

# ANALYSIS OF FUEL TREATMENT ALTERNATIVES FOR THE IDAHO CITY RANGER DISTRICT, BOISE NATIONAL FOREST



Rich Zimmerlee  
Boise Smokejumper  
Bureau of Land Management  
National Interagency Coordination Center

January, 2006

Presented in partial fulfillment of the requirements for TFM 20

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## **PREFACE**

I am currently the Prescribed Fire Manager for the Boise BLM Smokejumpers. We provide fuels assistants to most federal and state agencies in the US. I have been a member of the Chico Max fire/trail crew for one year, sawyer on the Mendocino Hotshots for three years, Redding Smokejumper for two years, Boise BLM Smokejumper for six years and in my current position for three years. The past fifteen years have brought an array of experience in fire suppression and fuels work with most government agencies across the US.

I would like to thank my family, my supervisor, co-workers, TFM advisor and Washington Institute for allowing me the time and opportunity to attend Technical Fire Management.

Rich Zimmerlee  
January, 2006

## EXECUTIVE SUMMARY

Fire exclusion due to past management has contributed to the uncharacteristic fuel conditions on the Idaho City District. In 2000, the National Fire Plan identified the need to treat fuels in the wildland urban interface to reduce threats to life and property. The National Forest (NF) Land/Resource Management Plan (L/RMP) for Boise NF also identifies the need to reintroduce, restore and maintain forested lands. Idaho City District land managers have been trying to reduce fuel loads and restore historic conditions through the use of prescribed fire. However, due to the unusually thick duff layers around large ponderosa pine (*Pinus ponderosa* var. *scopulorum* Engel) trees unacceptable tree mortality (>10%) has occurred.

This project looks at two units. Both units are located within the Idaho City urban interface area and are in close proximity to the “Scenic Ponderosa Byway” (HWY 21). Maintenance of aesthetic value is the driving force behind this project.

The goal of this project is to find an alternative treatment with the least Cost Plus Net Value Change (C+NVC) that will reduce tree mortality during prescribed burning, thus indirectly improving aesthetics.

Although many alternatives were considered, the following three alternatives were chosen for this analysis: no action, tree well burning and tree well raking. These alternatives have been evaluated by the economic analysis C+NVC over a twenty year planning horizon. The alternative of applying generic prescribed fire treatments solely was discarded due to unacceptable mature tree mortality previously demonstrated by post prescribed fire monitoring. Computer applications predict acceptable mortality results but post treatment monitoring in similar projects shows mortality to be >10%.

Analysis methods included the collection of data on fuel loading, stand exams, fire occurrence records and weather data. These data were analyzed and modeled for fire behavior and fire effects using computer applications. Fire behavior and effects were modeled for the initial treatment and the resulting fuel load using the computer applications Behave Plus (Bevins D. Collins; Andrew L. Patricia. 2003) CONSUME (Seattle Forestry Sciences Laboratory. 2003) and First Order Fire Effects (FOFEM), (Rocky Mountain Research Station. 2002.) Tree well burning and raking is an ongoing research study on the Idaho City District through the Rocky Mountain Research Station (RMRS). I have consulted with Terrie Jain (RMRS Researcher) on tree well burning and raking issues. A fire risk analysis was done using the computer application FireFamily Plus (USDA Forest Service. 2002 – 2004) for fire occurrence and a statistical computer application called Probacre (Wiitala R. Marc. 1992). The National Fire Management Assessment System (NFMAS) was used to obtain resource values pertaining to the Boise NF. Tree well burning and suppression costs were obtained from the Boise NF. Tree well raking costs were taken from the Arizona Strip District, St. George, UT.

It has been determined through analysis that the tree well burning alternative is the least cost alternative and meets the project objective. Therefore, this alternative is recommended.

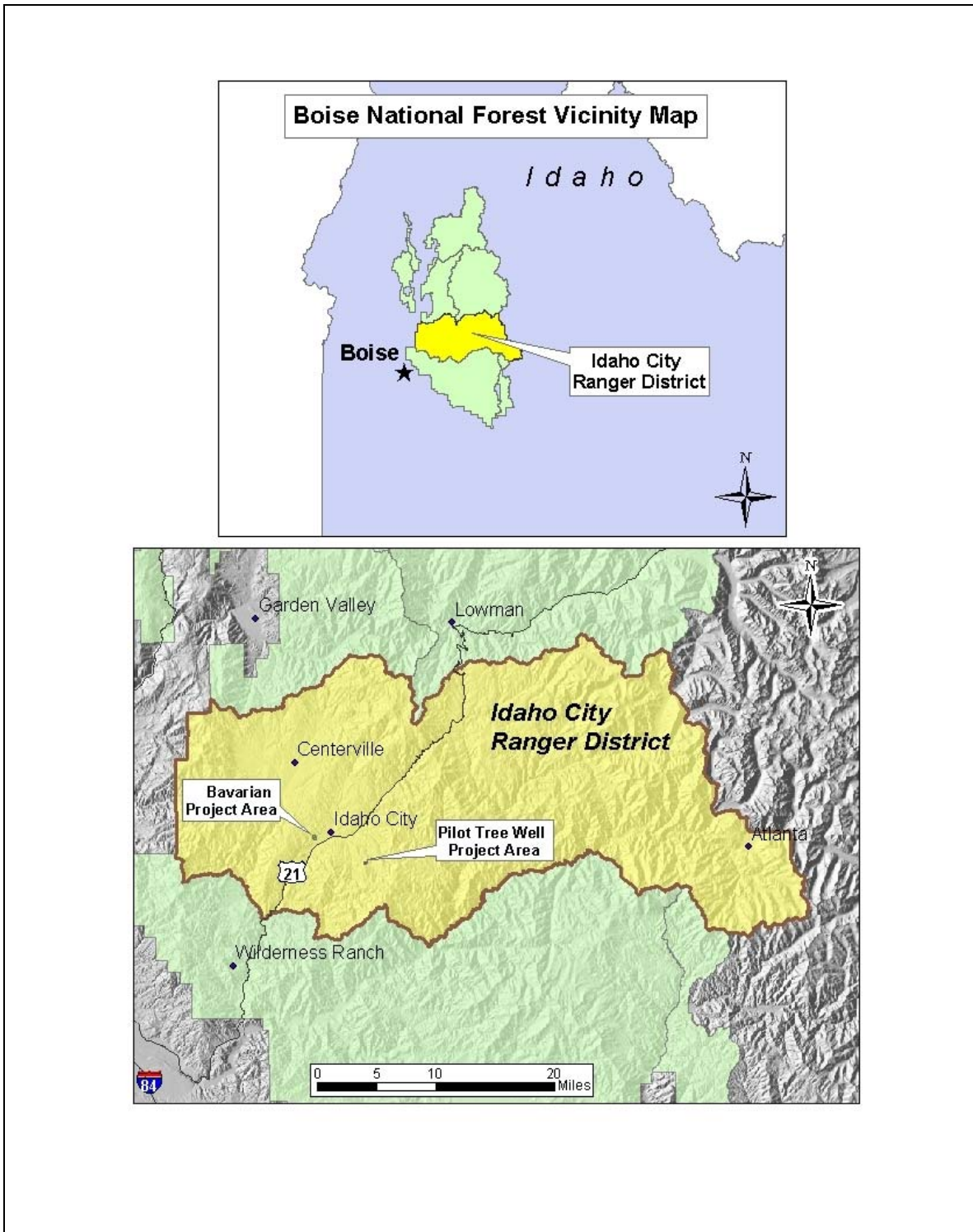
## INTRODUCTION

This project is located on the Boise National Forest (2.27 million acres), Idaho City District (354,047 acres) around the town of Idaho City, Idaho, approximately 38 miles northeast of Boise, Idaho. Two units are being evaluated. This project is an economic analysis of alternative treatments for treating deep duff layers in old *P. ponderosa* stands. Analysis will be cost plus net value change (C+NVC) over a twenty year planning horizon for three treatment alternatives. Social (aesthetics) and economic value are the driving force behind this project. In order to maintain aesthetic value, the mortality of 19"+ diameter at breast height (DBH) *P. ponderosa* trees will need to be kept at a minimum (<10%). The Bavarian unit covers 50 acres on a south aspect; the Pilot Tree Well unit covers 37 acres on a north aspect and alternatives will be evaluated with a combined total acreage of 87 acres.

This study looks at the manipulation of the fuel profile around the tree wells of large *P. ponderosa* for the treatments. It identifies the present fuel conditions and risks of continuing with current prescribed fire treatments or doing no treatments. It identifies desired fuel conditions and the benefits of alternative treatments. For the "No Action" alternative the worst case weather/environmental scenario at the 97th percentile is looked at. Twenty one years of historical weather data show there is a 3 to 7 percent probability of fire conditions being at extreme indices in the area. This paper analyzes how to most efficiently get to the conditions identified in the Land/Resource Management Plan (L/RMP) to correspond with reduced mortality and thus increase post-fire aesthetics. Figure 1 depicts the project area vicinity.

Vicinity Map

FIGURE 1



## BACKGROUND AND SIGNIFICANCE

Pre-settlement conditions in this area consisted of open “park-like” *P. ponderosa* with some small patches of Douglas-Fir (*Pseudotsuga menziesii* (Mirbel) Franco (Pinaceae), (Crane and Fisher, 1986). Historically, low intensity surface fires burned this area every 10 to 20 years. These fires would remove stands of small trees, prepare seed beds, reduce litter and duff, thereby maintaining open stand conditions (Arno 1980, Covington, et al. 1997, Sloan in press, Pearson 1950). Grazing and fire suppression policies started in the early 1900’s resulted in the current condition of an unusually thick duff layer that is prone to stand replacing, high intensity wildfires.

The Idaho City area has been declared an “Urban Wildland Interface Community within the Vicinity of Federal Lands That Are at High Risk from Wildfire” (L/RMP 2003); this project lies within the designated area. Social (aesthetics) and economic values (recreation, commercial timber) of this area are a primary concern to the residents of Idaho City.

The Boise National Forest Line Officer is concerned about the secondary prescribed fire mortality of large *P. Ponderosa* pine trees around Idaho City. Large, mature pines have ecological and social importance on the forest. Post prescribed fire monitoring is showing unacceptable mortality of >10% (RMRS Researchers and the Idaho City Fuels Specialist, personal communication, December, 2005). Reducing the mortality to <10% would improve the aesthetic value in the *P. ponderosa* pine stands (RMRS Researchers and the Idaho City Fuels Specialist, personal communication, December, 2005).

Idaho City Land Managers have been trying to reduce fuel loads and restore historic conditions through the use of prescribed fire. However, before generic broadcast prescribed fire can be implemented, the vulnerable mycorrhizae roots need to be treated. This can be done by burning or raking tree wells. Burning with high duff moisture seems counterintuitive. As the snow melts, leaving the tree well duff layer exposed, the top layer dries out but the deeper layer will stay wet, protecting the dormant roots. This will enable the top layer to be consumed by fire, which in turn allows excessive moisture to evaporate during the summer months promoting deeper mycorrhizae root growth. Tree well raking under the same conditions will allow the excessive moisture to evaporate during the summer months promoting deeper root growth as well.

Rocky Mountain Research Station (RMRS) researchers are analyzing the effects of reintroducing fire on *P. ponderosa* stands that have developed in long duration fire free periods, with particular emphasis on the effect of fire on tree roots. Researchers have noticed that some trees with heavy accumulations of duff at the tree base have shown signs of negative second order fire effects (>10% mortality) following burning when the heavy duff loading contributed to higher intensities. Core samples from the base of these trees with deep duff depths (8-10 cm) show an abnormally high occurrence of mycorrhizae root hairs, a condition which is thought to be brought on by fire exclusion. Without regular fire occurrence following historic patterns, the duff layer becomes unusually thick and holds excessive moisture. This promotes excessive mycorrhizae root growth too close to the surface. Further studies indicated that mycorrhizae root hairs are very susceptible to damage from a surface fire when they develop close to the surface which contributes to tree mortality, despite the lack of needle scorch or cambial damage.

Again, before a generic broadcast fire can be implemented with positive effects, the aforementioned treatments need to be conducted to realize positive effects needed as stated in the L/RMP, 2003 (Terrie Jain, Ph. D, RMRS Researcher, personal communication, January, 2006).

In order to minimize mycorrhizae root damage during broadcast prescribed burning treatments, RMRS Researchers in conjunction with the Idaho City Fuels Specialist, wish to pre-treat *P. ponderosa* pine stands. This can be done by tree well burning or raking in early spring conditions when the duff moisture is very high (>75%) and soil temperatures are 40°F or lower. Treating when roots are dormant will reduce shock to the roots. These conditions are present during the early spring when surrounding snow has melted from around the tree wells of individual trees.

#### Alternatives being evaluated

1. No Action – Continue to apply generic prescribed fire treatments to this area and risk receiving the unacceptable secondary mortality (>10%) or do not prescribe burn and risk experiencing a catastrophic wildfire.
2. Tree well burning – applying fire to the snow free areas around the trees (tree wells). This entails burning the tree wells out to the drip line of large *P. ponderosa* pine trees with a prescription to consume up to 70% of the duff layer around the trees. This would be done within the snow free areas around the trees. Approximately two years later, the mycorrhizae roots will have had a chance to establish themselves deeper in the soil and generic prescribed fires can again be implemented.
3. Tree well raking – mixing or churning the duff layer with a hand tool. This involves raking the duff layer around the tree well out to the drip line of the tree to promote loss of duff moisture and promoting deeper root establishment. The entire duff layer around the tree will not need to be removed, just churned or mixed up allowing the moisture to evaporate. This would be done within the snow free areas around the trees and approximately two years later the mycorrhizae roots will have had a chance to develop deeper and generic prescribed fires can be implemented.

#### Assumption:

- For the purpose of this paper, it is assumed that one pre-treatment (tree well burning or raking) prior to prescribed fire treatments will be adequate. However, more than one treatment may be needed depending on weather and condition of fuels during and after the treatment.

Alternatives will be analyzed using C+NVC to determine economic efficiency over a twenty year period.

