2014 Beaver Fire
Klamath National Forest

Fire Behavior Assessment Summary Report

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And

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Photos immediately before and after the fire at plot 8, and shot from video while the area burned.

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Introduction

Wildland fire management relies on quality fire behavior and resource effects predictions. Existing prediction models are based upon limited field data from wildfires, especially quantitative data. The Fire Behavior Assessment Team (FBAT) collects data to improve our ability to predict fire behavior and resource effects in the long-term and provides short-term intelligence to wildland fire managers and incident management teams on fire behavior, fuel, and effects relationships. Increasing our knowledge of fire behavior is also important to fire fighter safety, so we can mitigate hazards and prevent accidents.

This report contains the results of a one and a half week assessment of fire behavior, vegetation and fuel loading, consumption, and fire effects for the Beaver Fire. The Beaver fire started by lightning on July 30th, 2014 at approximately 1700. The fire started 16 miles northwest of Yreka, CA, between the upper reaches of Beaver Creek and Christmas tree ridge. Over the course of the next week, the fire grew in size along both the east and west sides of Beaver creek, but was held along the north at Christmas tree ridge and to the south at Highway 96.

Fuels plots and fire behavior equipment were installed at 10 locations in the vicinity of the Beaver fire, eight of which were burned by the fire. FBAT installed plots between August 7th and 11th. Fire growth was low between August 6th and 9th, but on August 10th the fire growth was significant. Over half of the plots burned on this day.

Objectives

Our objectives were to:

1. Characterize fire behavior and quantify fuels for a variety of fuel conditions. Safety, access, and current fire conditions restrict which areas can be measured.
2. Gather energy transport data during active burning fires, in conjunction with site characteristics, for the Missoula Fire Lab's safety zone research.
3. Gather and measure representative vegetation and fuel samples to calculate moisture content to support emission and fire behavior modeling.
4. Assess fire severity and effects based on immediate post-fire measurements.
5. Aid in fuel treatment effectiveness reporting as required by the Fuel Treatment Effectiveness Monitoring program. Database: *http://www.nwportal.fs.usda.gov*

Approach/Methods

FBAT selects study sites to represent a variety of fire behavior and vegetation/fuel conditions. Plot selection priorities are also based on safe access and areas that would most likely be burned over within the timeframe that FBAT could be at the incident. Within each plot, data is gathered on both fuels and fire behavior; a graphic of a plot set up is shown below (Figure 1), though the plot layout changes based on terrain, fuels, and additional objectives (radiant and convective heat for safety zone dataset). Pre- and post-fire fuels and fire behavior measurements were taken at 8 plots near the west side of the Beaver fire on the Klamath NF from Aug. 6 to 13, 2014. The map (Figure 2) displays daily fire progression and approximate plot locations.

Figure 1: Schematic of FBAT fuels and fire behavior plot set up.

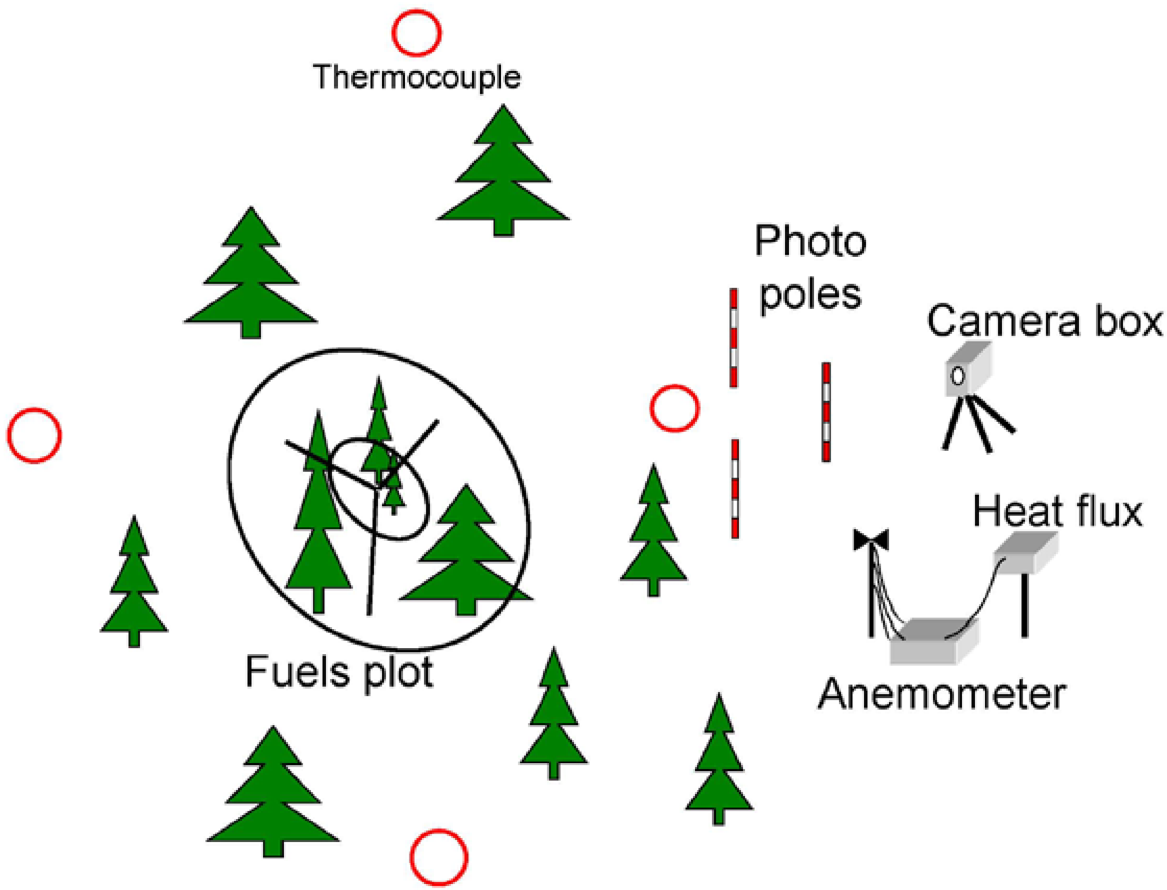
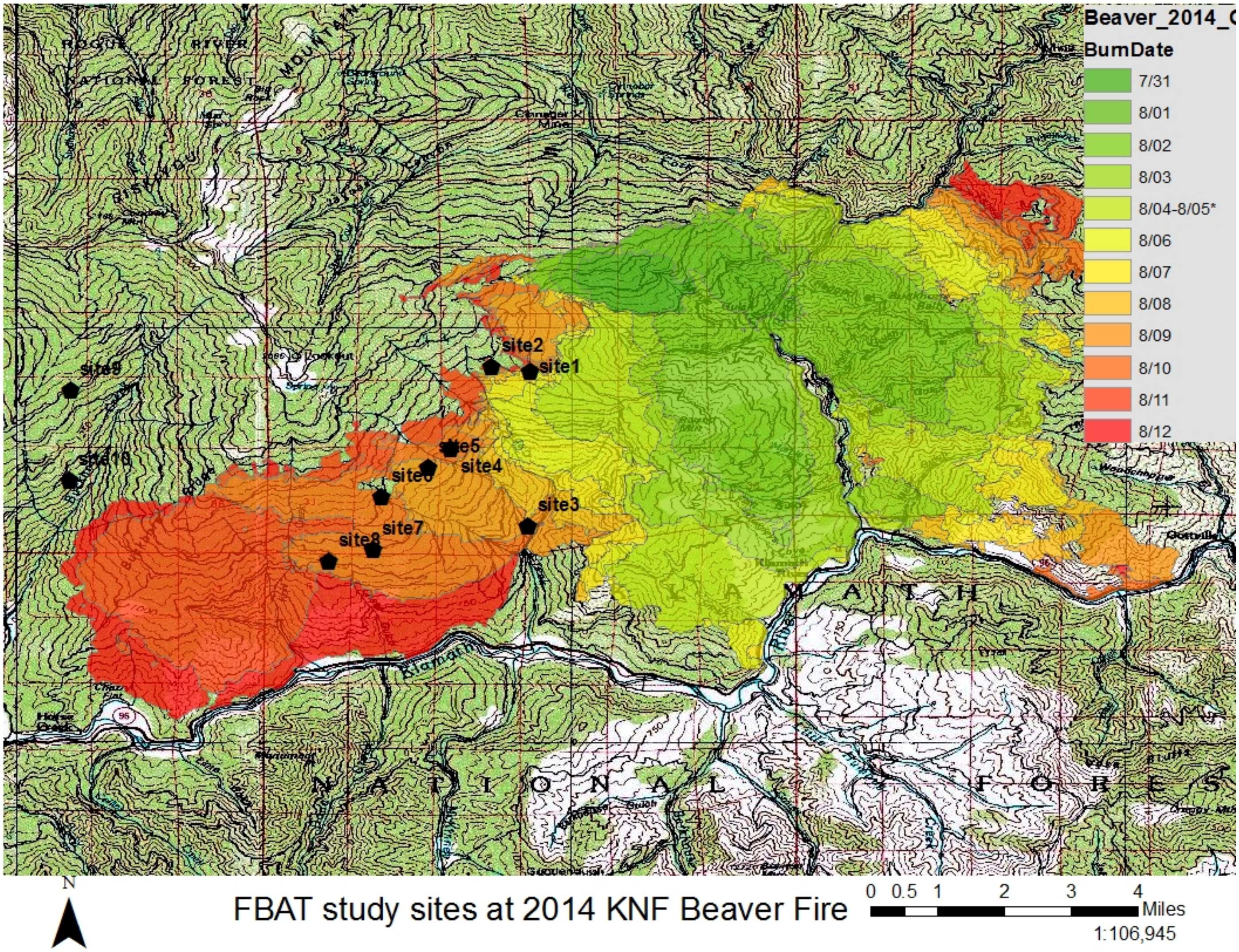


Figure 2: Fire progression and location of FBAT fuels and fire behavior plots in the Beaver Fire. Note the progression date does not always match the date we captured fire behavior due to green islands burning and the time of day of infra-red mapping.



