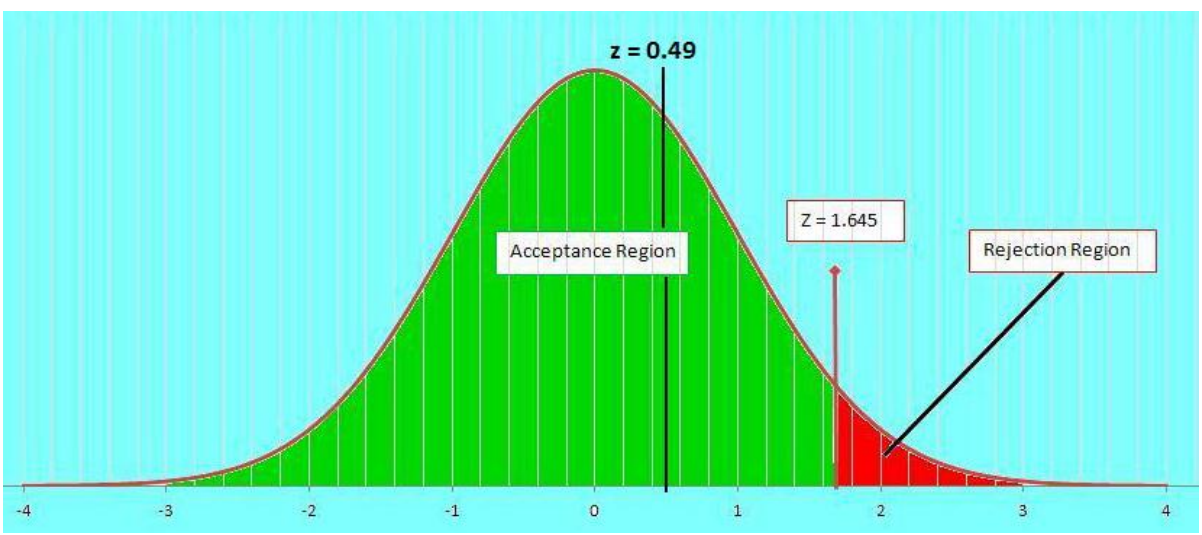
Geospatial Analysis under 70th percentile BI weather streams showed 7 fires impacting surrounding values. Therefore:

$\mathbf{H_O}$: p ≤ 0.05	**n** = 108	**α** = 0.05
$\mathbf{H_A}$: p > 0.05	$\boldsymbol{x}$ = 7	$\boldsymbol{p}$ = 0.05

$$z = \frac{x \pm \frac{1}{2} - np_o}{\sqrt{np_o(1-p_o)}} = \qquad z = \frac{7 - \frac{1}{2} - 108(0.05)}{\sqrt{108 * 0.05(1-0.05)}} = \mathbf{0.49}$$

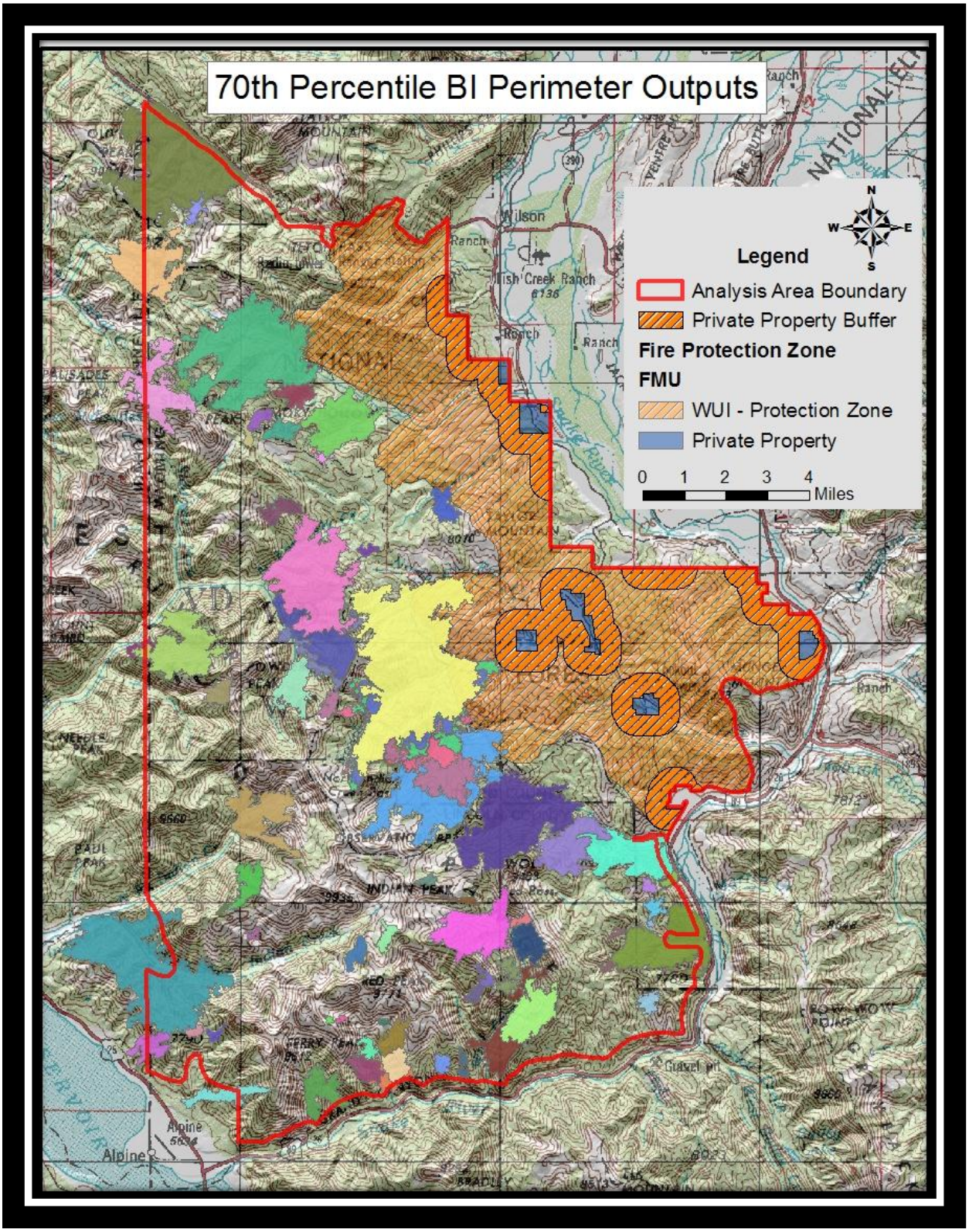
Subtraction "-" is used because x(fire impacts) > np_O (sample size * probability $\mathbf{H_O}$) = 7 > 108(0.05) = 7 > 5.4; (Freund 2007).

FIGURE 17. z-score 70% BI



The null hypothesis $\mathbf{H_O}$: $p \leq 0.05$ must be accepted (Figure 17).

FIGURE 18. FARSITE 70% perimeters



90th Percentile BI

Under 90th percentile weather stream data, fires burned an average of about 3800 acres. The total burned area for 108 fires modeled was 412,113 acres, and 35 of the fires impacted values around the study area (32.4%). The resulting map of fire perimeters as illustrated in ArcGIS shows many impacts to the surrounding private property buffers and highways (Figure 20).