### Site description

There are two project sites being evaluated. The Bavarian unit (50 ac.) is located one air mile west of Idaho City and borders the Bavarian Village Subdivision on the north side. The Pilot Tree well unit (37 ac.) is located two air miles southeast of Idaho City and is within the Boise Basin Experimental Forest (BBEF). Both units are in Management Area 8, as stated in the L/RMP 2003 and also are included within Fire Management Unit 2, as stated in the Fire Management Plan (FMP 2005).

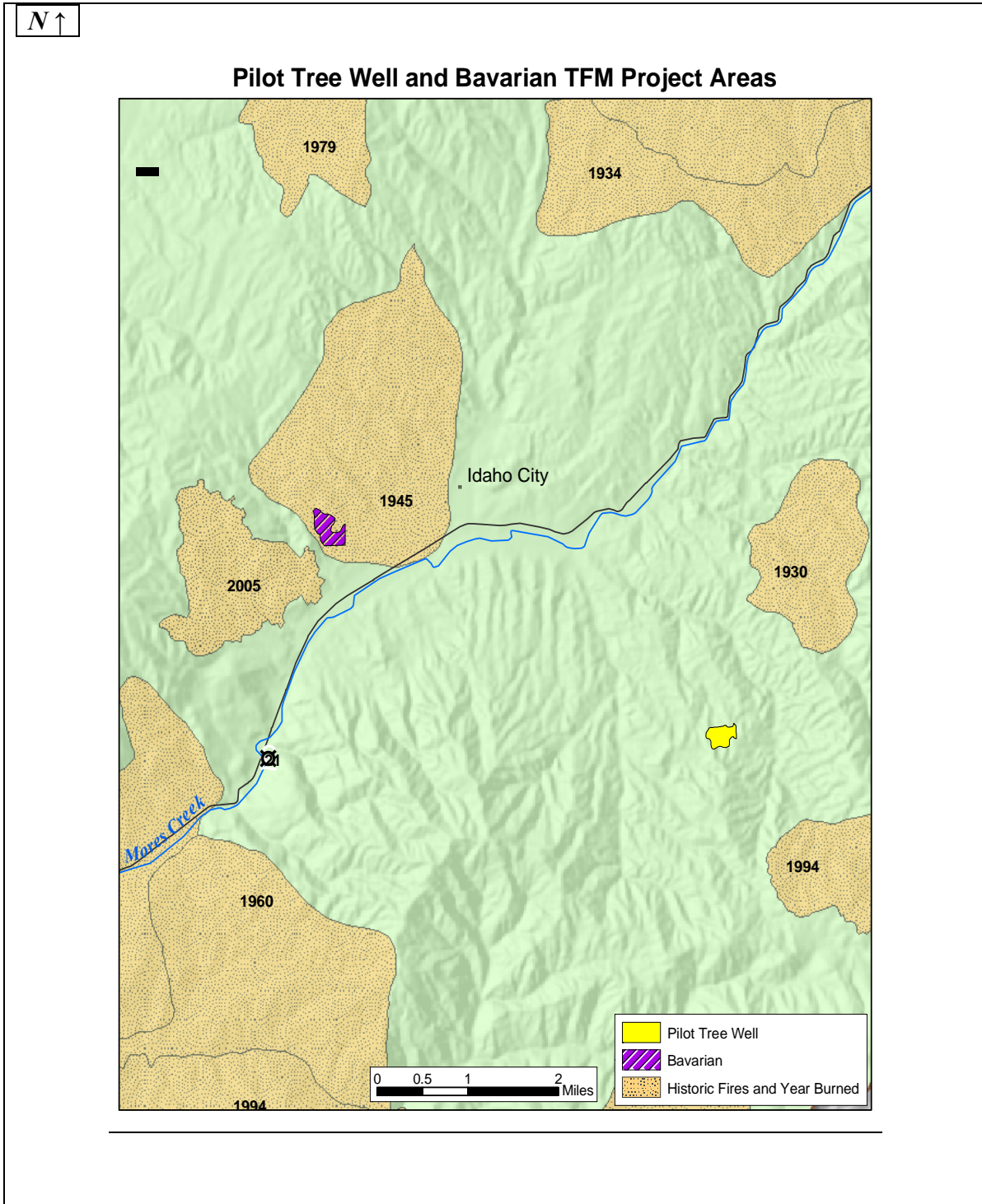
Fuels in the Bavarian unit (south aspect) consist of dominant over stocked *P. ponderosa* pine stands with a deep duff layer/grass and shrubs making up the understory. A mix of fuel model 9 (80%) and 2 (20%) best represent this unit.

Fuels in the Pilot Tree Well unit (north aspect) consist of dominate *P. ponderosa* stands with a deep duff layer/brush understory. A mix of fuel model 9 (80%) and 5 (20%) best represents this unit.

In conversation with the Boise NF Fuels Specialist, this mix of fuel models best represents the study units when running Behave Plus. The Society of American Foresters (SAF) 237 model (Interior Ponderosa Pine), set to heavy, best represents the units when running first Order Fire Effects (FOFEM). Hal E. Anderson's, "Aids to Determining Fuel Models for Estimating Fire Behavior" was used along with the William C. Fischer "Photo Guide For Appraising Down Woody Fuels In Montana Forests" were used for computer applications. Figures 2, 3 and 4, display project and fire management areas.

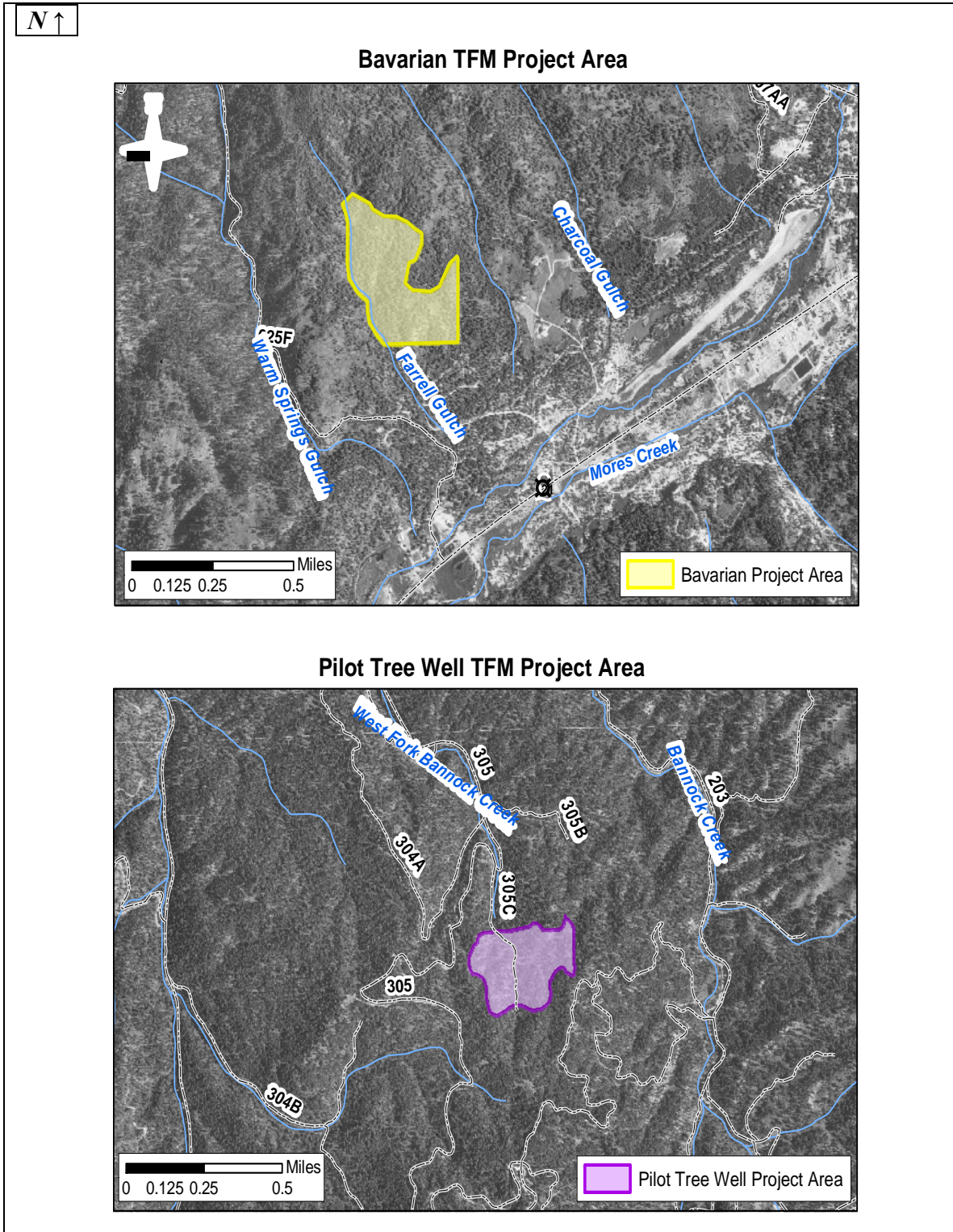
Project Area Map

FIGURE 2



Project Area Map (zoomed in view)

FIGURE 3

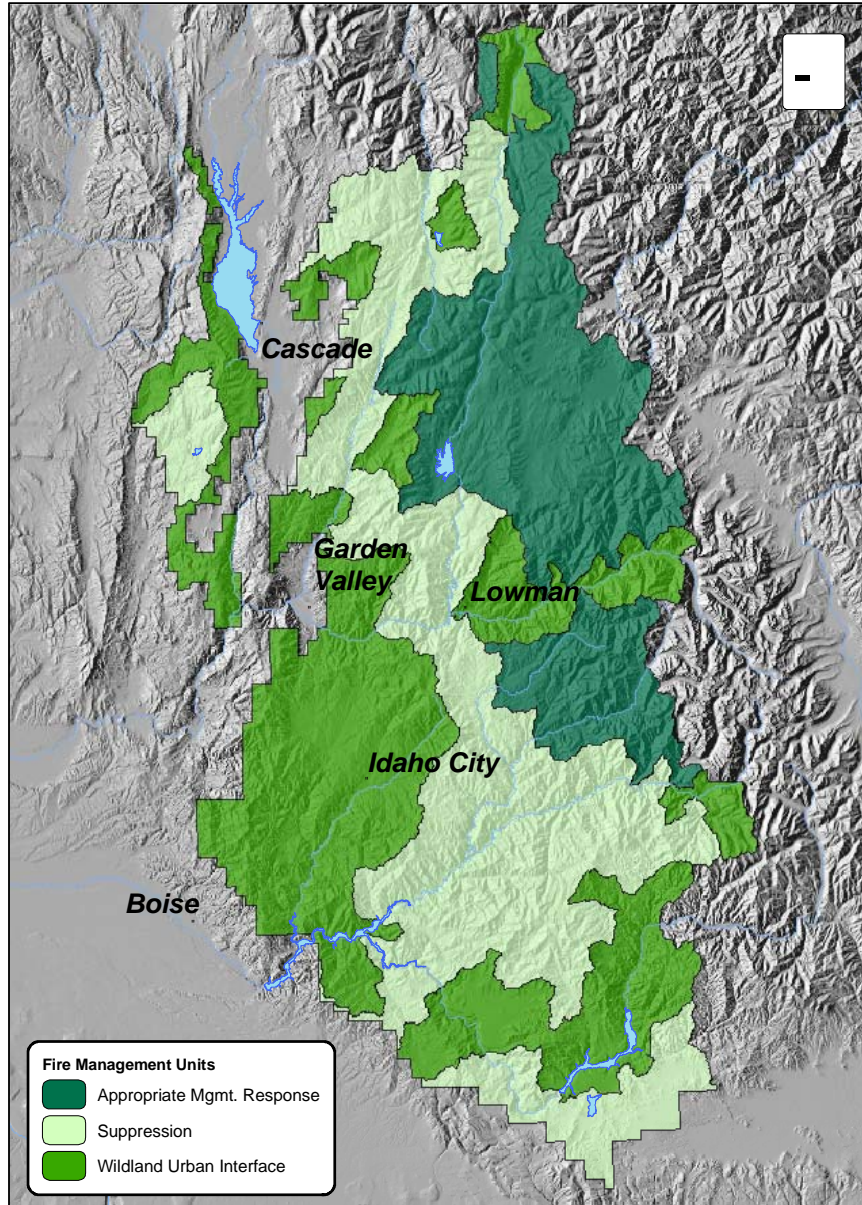


Fire Management Units

FIGURE 4

$N \uparrow \frac{1}{2}'' = 2 \text{ mi.}$

**Boise N.F. Fire Management Units**



- FMU 1 is listed as “appropriate Mgmt. Response” above
- FMU 2 is listed as “Wildland Urban Interface” above
- FMU 3 is listed as “Suppression” above

## Fire History

In the past 49 years, the Boise National Forest experienced a high volume of fire activity with a total of 771,714 acres burned (See Boise National Forest Fire Summaries/Appendix E). Within a 23 year time period, approximately 65% of the acres burned or a total of 229,200 acres were located on the Idaho City District. The majority of these fires are Class A and B fires (See Idaho City District Fire Summaries/Appendix E). During the writing of this paper the 2005 fire data had not been entered into the FireFamily Plus database. However, the large Gregory fire (1132 acres) burned next to the west boundary of the Bavarian unit and is used for the large fire cost comparison.

## Fire Occurrence

In the period from 1956 to 2004, 128 fires 100 acres or larger have burned 741,179 acres on the Boise NF. The largest of these fires was the Foothills Fire, which occurred in 1992 and burned 177,544 acres (See Appendix E).

In the period from 1982 to 2004, 13 fires 100 acres or larger have burned 228,171 acres on the Idaho City District (See Appendix E). Idaho City District fire occurrence data was queried using the FireFamily Plus computer application (See Appendix E). The Idaho City District was chosen based on the small size of the project area (87 acres) to represent fire frequencies. There are 23 years of recorded fire history found in this database, beginning with the year 1982. Between 1982 and 2004, 798 fires have burned a total of 229,199 acres. The largest fire burned 154,226 acres in 1994. The Idaho City District appears to be too large of a database to be representative of fire frequencies. In conversation with the Idaho City Fuels Specialist, this area does not experience any unique weather patterns or have topographic influences that would change the project area from what the district experiences. Therefore, the Idaho City District fire frequencies are used for the computer application Probacre.