Pre- and Post-Vegetation and Fuel Measurements

Vegetation and fuels were inventoried both before the fire reached each plot and then again after the fire (Figure 3). Plots were "monumented" with rebar to facilitate further monitoring options.

Figure 3. Re-reading tree plot post-fire.

Overstory Vegetation Structure and Crown Fuels

Variable radius sub-plots were used to characterize crown fuels and overstory vegetation structure. A relescope (slope-correcting tree prism) was used to create individual plots for both pole (>2.5 to 5.9 in diameter at breast height (DBH) and overstory (>6 in DBH) trees. When possible a basal area prism factor was selected to include between 5 and 10 trees for each classification. Tree species, status (alive or dead), DBH, height, canopy base height, and crown classification (dominant, co-dominant, intermediate or suppressed) was collected for each tree before the fire. Tree height measurements were completed with a laser rangefinder; DBH was measured with a diameter tape.

After the fire, maximum bole char, crown scorch, torch heights and percentages scorch and torch were recorded for each tree. After fire, trees were assumed to be alive if any green needles were present. Changes in canopy base height were estimated from heights of scorch and torch on tree branches, or if necessary from percent of scorch rather than the maximum heights because uneven scorch values occurred sometimes due to trees affected by slope and alignment with heat. Because of smoke and poor lighting, visibility of the full crown is sometimes difficult. If a more accurate assessment of tree survivorship in the plots is desired we recommend another plot visit next year.

The Forest Vegetation Simulator program (FVS, Crookston and Dixon 2005) and its Fire and Fuels Extension (FFE-FVS, Rebain 2010) was used to calculate canopy bulk density, canopy base height, tree density, and basal area both pre- and post-fire. FVS/FFE-FVS is stand level growth and yield program used throughout the United States. The California variant was used for all calculations.

Understory Vegetation Structure and Loading

Understory vegetation was measured in a one meter wide belt along three 50-foot transects before and after the fire. The fuel and vegetation transects were always in view of the video camera (which will be described below in the "Fire Behavior Measurements and Observations" section). Species, average height and percent cover (based on an ocular estimation) were recorded for all understory shrubs, grasses and herbaceous plants. Biomass of live woody fuels (shrubs and seedlings) and live herbaceous fuels (grasses, herbs, subshrubs) were estimated using coefficients developed for the BEHAVE Fuel Subsystem (Burgan and Rothermel 1984), but calculations were done on a spreadsheet (Scott 2005).

Surface and Ground Fuel Loading

Surface and ground fuels were measured along the same three 50-foot transects as the understory vegetation at each plot. Surface fuel loadings (litter, 1-hr, 10-hr, 100-hr and 1000-hr time lag fuel classes and fuel height) were measured using the line intercept method (Brown 1974, Van Wagner 1968). One and 10-hr fuels were tallied from 0 to 6 ft, 100-hr from 0 to 12 ft and 1000-hr from 0 to 50 ft. Maximum fuel height was recorded from 0 to 6 ft, 6 to 12 ft and 12 to 18 ft. Litter and duff depths were measured at 1 and 6 ft. All measurements were taken both pre- and post-fire.

The measurements were used to calculate surface and ground fuel loading with basal area weighted species specific coefficients (van Wagtendonk et al. 1996; 1998); and ultimately percent fuel consumption.

Burn Severity

A rapid assessment of burn severity was completed along each transect and for the entire plot area to document the effects of fire on the surface and ground (USDI National Park Service 2003). The National Park Service (NPS) uses fire severity rating codes from 1 to 5 when evaluating fire severity. In this rating system, 1 represents unburned areas, while 5 represents areas with high fire severity (Appendix B).

Fire Behavior Measurements and Observations

At each plot, multiple sensors (thermocouples, heat flux sensors, and anemometers) and a video camera were set up to gather information on fire behavior. The thermocouples arrayed across the plot have the capability to capture day and time of temperatures from which rate of spread can be calculated. The heat flux sensors capture total, radiant, and convective heat flux from the flame front while the associated anemometers capture wind speed. The video camera is used to determine fire type, flame length, variability and direction of rate of spread, flame duration, wind direction and the direction of fire spread in relation to slope and wind. The sensors are described in more detail below.

Figure 4: Examples of fire behavior equipment set up at the Beaver Fire. Upper photo shows camera box in foreground, lower photo shows heat flux sensor and anemometer.

Rate of Spread and Temperature

Rate of spread was determined both by estimating rate of spread from video analysis and by calculating rate of spread with time stamps from sensors (data loggers with a thermocouple attached). The data loggers are buried underground with the thermocouple at the surface of the fuel bed. The thermocouple is able to record temperature up to six days or until thermocouple is damaged by heat. The distances and azimuths among thermocouples were measured and these geometrical data and time of fire arrival were used to estimate rate of spread from Simard et al. (1984).

Fire Type

Fire type is classified as surface fire (low, moderate or high intensity) or crown fire. Crown fire can be defined as either passive (single or group torching) or active (tree to tree crowning). Fire type was determined from video as well as post-fire effects at each plot. For example, plots where there was complete consumption of tree canopy needles indicate at least torching or passive crown fire.

Flame Length and Flaming Duration

Flame length was primarily determined from video footage. If needed, flame length values could be supplemented by tree char height. Flaming duration was based on direct video observation and/or when temperature was measured, from those sensors as well.

Energy Transport

Energy transport data are collected with a heat flux sensor, where flux refers to the rate of energy transfer onto the surface of the sensor measured in units of kW/m^2. As with other recent work (e.g., Frankman *et al.* 2012, Butler *et al.* 2014), we use a Medtherm® Dual Sensor Heat Flux sensor (Model 64-20T), along with calibration relationships derived from laboratory measurements and theory, to provide incident total and radiant energy flux. Radiant flux is detected behind a sapphire window while total flux is detected underneath a blackened surface on the face of the copper plug that houses the detectors. The difference between total and radiant flux is an estimate of convective flux to the sensor (e.g., Frankman et al. 2012). Though safety zone guidelines are based on radiant flux alone, Butler (2014) recommends a consideration of total heat flux. The maximum incident heat flux tolerable by firefighters wearing nomex and protective head and neck equipment was described as 7 kW/m^2 by Butler and Cohen (1998) in their work on safety zone guidelines. Apart from firefighter safety, heat flux data are useful in developing a fundamental understanding of wildland fire spread and fire effects on trees and soils. Orientation of the sensor relative to the oncoming fire is critical and a successful data collection requires that the flame front approach the sensor within less than approximately +/- 30 degrees of the sensor face (where perpendicular is 0 degrees). The sensor is placed at 1 m above the ground surface and, for small flames, may not be impacted directly by flames, resulting in low heat flux at the sensor.

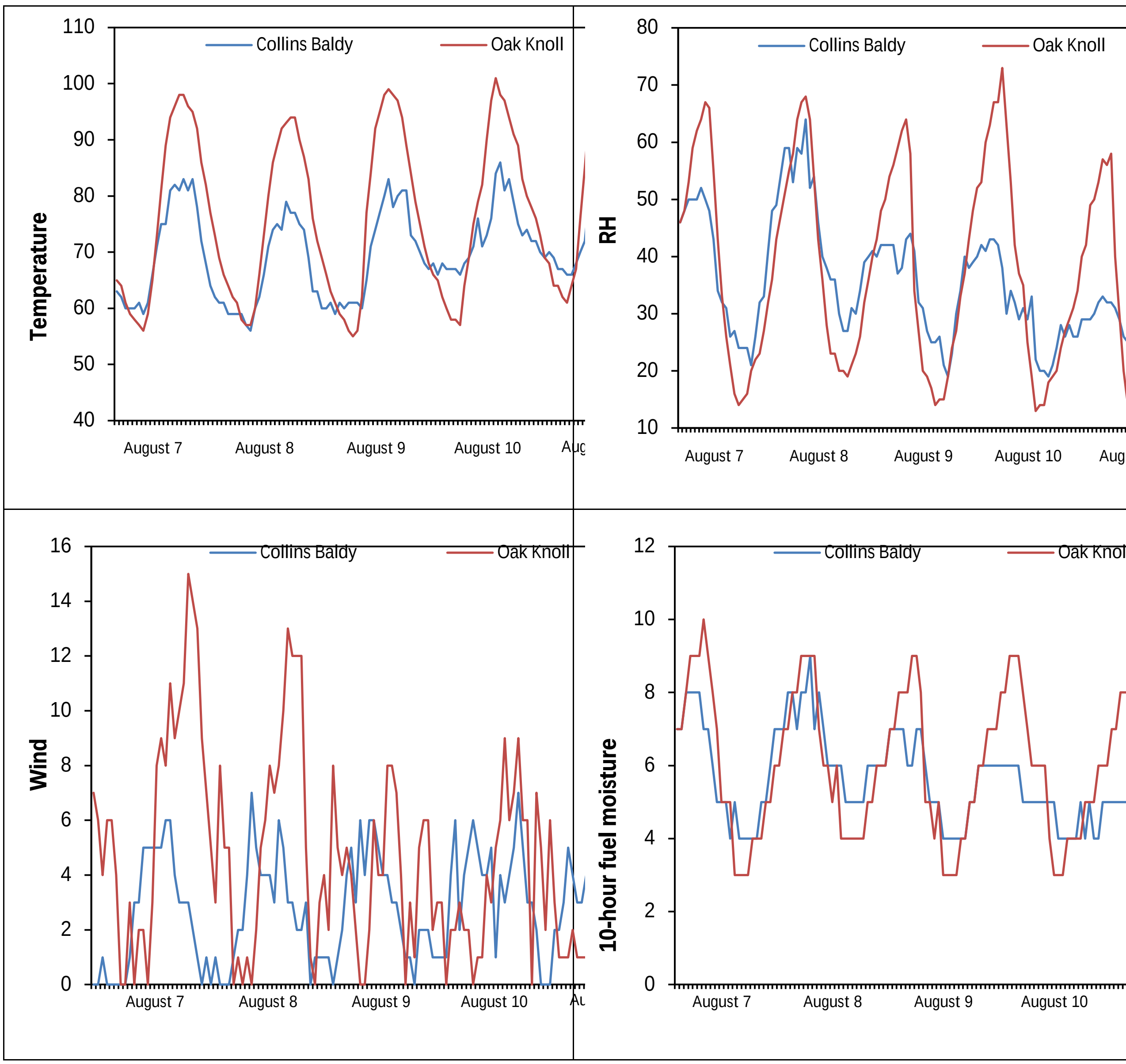
Plot Wind Speed

Wind data collected with cup anemometers placed 5 feet above ground at the locations of the heat flux sensors gives an indication of the wind experienced at each plot as the fire passed through. Wind data on plots with intense fire is only valid only up until the plastic anemometer melts or otherwise is compromised. Wind data were recorded at 1 second intervals and averaged over 10-seconds.