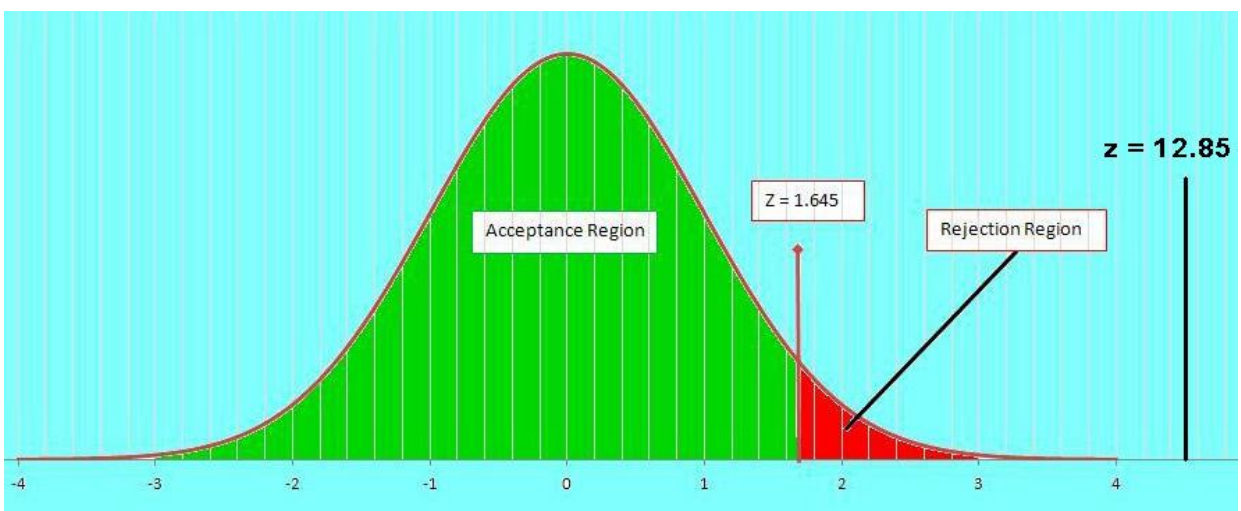
Geospatial Analysis under 90th percentile BI weather streams showed 35 fires impacting surrounding values. Therefore:

$\mathbf{H_O}$: p ≤ 0.05	$\boldsymbol{n}$ = 108	$\boldsymbol{\alpha}$ = 0.05
$\mathbf{H_A}$: p > 0.05	$\boldsymbol{x}$ = 35	$\boldsymbol{p}$ = 0.05

$$z = \frac{x \pm \frac{1}{2} - np_o}{\sqrt{np_o(1-p_o)}} = \qquad z = \frac{35 - \frac{1}{2} - 108(0.05)}{\sqrt{108 * 0.05(1-0.05)}} = \mathbf{12.85}$$

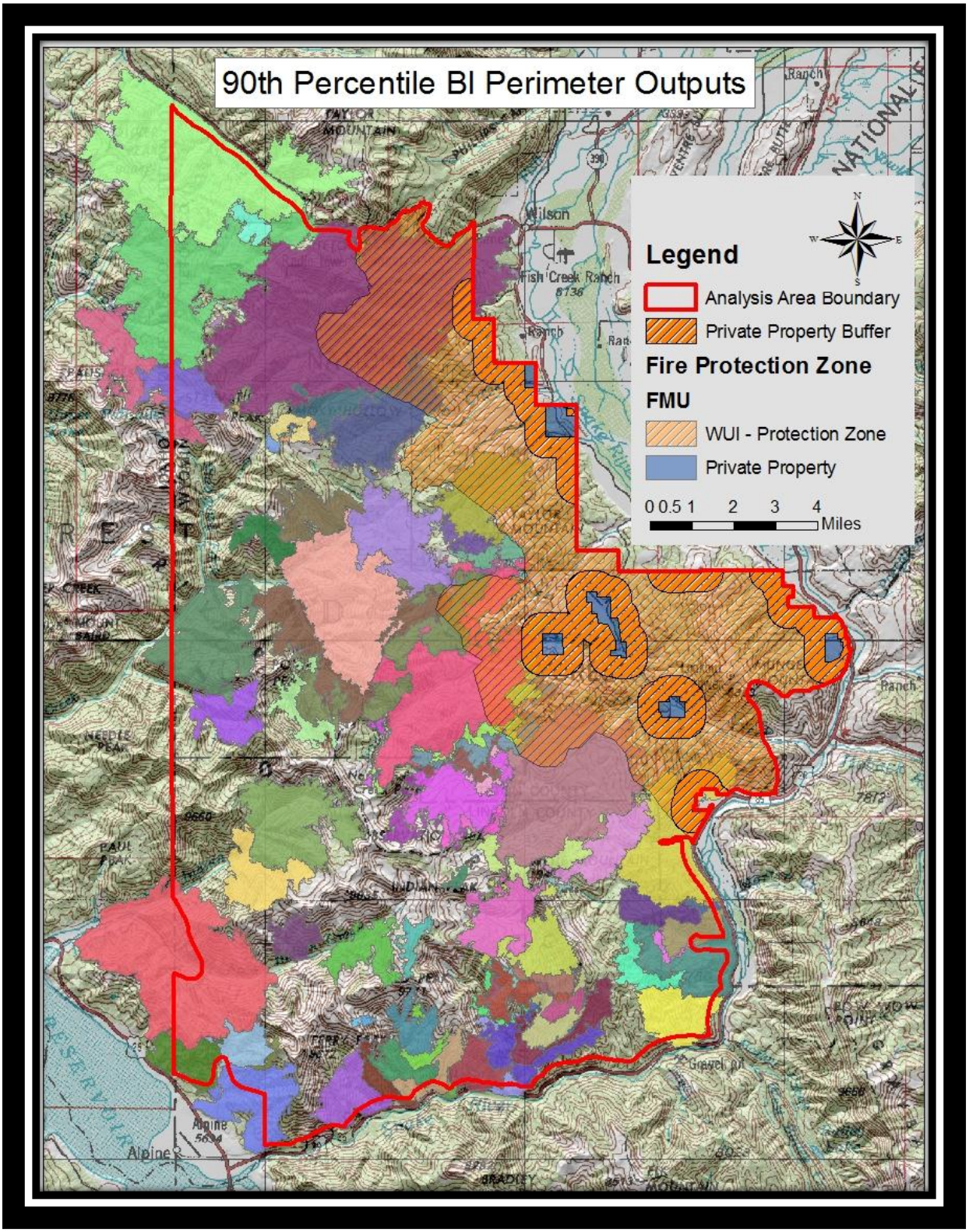
Subtraction "-" is used because x (fire impacts) > np_O (sample size * probability $\mathbf{H_O}$) = 35 > 108(0.05) = 35 > 5.4, (Freund 2007).

FIGURE 19. *z*-score 90% BI



The null hypothesis $\mathbf{H_O}$: p ≤ 0.05 must be rejected (Figure 19).

FIGURE 20. FARSITE 90% BI Perimeters



Discussion & Recommendations

The results of this analysis under 50th and 70th percentile BI weather support the hypothesis that 5 percent or less of fires starting in the Palisades WSA will impact values surrounding the study area. Under 90th percentile BI weather conditions, the results show that significantly more than 5 percent of fires will impact private property and/or highway corridors.

When compared to historical fires within the area in and around the analysis boundary, the modeled fires showed realistic sizes. The largest fire modeled (14,110 acres) was larger than any of the historical fires in the immediate area, however, it was smaller than the Purdy fire which started to the east of the analysis area in 2006 and burned 22,613 acres. Other local historic large fires with similar terrain were the 2007 Horse Creek fire at 8,590 acres, and the 2008 New Fork fire burning over 15,000 acres. Larger fires have occurred on the far north end of the forest, such as the 1988 Huck (117,896 acres) and Mink (164,560 acres) fires. The terrain there is rolling and more exposed to wind differentiating it from the analysis area.