## Historical Fire Regime

Fire regimes can be considered as a combination of weather, topography, fire behavior, fuels, vegetation, forest structure and historical fire occurrence, which determine the fire interval (James K. Agee 1993).

Fire regimes describe the historic characteristics of fire in a given ecosystem with factors such as fire frequency, intensity, severity and patch size (James K. Agee 1993).

The historical fire regime in this area is about 40% mixed 1 or 2 (fire regime III) and 60% non-lethal (fire regime I). Approximately 32% of the areas regime has vegetation conditions that are highly departed from the historic range of variability.

This fire management unit (FMU) 2 has the greatest amount of area in the historically non-lethal fire regime compared to the other FMUs on the forest. Most of this departure occurs in the historically non-lethal fire regime areas. The shift to a higher severity fire regime, particularly in the non-lethal areas, has increased intensity, severity and resistance to control. Table 1 depicts the historic fire regimes in FMU 2.

The current fire regime in contrast to the historic fire regime has been found to have a substantial increase in fire interval length (L/RMP 2003). Consequently, downed fuels combined with thickets of understory ladder fuels have promoted a shift in fire potential; from a non-lethal severity to a mixed I and II (fire regime III) and possibly to a lethal (fire regime V).

TABLE 1 Historical Fire Regimes; FMU 2 (Boise FMP, 2005)

Historical Fire Regime	Percent of FMU 2
<b>Forested Communities</b>	
I (non-lethal)	43
III (mixed1 to mixed2)	27
V (lethal)	4
<b>Non-Forested Communities</b>	
II and IV (mixed2 to lethal)	26

### Condition Class

Condition classes are defined within the following three categories:

- I – within the historical range
- II – moderate shift out of historical range
- III – large shift out of historical range

Condition class in the project area is used to describe the departure of the current fire regime from the historical fire regime to represent the potential risk from a wildfire (L/RMP 2003). Each project area is a mix of Condition Class 2 and 3. Without fire as a natural process in the project area, local historic evidence suggests it may trend to all Condition Class 3. Under extreme weather conditions, the accumulation of live and dead fuels may produce high severity fires characterized by Condition Class 2 and 3 (L/RMP 2003). Due to the change in the forest structure, high intensity fires increase risks to firefighter and public safety and ecosystem components, (L/RMP 2003). Table 2 depicts the current condition classes by percent area of FMU 2.

TABLE 2 Current Condition Classes; FMU 2 (Boise FMP, 2005)

Condition Class	Percent of FMU 2
1	41
2	36
3	24

### Typical Tree Stocking

The Pilot Tree Well Unit stand exam shows a stocking of 245 trees (1”+ DBH) in the unit. There is a mean of five large *P. ponderosa* pine trees/acre, 19”+ DBH in size (See Appendix F).

The Bavarian unit stand exam shows a stocking of 210 trees (1”+ DBH) in the unit. There is a mean of twenty six large *P. ponderosa* pine trees/acre, 19”+ DBH in size (See Appendix F). The total project area of 87 acres has a mean large *P. ponderosa* pine tree stocking of 16 trees per acre and a total of 1,392 large *P. ponderosa* pine trees in the combined project area.

### Management Direction

Wildland fires occur more frequently in this management area than any other on the Idaho City District, both from lightning and human causes. The majority of these fires (A and B class fires) are successfully suppressed in the initial attack stage. Large fires in this area since 1989 include the Minneha, King Gulch, Mores-Bannock Creek, Dunnigan, Star Gulch and Gregory. Portions of the Boise Basin Experimental Forest (BBEF) burned in 1994, which is where the Pilot Tree Well unit is located, but the project area itself did not burn. Due to the amount of Wildland Urban Interface (WUI) in this FMU, Wildland fire Use is not a management option. The L/RMP prescription category for the project area is Active Restoration and Maintenance of Aquatic, Terrestrial and Hydrologic Resources. Timber harvesting, pre-commercial thinning and prescribed fires have been used to treat stands in the vicinity, but further treatments are needed to continue restoration and maintenance. This policy will continue due to the need to decrease large catastrophic wildfires in high occurrence WUI areas. As such, treatments will be limited to prescribed fire or mechanical methods.

In addition to forest wide goals, objectives, standards and guidelines that provide direction for all management areas, the following direction has been developed specifically for this area (L/RMP 2003):

- General objective #0808 – continue to cooperate with Rocky Mountain Research Station (RMRS) on management of the BBEF (Pilot Tree Well Unit area).
- Vegetation standard #0810 – vegetation management actions using both prescribed fire and mechanical treatment methods may occur as part of planned research activities, or to achieve other objectives, provided that research objectives are not compromised.
- Fire guideline #0813 – the full range of fire suppression strategies may be used to suppress wildfires.
- Objective #0875 – provide for visual quality along the Highway 21 “Scenic Ponderosa Byway” corridor by developing a vegetation management plan.
- Objective #0876 – design projects to provide for scenic values along the Highway 21 corridor.

### Climate

The area is characterized by dry, warm summers and wet, cold winters. Annual precipitation received in this area averages 25 inches. The majority of precipitation falls in the form of snow during the winter (L/RMP 2003). During the summer, moisture from the Gulf of Mexico may move north and combine with warm temperatures and steep topography to produce thunderstorms, often accompanied by dry lightning. Lightning ignited wildfires typically begin in May and June lasting through mid September (L/RMP

2003). Maximum summertime temperatures can reach over 100 degrees. The growing season can last for approximately 150 days.

### Air Quality/Smoke Management

Air quality in the project area is managed and monitored by the Montana/Idaho Airshed Group, and is located in airshed ID-21B. The Boise National Forest voluntarily entered into the Montana/Idaho Airshed Group to comply with the Idaho Department of Environmental Quality's State Implementation Plan (SIP). The SIP states the National Ambient Air Quality Standards (NAAQS) in Idaho for particulate matter (PM), which is 150 micrograms for PM10, and 65 micrograms for PM2.5. The Montana/Idaho Airshed group can approve or decline a planned prescribed fire ignition based on meteorological conditions. The Airshed Group also monitors visibility impacts to Class I airsheds. The closest Class I airshed is located in the Sawtooth Wilderness and is approximately 26 air miles east of the project area (L/RMP 2003). Prescribed fire treatments will be done on good dispersion days and will have short-term impacts (two to three days) on local residents. Prescribed fire air quality levels must comply with State and Federal air quality regulations.

### Topography

This area has highly variable terrain, ranging from deep, steep walled canyons to relatively flat benches and ridges. Elevations range from 3,000 feet to 6,000 feet. Slope gradients average between 10 – 50 percent.

### Soils, Water, Riparian and Aquatic Resources

The area is predominantly underlain by granitics of the Idaho batholiths (L/RMP 2003). Soils in the area are moderately deep with organic layers (0-4"). Soil textures tend to be dark brown gravelly sandy loams. Excessive erosion due to precipitation run-off is uncommon due mainly to high infiltration rates in the soil and good effective ground cover.

Water quality in the area is functioning at risk due to localized sediment from roads, mining, timber harvest and recreation. The only pollutant of concern to the watershed in this area is sediment. There are no adverse affects expected from the proposed treatments (BBEF, Environmental Assessment, 1999).

Anadromous fish species no longer exist within area streams due to downstream dams that block their migration route to and from the ocean. Brook trout (*Salvelinus fontinalis* Mitchill) are doing well in the area. However, this area is identified as being important to Bull trout (*Salvelinus confluentas* Suckley) recovery, which is a high priority (BBEF, Environmental Assessment, 1999). There is specific management direction concerning helicopter dip sites, water drafting and hazardous materials (fuel) use identified in the FMP.

## Wildlife

Sensitive species habitat for the white-headed wood pecker (*Picoides albolarvatus* Cassin), flammulated owls (*Otus flammeolus* Kaup), northern goshawk (*Accipiter gentiles* Linnaeus) and spotted frogs (*Rana luteiventris* L. *luteus*) do exist within the project area. A complete Biological Evaluation for sensitive wildlife species and a Biologic Assessment was completed and is in the project record. No adverse affects are expected from treatments.

## Vegetation

Vegetation in this area is typically made up of grasslands, shrub lands and *P. ponderosa* stands with small patches of *P. menziesii*. Shrub lands include Mountain Big Sage (*Artemisia tridentate vaseyana* Nutt.) and Bitterbrush (*Purshia tridentate* Pursh). The *A. tridentate vaseyana* and Montane Shrub groups are functioning properly, but are trending toward old age structure, dense canopies and low levels of herbaceous ground cover due to fire exclusion. The perennial grass group is also functioning properly. *P. tridentata* is functioning at risk because of impacts from fire exclusion. Native species are competing with introduced species like cheatgrass (*Bromus tectorum* L.), spotted knapweed (*Centaurea maculosa* Lam.) and rush skeletonweed (*Chondrilla juncea* Asteraceae).

## Cultural Resources

Cultural themes in this area include Mining, Ethnic Heritage, Timber Industry, Transportation, Forest Service History and Civilian Conservation Corps (CCC), (L/RMP 2003). Mores Creek has the highest density of cultural sites of all the management areas. Idaho City is a historic mining town and is listed on the National Register of Historic Places. After 1900, logging became increasingly important to the area's economy. In the 1920's, the Boise-Payette Lumber Company started doing business in the area. As a result there are several historic logging camps in the area. The project area has been inspected, and no archeological sites are known to exist in the project area.

## Recreational Resources

Paved road access, local residences and the proximity to Boise and Idaho City make this area heavily used year-round. Recreation such as hunting, hiking, site seeing, snowmobiling, backcountry skiing, off road vehicle use and camping occurs throughout the area in all seasons. Some of these activities may be impacted during the time of treatments.

## **SCOPE**

The alternatives being looked at are located within the "Scenic Ponderosa Byway", Hwy 21 and the Idaho City WUI area. This paper is focused on the two units mentioned earlier but may be applied to other areas. The concern is the mortality to large *P. ponderosa* trees (19"+DBH) within this area. This is due to the mycorrhizae roots being too close to the surface and vulnerable to wildfire or prescribed fire heating effects. When the fuels specialist applies generic prescribed fire to these stands that have been

altered from their historic fire regime, the second order fire effects are unacceptable (>10% loss of mature *P. ponderosa* trees). Monitoring by RMRS Researchers and the Idaho City Fuels Specialist has shown that two to five years post treatment by prescribed fire these trees are dying as a result of the prescribed fire treatment. This issue may be resolved by pre-treating with either tree well burning or raking. For this paper, it is assumed that once a pre-treatment has been done, generic prescribed fire treatments can be implemented to restore and maintain the forest health objective as stated in the L/RMP, without the adverse effects.

It is assumed that the current management and public concerns will continue within the twenty year planning horizon this paper addresses.

### **DECISION-MAKER'S PROBLEM**

The Line Officer and Fuels Specialist of the Idaho City District, Boise National Forest are uncertain about which treatment alternative over the planning horizon will be best in terms of cost efficiency (lowest C+NVC).

### **MANAGEMENT GOAL**

According to the Land/Resource Management Plan (L/RMP 2003), the project area should be managed for aesthetics (least mortality within 19" *P. ponderosa*) with restoration and a maintenance emphasis within forested landscapes.

### **PROJECT OBJECTIVE**

This project evaluates three alternatives which include: No Action, Tree Well Burning and Tree Well Raking. An economic analysis of cost plus net value change over a twenty year planning horizon where any alternative results in <10% mortality of large diameter *P. ponderosa* while conducting prescribed fire burns is preferred.

### **METHODS**

Methods are broken into the following categories: weather analysis, stand data, fire behavior and fire effects, fire risk and economic analysis.

#### Weather Analysis

FireFamily Plus is a software application for summarizing daily weather observations and computing fire danger indices based on the National Fire Danger Rating System (NFDRS). Data for FireFamily Plus was acquired from the Weather Information Management System (WIMS) data base.

The weather data for this study were retrieved from archived data from the RAWS weather station 101708 (Town Creek) encompassing the years 1985 through 2005. The annual filter of February 1<sup>st</sup> to October 31<sup>st</sup> was used to define the prescribed fire and suppression weather seasons. The Town Creek RAWS station has 6,224 weather records for the years 1985 through 2005. Weather data for this time period was checked for errors and completeness. According to Jim Brain at TFM (class notes 2005), the weather data should include at least ten years with eighty percent of the days recorded for valid statistical analysis. Data gathered includes twenty one years with over ninety percent of the days displaying data. Years 1982 and 1983 are not used due to incomplete weather

data. FireFamily Plus was used to help establish the probability of a large fire occurring in the area within the twenty year planning horizon. Also, the 97<sup>th</sup> and 15<sup>th</sup> percentile weather is used for fire season and prescribed fire conditions (See Table 3 & figure 10).

### Stand Data

The entire stand data received from the Boise NF was single tree data. The number of trees per acre was not given. To determine the number of trees per acre a single tree represented, a formula was used in Excel to convert the data. Three inputs are required for this formula: basal area factor (BAF) used to collect the stand data (See Figure 5), the Diameter at Breast Height (DBH) of the individual trees and the conversion unit (See Excel Spreadsheets/Appendix F & Tables 4 & 5).

FIGURE 5 Trees Per Acre Formula

$\text{Trees Per Acre} = \frac{\text{Basal Area Factor}}{(\text{Diameter Breast Height})^2 * \text{Conversion Factor}}$
---

### Fire Behavior and Fire Effects

Behave Plus 2.0.2 is a software application to predict wildland fire behavior for fire management purposes. Wildland fire managers who are trained in applying Behave model outputs to fire management decisions are the intended users. Behave Plus uses site-specific input data to predict fire behavior for a point in time and space. It is based on Rothermel's surface spread model illustrated in figure 6.