Weather

Weather data were downloaded from two permanent remote automated weather stations (RAWS); Oak Knoll and Collins Baldy (Figure 4) from FAMWEB. High temperatures were in the mid to upper 90's and low RH's were in the teens. Ten-hour fuel moistures were 3 to 10 and 4 to 8 at Oak Knoll and Collins Baldy, respectively on August 7th. Ten-hour fuel moistures only recovered to 5% at Collins Baldy the night of August 10th. Afternoon winds were greater than 10 miles per hour at the Oak Knoll RAWS on August 7th, 8th and 11th.

Figure 4: Temperature, Relative humidity (RH), Wind speed and 10-hour fuel moisture for Beaver fire area during days when plots burned.



Findings/Results

A portion of either fuels or fire behavior data were collected at eight plots. The eight plots represented different forest/vegetation types (Table 1). Only a camera was set up at plot 5; there was not enough time to set up the other sensors or measure fuels. Fuels plots were completed pre- and post-fire for plots 1-8. Paired photographs of plots with fuels data are available in Appendix A. Cameras functioned properly and collected video and rate of spread sensors captured data on plots 2, 3, 4, 6, 7 and 8. The heat flux sensors were set up and collected data on plots 2, 3, 4 and 6.

Table 1: Description of the eight plots which burned.

Plot	Forest/Vegetation Type	Slope (%)	Aspect
1	Dense mixed conifer	50	340
2	Younger pine plantation	35	200
3	Younger pine plantation	30	100
4	Dense mixed-age mixed conifer	35	110
5	Middle-aged pine plantation	5	90
6	Dense mixed-age mixed conifer	60	80
7	Dense mixed-age mixed conifer	25	260
8	Open mixed-conifer	40	300

Pre- and Post-Vegetation and Fuel Measurements

Overstory Vegetation Structure and Crown Fuels

The data collected during the Beaver fire encompassed a variety of vegetation and burning conditions and can illustrate conditions in which canopy characteristics factor into fire behavior (Table 2). Canopy base height, canopy bulk density, and canopy continuity are key characteristics of forest structure that affect the initiation and propagation of crown fire (Albini 1976, Rothermel 1991). Canopy base height (CBH), or the bottom of the tree canopy fuels, is important because it affects crown fire initiation. As stated in Scott and Reinhardt (2001), the basis for canopy fuel calculations in FVS-FFE, "Canopy base height (CBH) is not well defined or easy to estimate for a ***stand*****.** Neither the lowest crown base height in a stand nor the average crown base height is likely to be representative of the stand as a whole. Canopy base height is difficult to measure in multistory stands and stands with ladder fuels…. Defined in terms of its consequences to crown fire initiation, CBH is the *lowest* height above the ground at which there is sufficient canopy fuel to propagate fire vertically through the canopy." Canopy Bulk Density (CBD), is the mass of canopy fuel available per unit canopy volume (Scott and Reinhardt 2001). Continuity of canopies is more difficult to quantify, but clearly patchiness of the canopy will reduce the spread of crown fire.

Forest treatments that target canopy base height and canopy bulk density can be implemented to reduce the probability of crown fire (Graham et al. 2004). Canopy bulk density varies considerably within the stands measured on the Beaver fire, and reaches a maximum value of 0.35 kg/m^3 at plots 1, 6 and 7. Thinning to reduce canopy bulk density to less than 0.10 kg/m^3 is generally recommended to minimize crown fire hazard (Agee 1996, Graham et al. 1999), and for the most part below this point, active crown fire is very unlikely (Scott and Reinhardt 2001). Canopy bulk densities were at or below this threshold for Beaver fire plots 2, 3, 8 and 9 before the fire. Fire is a natural process for reducing canopy fuels. Tree mortality and canopy fuel changes cannot be determined with certainty until one or more years post-fire due to delayed mortality effects and tree recovery rates. Based on immediate post-fire data, almost all of the plots on the Beaver fire which burned, except plot 1 (which only partially burned), may be close to or below the 0.10 CBD kg/m^3 threshold for being able to support crown fire in the near future.

Changes in canopy base height were variable. On plots 3 and 4, the fire raised canopy base heights. In plot 3, tree crowns were torched almost 70% (Figure 7), raising the canopy base height, whereas in Plot 4, entire pole trees and some overstory trees were 100% torched, and were removed from canopy base height calculations, increasing the canopy base height drastically. Both plots 3 and 4 had some of the lowest CBD values post-fire. In plot 6, high levels of torch occurred, and similar to plot 4, many trees were 100% torched and removed from post-fire canopy fuels, however the canopy base height only raised by 1 foot. This plot was left with a CBD of 0.11 and must have shown just enough canopy fuels for FVS-FFE to calculate little change in canopy base height. In plots 2, 7 and 8 the whole stand was either scorched or torched, and so no canopy fuels were considered to remain post-fire.

The transition of fire from surface to crown fuels is difficult to model for various reasons. Video of plot 6 show this transition, making the data for plot 6 a unique case study for surface-to-crown fire transition.

Table 2: Pre- and post-fire overstory vegetation and crown fuel data by plot. QMD is the quadratic mean diameter based on tree data collected at the plot scale.

Plot	Overstory (>6 in DBH) trees/acre		Pole-size (<6 in DBH) trees/acre		QMD (in)		Basal Area (ft^2/acre)		Canopy Cover (%)		Canopy Height (ft)		Canopy Base Height (ft)		CBD (kg/m^3)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	528	528	63	63	11	11	365	365	88	88	87	87	22	22	0.35	0.35
2	0	0	603	0*	2	0*	20	0*	29	0*	11	0*	1	0*	0.10	0*
3	25	25	173	173	5	5	30	30	20	20	35	35	1	9	0.07	0.02
4	399	74	274	0	8	14	224	79	92	49	67	67	1	57	0.11	0.01
6	747	116	157	0	9	16	375	160	93	47	80	83	20	21	0.35	0.11
7	847	0*	380	0*	9	0*	579	0*	98	0*	88	0*	10	0*	0.35	0*
8	124	0*	104	0*	10	0*	130	0*	50	0*	71	0*	12	0*	0.08	0*
9**	77	N/A	57	N/A	15	N/A	164	N/A	50	N/A	94	N/A	30	N/A	0.05	N/A
10**	224	N/A	42	N/A	9	N/A	110	N/A	54	N/A	44	N/A	3	N/A	0.12	N/A

*Note that zero's in post data where pre-fire data was greater than zero indicate all trees were torched and appeared dead at the time of post-fire sampling.
**Plots 9 and 10 were not burned.

Fire Effects: Tree Canopy Scorch and Torch and Bole Char

A few days after the fire burned through each plot (allowing for smoldering combustion to complete and some fire-weakened trees to fall) additional measurements were gathered (char height, maximum scorch and torch heights, and percentage of the crown scorched and torched) to better assess the fire effects at each plot. Percentage values were determined using ocular estimations, and heights were measured with a laser rangefinder. Severity or fire effects can be accessed from the percentage of scorch and torch for each study plot (Figures 5&6). The fire had only scorched (caused browning of) portions of tree canopies in the plots, and torched (consumed) portions or all of some tree canopies. Essentially the entire canopy on plots 7 and 8 was either scorched or torched. Bole char was highest on plots 7 and 8 and was lowest on plot 1.

Figure 5. Average scorch and torch as a percent of tree crown. The portion of tree crown which is still living and not scorched or torched is labeled "green."

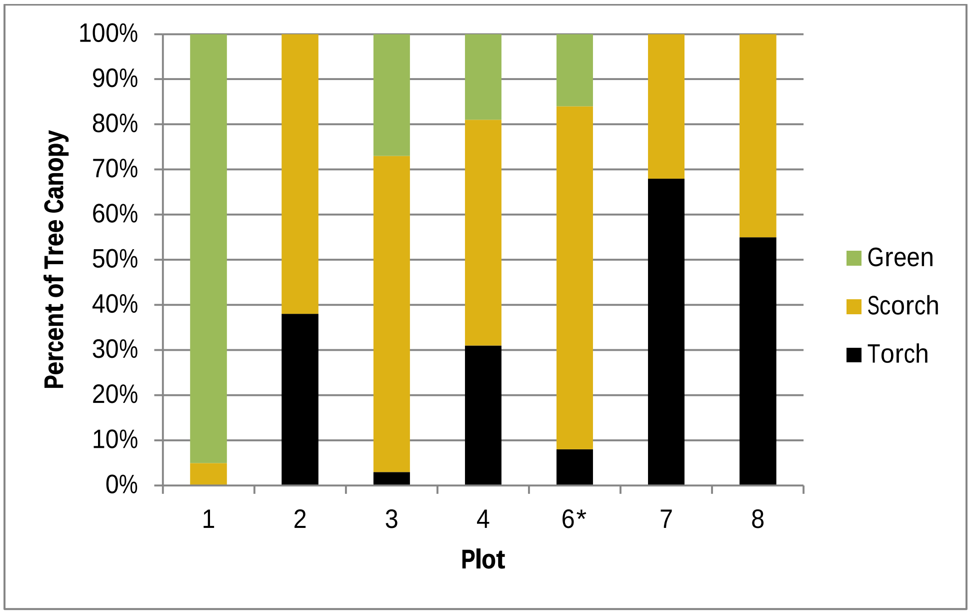
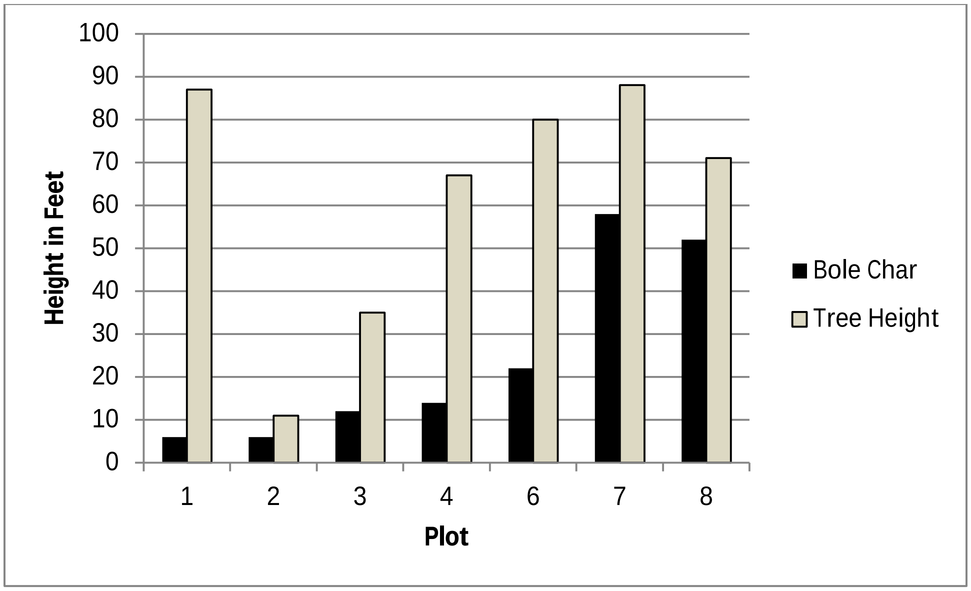