This analysis may be best used by providing a reference which will aid the decision making process concerning future ignitions in the Palisades WSA to North Zone Line Officers and Fire Management staff by comparing future ERC and fuel moistures to those represented in this analysis. Higher ERC indices may indicate that fires will move through grass and shrub fuel models in ways not represented in this study. This analysis may be used for pre-planning ignitions in the Palisades WSA to help align management strategies to the Bridger-Teton Land and Resource Management Plan Revision of Fire Management Standards and Guidelines (2004), and the Wyoming Wilderness Act of 1984.

It is reasonable to assume the study area has been impacted by fire suppression, and that processes of natural change have been altered. Even under 50th percentile BI weather conditions the modeled landscape shows large areas of fire growth. Even if only a small percentage of fires burned as modeled, portions of the landscape would be impacted by changes in fuels characteristics, such as that exhibited by the Green Knoll fire. These impacts, especially in the "Identified Risk" areas, would reduce the potential for future large fire growth. Without fuel treatments like those described in the Teton to Snake Fuels Management Project (2010), long-term management actions will remain limited because of the conflicting objectives of the Teton County Community Protection Plan (2005) and Wyoming Wilderness Act (1984). The area of "Identified Risk" is over 37,000 acres. This analysis determined that when excluded from the Wilderness Study Area this leaves only about 63,000 acres which might be managed with a full complement of wildland fire strategies. This number represents less than half the Palisades WSA.

Findings of this study were used to identify areas prone to large fire growth. Continuous fuels and lack of natural barriers are thought to be key factors for the large fire growth that was

simulated in this analysis. Additionally, an area of low impact probability was identified, and may be used to influence decisions on future ignitions in the Palisades WSA.

Outcomes of the FARSITE modeling identified five distinct areas prone to fire growth which may impact private property on the east side of the study area, the community of Alpine on the south-west corner of the study area, and Highways 22, and 89 on the north and south side of the study area respectively. These areas are referred to as "Identified Risk Areas" in Figure 22, where risk is associated with the chances of fires impacting values surrounding the analysis area as described above.

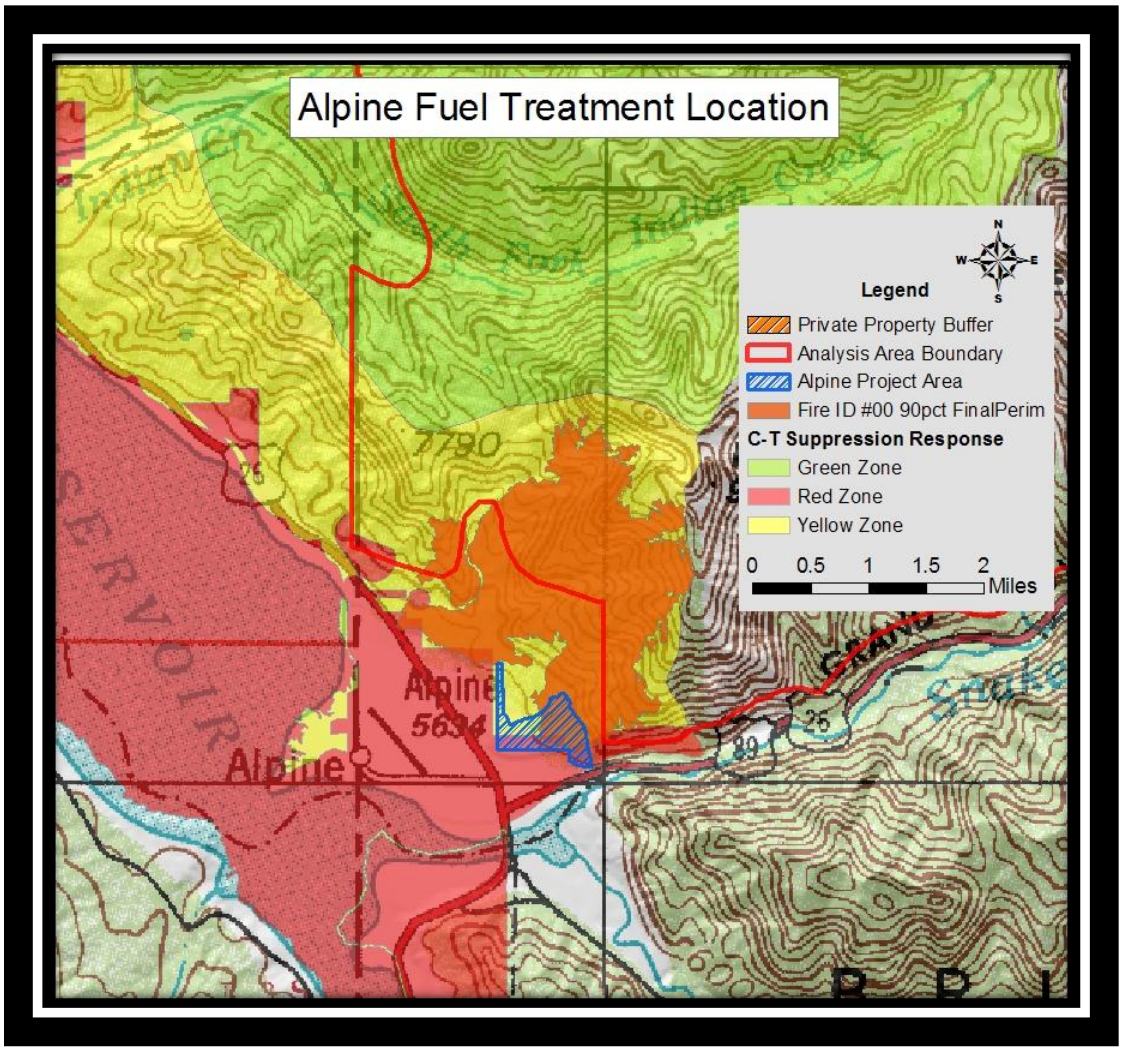
Risk Area 1 shows fires starting in that area have a tendency to move northwest and impact the Wyoming Highway 22 / Teton Pass corridor. Most of the fire impact from Risk Area 1 is the west side of Teton Pass, however during 90th percentile runs, fires threaten the entire north boundary of the study area and burned into the community of Wilson, Wyoming (Figure 20). Recommended strategies for fires in this Risk Area 1, based on this analysis, should be managed using limited or full suppression response during early or mid-summer, or under higher burning indices.

Risk Area 2 impacts the WUI and the Trails End Ranch. Fires were prone to large growth in Risk Area 2 from many fire ignition locations and under all weather conditions modeled. It is suggested to use partial and full suppression tactics for future ignitions this area. Fuels treatments such as those described in the Teton to Snake Fuels Management Project would likely reduce impacts from fires starting in this area. While the potential threat to private property is high in Risk Area 2, it is recommended to aggressively pursue allowing naturally ignited fire to operate in this area when burning indices are low to moderate. This should serve to help break up the continuity of fuels, and create "fire breaks" to protect against fire leaving National Forest lands under more severe weather conditions. While some natural barriers exist in Risk Area 2, spotting potential may reduce the effectiveness of those barriers.

Risk Area 3 also exhibited large fire growth in many fire start locations and weather influences. Recommendations for Risk Area 3 are similar to those of Risk Area 2, with the exception that this is outside of the Teton to Snake Fuels Management Project area. Values at risk in this area include private property and highway corridors. Limited and/or full suppression strategies are warranted, except in cases of lower predicted fire behavior potential.

Risk Area 4 threatens the community of Alpine, Wyoming. Fuels treatments, including commercial harvest and hand piling and thinning have already been implemented in the area and would likely have impacted fire growth in a real event. Figure 21 shows the fuels treatment and how it would likely have reduced impact on the Alpine community.

FIGURE 21. Alpine Fuel Treatment



Risk Area 5 was identified as an area that is likely to impact Highway 89 and its power lines. Limited suppression is recommended in Risk Area 5 along the highway corridor, allowing fire to move northerly and upslope, but not southerly toward the highway.