FIGURE 6 Fire Behavior Formula

$R = \frac{I_R * \xi * (1 + \phi_w + \phi_s)}{\rho_b * \epsilon * Q_{ig}}$
--

First Order Fire Effects (FOFEM) 5.0 was used to model fire behavior, mortality and fire effects. FOFEM is a computer program that was developed to meet needs of resource managers, planners and analysts in predicting and planning for fire effects. Quantitative predictions of fire effects are needed for planning prescribed fires that best accomplish resource needs, fire impact assessment and long-range planning.

### Fire Risk

Probacre is a program developed for purposes of assessing the long term risk associated with the level of fire protection provided to an area. The risk of concern centers on the chance that a protection area over time will receive catastrophic consequences from a single or series of wildfire events.

Probacre accomplishes the risk assessment in two ways. First, it calculates the probability of major single fire events. Second, it computes the long term probability that combinations of fire events, both large and small, will result in total burned acres in excess of some number.

All probabilities are computed from information on the annual frequencies of fires by size class for the protected area of concern. Probability estimates are based on the Poisson probability model (See Figure 7). This program assumes that the frequency and distribution of fire sizes will remain constant over any assessment timeframe. (Marc R. Wiitala, 1992).

FIGURE 7 Poisson Probability Formula

$$\text{Poisson: } f(x) = \frac{(e^{-\lambda})\lambda^x}{X!}$$

e = base of natural log  
 $\lambda$  = annual fire frequency  
X = projected years (a random variable)

### Economic Analysis

The No Action, Tree Well Burning and Tree Well Raking alternatives will be evaluated with Cost Plus Net Value Change (C+NVC) over a 20 year planning horizon. This will determine which alternative is the most cost efficient. The 20 year planning horizon was chosen to stay within current management plan direction.

A compounding formula was entered in an Excel spreadsheet to calculate the present day cost for each alternative (See Appendix A & Figure 8). A discounting formula (See Figure 9) was used to verify prescribed fire treatments in year 2009 and 2019 are the same as current costs.

FIGURE 8 Compounding Formula

$$V_n = V_o (1+i)^n$$

$V_o$  = past value  
 $V_n$  = present value (2006)  
i = discount rate (.04)

FIGURE 9 Discounting Formula

$$V_o = V_n (1+i)^{-n}$$

$V_o$  = present value (2006)  
 $V_n$  = future value (value in year n)  
i = discount rate (.04)

## **ASSUMPTIONS**

Fires smaller than one hundred acres are contained in the initial attack phase; fires reaching one hundred acres typically develop into larger extended attack fires (L/RMP 2003).

The fire risk analysis determined that there is a 100% probability that this area will experience a hundred acre fire in the twenty year project period. This was determined using the computer application Probacre (See Appendix B). I am assuming the entire project area would burn in the event of a wildfire. Also, Probacre analysis shows a 100% probability that the project area will experience at least four small fires in twenty years. Small fire frequencies were taken from the class A and B size classes, off of the Idaho City District. I am assuming the area will experience four fires and I have input the corresponding figure into the cost analysis for comparison.

In conversation with Terri Jain (RMRS Researcher), there is no scientific evidence showing a difference in pre-treating tree wells with tree well burning or raking, to reduced mortality post prescribed fire treatment. I am assuming either pre-treatment will accomplish the objective of reducing duff moisture and promote deep root growth on an equal basis. However, this research is continuing and should be monitored.

Once the NEPA document has been completed, it is assumed that it will not expire or need to be rewritten in the twenty year planning horizon this paper looks at. Therefore, the reason for a one time NEPA cost input for the economic analysis.

See also, the assumptions listed throughout the paper.

## **RESULTS**

Results are broken into the following categories: weather analysis, stand data, fire behavior and effects, fire risk and economic analysis.

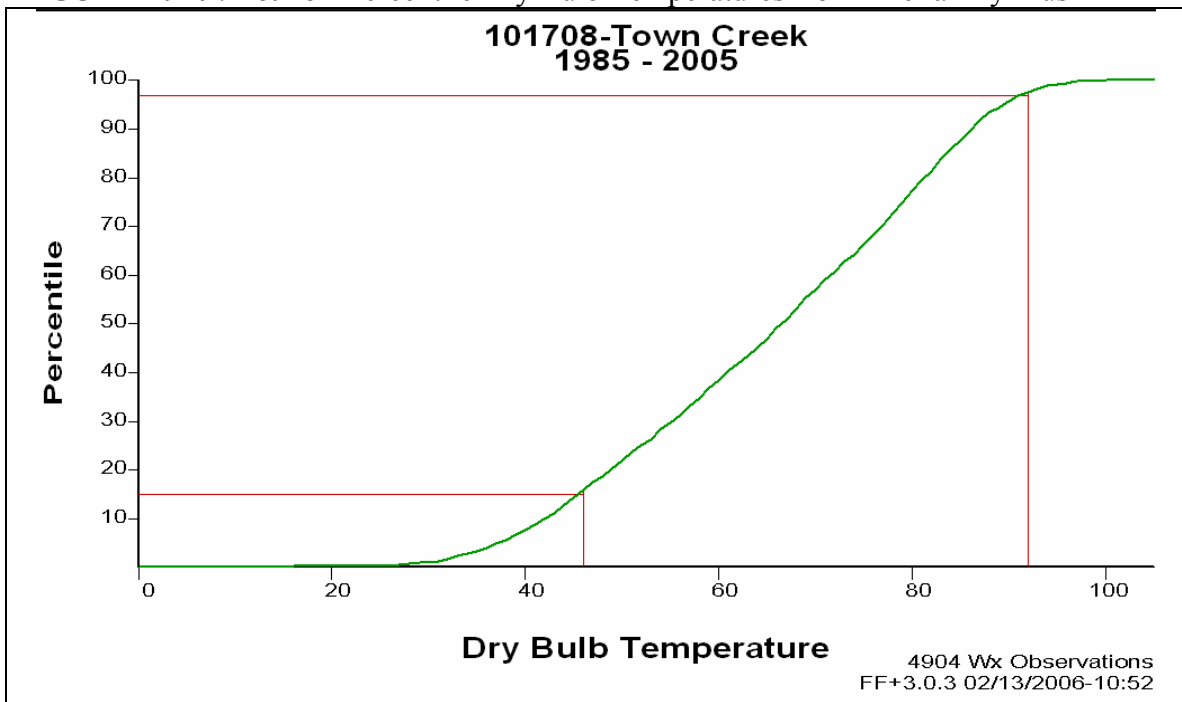
### Weather Analysis

Using the weather records from FireFamily Plus the fire season was defined as occurring between June 1<sup>st</sup> and October 31<sup>st</sup> (L/RMP 2003). FireFamily Plus was used to obtain the index values listed in Table 3 and Figure 10.

TABLE 3 FireFamily Plus Percentile Weather Report

Station	Town Creek			
Model	7G3PE3			
Data years	1985 - 2005			
Data Range	February 1 – October 31st			
Wind Directions	S, SW, W, NW			
Percentiles, Probabilities and Mid-Points				
Variable/Component Range	Low	Moderate	High	Extreme
Percentile Range	0-15	16-89	90-97	98-100
Climatology Prob.	15	75	7	3
Mid-Point BI	0 - 0	45 - 45	69 - 69	81 - 81
# of Observations	311	203	81	20
Spread Component	6	8	13	16
Calculated ERC	10	44	74	81
Fuel Moistures (FM)				
1 Hour FM	12.50	5.90	3.70	3.10
10 Hour FM	34.70	9.40	5.90	4.80
100 hour FM	18.70	11.70	6.70	6.40
Herbaceous FM	22.90	24.80	13.40	7.70
Woody FM	77.20	76.00	64.20	67.40
20' Wind Speed	3.90	4.50	6.10	8.10
1000 Hour FM	22.80	14.60	8.60	7.20
Mean Temperature	46	88	93	105

FIGURE 10 97<sup>th</sup> & 15<sup>th</sup> Percentile Dry Bulb Temperatures from FireFamily Plus



- The 97<sup>th</sup> percentile temperature is 93°F and the 15<sup>th</sup> percentile temperature is 46°F

## Stand Data

TABLE 4 Pilot Tree Well Unit (37 ac.), Site 0866: *P. ponderosa* 19"+ DBH Trees/Acre

Plot # 1	0
Plot # 2	0
Plot # 3	20
Plot # 4	5
Plot # 5	4
Plot # 6	4
Plot # 7	5
Plot # 8	5
Mean Trees/Acre	5

TABLE 5 Bavarian Unit (50 ac.), Site 532: *P. ponderosa* 19"+ DBH Trees/Acre

Plot # 1	29
Plot # 2	12
Plot # 3	29
Plot # 4	10
Plot # 5	67
Plot # 6	61
Plot # 7	16
Plot # 8	0
Plot # 9	40
Plot # 10	19
Plot # 11	6
Mean trees/Acre	26
<b>Combined Unit Mean Trees/Acre</b>	16
<b>Total Trees/Project Area</b>	1,392

## Fire Behavior and Effects

In conversation with the Idaho City Fuels Specialist the Behave Plus computer application is used to evaluate the fire behavior using the 97<sup>th</sup> and 15<sup>th</sup> percentile weather conditions for wildfire and prescribed fire conditions (See Appendix C). Table 6 and 7 depict the inputs and outputs.

TABLE 6 Pilot Tree Well Unit Fire Behavior Inputs and Outputs (97<sup>th</sup> & 15<sup>th</sup> Wx Ob.'s)

Modules: Surface, Size, Scorch And Mortality		
Fuel And Vegetation		
First Fuel Model	9	
Second Fuel Model	5	
First Fuel Model Coverage	80%	
Tree height	80ft.	
Crown Ratio	.6	
Mortality Tree Species	<i>P. ponderosa</i>	
D.B.H.	19,22,25,28,31 inches	
Fuel Moisture		
1-hr. Moisture	3%	13%
10-hr. Moisture	5%	35%
100-hr. Moisture	6%	19%
Live Woody Moisture	64%	30%
Weather		
20ft. Wind Speed	6 mph	4 mph
Wind Adjustment Factor	.2	.2
Direction of Wind Vector	0°	180°
Air Temperature	93°F	58°F
Terrain		
Slope Steepness	40%	40%
Fire		
Elapsed Time	2,8 hr.'s	2,8 hr's
Fire Behavior Outputs		
Flame Length	5.5ft.	1.3ft.
Scorch Height	50ft.	4ft.
Probability of Mortality, 19" DBH	36%	7%
Probability of Mortality, 22" DBH	29%	5%
Probability of Mortality, 25" DBH	24%	4%
Probability of Mortality, 28" DBH	20%	3%
Probability of Mortality, 31" DBH	17%	3%

TABLE 7 Bavarian Unit Fire Behavior Inputs and Outputs for the 97<sup>th</sup> & 15<sup>th</sup> Wx Ob.'s  
 Modules: Surface, Size, Scorch And Mortality

<b>Fuel And Vegetation</b>		
First Fuel Model	9	
Second Fuel Model	2	
First Fuel Model Coverage	80%	
Tree height	80ft.	
Crown Ratio	.6	
Mortality Tree Species	<i>P. ponderosa</i>	
D.B.H.	19,22,25,28,31 inches	
<b>Fuel Moisture</b>		
1-hr. Moisture	3%	13%
10-hr. Moisture	5%	35%
100-hr. Moisture	6%	19%
Live Herbaceous Moisture	30%	30%
<b>Weather</b>		
20ft. Wind Speed	6 mph	4 mph
Wind Adjustment Factor	.2	.2
Direction of Wind Vector	0°	180°
Air Temperature	93°F	58°F
<b>Terrain</b>		
Slope Steepness	40%	40%
<b>Fire</b>		
Elapsed Time	2,8 hr.'s	2,8 hr.'s
<b>Fire Behavior Outputs</b>		
Flame Length	5.4ft.	1.3ft.
Scorch Height	50ft.	4ft.
Probability of Mortality, 19" DBH	35%	7%
Probability of Mortality, 22" DBH	28%	5%
Probability of Mortality, 25" DBH	23%	4%
Probability of Mortality, 28" DBH	19%	3%
Probability of Mortality, 31" DBH	16%	3%

Using the 97<sup>th</sup> percentile weather inputs FOFEM runs show a flame length of 6.7ft., scorch height of 50.20ft and mortality at 38% (19"+ *P. ponderosa*). These results are unacceptable under the conditions stated in the L/RMP.

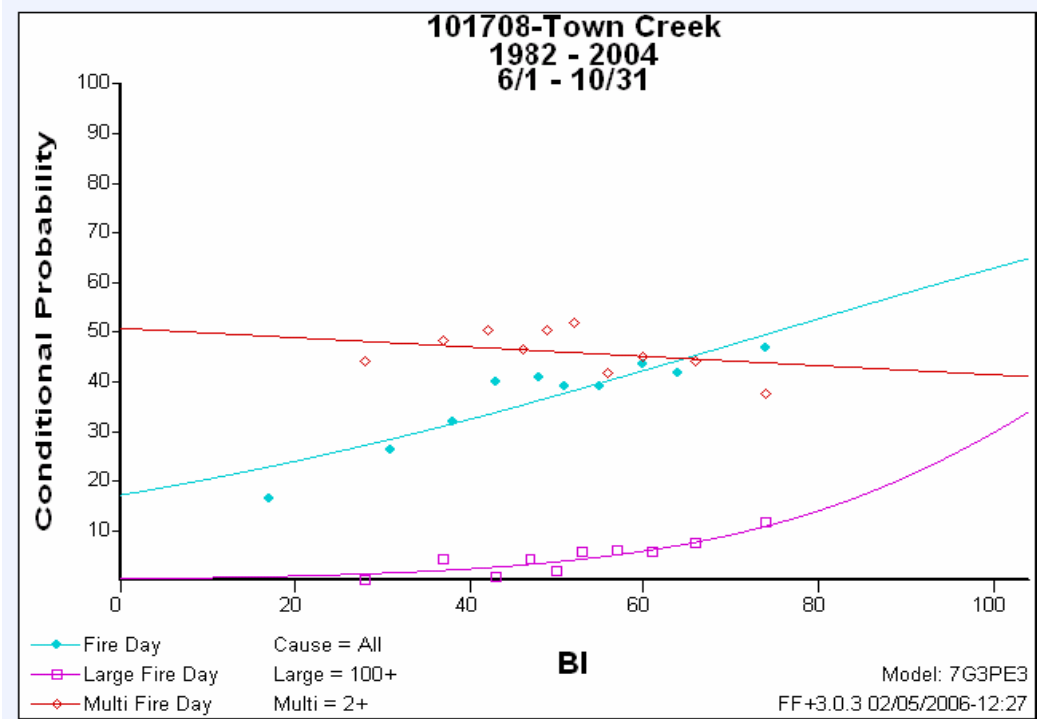
Using the 15<sup>th</sup> percentile weather, these runs show a flame length of 1ft., scorch height of 3.18ft, duff consumption of 51% and mortality of 8%. These results are in the L/RMP acceptable range (See Appendix D). However, in conversation with the RMRS researcher, the modeled mortality is higher than similar projects using the 15<sup>th</sup> percentile weather prescription conducted in the past. The RMRS Researchers have found current mortality to be about one percent post tree well burning or raking pre-treatment with follow-up prescribed fire treatment. Post treatment mortality monitoring of similar near by units has been ongoing for four years now.