Figure 6. Average bole char compared to total tree height for each plot.



Understory Vegetation Structure and Loading

The understory was sparse to patchy, and sometimes almost completely undetected, potentially due to shading by trees and dead and downed forest debris (Tables 3&4). Plot 2 had the highest amount of fuel recorded as live shrubs, however, this was due in part to a large multi-stem shrub-growth-form pacific madrone on one transect. Plot 2 had only small trees and the highest amount of grass fuels. Several of the plots had very dense tree canopies and very little understory. Plot1 had no grasses or herbs on any transects, and very little shrub fuel. Plots 6 and 8 also had only a trace of grass and shrub fuels. Both understory grasses and shrubs were completely consumed on plots 4 to 8, where FBAT recorded higher fire severities. The paired photographs in Appendix A show a sample of the distribution and density of understory flora for each plot, as well as illustrate the change post-burn.

Table 3: Pre-and post-fire understory vegetation fuel loading by plot.

Plot	Grass/Herb (ton/ac)						Shrub (ton/ac)					
	Pre-Fire			Post-Fire			Pre-Fire			Post-Fire		
	Live	Dead	Total	Live	Dead	Total	Live	Dead	Total	Live	Dead	Total
1	<0.005	0	<0.005	<0.005	0	<0.005	0.04	<0.005	0.04	<0.005	<0.005	0.02
2	0.02	0.02	0.03	<0.005	0.01	0.01	5.22	0	5.22	5.00	<0.005	0.09
3	<0.005	0.03	0.03	0	<0.005	<0.005	0.25	0	0.25	0.04	<0.005	0.11
4	<0.005	0	<0.005	0	0	0	0.28	0.02	0.29	0	0	0
6	<0.005	0	<0.005	0	0	0	<0.005	0	<0.005	0	0	0
7	<0.005	<0.005	0.01	0	0	0	0.56	<0.005	0.56	0	0	0
8	<0.005	<0.005	<0.005	0	0	0	0.03	0.01	0.05	0	0	0

Table 4: Understory vegetation consumption by plot.

Plot	Consumption (%)	
	Grass/Herb	Shrub
1	50	41
2	83	98
3	99	58
4	100	100
6	100	100
7	100	100
8	100	100

Surface and Ground Fuel Loading

The predominant fuels making up the majority of the total surface and ground fuel loadings were 1000-hour downed woody fuels and litter and duff. Some plots, such as the young plantations, had much lower levels of litter and duff. Plots 7 and 8 had 40.5 and 60.5 tons per acre of 1000-hour fuels, respectively, whereas the young plantation plots, 2 and 3, had 5.2 and 0.8 tons/acre (Table 5).

Table 5: Average pre-and post-fire fuel loading and fuel bed depth.

Plot	Mean Fuel Loading (tons/acre)														Fuel Bed Depth (ft)	
	Duff		Litter		1-hr		10-hr		100-hr		1000-hr		Total load			
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	14.2	4.3	2.9	1.5	0.3	0.2	0.8	0.5	0.9	0.6	1.5	0.0	20.5	7.1	0.71	0.27
2	0.6	0.0	1.3	0.5	0.1	0.0	0.6	0.2	1.4	0.4	5.2	1.5	9.3	2.6	0.60	0.12
3	5.2	0.0	4.1	1.2	0.2	0.1	1.0	0.1	1.8	0.0	0.8	0.0	13.1	1.4	0.69	0.01
4	26.7	0.0	7.2	0.0	0.7	0.0	0.7	0.0	0.7	0.0	9.8	0.0	45.7	0.0	0.56	0.00
6	8.6	0.0	6.9	0.0	0.6	0.0	1.1	0.0	0.0	0.0	1.2	0.0	18.4	0.0	0.49	0.00
7	17.8	0.0	15.2	0.0	0.2	0.0	1.1	0.0	2.9	0.0	40.5	36.1	77.7	36.1	0.71	0.00
8	30.4	0.0	6.9	0.0	0.4	0.0	0.5	0.0	1.3	0.0	60.5	0.8	100.0	0.8	0.51	0.00

Each metric is based on an average of three transects.

Consumption ranged from moderate to complete consumption of surface and ground fuels (Table 6). The burn pattern in plot 1 was patchy, including some areas that did not burn, leading to 66% consumption overall for the plot. Plot 2 also had lower consumption than other plots, likely due to light, patchy fuels. Plot 4, 6 and 8 pre- and post-fire fuels comparison indicated almost complete consumption of surface and ground fuels. Plot 7 consumption was fairly complete; however a 40-inch diameter downed log did not burn, which kept 1000-hour, and therefore total consumption lower.

Table 6: Average percent fuel consumption per metric and for plot overall, based on above table.

Plot	Percent Consumption (%)							Change in Fuel Bed Depth (%)
	Duff	Litter	1-hr	10-hr	100-hr	1000-hr	Total consumption on plot	
1	70	50	37	33	33	100	66	62
2	100	60	75	62	75	72	72	79
3	100	72	65	86	100	100	90	98
4	100	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100	100
7	100	100	100	100	100	11	54	100
8	100	100	100	100	100	99	99	100

Burn Severity Rating

The National Park Service's severity categories were used to assess post-burn soil/substrate and understory vegetation severity along each transect and for the entire plot. Vegetation burn severity is only based on the vegetation that was documented pre-burn. For full descriptions of the categories, please see Appendix B. Substrate severity was fairly high in plots 3, 6, 7 and 8 and mainly moderate in the other plots (Figure 7). Vegetation severity was highest in plots 7 and 8, and moderate in plots 3 to 6 and lower in plots 1 and 2 (Figure 8). The entire area of plots 7 and 8 were rated as high or extremely high for both substrate and vegetation severity.

Figure 7: Post-fire surface soil (substrate) severity rating by plot.

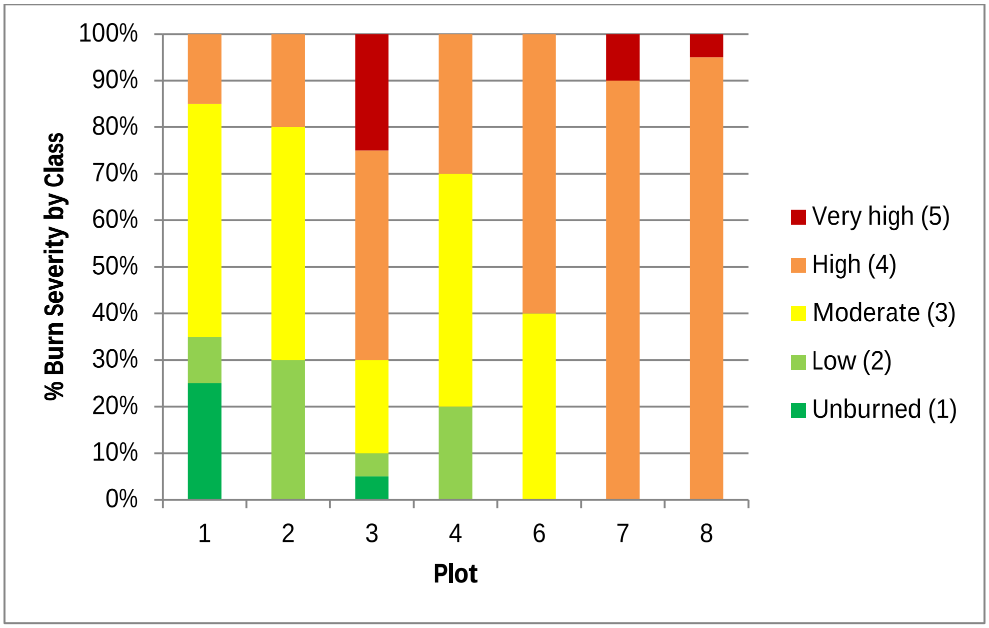
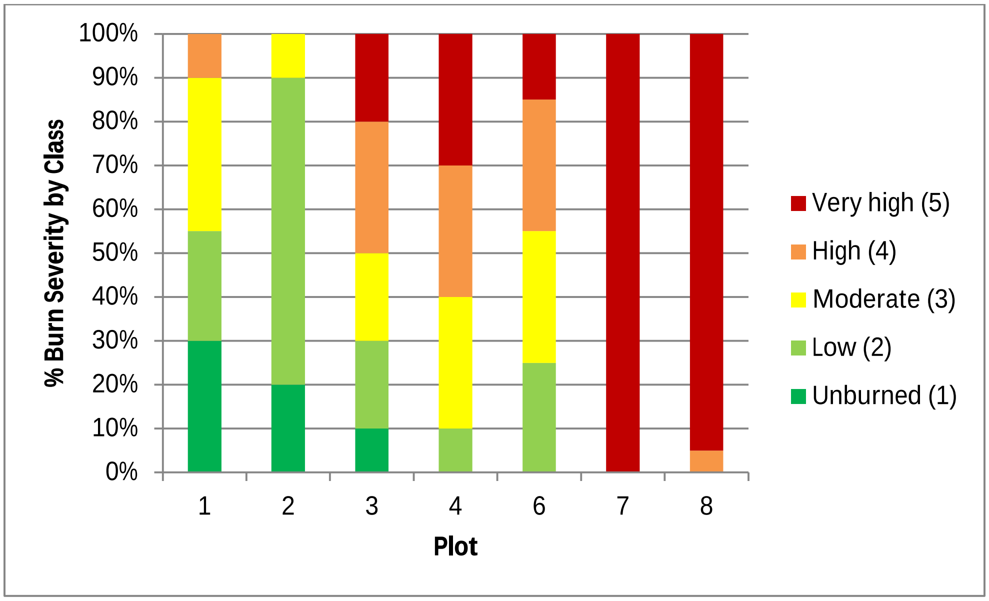


Figure 8: Post-fire understory vegetation severity rating by plot.