FIGURE 22. Risk Areas

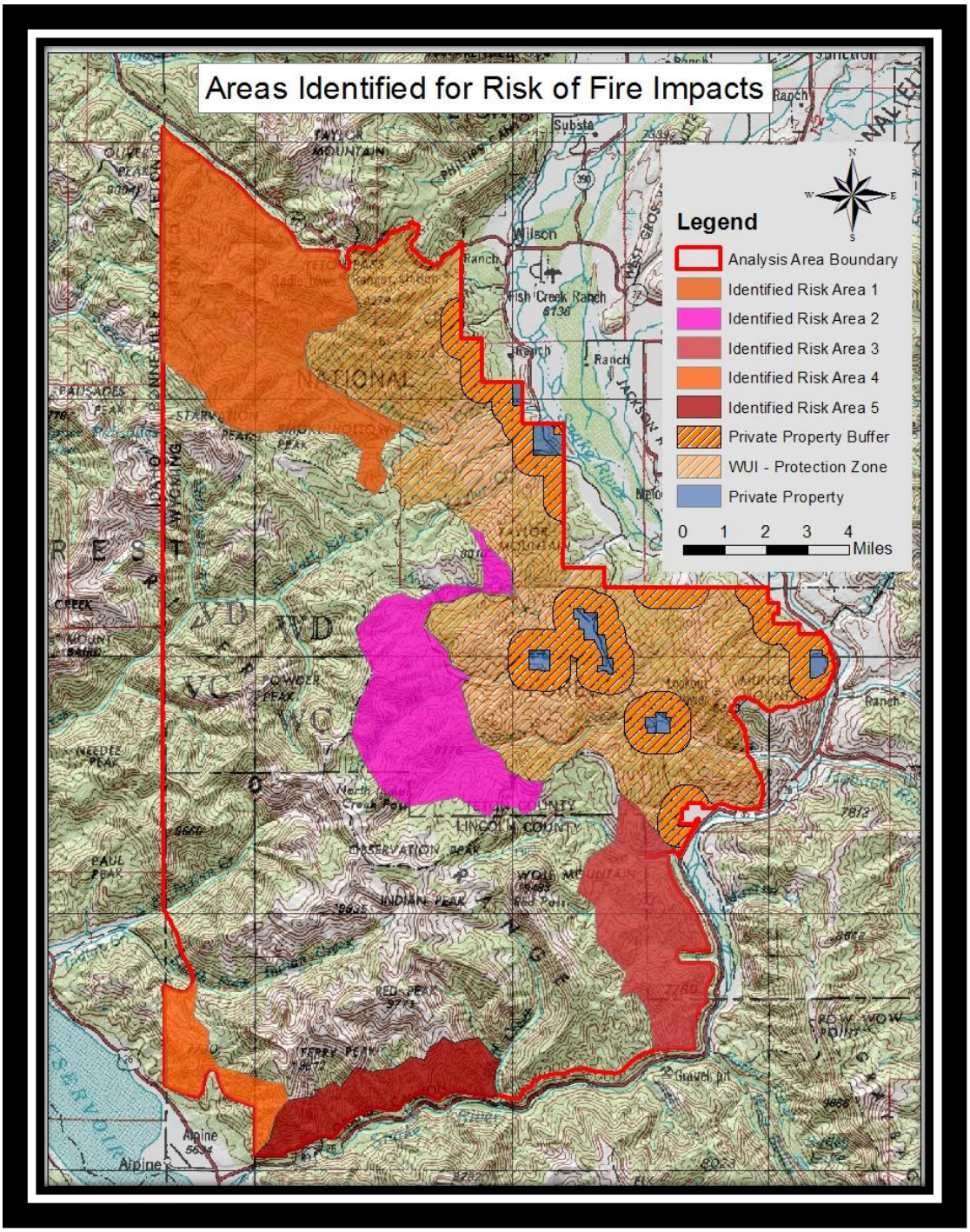
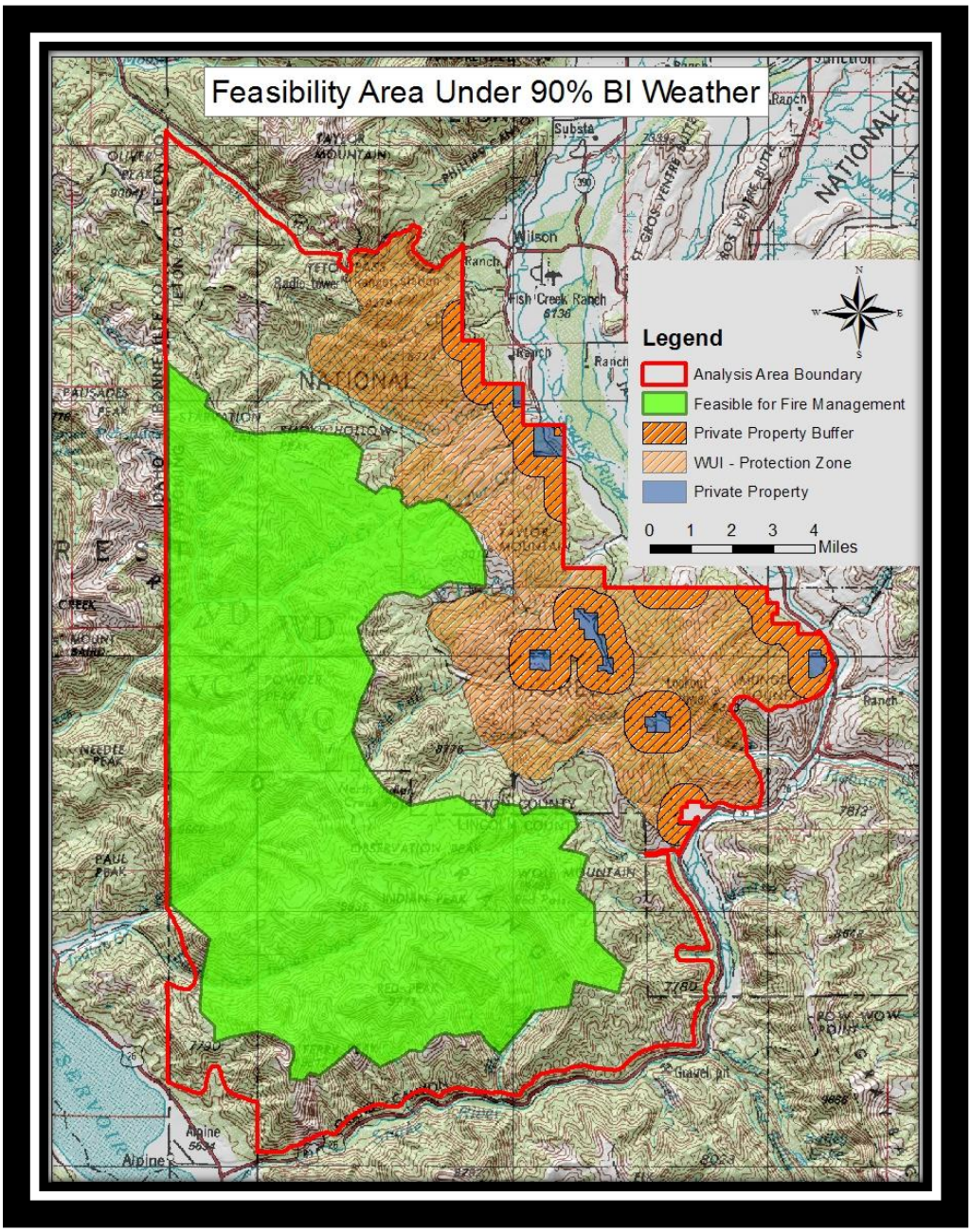


Figure 23 shows an area feasible for fire to be managed under all weather conditions tested. This area was developed by exclusion of the "Identified Risk" areas and moving the perimeter up against fires that did not impact values. This area is **only** viable given the parameters of this analysis, but will provide decision makers and local fire specialists with supplementary information.