To summarize, the above 15<sup>th</sup> percentile weather outputs are realized post-treatment. Computer applications will show acceptable results during generic prescribed fire but in reality what is being experienced is >10% mortality, Thus, a need for a pre-treatment.

### Fire Risk

The computer application Probacre was used for an analysis of fire risk. There is a 100% probability that the project area will experience a 100 acre fire in the next twenty years and a 100% probability that this area will experience at least four small fires (A & B class fires: 0 – 9.9 ac.) in the same time period (See Appendix B). Figure 11 depicts conditional probability of fire occurrence.

FIGURE 11 Conditional Probability of Fire Occurrence



### Economic Analysis

#### Initial Costs:

The National Environmental Policy Act (NEPA) cost is a one time lump sum amount added to all three alternatives. The cost includes plan preparation. The amount of \$12,000.00 in 2005 dollars was given (Tenna Biggs, personal communication, December, 2005). Brought forward using the compounding formula (See Appendix A), this amount came to \$12,480.00 in 2006 dollars.

Costs for small fire suppression are taken from ten local small fires and the average is used for this cost analysis. This cost is applied to all three alternatives. The suppression cost per/acre came to \$8,486.40 in 2005 dollars; this amount brought forward to 2006 and multiplied by four is used. Probacre calculates a 100% probability that the project area will experience at least four small fires in twenty years (See Appendix B). I am

multiplying the cost per/acre by four to reflect this probability. This amount came to \$35,303.44 in 2006 dollars for the 20 year planning horizon.

Costs for the no action alternative were taken from the Gregory Fire, 2005. These costs include: suppression, post-fire rehabilitation and NEPA. The Gregory fire burned 1,132 acres in a WUI area adjacent to the Bavarian Unit. Total suppression (\$1,600,000.00) and rehabilitation (\$87,000.00) costs in 2005 were \$1,687,000.00 (Tenna Biggs, personal communication, December, 2005). In conversation with the Boise Forest fire planner, it was felt that these costs brought forward to 2006 are representative of the project area. Suppression cost per acre figured out to \$1,549.89 per acre, this cost per acre was used for the C+NVC analysis.

Costs for the tree well burning were gathered from similar past prescribed fire projects implemented on the Idaho City District, Boise NF. These costs include NEPA compliance, monitoring, prescribed fire plan writing and implementation. Costs given in year 2005 for tree well burning were in a range of \$33.00 - \$50.00/acre (Evans Kuo, personal communication, January, 2005). Talking with the Idaho City Fuels Specialist, the high end of \$50.00/acre brought forward to 2006 dollars best represents this project area. Factors considered are accessibility, number of trees/acre and the time to monitor “cat faced” trees during and after treatment. Due to years of fire exclusion these “cat faces” are rotten and vulnerable to fire, not fire hardened or fire resistant, as they would have been during the historic fire regime.

Costs for the tree well raking were gathered from similar past projects implemented on the BLM Arizona Strip District, St. George, UT. These costs include NEPA compliance, environmental monitoring and implementation. Costs given for this treatment in 2005 dollars were given in a range of \$45.00 - \$225.00/acre (Tim Duck, personal communication, December, 2005). The factors considered are drive time, trees/acre, duff/litter depth and diameter to be raked. With these factors being considered I was given a substantial cost range. While evaluating these treatment option costs with the Fuels Specialist of the Idaho City District, it was felt that the mean figure compounded forward to 2006 dollars would represent the local project costs. This amount came to \$140.40/acre.

Costs for the generic prescribed fire treatments were gathered from similar past projects implemented on the Idaho City District, Boise NF. These costs include NEPA compliance, monitoring, plan writing and implementation. Costs given for this treatment in 2005 dollars are \$90.00/acre (Evans Kuo, personal communication, December, 2005). After the initial tree well and raking treatment has been implemented, generic prescribed fire treatments will be conducted. These will be in year 2009 and year 2019.

To determine the present day cost per acre for the no action, tree well burning and tree well raking alternatives, a discount rate of four percent was used (Rideout and Hesseln, 2001). Figure 8 shows the compounding formula.

An Excel spread sheet was built using the compounding formula to calculate the present day cost for the three alternatives (See Appendix A). The present day cost per

acre is multiplied by the total project area of 87 acres to calculate the total cost (See Table 8).

TABLE 8 Present Day Costs

<b>Alternative</b>	<b>Suppression/Treatment Cost/Acre (87ac.)</b>	<b>NEPA Costs Year 2006</b>	<b>Year 2006 Total Cost</b>
<b>No Action</b>	\$1,549.89	\$0.00	\$134,840.43
<b>Tree Well Burning</b>	\$52.00	\$12,480.00	\$17,004.00
<b>Tree Well Raking</b>	\$140.40	\$12,480.00	\$24,694.80

Assumption:

- The NEPA cost will occur only once.

Resource Values:

Boise NF resource values given are for year 2005 and are from the National Fire Management Analysis System (NFMAS). Project area values include timber, forage, fisheries, wildlife and recreation. The project area forest value is \$496.18/acre, at the Fire Intensity Level (FIL) of 4, (See Appendix G) in 2005 dollars; this amount multiplied by project acres and brought forward to 2006 is \$516.03/acre with a total project area value of \$44,894.61. FIL levels are chosen from predicted flame lengths using Behave Plus and can be found in Appendix G.

In conversation with the Idaho City Fuels Specialist it is believed that additional treatments for the tree well burning and tree well raking alternatives would be needed in three and thirteen years post treatment. In calculating a C+NVC the net present value (NPV) of the cost/value are used (Rideout and Hesseln 2001). The NPV of the additional prescribed fire treatments planned for years 2009 and 2019 was verified to be the same as the current cost with the use of the discounting formula (See Figure 9). Table 9 displays the adjusted costs for each alternative.

TABLE 9 Adjusted Costs in 2006 Dollars

<b>Alternatives</b>	<b>Total Costs (2006) (from table 8)</b>	<b>Additional Treatment Costs</b>	<b>Adjusted Total Costs (2006)</b>
<b>No Action</b>	\$134,840.43	\$0.00	\$134,840.43
<b>Tree Well Burning</b>	\$17,004.00	\$16,286.40	\$33,290.40
<b>Tree Well Raking</b>	\$24,694.80	\$16,286.40	\$40,981.20

Multiplying the current value by the probability of a fire exceeding 100 acres for each alternative and the expected net value cost can be calculated. Multiplying costs over the 20 year planning horizon by the probability of a fire exceeding 100 acres for each alternative and the expected cost can be calculated. Adding the expected NVC and the expected cost will give the expected C+NVC (Rideout and Hesseln, 2001). The expected C+NVC for all three alternatives is shown in Table 10.

TABLE 10 Expected C+NVC

<b>Alternatives</b>	<b>No Action</b>	<b>Tree Well Burning</b>	<b>Tree Well Raking</b>
<b>2006 Land Value</b>	\$44,894.00	\$44,894.00	\$44,894.00
<b>Prescribed Fire Or Raking Costs</b>	\$0.00	\$-33,290.40	\$-40,981.20
<b>Small Fire Costs</b>	\$-35,303.44	\$-35,303.44	\$-35,303.44
<b>Large Fire Costs</b>	\$-134,840.00	\$-134,840.00	\$-134,840.00
<b>Probability of a Fire Exceeding 100 acres</b>	1.00	0.10	0.10
<b>Expected Costs</b>	\$-170,143.44	\$-203,433.84	\$-211,124.64
<b>Expected NVC</b>	\$-44,894.00	\$-4,894.40	\$-4,894.40
<b>Expected C+NVC</b>	\$-215,037.44	\$-208,328.24	\$-216,019.04

The results of the economic analysis show that the tree well burning alternative has the least expected C+NVC in comparison to the other alternatives, thus, being the most cost efficient.

Assumptions:

- Recent prescribed fires costs are representative of the project area
- Recent fire suppression costs are representative of the project area
- A fire that exceeds the 100 acre threshold will burn the entire project area
- Discount rate of .04 is representative of actual inflation
- Additional prescribed fire treatments will be needed in three and thirteen years
- Prescribed fire will not have a negative impact on values
- Prescribed fire will prevent > 100 acre fires
- Ten percent probability was used for the pre-treatments due to the two year period between the pre-treatment and generic prescribed fire. This is 10% of the twenty year planning horizon being looked at.

**DISCUSSION AND RECOMMENDATION**

The project goal is to analyze and recommend a viable treatment alternative that will provide for aesthetics with a restoration and maintenance emphasis within the project area.

The project objective of this analysis is to evaluate alternatives which will reduce duff layer depth or moisture around the existing *P. ponderosa* trees (thus, indirectly reducing the second order fire effect to <10% mortality) and producing the lowest C+NVC. Three alternatives were developed to meet this objective:

- No Action
- Tree Well Burning
- Tree Well Raking

The alternative of applying generic prescribed fire treatments alone over the twenty year planning horizon was not evaluated. This is due to the fact that computer

applications will show an acceptable outcome (See Table 6, 7 & Appendix H), but through research it has been discovered that post treatment mortality is unacceptable.

Each of these alternatives has been evaluated to meet the project's objectives. Each viable alternative was then evaluated by the expected C+NVC over a 20-year planning horizon. The following is a discussion of each alternative.

The "No Action" or current management alternative is not recommended. If a wildfire were to occur it would not meet the objective in the land management plan. The existing conditions of the no action alternative set a benchmark to compare all of the alternatives. It is shown with Behave Plus computer modeling that a wildfire burning in the 97<sup>th</sup> percentile weather conditions would produce an unacceptable tree mortality of >10%. The flaming front would be just outside the direct attack parameters for initial attack forces. With modeled flame lengths pushing six feet and with containment time for initial attack forces compromised by fire behavior, the fire perimeter would have a good chance of reaching the hundred acre threshold (See Appendix C), which in past history usually turns into an extended attack fire with exponentially higher suppression costs.

Here again, "No Action" has two parts. Do truly nothing and risk experiencing a wildfire or continue doing generic prescribed fire treatments and risk experiencing >10% mortality post-treatment.

Economic analysis of the no action alternative gave an expected C+NVC of \$-215,037.44. This cost was only for the 87 acre project area, and could have been much higher depending on the actual fire size. Uncharacteristic fire behavior associated with increasing tree density and fuel loading may have additional negative impacts to soil, fisheries, timber and wildlife resources. Analysis of these factors is beyond the scope of this project.

The "Tree Well Burning" alternative meets the project objective and is the recommended alternative. Research and computer modeling show the duff layer can be reduced to within the acceptable parameters of 40 to 70% loading, which is needed to reduce second order mortality.

Tree well burning projects could be implemented at a cheaper cost if the land manager had a larger area to be treated. This alone would lower costs. Also, using a helicopter with a plastic sphere dispenser machine, over large areas, could be substantially cheaper. Tree well burning smaller *P. ponderosa* trees are being looked at for pre-treatment to generic prescribed fire; this could be a viable treatment for over stocked crown fire prone plantations.

The "Tree Well Raking" alternative does not meet the project, least cost, objective and is not recommended at this time. Raking will reduce the duff moisture and prepare the tree for generic broadcast burns with acceptable mortality (RMRS researcher, Terre Jain, personal communication, December, 2005) but shows a higher C+NVC. However, raking has its pluses. There is no burn plan required for this manual treatment and it has fewer NEPA restrictions. In theory, a manager would experience more work days to

implement the treatment alternative, and considering all the factors involved, there may be situations when raking would be the better alternative. Table 11 shows a comparison of analysis outcome by alternative.

TABLE 11 Comparison of Analysis Outcome by Alternative

	<b>No Action</b>	<b>Tree Well Burning</b>	<b>Tree Well Raking</b>
<b>Reduce Duff Depth/ Duff Moisture</b>	NO	YES	YES
<b>Reduction in Mortality</b>	NO	YES	YES
<b>C+NVC</b>	\$-215,037.44	\$-208,328.24	\$-216,019.04

As mentioned earlier, tree well burning and raking for pre-treating large *P. ponderosa* for generic prescribed fire treatments is ongoing. The continuation of research and monitoring units that have been treated is vital and need to continue. Currently, the Idaho City District has several tree well burning projects identified for treatment; which will give additional data and need to be monitored for results.