Fire Behavior Observations and Measurements

The narratives below attempt describe fuels and the fire behavior movement through the plot. The metal poles in the video camera's field of view are marked in 1-foot increments; however, often it is difficult to determine how close the flame is to these poles, making flame length estimates approximate. Rate of spread was estimated from the video, when possible, by timing the fire progress between visually-estimated distances. The initial fire front is generally the behavior described in fire behavior models such as BEHAVEPlus, however, the fire spread is rarely a simple forward-moving front which can be seen well by the video.

Plot 1, Dense mixed conifer

Plot 1 was located below a road, in dense mixed conifer stand on steep ground. Douglas fir was the dominant tree species with other conifer species present at the plot. The understory fuels were mainly conifer litter and down woody material with little grass or shrubs. The video camera was triggered prior to fire arrival, possibly due to moisture, so *no fire video footage was captured for this plot*. A large portion of the plot burned, and was likely low intensity surface fire.

Plot 2, Younger pine plantation

Plot 2 was located below a road in a flat, younger ponderosa pine plantation. The trees were approximately 13 feet tall, and the understory consisted of light, cured grasses and occasional shrubs and large down woody debris. Very little litter or duff was present on the plot. The fire moved very slowly across the slope toward the camera. The fire moved between fuel pockets as generally low intensity surface fire with isolated torching. Note that only very low flame lengths were needed for torching because the young tree crowns extended to the ground, into surface fuels (Figure 9).

Figure 9. Fire torches a small plantation tree in plot 2.

Plot 3, Younger pine plantation

Plot 3 had a road several chains above and below it. Plot 3 was in a relatively flat, young plantation, with several older trees in the area. This plot had fewer pole-size trees per acre than plot 2. The understory had some light, cured grasses and scattered shrubs. A finger of fire backed downhill into the plot against the wind as low intensity surface fire. Eventually flanking portions, and fire below the plot, moved uphill into pockets of unburned fuel and burned with moderate intensity, higher flame lengths, and isolated torching. Note that the young tree crowns extended to the ground, so minimal understory or surface fuels were needed for the fire to transition to torching behavior (Figure 10).

Figure 10. Left photo was from camera uphill of plot 3 and right photo was from camera downhill of plot 3.

Plot 4, Dense mixed-age mixed conifer

Plot 4 was located below a road in dense mixed-age conifer with moderate slope. The area was rocky, yet had heavy duff fuels. The overstory and understory trees were dense. The fire and light winds moved uphill. The fire initially moved into the field of view through burning pine needles lofted 15 ft and spotting into the plot. The fire burned as low intensity surface fire in the opening near the camera. When fire moved into the denser pockets of trees with ladder fuels, group torching occurred and the associated air movement appeared to increase surface intensity fire (Figure 11).

Figure 11. Left photo depicts glowing pine needles which ignited fuels near camera in plot 4. Right photo shows group torching.

Plot 5, Middle-aged pine plantation

Only a video camera was set up at plot 5 due to time constraints. The camera was set up in a relatively flat, middle-aged pine plantation about 6 chains off the road, down a very gentle slope, near the upper end of a draw. The camera triggered after the main fire front had passed through, and showed the bole bark and all branches burning. All needles had already been consumed. Surface fires were still burning as the video started. Initial surface fuels at the plot consisted of pine litter and occasional shrubs or young fir trees. We suspect that the fire moved through the area quickly as an active crown fire (Figure 12).

Figure 12. Fire in plot 5 just as camera was triggered. Needles and much of the surface fuels have already been consumed.

Plot 6, Dense mixed-age conifer

Plot 6 was set up below a road in an area that was burned out, west of Drop Point 60. Douglas fir was the dominant tree species and surface fuels were largely conifer litter and duff and downed woody material. This plot had one of the highest tree densities of all plots burned. The camera triggered after the fire moved into the plot from downhill as a finger of moderate-intensity surface fire and also through spotting near the camera. About 45 seconds into the video, torching starts, the fire intensity picks up, and the fire transitions to crown fire. Winds increase greatly during the crowning, which appeared to be captured on the anemometer for about 20 seconds before it melted. After about 1 minute, most crown needles in the plot are consumed and just branches and residual surface fuels burn after the main fire front has passed. Fifteen minutes after the start of the video, most flaming combustion was complete except for stumps (Figure 13).

Figure 13. Crown fire in background of plot 6.

Figure 14. Fire moving up tree boles in plot 7.

Plot 7, Dense mixed-age conifer

Plot 7 was below a road near a draw, and largely on a flat bench. The base of the tree canopy was high off the ground with almost no ladder fuels. There were many fallen trees in the plot. This plot had the highest tree density of all plots. Surface fuels consisted of fairly high loadings of litter and duff as well as large down woody material. The video starts after fire had established in the plot, near the camera. Fire moves through the surface fuels as a moderate intensity, and occasionally high intensity surface fire which moved easily up the boles of trees. The fire was pushed in the direction of the camera, making flame geometry estimates difficult. Crown fire can be seen in the distance. Almost all flaming combustion was finished by the end of the video (about 50 minutes later), even on the 1000-hour fuels in view of the camera (Figure 14 above).

Plot 8, Open mixed-conifer

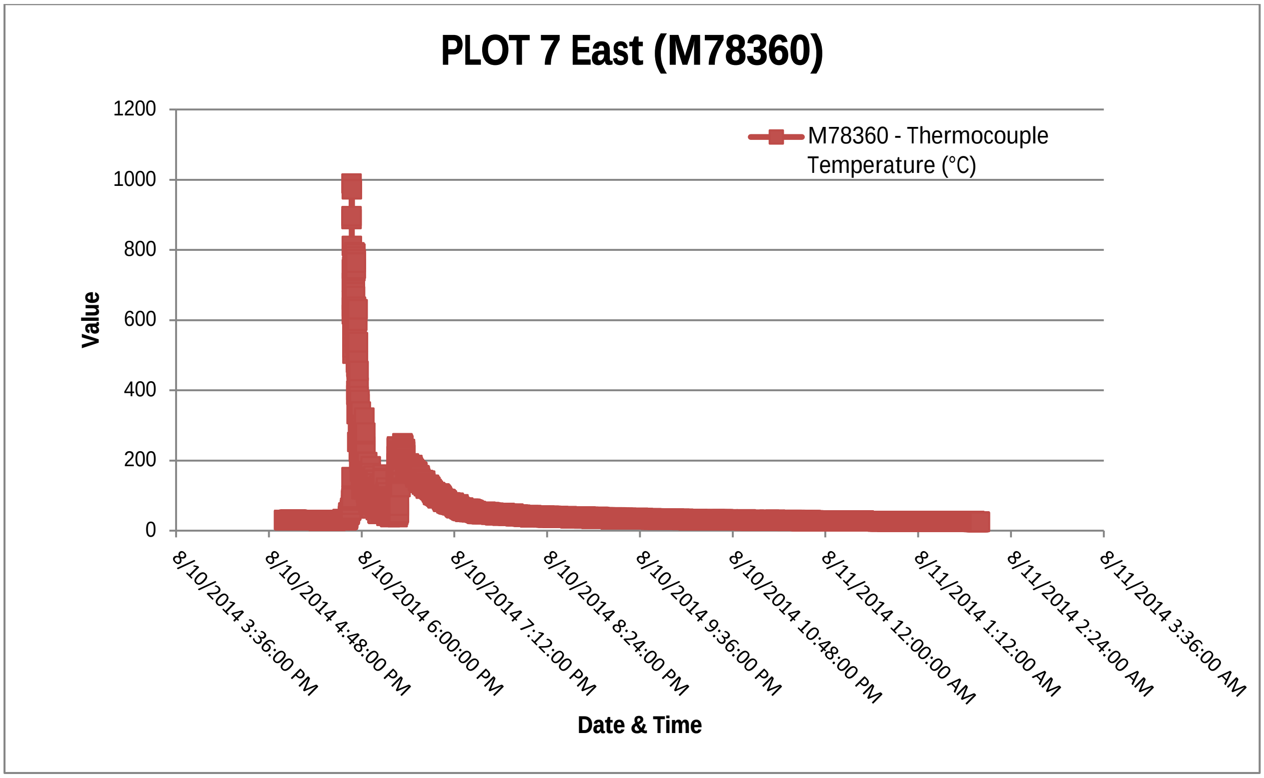
Plot 8 was on a slope below the road in an open, mixed-conifer stand consisting of ponderosa and sugar pine and Douglas fir. Shrubs and grasses were relatively abundant in the understory. Plot 8 had the highest amount of duff and 1000-hour fuels of all the plots which burned. The camera triggered after the fire had passed entirely through the plot and consumed most fuels in the foreground, suggesting that the original fire front moved through fairly quickly. 1.5 minutes into the video, needles can be seen on the understory trees, suggesting that mainly moderate intensity surface fire moved through at first. After passage of the main fire front, torching occurs and the fire burns with occasional higher intensity (Figure 15).