FIGURE 23. 90% Non-Impact Area



Desired future conditions of the Palisades Wilderness Study area emphasize natural processes and protection of wilderness character (U.S.D.A. Forest Service 2010). Of the 135,800 acres in the Wilderness Study Area, over 37,000 acres are identified as "Risk" areas. In order to allow for natural processes to maintain wilderness character, restoration of fire must be managed to include protection of private lands, power-lines, and transportation corridors. Through incorporation of fuels treatments to protect these values, such as the Alpine fuels project conducted by the Caribou-Targhee, a better balance of fire management strategies would be obtained. Because the Palisades WSA borders private property, fuel treatments in the WSA should be considered along with development of fuels treatments along Highways 22 and 89.

In the future, and under favorable conditions, it may be desirable to use limited suppression strategies in the WUI protection zone. Ideally fires allowed to play their natural role will create a mosaic of fuel and vegetation types. This would allow greater latitude of non-suppression or limited suppression management options and increased protection of values from large, high intensity fires. There is a necessary balance of risk that is most pronounced at the beginning of this practice, and the side of safety to the public and firefighters will always be considered foremost. The more decision makers and fire managers are committed to allowing fires to play their natural role, and the more fires are allowed to function as a natural process, the less suppression will be needed. Long term success means fuels treatments and fire suppression will take a backseat, while allowing natural ecological processes to enhance Wilderness character in the Palisades Wilderness Study Area and to optimize chances for future Wilderness designation.

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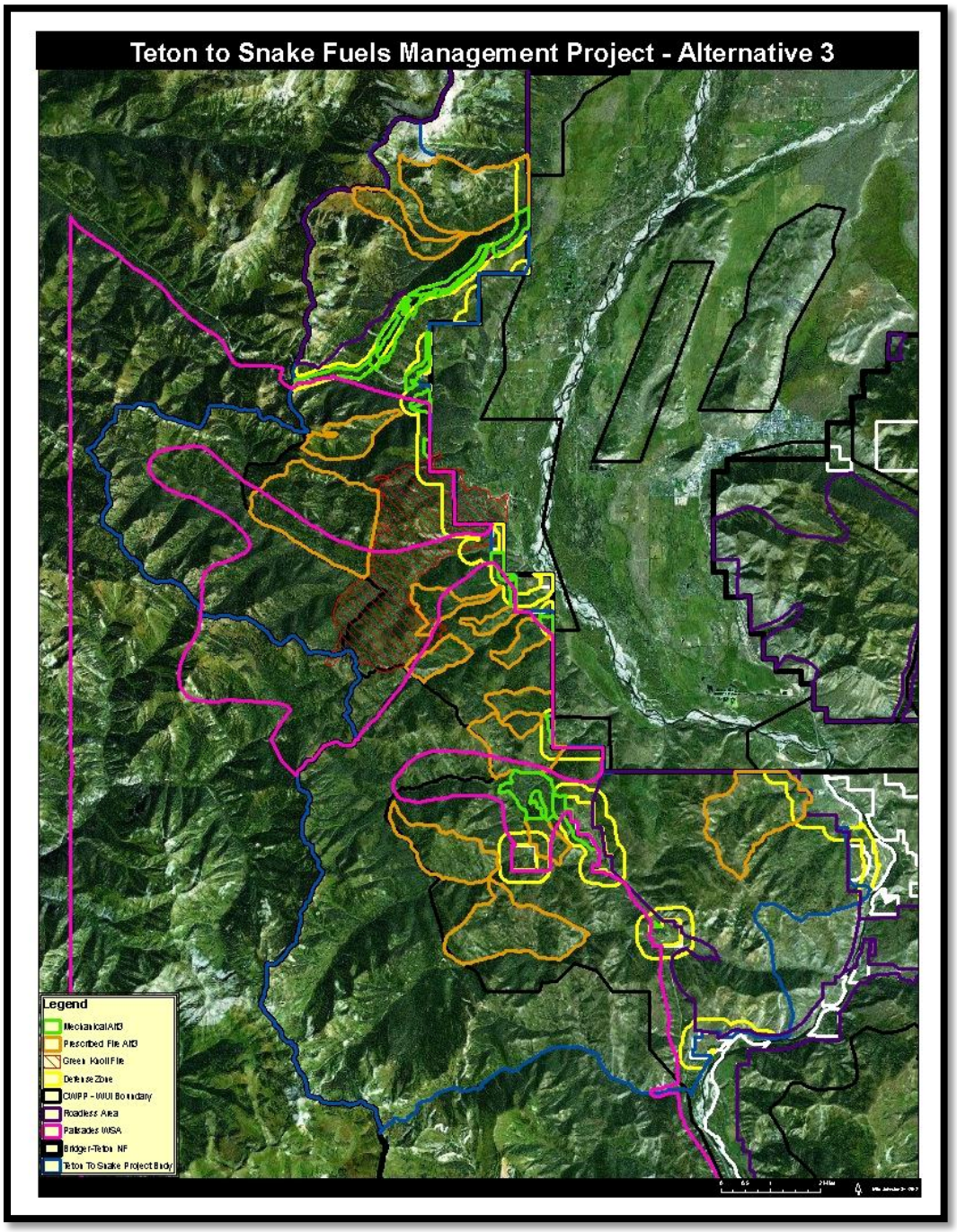
Appendices

APPENDIX A: Teton to Snake Fuels Management Project Area and proposed Treatments.