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## APPENDIX A

### Economics Excel Spreadsheet

Costs	Year	Cost/Ac.	Year	Int. Rate	Cost/Ac.	Total Cost
Large Fire	2005	1490.28	2006	0.04	1549.89	134840.53
Forest Value	2005	496.18	2006	0.04	516.03	44894.366
TW Burning	2005	50	2006	0.04	52	4524
TW Raking	2005	135	2006	0.04	140.4	12214.8

Costs	Year	Cost	Year	Int. Rate	Cost	Total Cost
NEPA	2005	12000	2006	0.04	12480	12480

Costs	Year	Cost/Ac.	Year	Int. Rate	Cost/Ac.	Total Cost
Prescribed Fire	2005	90	2006	0.04	93.60	8143.20

Costs	Year	Cost/Ac.	Year	Int. Rate	Cost/Ac.	Total Cost
Small Fire	2005	8486.4	2006	0.04	8825.86	35303.44

### Compounding Formula

$$V_n = V_o (1+i)^n$$

$V_o$  = past value

$V_n$  = present value (2006)

$i$  = discount rate (.04)

### Discounting Formula

$$V_o = V_n (1+i)^{-n}$$

$V_o$  = present value (2006)

$V_n$  = future value (value in year n)

$i$  = discount rate (.04)

APPENDIX B


Probacre Run

PROBACRE.EXE								
SIZE	FIRE FREQUENCY		PROBABILITY OF NUMBER OF FIRES PER PERIOD					
CLASS	ANNUAL	PERIOD	NONE	1	2	3	4	>4
5	33.130	662.600	0.000000	0.000000	0.000000	0.000000	0.000000	1.0000
55	1.000	20.000	0.000000	0.000000	0.000000	0.000003	0.000014	1.0000
500	0.087	1.740	0.175520	0.305405	0.265703	0.154108	0.067037	0.0322
3000	0.043	0.860	0.423162	0.363919	0.156485	0.044859	0.009645	0.0019
5000	0.260	5.200	0.005517	0.028686	0.074584	0.129279	0.168063	0.5939
PROBABILITY OF EXCEEDING			100	ACRE THRESHOLD IN		20	YEARS IS	1.00000
PROBABILITY OF EXCEEDING			1,000	ACRE THRESHOLD IN		20	YEARS IS	1.00000
PROBABILITY OF EXCEEDING			10,000	ACRE THRESHOLD IN		20	YEARS IS	0.99104


# APPENDIX C


## Behave Plus Runs


**Modules:** SURFACE, SIZE, SCORCH, MORTALITY


Description  Pilot Tree Well 15th Percentile Wx Obs.


**Fuel/Vegetation**


First Fuel Model  9


Second Fuel Model  5

First Fuel Model Coverage %  80


Tree Height ft  80


Crown Ratio  .6


Mortality Tree Species  PinPon


D.B.H. in  19, 22, 25, 28, 31


**Fuel Moisture**

1-h Moisture %  13


10-h Moisture %  35


100-h Moisture %  19


Live Herbaceous Moisture % 


Live Woody Moisture %  77

**Weather**


20-ft Wind Speed mi/h  4

Wind Adjustment Factor  .2

Direction of Wind Vector (from upslope) deg  180

Air Temperature °F  58

**Terrain**

Slope Steepness %  40

**Pilot Tree Well 15th Percentile Wx Obs.**  
Rate of Spread (maximum) (ch/h)

Tree D.B.H.	Elapsed Time	
	h	
in	2.0	8.0
19	1.8	1.8
22	1.8	1.8
25	1.8	1.8
28	1.8	1.8
31	1.8	1.8

Pilot Tree Well 15th Percentile Wx Obs.  
Heat per Unit Area (Btu/ft<sup>2</sup>)

Tree D.B.H. in	Elapsed Time h	
19	2.0	8.0
22	320	320
25	320	320
28	320	320
31	320	320

Pilot Tree Well 15th Percentile Wx Obs.  
Fireline Intensity (Btu/ft/s)

Tree D.B.H. in	Elapsed Time h	
19	2.0	8.0
22	11	11
25	11	11
28	11	11
31	11	11

Pilot Tree Well 15th Percentile Wx Obs.  
Flame Length (ft)

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	1.3	1.3
22	1.3	1.3
25	1.3	1.3
28	1.3	1.3
31	1.3	1.3

Pilot Tree Well 15th Percentile Wx Obs.  
Reaction Intensity (Btu/ft<sup>2</sup>/min)

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	2069	2069
22	2069	2069
25	2069	2069
28	2069	2069
31	2069	2069

Pilot Tree Well 15th Percentile Wx Obs.  
Area (ac)

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	0.9	14.3
22	0.9	14.3
25	0.9	14.3
28	0.9	14.3
31	0.9	14.3

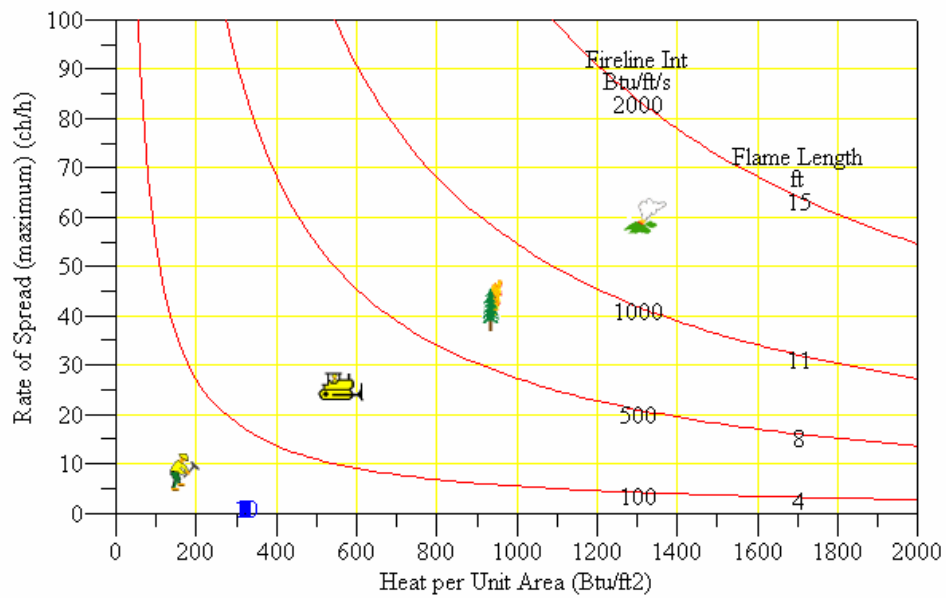
Pilot Tree Well 15th Percentile Wx Obs.  
Scorch Height (ft)

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	4	4
22	4	4
25	4	4
28	4	4
31	4	4


Pilot Tree Well 15th Percentile Wx Obs.  
Probability of Mortality (%)

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	7	7
22	5	5
25	4	4
28	3	3
31	3	3








Pilot Tree Well 15th Percentile Wx Obs.  
Fire Characteristics Chart








**Modules: SURFACE, SIZE, SCORCH, MORTALITY**

Description  Pilot Tree Well 97th Percentile Wx Obs.

**Fuel/Vegetation**

First Fuel Model			9
Second Fuel Model			5
First Fuel Model Coverage	%		80
Tree Height	ft		80
Crown Ratio			.6
Mortality Tree Species			PinPon
D.B.H.	in		19, 22, 25, 28, 31

**Fuel Moisture**

1-h Moisture	%		3
10-h Moisture	%		5
100-h Moisture	%		6
Live Herbaceous Moisture	%		
Live Woody Moisture	%		64

**Weather**

20-ft Wind Speed	mi/h		6
Wind Adjustment Factor			.2
Direction of Wind Vector (from upslope)	deg		0
Air Temperature	oF		93

**Pilot Tree Well 97th Percentile Wx Obs.**

Rate of Spread (maximum) (ch/h)

Tree D.B.H.	Elapsed Time	
	h	
in	2.0	8.0
19	7.2	7.2
22	7.2	7.2
25	7.2	7.2
28	7.2	7.2
31	7.2	7.2

Pilot Tree Well 97th Percentile Wx Obs.  
Heat per Unit Area (Btu/ft<sup>2</sup>)

Tree	Elapsed Time	
D.B.H.	h	
in	2.0	8.0
19	766	766
22	766	766
25	766	766
28	766	766
31	766	766

Pilot Tree Well 97th Percentile Wx Obs.  
Fireline Intensity (Btu/ft/s)

Tree	Elapsed Time	
D.B.H.	h	
in	2.0	8.0
19	228	228
22	228	228
25	228	228
28	228	228
31	228	228

Pilot Tree Well 97th Percentile Wx Obs.  
Flame Length (ft)

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	5.5	5.5
22	5.5	5.5
25	5.5	5.5
28	5.5	5.5
31	5.5	5.5

Pilot Tree Well 97th Percentile Wx Obs.  
Reaction Intensity (Btu/ft<sup>2</sup>/min)

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	3355	3355
22	3355	3355
25	3355	3355
28	3355	3355
31	3355	3355

Pilot Tree Well 97th Percentile Wx Obs.  
Area (ac)

Tree	Elapsed Time	
D.B.H.	h	
in	2.0	8.0
19	11.9	190.0
22	11.9	190.0
25	11.9	190.0
28	11.9	190.0
31	11.9	190.0

Pilot Tree Well 97th Percentile Wx Obs.  
Scorch Height (ft)

Tree	Elapsed Time	
D.B.H.	h	
in	2.0	8.0
19	50	50
22	50	50
25	50	50
28	50	50
31	50	50


Pilot Tree Well 97th Percentile Wx Obs.  
Probability of Mortality (%)

Tree D.B.H.	Elapsed Time h	
in	2.0	8.0
19	36	36
22	29	29
25	24	24
28	20	20
31	17	17







Pilot Tree Well 97th Percentile Wx Obs.  
Probability of Mortality (%)

Tree D.B.H.	Elapsed Time h	
in	2.0	8.0
19	36	36
22	29	29
25	24	24
28	20	20
31	17	17




**Modules: SURFACE, SIZE, SCORCH, MORTALITY**

Description  Bavarian 15th Percentile Wx Obs.


**Fuel/Vegetation**

First Fuel Model			9
Second Fuel Model			2
First Fuel Model Coverage	%		80
Tree Height	ft		80
Crown Ratio			.6
Mortality Tree Species			PinPon
D.B.H.	in		19, 22, 25, 28, 31


**Fuel Moisture**

1-h Moisture	%		13
10-h Moisture	%		35
100-h Moisture	%		19
Live Herbaceous Moisture	%		30
Live Woody Moisture	%		77

**Weather**

20-ft Wind Speed	mi/h		4
Wind Adjustment Factor			.2
Direction of Wind Vector (from upslope)	deg		180
Air Temperature	oF		58

**Terrain**

Slope Steepness	%		40
-----------------	---	---	----

**Bavarian 15th Percentile Wx Obs.  
Rate of Spread (maximum) (ch/h)**

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	2.2	2.2
22	2.2	2.2
25	2.2	2.2
28	2.2	2.2
31	2.2	2.2

**Bavarian 15th Percentile Wx Obs.  
Heat per Unit Area (Btu/ft<sup>2</sup>)**

Tree D.B.H. in	Elapsed Time h	
19	320	320
22	320	320
25	320	320
28	320	320
31	320	320

**Bavarian 15th Percentile Wx Obs.  
Fireline Intensity (Btu/ft/s)**

Tree D.B.H. in	Elapsed Time h	
19	11	11
22	11	11
25	11	11
28	11	11
31	11	11

Bavarian 15th Percentile Wx Obs.  
Flame Length (ft)

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	1.3	1.3
22	1.3	1.3
25	1.3	1.3
28	1.3	1.3
31	1.3	1.3

Bavarian 15th Percentile Wx Obs.  
Reaction Intensity (Btu/ft<sup>2</sup>/min)

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	2069	2069
22	2069	2069
25	2069	2069
28	2069	2069
31	2069	2069

Bavarian 15th Percentile Wx Obs.  
Area (ac)

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	1.2	19.8
22	1.2	19.8
25	1.2	19.8
28	1.2	19.8
31	1.2	19.8

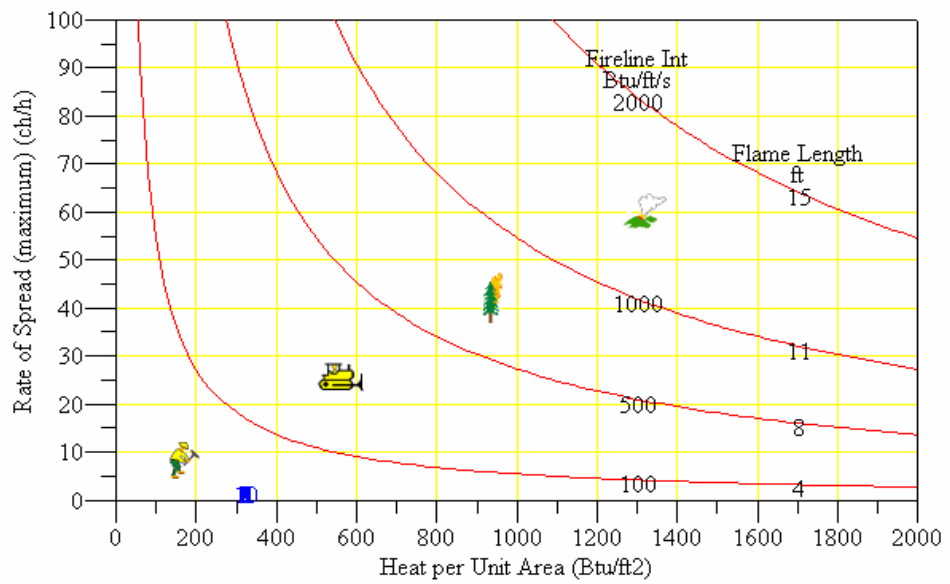
Bavarian 15th Percentile Wx Obs.  
Scorch Height (ft)

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	4	4
22	4	4
25	4	4
28	4	4
31	4	4


Bavarian 15th Percentile Wx Obs.  
Probability of Mortality (%)

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	7	7
22	5	5
25	4	4
28	3	3
31	3	3








Bavarian 15th Percentile Wx Obs.  
Fire Characteristics Chart








**Modules: SURFACE, SIZE, SCORCH, MORTALITY**

Description  Bavarian 97th Percentile Wx Obs.