Figure 15. Surface fire and torching in plot 8.

Rate of Spread and Temperature

Rate of spread and temperature data were gathered using 5 fire resistant data loggers, or sensors, at each plot. One rate of spread calculation can be performed for each triangle formed by three sensors, and was calculated for the larger triangles when possible. If more than one triangle of sensors burned, a range of rates of spread were reported. The temperature sensors logged temperature at 2 second intervals. The east sensor for plot 7 shows a sharp increase in temperature, which is the fire arrival, and then decays through time (Figure 16). This peak followed by a slow decay in temperature as fuels smolder and then the fire dies out are typical of most temperature data.

Figure 16: Thermocouple temperature graph for east sensor at Plot 7.



Fire Type, Flame Length and Duration

In addition to the sensors, fire behavior data can be obtained from the video footage. Table 7 below lists the fire type, flame length, flame angle and rate of spread determined by watching the video footage using photo poles in view of the camera. The rate of spread estimates from the sensors are also listed along with the rate of spread values determined by watching the video. Subtle differences were found between the fire behavior measurements between the video camera and the other sensors for slow-moving fires. For quicker, more intense fires, there was more variability between the rate of spread determined using video and the rate of spread from sensors. There was even a fair amount of variability in rate of spread calculated from sensors. For instance, on plot 7, the fire spotted into the plot and after a few minutes, the spots grew together and all surface fuels were ignited. The rate of spread estimate from video depicts the estimated rate of spread of any particular portion of fire, but may not describe the overall rate of spread due to spotting. The sensors were all triggered within 3.5 minutes of each other, which describes the overall spread of fire through plot by spots growing together. Some triangles created by sensors showed faster rates of spread because the sensors were all triggered at nearly the same time, whereas others were not burned as quickly and triangles containing those sensors show slower rates of spread.

Table 7: Fire behavior data based on the video camera footage and from sensors.

Plot	Fire Type	Flame Length (ft)	Flame Angle* (%)	ROS (ch/hr) camera	ROS (ch/hr) sensors	Date, Approximate Start of Fire
1	Camera malfunction				n/a[1]	
2	Low intensity surface fire with isolated torching	1	80 max	1	0.5	8/11, 1527
3	Backing/flanking surface fire with torching	1-6	40-45	0.5-1	0.8-2.3	8/9, 1840
4	Low to moderate surface fire with group torching	<1-6	<100	1-2	0.1-2.9	8/10, 1506
5	Possibly active crown fire			n/a[2]	None set up	8/9, n/a[2]
6	High intensity surface fire with torching, transitions to active crown fire[1]	2-4[2, 3]	0-100+[2, 3]	n/a[2, 3]	0.1-0.3	8/10, 1053
7	High intensity surface fire which moves up tree boles	1-6	40	1	2.4-22.3	8/10, 1751
8	Moderate to high intensity surface fire with torching	0.5[2]	0-100[2]	n/a[2]	3.4-54	8/10, 2055

*Angle from the line between flame tip to center of flame base then to ground surface.
[1] Most sensors failed; of those which recorded data, no triangle could be formed to calculate ROS
[2]Camera triggered after initial fire front passed through, so any surface fire estimates are approximate.
[3]Fire spread consists of several spots in foreground plus a surface fire transition to crown fire in background which quickly runs out of view of the camera. ROS and flame geometry estimates are for surface fire portion only.

Energy Transport

Initial assessment of our data from the Beaver Fire indicates that energy data collections at plots 2, 3, 4, and 6 were successful, though intensities were low in front of the sensors at plots 2 and 3 (Table 8). Plot 1 burned too patchily near the sensor to provide useful data. Heat fluxes in plot 7 were so high that the sensor quickly overheated. On the Beaver Fire, peak radiant heat fluxes ranged from 3 kW/m^2 in light/patchy fuels burning at low intensity in front of the sensor up to 98 kW/m^2 in forest fuels while peak total fluxes ranged from 9 to 266 kW/m^2 at the same locations. Plot 2 was located in grassy fuels in an open-canopy, young pine plantation and had peak total heat flux of 9 kW/m^2. During most of the time the fire was active these values were lower than 3 or 4 kW/m^2, which would have been tolerable by firefighters wearing protective equipment. Plot 3 had light grassy fuels and scattered shrubs and low to moderate fire intensity and radiant and total heat flux peaks were 9 and 24 kW/m^2, respectively (Figure 16). Plot 4 had moderate to high fire intensity, which burned through heavy fuels under a mixed-conifer overstory with shrub and downed woody material (Figure 17). Plot 6 total heat flux data were suspect. Radiant and total heat fluxes for plot 4 were 98 and 266 kW/m^2, respectively, modest compared with crown fire measurements (Butler 2014). Plots 2, 3, and 4 were on slopes of 30-35% and had 61-63% of their total peak heat come from convective heating, which is comparable to other measurements (Butler 2014).

Table 8. Summary of energy transport to heat flux sensors during the Beaver Fire. Convective heat flux is the difference between total and radiant. The percentage of total heat flux accounted for by convective is shown.

	Heat flux (kW/m2)				
Plot	Radiant	Total	Convective	Percent Convective	Comment
2	3	9	6	63%	Young plantation with grassy fuels
3	9	24	15	61%	Young plantation with grass/shrub fuels
4	98	266	168	63%	Mixed conifer overstory with heavy duff loading
6	82	NA	NA	NA	Mixed conifer overstory with modest fuel loading

Figure 16: Radiant and total heat flux for Plot 3 on the Beaver fire.

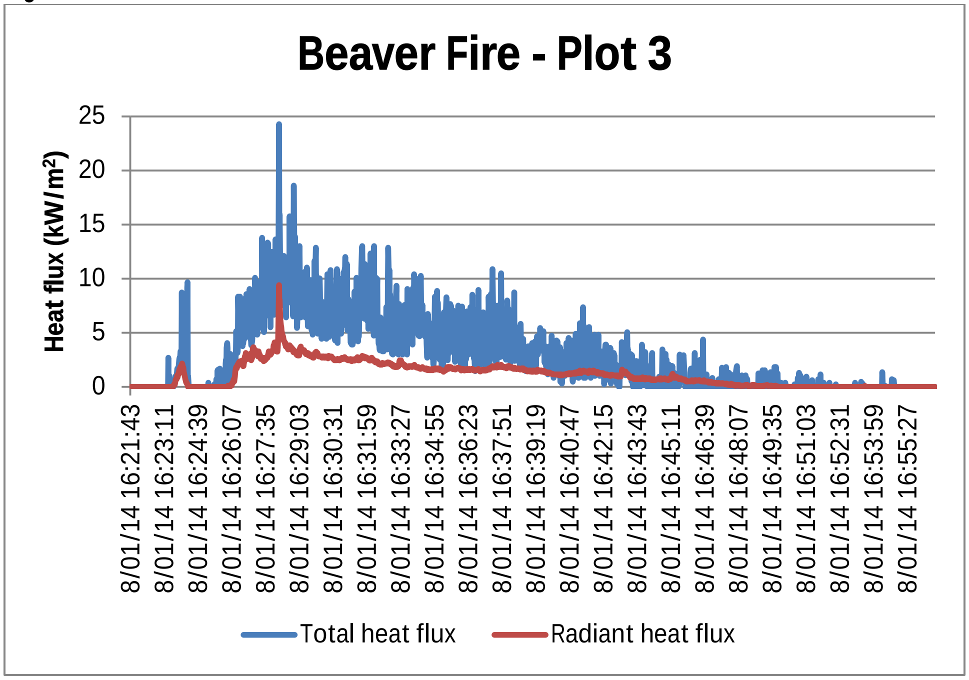
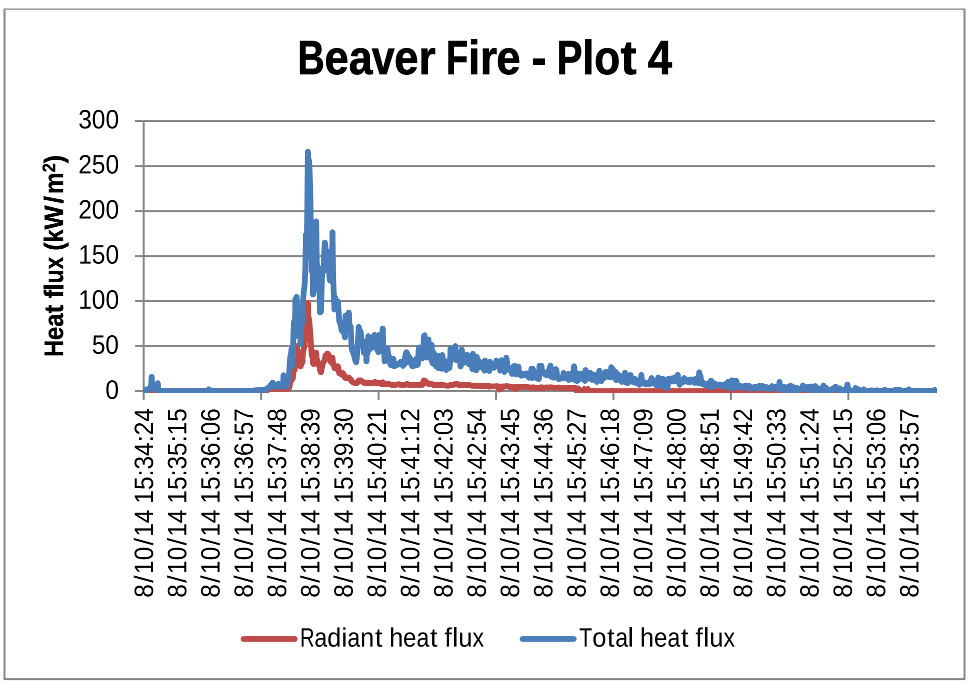


Figure 17: Radiant and total heat flux for Plot 4 on the Beaver fire. Note difference in vertical axis scale in comparison with Figure 16.