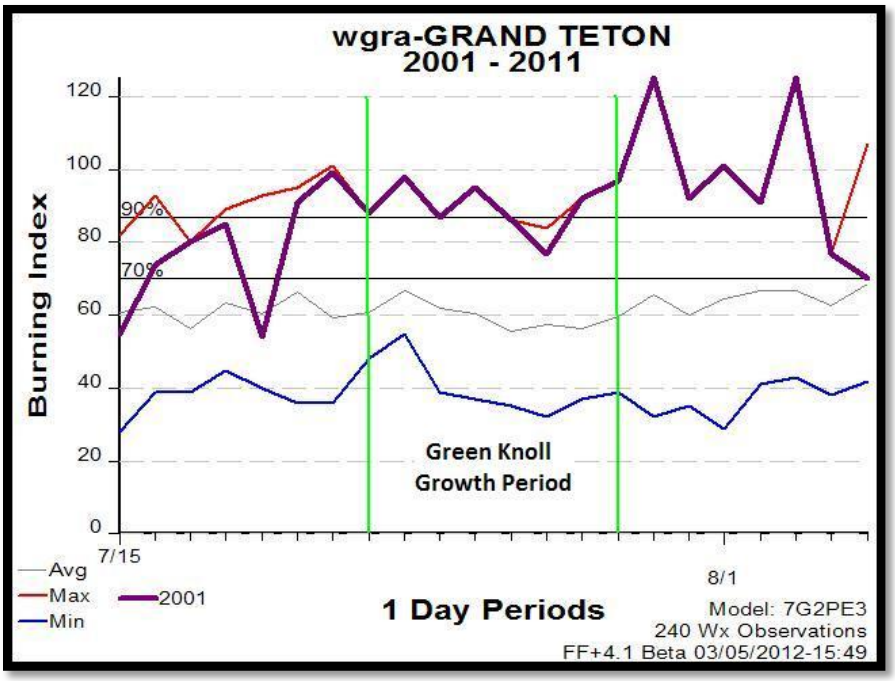


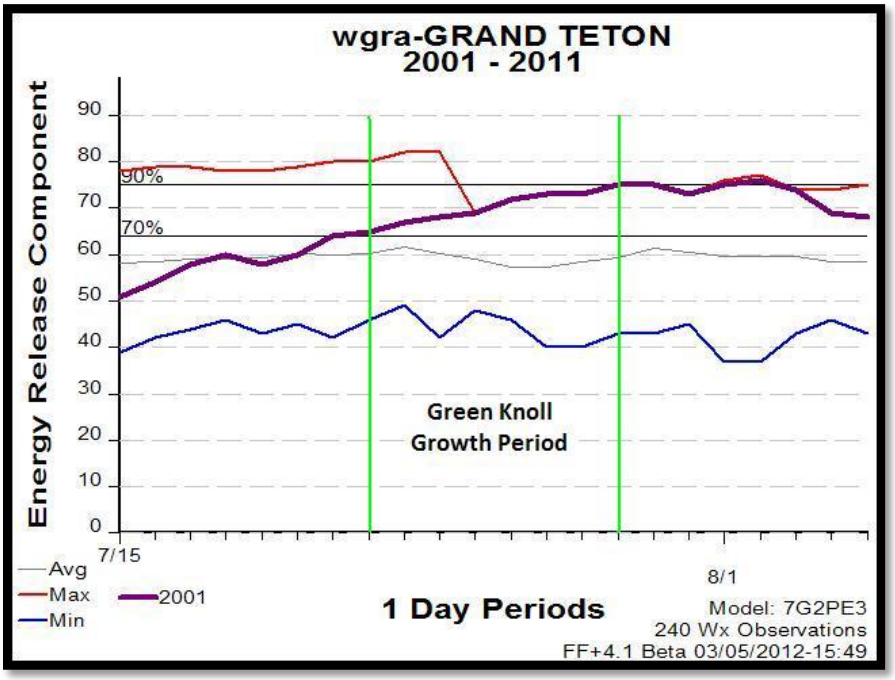
APPENDIX B: Fire ID numbers, Acres, Surrounding Value Impact

FID_Origin	All Fires					
	50th percentile Acres	Impact	70th percentile Acres	Impact	90th percentile Acres	Impact
0	16	NO	331	YES	2402	Yes
1	104	NO	458	YES	1466	Yes
2	143	NO	527	NO	1979	Yes
3	124	NO	254	NO	1719	Yes
4	26	NO	76	NO	2925	Yes
5	28	NO	93	NO	1545	Yes
6	107	NO	306	NO	1519	Yes
7	1	NO	1	NO	1	No
8	1	NO	1	NO	1	No
9	108	NO	296	NO	2851	Yes
10	38	NO	97	NO	1365	No
11	104	NO	241	NO	686	No
12	37	NO	54	NO	1192	No
13	30	NO	169	NO	2238	No
14	1103	NO	1365	NO	4702	No
15	8	NO	30	NO	70	No
16	4	NO	21	NO	648	No
17	1	NO	1	NO	1	No
18	1	NO	1	NO	1	No
19	15	NO	19	NO	30	No
20	228	NO	752	NO	2242	No
21	1	NO	1	NO	2	No
22	73	NO	132	NO	3078	Yes
23	1	NO	1	NO	1	No
24	53	NO	85	NO	3937	No
25	1609	NO	3512	NO	7020	Yes
26	34	NO	155	NO	4061	No
27	49	NO	185	NO	4103	No
28	33	NO	133	NO	3968	No
29	29	NO	67	NO	3773	No
30	0	NO	0	NO	0	No
31	640	YES	1228	YES	3816	No
32	37	NO	150	NO	991	No
33	484	YES	1120	YES	3840	Yes
34	614	YES	1431	YES	3742	Yes
35	921	NO	1085	NO	3363	No
36	903	NO	1223	NO	4004	No
37	22	NO	364	NO	2809	No
38	1	NO	1	NO	1	No
39	12	NO	38	NO	592	No
40	51	NO	125	NO	326	No
41	890	NO	1109	NO	3398	No
42	28	NO	99	NO	2327	Yes
43	28	NO	107	NO	2155	No
44	1	NO	1	NO	1	No
45	174	NO	288	NO	1380	No
46	6	NO	61	NO	1582	No
47	1	NO	1	NO	3829	Yes
48	68	NO	308	NO	3235	No
49	68	NO	308	NO	3235	No
50	35	NO	54	NO	106	No
51	10	NO	72	NO	2941	Yes
52	17	NO	608	NO	2873	Yes
53	331	NO	1032	NO	3783	Yes
54	781	NO	1477	NO	4550	Yes
55	314	NO	1364	NO	5188	No
56	1611	NO	2776	NO	6891	No
57	3065	NO	6248	NO	10381	No
58	3065	NO	6248	NO	10381	No
59	2	NO	2	NO	4	No

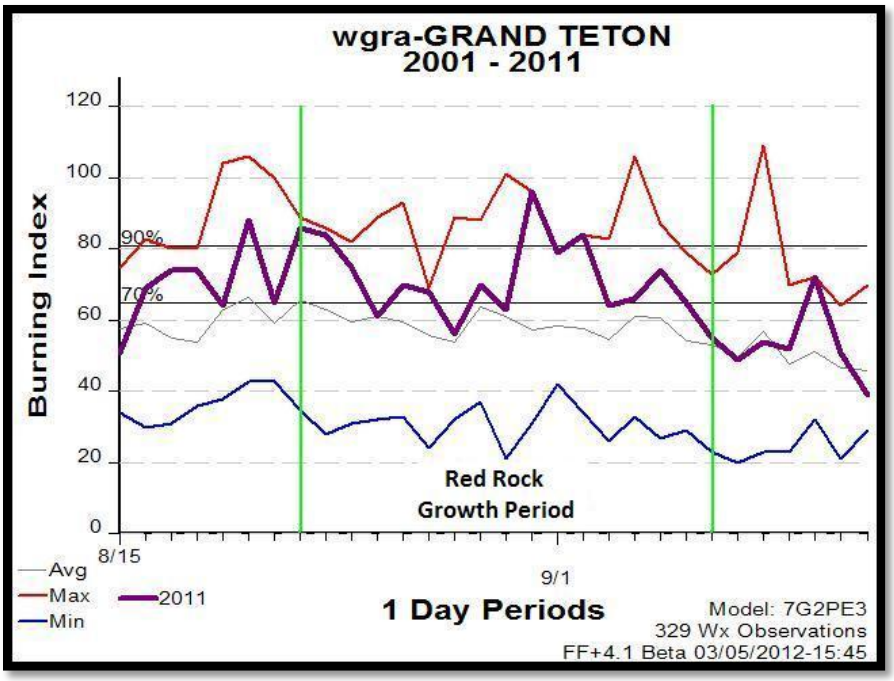
60	2	NO	4	NO	8277	No
61	524	NO	960	NO	2833	No
62	2	NO	5	NO	6823	No
63	1	NO	1	NO	3	No
64	1	NO	1	NO	1	No
65	1	NO	1	NO	1	No
66	3159	NO	4965	NO	10780	Yes
67	3380	NO	6830	NO	12252	Yes
68	1	NO	1	NO	1	No
69	150	NO	193	NO	1812	No
70	3382	NO	6160	YES	11459	Yes
71	3269	NO	6046	NO	11051	Yes
72	2672	NO	5501	NO	10157	Yes
73	1947	NO	1133	NO	7704	No
74	2675	NO	5770	NO	9901	Yes
75	1	NO	1	NO	1	No
76	360	NO	1310	NO	3012	No
77	350	NO	1265	NO	11180	Yes
78	1821	NO	5524	NO	11180	Yes
79	2338	NO	6032	NO	1905	No
80	1	NO	1	NO	1	No
81	540	NO	2448	NO	10025	No
82	609	NO	2503	NO	6975	No
83	989	NO	2296	NO	6224	No
84	10	NO	60	NO	2483	No
85	1	NO	1	NO	823	No
86	1	NO	1	NO	938	No
87	1	NO	1	NO	1196	No
88	3	NO	3	NO	1103	No
89	28	NO	227	NO	1057	No
90	49	NO	232	NO	1988	No
91	10	NO	57	NO	1190	No
92	507	NO	1060	NO	4727	No
93	28	NO	189	NO	1649	No
94	517	NO	1105	NO	4262	No
95	60	NO	142	NO	384	No
96	33	NO	119	NO	5143	Yes
97	499	NO	1108	NO	6281	No
98	1969	NO	3085	NO	13064	Yes
99	1625	NO	2589	NO	12254	Yes
100	29	NO	833	NO	9536	Yes
101	29	NO	833	NO	9536	Yes
102	59	NO	179	NO	2091	No
103	74	NO	3290	NO	14110	Yes
104	552	NO	1135	NO	10024	Yes
105	1	NO	1	NO	1499	No
106	315	NO	2045	NO	4121	Yes
107	956	NO	3144	YES	7846	Yes
Total Acres	53820		118682		412113	
Average Acres	498.3333		1098.907		3815.861	
Impacts		3		7		35
%Impact		0.027777778		0.064814815		0.324074074
No Growth Fires	20		20		13	
% No Growth	0.185185		0.185185		0.12037	