**Fuel/Vegetation**

First Fuel Model			<input type="text" value="9"/>
Second Fuel Model			<input type="text" value="2"/>
First Fuel Model Coverage	%		<input type="text" value="80"/>
Tree Height	ft		<input type="text" value="80"/>
Crown Ratio			<input type="text" value=".6"/>
Mortality Tree Species			<input type="text" value="PinPon"/>
D.B.H.	in		<input type="text" value="19, 22, 25, 28, 31"/>

**Fuel Moisture**

1-h Moisture	%		<input type="text" value="3"/>
10-h Moisture	%		<input type="text" value="5"/>
100-h Moisture	%		<input type="text" value="6"/>
Live Herbaceous Moisture	%		<input type="text" value="30"/>
Live Woody Moisture	%		<input type="text" value="64"/>

**Weather**

20-ft Wind Speed	mi/h		<input type="text" value="6"/>
Wind Adjustment Factor			<input type="text" value=".2"/>
Direction of Wind Vector (from upslope)	deg		<input type="text" value="0"/>
Air Temperature	oF		<input type="text" value="93"/>

**Bavarian 97th Percentile Wx Obs.  
Rate of Spread (maximum) (ch/h)**

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	8.3	8.3
22	8.3	8.3
25	8.3	8.3
28	8.3	8.3
31	8.3	8.3

**Bavarian 97th Percentile Wx Obs.  
Heat per Unit Area (Btu/ft<sup>2</sup>)**

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	563	563
22	563	563
25	563	563
28	563	563
31	563	563

**Bavarian 97th Percentile Wx Obs.  
Fireline Intensity (Btu/ft/s)**

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	226	226
22	226	226
25	226	226
28	226	226
31	226	226

**Bavarian 97th Percentile Wx Obs.  
Flame Length (ft)**

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	5.4	5.4
22	5.4	5.4
25	5.4	5.4
28	5.4	5.4
31	5.4	5.4

**Bavarian 97th Percentile Wx Obs.  
Reaction Intensity (Btu/ft<sup>2</sup>/min)**

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	4082	4082
22	4082	4082
25	4082	4082
28	4082	4082
31	4082	4082

Bavarian 97th Percentile Wx Obs.  
Area (ac)

Tree	Elapsed Time	
D.B.H.	h	
in	2.0	8.0
19	15.9	254.3
22	15.9	254.3
25	15.9	254.3
28	15.9	254.3
31	15.9	254.3

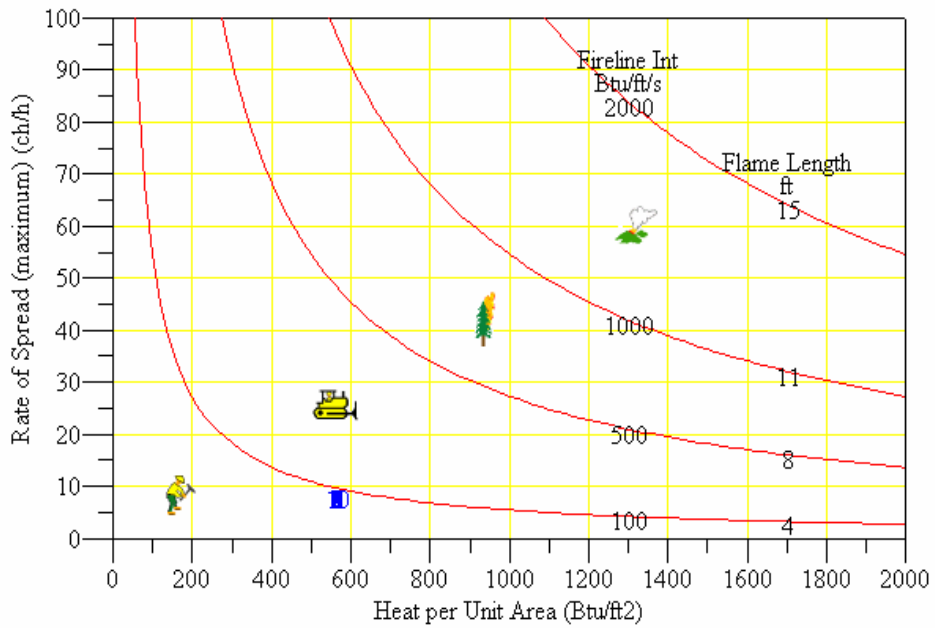
Bavarian 97th Percentile Wx Obs.  
Scorch Height (ft)

Tree	Elapsed Time	
D.B.H.	h	
in	2.0	8.0
19	50	50
22	50	50
25	50	50
28	50	50
31	50	50

Bavarian 97th Percentile Wx Obs.  
Probability of Mortality (%)

Tree D.B.H. in	Elapsed Time h	
	2.0	8.0
19	35	35
22	28	28
25	23	23
28	19	19
31	16	16

Bavarian 97th Percentile Wx Obs.  
Fire Characteristics Chart



**APPENDIX D**

**FOFEM RUNS**

**TITLE: 97th Percentile Wx Obs.**

**FUEL CONSUMPTION CALCULATIONS**

Region: Interior\_West  
Cover Type: SAF/SRM - SAF 237 - Interior P. PONDEROSA  
Fuel Type: Natural  
Fuel Reference: FOFEM 011

**FUEL CONSUMPTION TABLE**

Fuel Component Name	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Moisture (%)
Litter	2.80 +	2.80	0.00	100.0	
Wood (0-1/4 inch)	0.11 +	0.11	0.00	100.0	3.0
Wood (1/4-1 inch)	0.94 +	0.94	0.00	100.0	6.0
Wood (1-3 inch)	1.20 +	1.20	0.00	100.0	
Wood (3+ inch) Sound	9.00 +	5.91	3.09	65.7	10.0
Wood (3+ inch) Rotten	1.00 +	0.83	0.17	83.1	10.0
Duff	33.33 u	26.48	6.85	79.4	10.0
Herbaceous	0.20	0.20	0.00	100.0	
Shrubs	0.60 +	0.36	0.24	60.0	
Crown foliage	9.00 +	0.00	9.00	0.0	
Crown branchwood	1.05 +	0.00	1.05	0.0	
<b>Total Fuels</b>	<b>59.23</b>	<b>38.83</b>	<b>20.40</b>	<b>65.6</b>	

'u' Preburn Load is User adjusted  
'+' Preburn Load is Heavy/Abundant

**FIRE EFFECTS ON FOREST FLOOR COMPONENTS**

Duff Depth Consumed (in) 2.5 Equation: 6  
Mineral Soil Exposed (%) 94.6 Equation: 10

**TITLE: 97th Percentile Wx Obs.**

TREE MORTALITY MODULE:  
REGION: Interior West

**SCORCH HEIGHT (FT): 50.00**

Flame Length: 6.69

ORIGINAL STAND DENSITY AS INPUT TO FOFEM

Species	DBH (in)
Code	20
<hr/>	
P. PONDEROSA	16
<hr/>	
TOTALS	16

POSTFIRE STAND DENSITY (TREES/ACRE)

Species	DBH (in)
Code	20
<hr/>	
P. PONDEROSA	10
<hr/>	
TOTALS	10

TREES PER ACRE KILLED BY THE FIRE

Species	DBH (in)
Code	20
<hr/>	
P. PONDEROSA	6
<hr/>	
TOTALS	6

PROBABILITY OF MORTALITY FOR EACH SPECIES/DIAMETER ENTRY

Species	Diameter	Number	Prob	Mort Equ
Code	(inch)	Trees	Mort	Number
<hr/>				
P. PONDEROSA	19	16	0.38	1

AVERAGE MORTALITY PROBS BY SCORCH HEIGHT BY SPECIES/DIAMETER ENTRY

Species	Tree	Scorch Height (feet)
Code	DBH	50
<hr/>		
P. PONDEROSA	19	0.38
<hr/>		
AVERAGES	19	0.38

STAND TREE MORTALITY, 97<sup>th</sup> Percentile Wx Obs.

Percent mortality: 38

Number of trees killed by the fire: 6

Average tree diameter (DBH) of fire killed trees: 19.0

Percent mortality for trees 19+ in DBH: 38

Total pre-fire number of trees: 16

Stand Basal Area:	sq/ft	Percent
Pre-fire Live:	31.50	100
Post fire Live:	19.46	62
Post fire Killed:	12.04	38

Stand Canopy Cover:	Percent
Pre-fire Live:	10
Post fire Live:	6
Change:	4

# Fuel Consumption Calculations

Mortality    Fuel    Smoke    Soil   
 C:\Program Files\F5\Fofem5\Fofem5.prj   
 Interior\_West   SAF/SRM

SAF 237 - Interior Ponderosa Pine   Spring   Moderate   Natural-Fuel

Fuels	Litter	0-1/4	1/4-1	1-3	3+	Duff	Herb	Shrub	Foliage	Branch
Tons/Acre	2.80	0.11	0.94	1.20	10.00	33.33	0.20	0.60	6.00	1.05
Adjustment	Heavy	Heavy	Heavy	Heavy	Heavy	User	Typical	Abundan	Typical	Abundan
Moisture %			16		30	75				
Log Rotten %					10.0	4.00	Duff Depth(in)		Crown Burn %	0.0
Log Loading Distribution					Even	Entire			Summaries:	

## Adjust canopy small branch biomass loading

TITLE: Results of FOFEM model execution on date: 2/22/2006

### FUEL CONSUMPTION CALCULATIONS

Region: Interior\_West  
 Cover Type: SAF/SRM - SAF 237 - Interior Ponderosa Pine  
 Fuel Type: Natural  
 Fuel Reference: FOFEM 011

### FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture (%)
Litter	2.80 +	2.80	0.00	100.0	999	
Wood (0-1/4 inch)	0.11 +	0.11	0.00	100.0	999	
Wood (1/4-1 inch)	0.94 +	0.94	0.00	100.0	999	16.0
Wood (1-3 inch)	1.20 +	1.20	0.00	100.0	999	
Wood (3+ inch) Sound	9.00 +	4.14	4.86	46.1	999	30.0
Wood (3+ inch) Rotten	1.00 +	0.61	0.39	61.3	999	30.0
Duff	33.33 u	17.25	16.08	51.8	2	75.0
Herbaceous	0.20	0.20	0.00	100.0	22	
Shrubs	0.60 +	0.36	0.24	60.0	23	
Crown foliage	6.00	0.00	6.00	0.0	37	
Crown branchwood	1.05 +	0.00	1.05	0.0	38	
<b>Total Fuels</b>	<b>56.23</b>	<b>27.62</b>	<b>28.61</b>	<b>49.1</b>		

'u' Preburn Load is User adjusted

'+' Preburn Load is Heavy/Abundant

**TITLE: Spring Tree Well Burning**

TREE MORTALITY MODULE:  
REGION: Interior West

**FLAME LENGTH (FT): 1.00**  
**Scorch Height: 3.18**

ORIGINAL STAND DENSITY AS INPUT TO FOFEM

Species Code	DBH (in)
P. PONDEROSA	16
TOTALS	16

POSTFIRE STAND DENSITY (TREES/ACRE)

Species Code	DBH (in)
P. PONDEROSA	15
TOTALS	15

TREES PER ACRE KILLED BY THE FIRE

Species Code	DBH (in)
P. PONDEROSA	1
TOTALS	1

DBH classes (in): 2: 0-2, 4: 3-4, 6: 5-6, 8: 7-8, 10: 9-10and so on...

PROBABILITY OF MORTALITY FOR EACH SPECIES/DIAMETER ENTRY

Species Code	Diameter (inch)	Number Trees	Prob Mort	Mort Equ Number
P. PONDEROSA	19	16	0.08	1

AVERAGE MORTALITY PROBS BY FLAME LENGTH BY SPECIES/DIAMETER ENTRY

Species Code	Tree DBH	Flame Length (feet)
--------------	----------	---------------------

P. PONDEROSA	19	0.08
--------------	----	------

AVERAGES	19	0.08
----------	----	------

STAND TREE MORTALITY

Percent mortality: 8

Number of trees killed by the fire: 1

Average tree diameter (DBH) of fire killed trees: 19.0

Percent mortality for trees 19+ in DBH: 8

Total pre-fire number of trees: 16

Stand Basal Area: sq/ft    Percent

Pre-fire Live: 31.50    100

Post fire Live: 29.04    92

Post fire Killed: 2.46    8

Stand Canopy Cover:    Percent

Pre-fire Live:    10

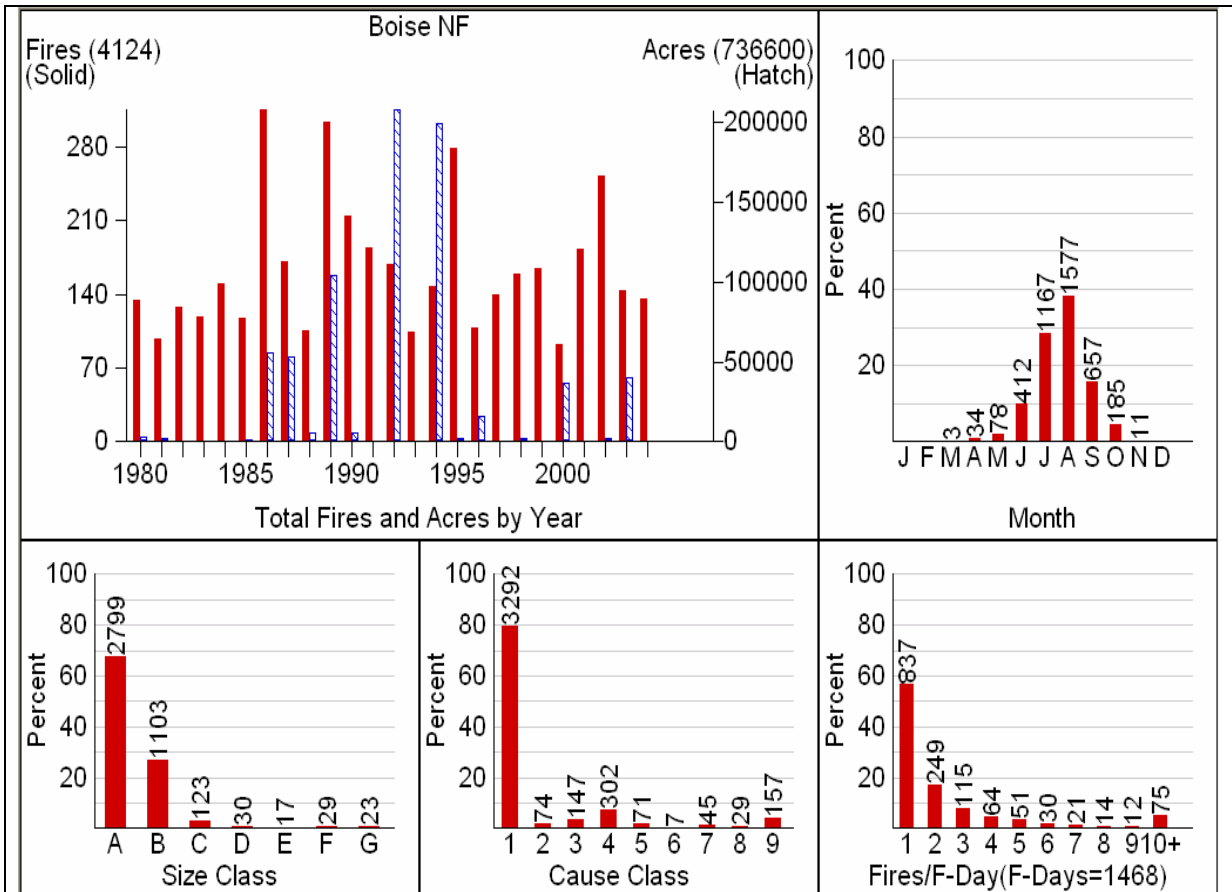
Post fire Live:    9

Change:    1





### Boise NF Fire Occurrence



\* Boise NF fire occurrence data were added to give additional data on the amount of fire frequencies within this geographical area.