Plot Wind Speed

Wind data were recorded at 1 second intervals and averaged over 10-seconds and displayed for the 20 minutes prior to fire arrival at the anemometer (Table 9). For Plot 1, the fire took a long time to move through the plot, becoming active in the late afternoon of two consecutive days. Wind data for Plot 1 are presented for both days. The anemometer at Plot 3 registered the highest wind velocity (Figure 18) while those at Plot 1 were near the lowest (Figure 19). In an effort to assess winds near the time of a shelter deployment on the Beaver Fire (11 August 2014 at approximately 5 PM local time), we present data from three anemometers that either did not burn over (Plots 8 and 9) or were in a plot where fire intensities were low and did not disable the anemometer (Plot 1). In general, caveats to the data are that they are at 5 ft (which would approximate mid-flame wind speeds for intense surface fires) and, thus, sheltered by the canopy (except for Plots 2 and 3, which were young plantations). In reference to winds at the time of shelter deployment, anemometers were on slopes while winds on the ridge where shelter deployment occurred would have been higher.

Table 9: Winds over 20 minutes prior to fire impacting heat flux sensor and associated anemometer (top of table) or at the time of shelter deployment (bottom). Both table sections are sorted by peak, then average wind speed. Peak wind speed is from the 10 second moving average. Plot 3, with the highest wind speeds is plotted in Figure 20 while the low wind speeds recorded at the time of shelter deployment in Plot 1 are shown in Figure 21. Times at which fire passed through plot based on thermocouple temperatures are shown. These thermocouple temperatures are averages from before fire arrival and approximate fuel bed temperatures.

	From ROS thermocouples				Wind speed (miles/hr) prior to fire arrival/burnover	
Plot	Date of fire arrival	Time of arrival	Time fire passed through plot	Pre-fire thermocouple temperature	20 minute average	Peak over 20 minutes in 10 s running average
Winds at time of plot burnover*						
3	8/9/2014	6:40pm	7:12pm	90	2.8	9.3
7	8/10/2014	5:50pm	5:53pm	84	2.5	7.8
4	8/10/2014	3:04pm	4:10pm	88	0.6	6.8
6	8/10/2014	7:01am	10:54am	79	2.0	6.8
1	8/9/2014	6:13pm	NA	NA	<0.1	2.5
1	8/10/2014	6:02pm	NA	NA	<0.1	2.5
2	8/11/2014	3:27pm	4:08pm	81	Anemometer failure	
Winds at time of shelter deployment						
9	8/11/2014	5:00pm	NA	NA	0.2	2.8
1	8/11/2014	5:00pm	NA	94	0.3	2.5

***Plot 1 burned patchily over two days.**

Figure 18: Winds at Plot 3 over a 20 minute window prior to fire impacting heat flux sensor and associated anemometer. Wind speed based on the running 10 second average is plotted. Plot 3 had the highest peak wind speed measured.

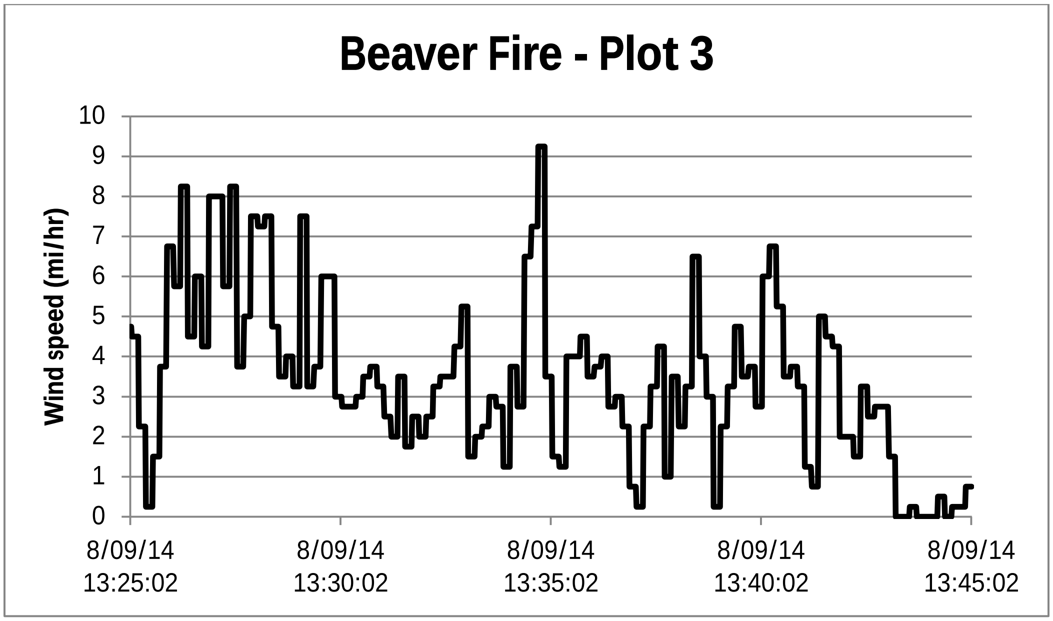
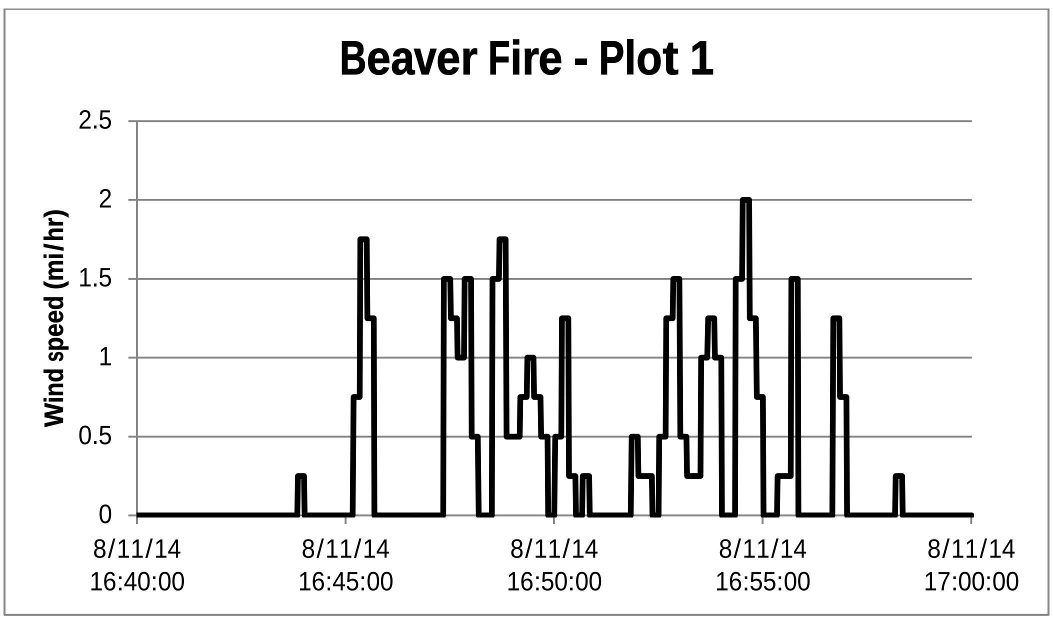


Figure 19: Winds at Plot 1 over a 20 minute window prior to the shelter deployment on 11 August at approximately 5 PM. Wind speed based on the running 10 second average is plotted. Winds at Plot 1 were near the lowest measured.



Summary

Our objectives were to:

1. Characterize fire behavior and quantify fuels for a variety of fuel conditions. Safety, access, and current fire conditions restrict which areas can be measured.
2. Gather energy transport data during active burning fires, in conjunction with site characteristics, for the Missoula Fire Lab's safety zone research.
3. Gather and measure representative vegetation and fuel samples to calculate moisture content to support emission and fire behavior modeling.
4. Assess fire severity and effects based on immediate post-fire measurements.
5. Aid in fuel treatment effectiveness reporting as required by the Fuel Treatment Effectiveness Monitoring program. Database: *http://www.nwportal.fs.usda.gov*

FBAT met our objectives on this incident. We installed and re-visited plots safely, mitigating for risks associated with data collection on active fires. Some of the data were used immediately, and some will be used over the course of the next couple years. The Beaver Incident Management Team used the fuel moistures for reference, and the Facilitated Learning Assessment team utilized the fuel moistures, video, wind, and consumption data somewhat to paint a clearer picture of fire behavior on the day very high-end fire behavior occurred and several firefighters were entrapped. FBAT also gathered heat flux data with newly calibrated equipment which will start to build a dataset which could be used to improve firefighter safety. FBAT also beta-tested a new soils sampling protocol and sent several soil samples off to Michigan State collaborators for analysis, which are the first steps in integrating soil nutrient and black carbon effects into FBAT protocol. FBAT also collected integrated fuels, consumption, fire effects and fire behavior data which will be used along with data from other fires and years to evaluate and possibly calibrate fire behavior or fire effects models.

The Beaver fire burned during drought conditions resulting in high fuel consumption and intense behavior on some plots. The data collected by FBAT will be used to improve understanding of fires burning under different conditions.

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References

Albini, Frank A. 1976. Estimating wildfire behavior and effects. USDA Forest Service. GTR INT-30. Intermountain Forest and Range Experiment Station.

Agee, J.K. 1996. The Influence of Forest Structure on Fire Behavior. 17th Forest Vegetation Management Conference. University of Washington, Seattle, WA.

Bradshaw, L. (technical contact). 2013. FireFamily Plus 4.1. Rocky Mountain Research Station Fire Sciences Laboratory, USDA Forest Service, Fire and Aviation Management, National Information Systems Group. Software available online: http://www.firelab.org/project/firefamilyplus

Brown, J.K., 1974. Handbook for inventorying downed woody material. USDA For. Serv. Gen. Tech. Rep. GTR-INT-16. 34 p.

Burgan, R. E. and Rothermel, R.C. (1984) BEHAVE: Fire Prediction and Fuel Modeling System -- FUEL Subsystem. General Technical Report, INT-167. USDA, Forest Service. Ogden UT. Calculation spreadsheet by Scott (2005), see below.

Butler, B.W. and Cohen, J.D. 1998. Firefighter Safety Zones: A theoretical model based on radiative heating. International Journal of Wildland Fire 8(2): 73-77.

Butler, B.W. 2014. Wildland firefighter safety zones: a review of past science and summary of future needs. International Journal of Wildland Fire 23(295-308).