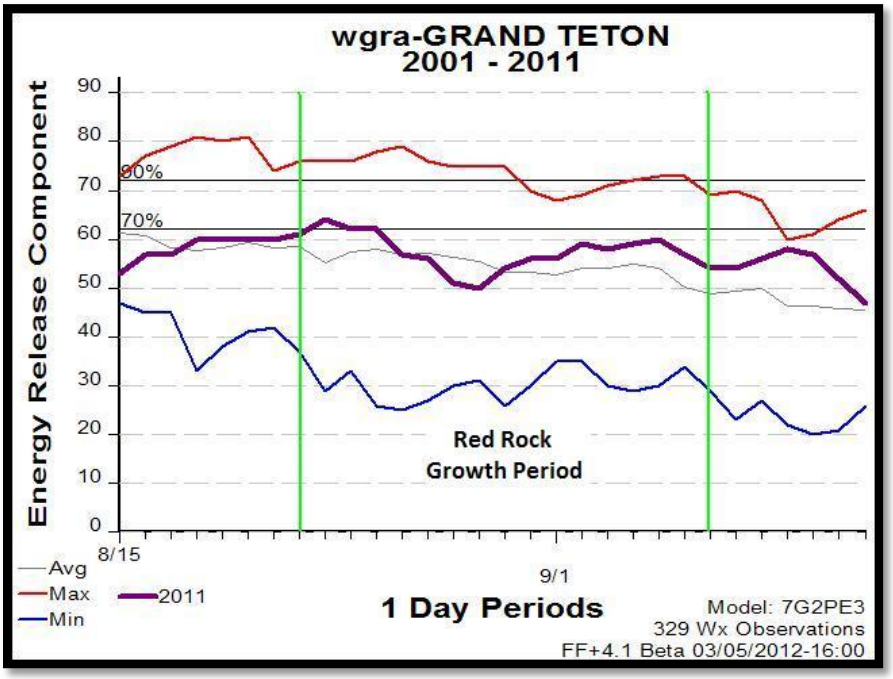
Appendix C: Green Knoll Fire BI and ERC charts





APPENDIX D: Red Rock BI and ERC Charts





APPENDIX E: Proportions of unsuppressed by Month that may be considered across the North Zone of the Bridger-Teton N.F.

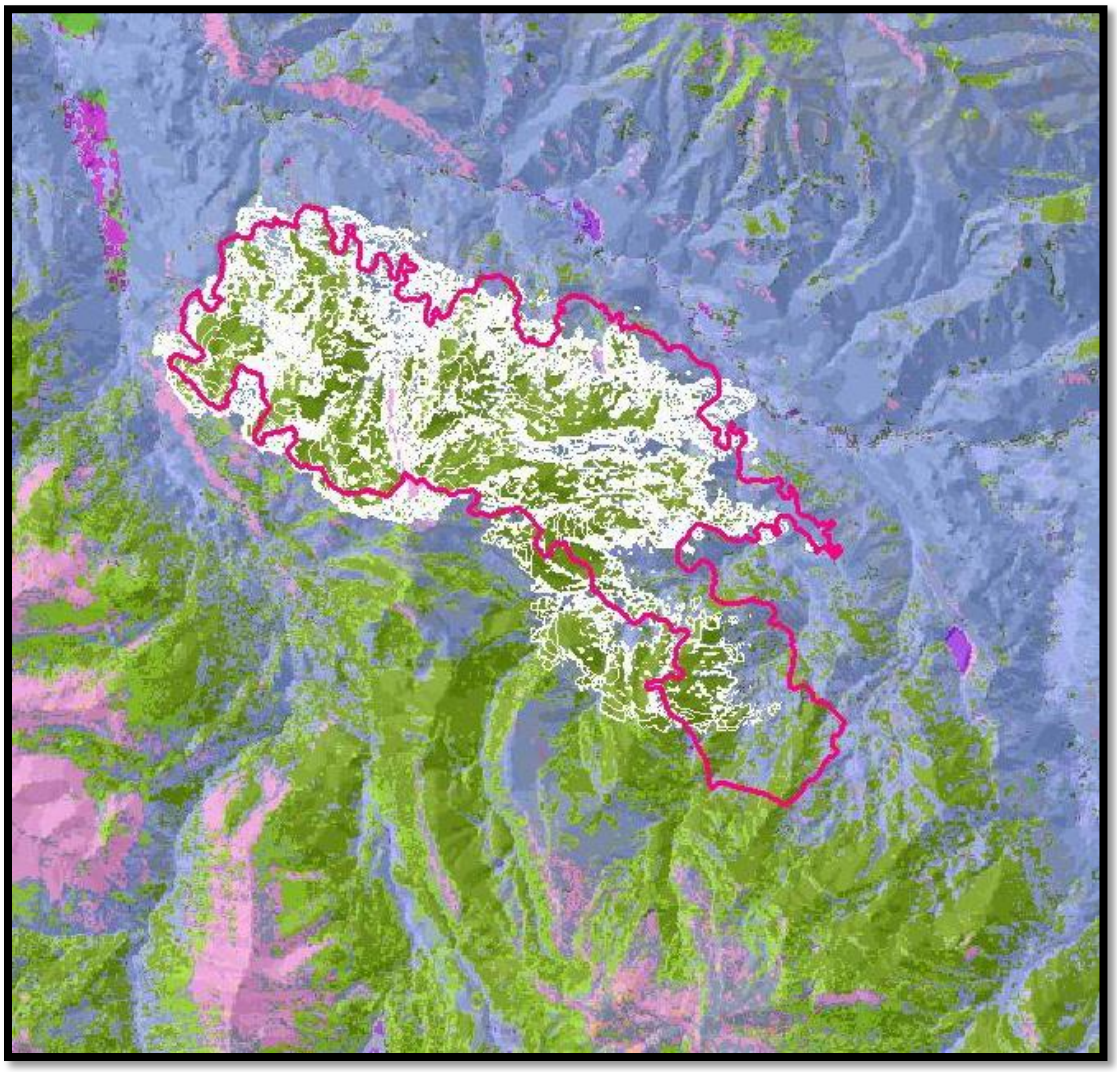
Month	Proportion of wildfires unsuppressed
May	0
June	10%
July	25%
August	45%
September	60%
October	80%
November	80%
December	80%

Estimates provided by Mike Johnston – North Zone Fire Management Officer.