Appendix F

Trees Per Acre (Bavarian Unit)

BAVARIAN UNIT, SITE 532: Ponderosa Pine Trees/acre								
Plot	Tree #	BAF	DBH	DBH <sup>2</sup>	Conversion Factor	Trees/Acre	19"+Trees/Acre	
1	1	30	17.8	316.84	0.005454154	17.36016521		
1	2	30	23.2	538.24	0.005454154	10.21922329	10	
1	3	30	16	256	0.005454154	21.48591697		
1	4	30	10.5	110.25	0.005454154	49.89020177		
1	5	30	22.5	506.25	0.005454154	10.86497727	11	
1	6	30	25.8	665.64	0.005454154	8.263317627	8	
							Total/Plot ▼	29
2	1	30	9.4	88.36	0.005454154	62.24982735		
2	2	30	9.5	90.25	0.005454154	60.94620216		
2	3	30	11	121	0.005454154	45.45780781		
2	4	30	18.3	334.89	0.005454154	16.4244819		
2	5	30	13.7	187.69	0.005454154	29.30574215		
2	6	30	21	441	0.005454154	12.47255044	12	
							Total/Plot ▼	12
3	1	30	25.9	670.81	0.005454154	8.199631408	8	
3	2	30	13.6	184.96	0.005454154	29.73829339		
3	3	30	20.2	408.04	0.005454154	13.4800381	13	
3	4	30	25.6	655.36	0.005454154	8.392936317	8	
							Total/Plot ▼	29
4	1	30	6.7	44.89	0.005454154	122.5305134		
4	2	30	16.6	275.56	0.005454154	19.96078801		
4	3	30	16.5	272.25	0.005454154	20.20347014		
4	4	30	23	529	0.005454154	10.39772164	10	
							Total/Plot ▼	10
5	1	30	28.9	835.21	0.005454154	6.585642826	7	
5	2	30	24.2	585.64	0.005454154	9.392109052	9	
5	3	30	17.8	316.84	0.005454154	17.36016521		
5	4	30	23.4	547.56	0.005454154	10.04528224	10	
5	5	30	22.6	510.76	0.005454154	10.76903975	11	
5	6	30	28.5	812.25	0.005454154	6.77180024	7	
5	7	30	15	225	0.005454154	24.44619887		
5	8	30	21.3	453.69	0.005454154	12.12368521	12	
5	9	30	22.7	515.29	0.005454154	10.67436734	11	
5	10	30	3.1	9.61	0.005454154	572.361576		
							Total/Plot ▼	67
6	1	30	17.9	320.41	0.005454154	17.16673869		
6	2	30	20.8	432.64	0.005454154	12.71356034	13	
6	3	30	21.6	466.56	0.005454154	11.78925485	12	
6	4	30	22.3	497.29	0.005454154	11.06073869	11	
6	5	30	22.3	497.29	0.005454154	11.06073869	11	
6	6	30	20.1	404.01	0.005454154	13.61450149	14	
6	7	30	16.3	265.89	0.005454154	20.70230248		
6	8	30	15.6	243.36	0.005454154	22.60188505		
							Total/Plot ▼	61
7	1	30	10.4	108.16	0.005454154	50.85424136		
7	2	30	25.3	640.09	0.005454154	8.593158376	9	
7	3	30	5.9	34.81	0.005454154	158.0119145		
7	4	30	27.2	739.84	0.005454154	7.434573347	7	
7	5	30	11.6	134.56	0.005454154	40.87689317		
7	6	30	9.1	82.81	0.005454154	66.42186626		
							Total/Plot ▼	16
8	1	30	16.4	268.96	0.005454154	20.45060509		
8	2	30	14.8	219.04	0.005454154	25.11137119		
8	3	30	18.8	353.44	0.005454154	15.56245684		
8	4	30	18.6	345.96	0.005454154	15.89893267		
8	5	30	4.5	20.25	0.005454154	271.6244319		
							Total/Plot ▼	0
9	1	30	17.5	306.25	0.005454154	17.96047264		
9	2	30	26.1	681.21	0.005454154	8.074448034	8	
9	3	30	17.5	306.25	0.005454154	17.96047264		
9	4	30	23.8	566.44	0.005454154	9.710463147	10	
9	5	30	21.4	457.96	0.005454154	12.01064448	12	
9	6	30	22.9	524.41	0.005454154	10.48872971	10	
							Total/Plot ▼	40
10	1	30	16.5	272.25	0.005454154	20.20347014		
10	2	30	18.6	345.96	0.005454154	15.89893267		
10	3	30	13.2	174.24	0.005454154	31.56792209		
10	4	30	25	625	0.005454154	8.800631592	9	
10	5	30	23.7	561.69	0.005454154	9.792580863	10	
							Total/Plot ▼	19
11	1	30	31.1	967.21	0.005454154	5.686867118	6	
							Total/Plot ▼	6
							Mean Trees/Acre =	26

### Trees Per Acre (Pilot Tree Well Unit)

PILOT TREE WELL UNIT, SITE 0866: Trees/acre								
Plot	Tree #	BAF	DBH	DBH <sup>2</sup>	Conversion Factor	Trees/Acre	PinPon 19"+Trees/Acre	Total/Plot ▼
1	1	10	0		0.005454154			0
2	1	10	10	100	0.005454154	18.3346491		
2	2	10	15.9	252.81	0.005454154	7.25234332		
2	3	10	10.6	112.36	0.005454154	16.3177725		
2	4	10	8.7	75.69	0.005454154	24.2233441		
2	5	10	12.6	158.76	0.005454154	11.5486578		
2	6	10	15.8	249.64	0.005454154	7.34443565		
2	7	10	13.5	182.25	0.005454154	10.0601641		
2	8	10	15.7	246.49	0.005454154	7.4382933		Total/Plot ▼
2	9	10	15.9	252.81	0.005454154	7.25234332		0
3	1	10	26.3	691.69	0.005454154	2.65070323	3	
3	2	10	19.3	372.49	0.005454154	4.9221856	5	
3	3	10	27.9	778.41	0.005454154	2.35539743	2	
3	4	10	19.8	392.04	0.005454154	4.6767292	5	
3	5	10	10.5	110.25	0.005454154	16.6300673		
3	6	10	15.3	234.09	0.005454154	7.83230772		
3	7	10	16.2	262.44	0.005454154	6.9862251		Total/Plot ▼
3	13	10	19.8	392.04	0.005454154	4.6767292	5	20
4	1	10	28.5	812.25	0.005454154	2.25726675	2	Total/Plot ▼
4	2	10	26.1	681.21	0.005454154	2.69148268	3	5
5	1	10	8.9	79.21	0.005454154	23.1468869		Total/Plot ▼
5	2	10	21.1	445.21	0.005454154	4.11820246	4	4
6	1	10	12.9	166.41	0.005454154	11.0177568		
6	2	10	30	900	0.005454154	2.03718324	2	
6	3	10	7.8	60.84	0.005454154	30.1358467		
6	4	10	29.6	876.16	0.005454154	2.09261427	2	
6	7	10	4	16	0.005454154	114.591557		Total/Plot ▼
6	9	10	2	4	0.005454154	458.366229		4
7	1	10	21.1	445.21	0.005454154	4.11820246		
7	2	10	2	4	0.005454154	458.366229		
7	7	10	4	16	0.005454154	114.591557		
7	9	10	4	16	0.005454154	114.591557		
7	10	10	4	16	0.005454154	114.591557		
7	11	10	2	4	0.005454154	458.366229		
7	12	10	14.6	213.16	0.005454154	8.60135539		Total/Plot ▼
7	13	10	19.6	384.16	0.005454154	4.77265961	5	5
8	1	10	10.2	104.04	0.005454154	17.6226924		
8	2	10	8.1	65.61	0.005454154	27.9449004		
8	3	10	7.7	59.29	0.005454154	30.9236788		
8	4	10	5.3	28.09	0.005454154	65.2710899		Total/Plot ▼
8	6	10	18.7	349.69	0.005454154	5.24311509	5	5
Mean Trees/Acre = 5								

## Appendix G

### Boise NF NVCs

NVC INPUT TABLE						
ANALYSIS ZONE: 02						
Boise N.F						
NVC PER ACRE INPUT TABLE						
DOLLAR AMOUNTS INFLATED TO 2005						
2005 \$ Year						
TABLE: 02 FOR REP LOCATION(S): 1 2 3 4 5 6 7 8 9 10 11						
RESOURCE	FIL 1	FIL 2	FIL 3	FIL 4	FIL 5	FIL 6
Mature Timber	-125.35	-125.48	-136.89	-429.78	-484.65	-487.78
Immature Poles	-4.11	-6.46	-14.72	-14.72	-14.72	-14.72
Immature S/Sap	-13.36	-20.01	-25.05	-25.05	-25.05	-25.05
Forage	0.70	1.92	4.11	4.11	0.00	-0.96
Water Use	0.00	0.00	0.00	0.00	0.00	0.00
Water Storage	0.00	0.00	0.00	0.00	0.00	0.00
Fish Wm/Cd Wtr	0.49	0.49	0.49	0.49	-49.48	-62.33
Fish Anad Sprt	0.00	0.00	0.00	0.00	0.00	0.00
Fish Commercl	0.00	0.00	0.00	0.00	0.00	0.00
Wildlife Big Gm	7.28	29.46	-9.13	-12.07	-25.12	-25.12
Wildlife Other	0.00	0.00	0.00	0.00	0.00	0.00
Rec Disp/Dev	0.00	0.00	-6.36	-19.16	-31.95	-44.82
Rec Wildernesss	0.00	0.00	0.00	0.00	0.00	0.00
Improvements	0.00	0.00	0.00	0.00	0.00	0.00
<b>TOTAL</b>	<b>-134.35</b>	<b>-120.08</b>	<b>-187.55</b>	<b>-496.18</b>	<b>-630.98</b>	<b>-660.78</b>

\* FIL 4 was chosen based on the predicted flame lengths from Behave Plus and FOFEM computer applications. See table below.

Flame Length (ft)	FIL
0 – 2	1
2 – 4	2
4 – 6	3
6 – 8	4
8 – 12	5
12+	6

## Appendix H

### CONSUME Run

**Consume 2.1**

File Tools View Help

Burn Unit: Project Area Unit/Permit Number: 3

**Fuels Information**

**Default Fuel Loadings (Fuel Characteristic Classes)**

Category	Fuel Class	Value (tons/acre)
Sound and Rotten	0.0 - 0.25 in. fuels	.11
	0.26 - 1.0 in. fuels	.94
	1.01 - 3.0 in. fuels	1.20
Sound	3.01 - 9.0 in. fuels	10.0
	9.01 - 20 in. fuels	0
	> 20.0 in. fuels	0
> 3.0 in. rotten fuels		7.70
Litter depth (in.)		.85 (2.55)
Duff depth (in.)		4.00 (48.40)
Shrub (tons/acre)		.60
Grass/Herb (tons/acre)		.20
<b>Total Fuels:</b>		<b>71.70</b>
FCC Number:		

\* Fuels data taken from computer application, FOFEM.

**Consume 2.1**

File Tools View Help

**Weather Zone Information** **Daily Weather Information**

Weather Zone: Town Creek Max Temp (°F): 53

Starting Date: 3/1/2006 Min Temp (°F): 27

Initial 1000 Hr FM (%): 75 Max Humidity (%): 90

Latitude (°): 43 Min Humidity (%): 33

Hours of Rain: 0 Days Since Significant Rain: 3

Valid 2/22/2006

Add Weather Zone Delete Weather Zone

Burn Unit Weather Consumption Emissions Reports Exit Consume

\* Weather data compiled with, FireFamily Plus.

Consumption (tons/acre)			
<b>0.0 - 0.25 in.:</b>	0.11	<b>3.01 - 9.0 in.:</b>	1.81
<b>0.26 - 1.0 in.:</b>	0.81	<b>9.01 - 20.0 in.:</b>	0.00
<b>1.01 - 3.0 in.:</b>	0.73	<b>20.01+ in.:</b>	0.00
<b>0.0 - 3.0 in. Total:</b>	1.65	<b>&gt; 3.0 in. Total Sound:</b>	1.81
		<b>Total Sound:</b>	3.46
		<b>&gt; 3.0 in. rotten:</b>	0.62
		<b>Total Woody:</b>	4.08
		<b>Shrub:</b>	0.42
		<b>Grass/Herb:</b>	0.20
		<b>Litter:</b>	1.40
		<b>Duff:</b>	27.81
		<b>Unit Total:</b>	33.92

\* There is approximately a 57% reduction in duff depth with tree well burning, which is within the favorable prescription.