Butler, B. W., Teskey, C., Jimenez, D., O'Brien, J. J., Sopko, P., Wold, C., Vosburgh, M., Hornsby, B. 2014. Observations of fire intensity and fire spread rate in grass and long leaf pine ecosystems – the RxCADRE Project. International Journal of Wildland Fire, in review.

Crookston, N.L., Dixon, G.E., 2005. The forest vegetation simulator: a review of its structure, content, and applications. Comput. Electron. Agric. 49, 60–80.

Frankman, D, Webb, BW, Butler, BW, Jimenez, D, Forthofer, JM, Sopko, P, Shannon, KS, Hiers, JK, Ottmar, RD. 2012. Measurements of convective and radiative heating in wildland fires. International Journal of Wildland Fire 22: 157-167. Graham, R.T., Harvey, A.E., Jain, T.B., Tonn, J.R. 1999. The effects of thinning and similar stand treatments on fire behavior in Western forests. Gen. Tech. Rep. PNW-GTR-463. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Graham, R.T., McCaffrey, S., Jain, T.B. (tech. eds.). 2004. Science basis for changing forest structure to modify wildfire behavior and severity. Gen. Tech. Rep. RMRS-GTR-120. Fort Collins, CO: Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Rebain, S.A. (Comp.), 2010. The Fire and Fuels Extension to the Forest Vegetation Simulator: Updated Model Documentation. USDA For. Serv. Int. Rep. 408 p. (revised July 2014)

Rothermel, R.C. 1991. Predicting behavior and size of crown fires in the Northern Rocky Mountains. Research Paper. INT-438. Ogden, UT: U.S. Dpt. of Agriculture, Forest Service, Intermountain Research Station.

Scott, J.H., Reinhardt, E.D. 2001. Assessing crown fire potential by linking models of surface and crown fire behavior. Research Paper. RMRS-RP-29. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Scott, J.H. 2005. Behave Fuel Subsystem calculations adapted to an excel spreadsheet, Pyrologics, joe.scott@pyrologix.com.

Simard, A., J. Eenigenburg, K. Adams, R. Nissen Jr., and A. Deacon. 1984. A general procedure for sampling and analyzing wildland fire spread. Forest Sci., Vol. 30, No. 1.

USDI National Park Service. 2003. Fire Monitoring Handbook. Boise, ID: Fire Management Program Center, National Interagency Fire Center, 274p. Program information available online: http://www.nps.gov/fire/fire/fir_eco_mon_protocols.cfm (Aug. 2, 2011).
van Wagtendonk, J.W., Benedict, J.M., Sydoriak, W.M., 1996. Physical properties of woody fuel particles of Sierra Nevada conifers. Int. J. Wildland Fire. 6, 117–123.
van Wagtendonk, J.W., Benedict, J.M., Sydoriak, W.M., 1998. Fuelbed characteristics of Sierra Nevada conifers. West. J. Appl. Forestry. 13, 73–84.
Van Wagner, C.E. 1968. The line intersect method in forest fuel sampling. Forest Sci. 14:20-26.

Appendix A: Representative Paired Photographs from Pre- and Post-Vegetation and Fuel Plots

Plot 1 Transect 2, 0-50 Pre

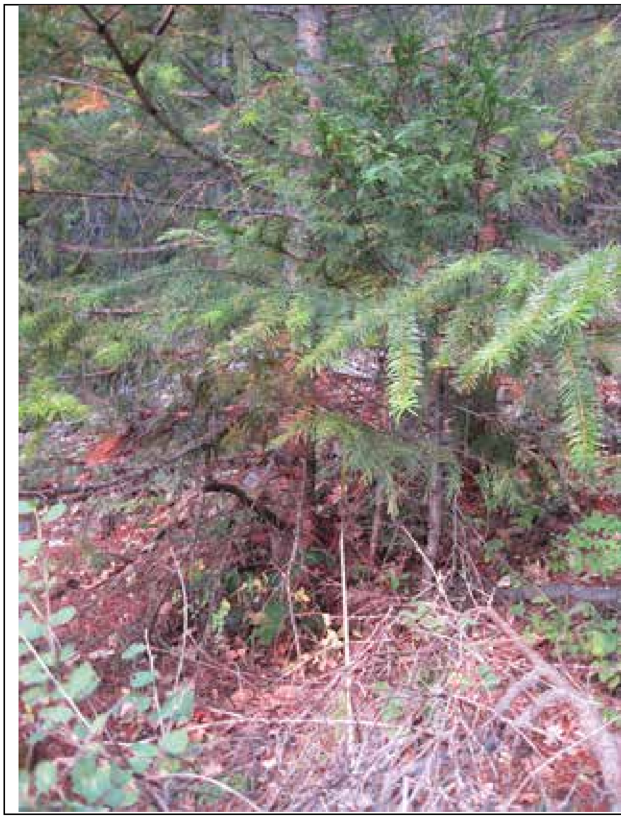
Plot 1 Transect 2, 0-50 Post

Plot 2 Transect 2, 0-50 Pre

Plot 2 Transect 2, 0-50 Post

Plot 3 Transect 3, 0-50 Pre

Plot 3 Transect 3, 0-50 Post



Plot 4 Transect 1, 0-50 Pre

Plot 4 Transect 1, 0-50 Post

Plot 6 Transect 1, 0-50 Pre

Plot 6 Transect 1, 0-50 Post

Plot 7 Transect 1, 50-0 Pre

Plot 7 Transect 1, 50-0 Post

Plot 8 Transect 1, 50-0 Pre

Plot 8 Transect 1, 50-0 Post

Appendix B: Burn severity coding matrix from the National Park Service

Table 12. Burn severity coding matrix from the National Park Service (USDI 2003).

Code	Forests		Shrublands	
	Substrate	Vegetation	Substrate	Vegetation
Unburned (1)	not burned	not burned	not burned	not burned
Scorched (2)	litter partially blackened; duff nearly unchanged; wood/leaf structures unchanged	foliage scorched and attached to supporting twigs	litter partially blackened; duff nearly unchanged; wood/leaf structures unchanged	foliage scorched and attached to supporting twigs
Lightly Burned (3)	litter charred to partially consumed; upper duff layer may be charred but the duff layer is not altered over the entire depth; surface appears black; woody debris is partially burned	foliage and smaller twigs partially to completely consumed; branches mostly intact	litter charred to partially consumed, some leaf structure undamaged; surface is predominately black; some gray ash may be present immediately after burn; charring may extend slightly into soil surface where litter is sparse otherwise soil is not altered	foliage and smaller twigs partially to completely consumed; branches mostly intact; less than 60% of the shrub canopy is commonly consumed
Moderately Burned (4)	litter mostly to entirely consumed, leaving course, light colored ash; duff deeply charred, but underlying mineral soil is not visibly altered; woody debris is mostly consumed; logs are deeply charred, burned-out stump holes are common	foliage, twigs, and small stems consumed; some branches still present	leaf litter consumed, leaving course, light colored ash; duff deeply charred, but underlying mineral soil is not visibly altered; woody debris is mostly consumed; logs are deeply charred, burned-out stump holes are common	foliage, twigs, and small stems consumed; some branches (0.25-0.50 inch in diameter) still present; 40-80% of the shrub canopy is commonly consumed.
Heavily Burned (5)	litter and duff completely consumed, leaving fine white ash; mineral soil visibly altered, often reddish; sound logs are deeply charred and rotten logs are completely consumed. This code generally applies to less than 10% of natural or slash burned areas	all plant parts consumed, leaving some or no major stems or trunks; any left are deeply charred	leaf litter completely consumed, leaving a fluffy fine white ash; all organic material is consumed in mineral soil to a depth of 0.5-1 in, this is underlain by a zone of black organic material; colloidal structure of the surface mineral soil may be altered	all plant parts consumed leaving only stubs greater than 0.5 in diameter
Not Applicable (0)	inorganic pre-burn	none present pre-burn	inorganic pre-burn	none present pre-burn

Appendix C: About the Fire Behavior Assessment Team (FBAT)

The Fire Behavior Assessment Team (FBAT) operates under the management of the Adaptive Management Services Enterprise Team (AMSET) of the USFS. We specialize in measuring fire behavior and fuels on active wildland and prescribed fires. We utilize fire behavior sensors and fire-resistant video cameras to measure direction and variation in rate of spread, fire type (e.g. surface, passive or active crown fire behavior), onsite weather, and couple this with measurements of fire effects, topography, and fuel loading and moisture. We measure changes in fuel loads from fire consumption and can compare the effectiveness of past fuel treatments or fires in terms of fire behavior and effects. We are prepared to process and report some data while on the incident, which makes the information immediately applicable for verifying LTAN or FBAN fire behavior prediction assumptions. In addition, the video and data are useful for conveying specific information to the public, line officers and others. We can also collect and analyze data to meet longer term management needs, such as calibrating fire behavior modeling assumptions for fire management plans, unit resource management plans, or project plans.

We are team of fireline qualified technical specialists and experienced fire overhead. The overhead personnel include a minimum of crew boss qualification, and more often one or more division supervisor qualified firefighters. The team can vary in size, depending upon availability and needs of order, from 5 to 12 persons. We have extensive experience in fire behavior measurements during wildland and prescribed fires. We have worked safely and effectively with over 17 incident management teams. We are comprised of a few AMSET FBAT core members and other on-call firefighters from the USFS and other agencies. We are available to train other interested and motivated firefighters while on fire incidences, as time allows.

We can be ordered from ROSS, where we are set up as "Fire Behavior Assessment Team", and are in the CA Mobilization Guide (near the BAER Teams). We can be name requested, and we'll request additional personal to join our team, like a Wildland Fire Module, based on the Module's availability. Please contact us directly by phone to notify us that you are placing an order, which will speed up the process. You can reach Carol Ewell at 530-559-0070 (cell) or via the Stanislaus NF dispatch (209-532-3671 x212). Or you can reach Alicia Reiner at 530-559-4860 (cell). We may be available if you call dispatch and we are already assigned to a fire. We can work more than one fire simultaneously and may be ready for remobilization. Our web page is below and has links to most of our Incident Summary Reports.

Website: http://www.fs.fed.us./adaptivemanagement/projects/FBAT/FBAT.shtml