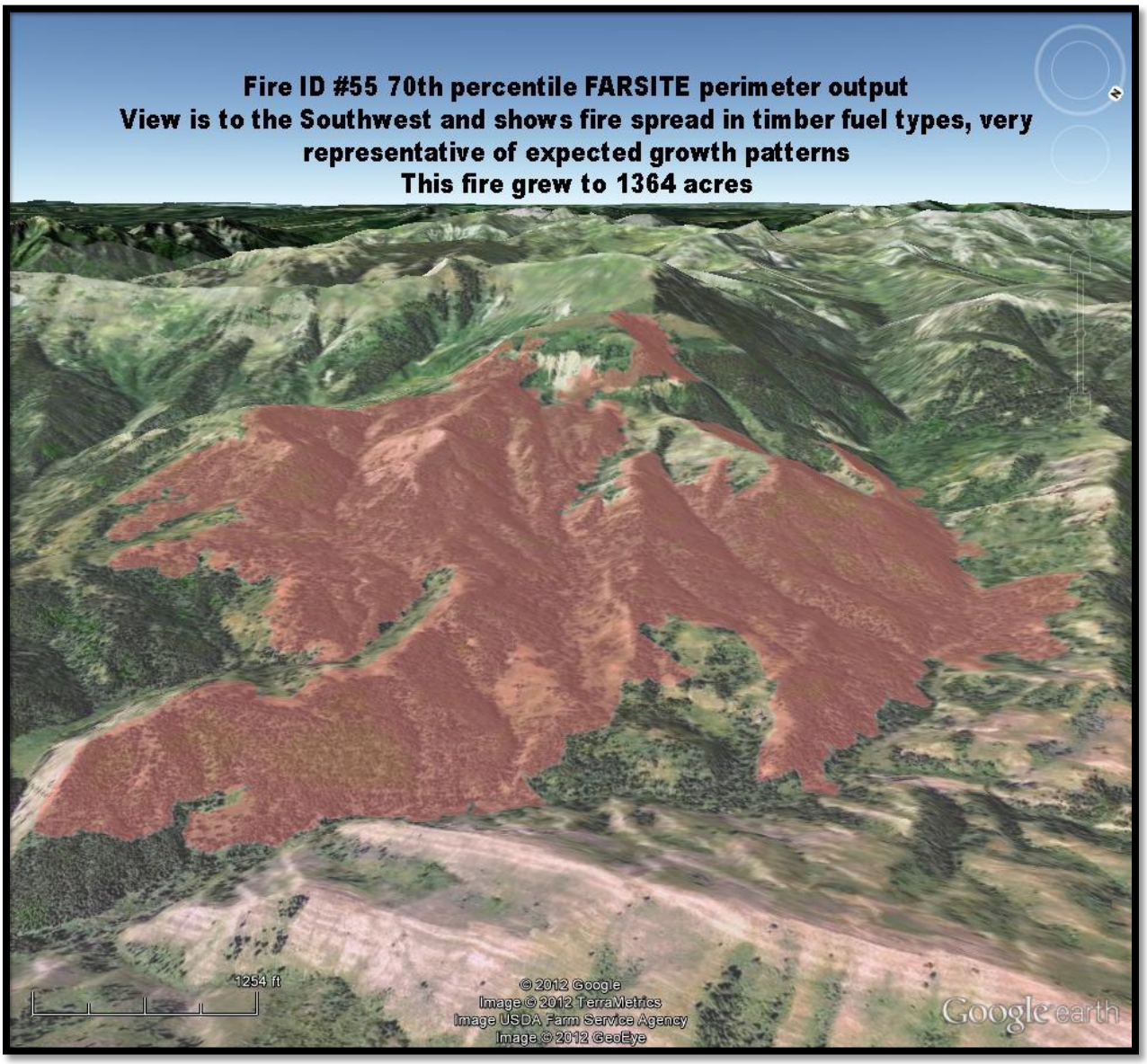
Appendix F: Percentile Category Values

Percentile	Burning Index	Energy Release Component	Live Herbaceous	Live Woody	Fuel Model Conversion "OFF"
	Value	Value			
50	51	51	120	140	101, 102, 121, 122, 141, 142
70	61	58	100	105	101, 121, 122
90	78	68	80	100	101

APPENDIX G: Example Red Rock Fire calibration run. White lines are areas burned in FARSITE calibration. Pink Lines is the actual fire perimeter.



APPENDIX H: FARSITE Modeled fire perimeter showing burned area in timber type fuels, and lack of spread in grass/shrub fuel models. This closely approximates how fires burn in representative conditions.



APPENDIX I: 6.5 mph average wind speed events with 90 percentile BI.

Event Definition:			**Event Definition:**		
Avg(Wind Speed) >= 6.50			Avg(Wind Speed) >= 6.50		
AND Min(Burning Index) >= 58.00			AND Min(Burning Index) >= 58.00		
4-Day Periods			7-Day Periods		
DATE Wind BI			DATE	Wind	BI
07/04/2001	**10.00**	**60.00**	07/20/2001	14.57	86.00
07/20/2001	**15.75**	**88.00**	07/27/2001	14.00	77.00
07/24/2001	**12.00**	**77.00**	08/22/2001	9.71	69.00
07/28/2001	**15.50**	**92.00**	08/29/2001	9.86	62.00
08/01/2001	**15.75**	**77.00**	07/31/2002	13.43	70.00
08/22/2001	**10.50**	**71.00**	08/07/2002	9.29	65.00
08/26/2001	**8.50**	**69.00**	08/14/2002	9.86	73.00
08/30/2001	**9.00**	**62.00**	08/01/2004	12.29	59.00
09/09/2001	**10.25**	**60.00**	09/02/2005	12.29	70.00
07/22/2002	**11.75**	**64.00**	07/26/2006	8.86	58.00
07/31/2002	**11.25**	**70.00**	08/08/2006	10.14	58.00
08/04/2002	**15.00**	**77.00**	07/01/2007	7.71	66.00
08/08/2002	**9.75**	**65.00**	07/18/2007	10.29	61.00
08/12/2002	**7.75**	**66.00**	07/25/2008	10.00	63.00
08/16/2002	**9.50**	**80.00**			
08/20/2002	**11.75**	**75.00**	14 hits out of 786 < 2%		
09/01/2002	**8.00**	**62.00**			
08/01/2004	**12.25**	**59.00**			
08/10/2005	**10.00**	**62.00**			
09/02/2005	**13.75**	**70.00**			
09/06/2005	**13.00**	**71.00**			
07/20/2006	**8.25**	**61.00**			
07/26/2006	**7.75**	**58.00**			
07/30/2006	**10.00**	**59.00**			
08/08/2006	**11.75**	**74.00**			
08/12/2006	**7.75**	**58.00**			
08/20/2006	**9.50**	**66.00**			
08/29/2006	**10.75**	**60.00**			
07/01/2007	**8.50**	**66.00**			
07/09/2007	**8.00**	**60.00**			
07/18/2007	**13.00**	**76.00**			
08/08/2007	**10.50**	**61.00**			
09/15/2007	**11.00**	**58.00**			
07/15/2008	**9.25**	**65.00**			
07/25/2008	**7.75**	**63.00**			
07/29/2008	**13.00**	**77.00**			
08/02/2008	**9.25**	**72.00**			
08/10/2008	**9.00**	**60.00**			
08/17/2008	**8.00**	**60.00**			
08/24/2008	**10.25**	**69.00**			
08/29/2008	**12.25**	**64.00**			
09/22/2008	**12.50**	**58.00**			
09/26/2009	**11.25**	**68.00**			
07/15/2010	**11.25**	**58.00**			
44 hits out of 769 = 5.7%					