Clover Wildland Fire Use Fire
Sequoia National Forest

Fire Behavior Assessment Report

Prepared 6/26/2008
Fire Behavior Assessment Team

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Executive Summary

Introduction

Wildland fire use and wildland suppression fire management are dependent upon good fire behavior and resource effects predictions. Existing fire behavior and resource effects prediction models are based upon limited data from fire in the field, 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 the wildland fire use managers and wildfire incident management teams on fire behavior-fuel and effects relationships. Increasing our knowledge of fire behavior is also important to fire fighter safety – the more we know the more we can mitigate hazards and prevent accidents.

This report contains the results of the assessment of fire behavior in relation to fuels, weather, topography, and fire effects to resources in relation to fire behavior for the Clover Wildland Fire Use Fire on the Sequoia National Forest on the Kern Plateau in the South Sierra Wilderness.

Objectives

Our objectives were to:

1. Characterize fire behavior in relation to fuels and weather for a variety of fuel conditions. A key consideration was which sites could be measured safely given access and current fire conditions.
2. Assess fire severity in areas where the Clover WFU Fire re-burned past fire areas.
3. Assess high severity gaps for Fisher habitat.
4. Create a report on our finding for the fire and local forest.

Accomplishments

Fire behavior, pre- and post-vegetation and fuel conditions were measured at 6 sites above Beck Meadow from June 18th to the June 21st 2008. Twenty rapid burn severity plots were completed to better understand the effectiveness of past fire events to alter fire severity on June 21st and June 22nd. Past fires visited which burned again by the Clover 2008 fire included the 1980 Clover Fire, the 2004 Crag Fire and the 2006 Broder/Beck Fire. A few high intensity gaps were measured and mapped to aid in understanding the potential impacts on the fisher.

Introduction

Both wildland fire use and wildland suppression fire management depend upon good fire behavior and resource effects predictions. Existing fire behavior and resource effects prediction models are based upon limited data from fire in the field, especially quantitative data. It is difficult to accurately predict fire behavior in the outside environment based upon laboratory data, limited experimental data on prescribed burns or broad field observations. The Fire Behavior Assessment Team (FBAT) collects data to improve our ability to predict fire behavior and resource effects in the long-term. In addition, FBAT provides short-term intelligence to the wildland fire use managers and wildland fire incident management teams on fire behavior and fuel effects relationships. Increasing our knowledge of fire behavior is also important to fire fighter safety – the more we know the more we can mitigate hazards and prevent accidents.

This report contains the results of the assessment of fire behavior in relation to fuels and weather, and immediate fire effects in relation to fire behavior for the Clover Wildland Fire Use Fire on the Sequoia National Forest. The Clover Fire started on 06/01/2008 and the sites were visited from 6/18/2008 through 6/22/2008.

Objectives

Our objectives were to:

1. Characterize fire behavior in relation to fuels and weather for a variety of fuel conditions. A key consideration was which sites could be measured safely given access and current fire conditions.
2. Assess fire severity in areas where the Clover WFU Fire re-burned past fire areas.
3. Assess high severity gaps for Fisher habitat.
4. Create a report on our finding for the fire and local forest.

Applications

The information will be shared with firefighters to improve situational awareness, managers to improve predictions for fire planning and scientists for improving fire behavior models. A proposal will be submitted to the Joint Fire Science Program to conduct further detailed analysis and more formal publication of the information.

Approach/Methods

Pre- and post-fire fuels and fire behavior measurements were taken at 6 sites above Beck Meadow on the Kern Plateau within the Clover Wildlanf Fire Use (WFU) Fire (Figure 1). Sites were selected to represent a variety of fire behavior and vegetation or fuel conditions. Priority was on sites that would most likely receive fire. In addition, a rapid assessment of fire severity and effects was conducted across the portions of the fire that burned into past fire perimeters, and high severity gaps were assessed for Fisher habitat.

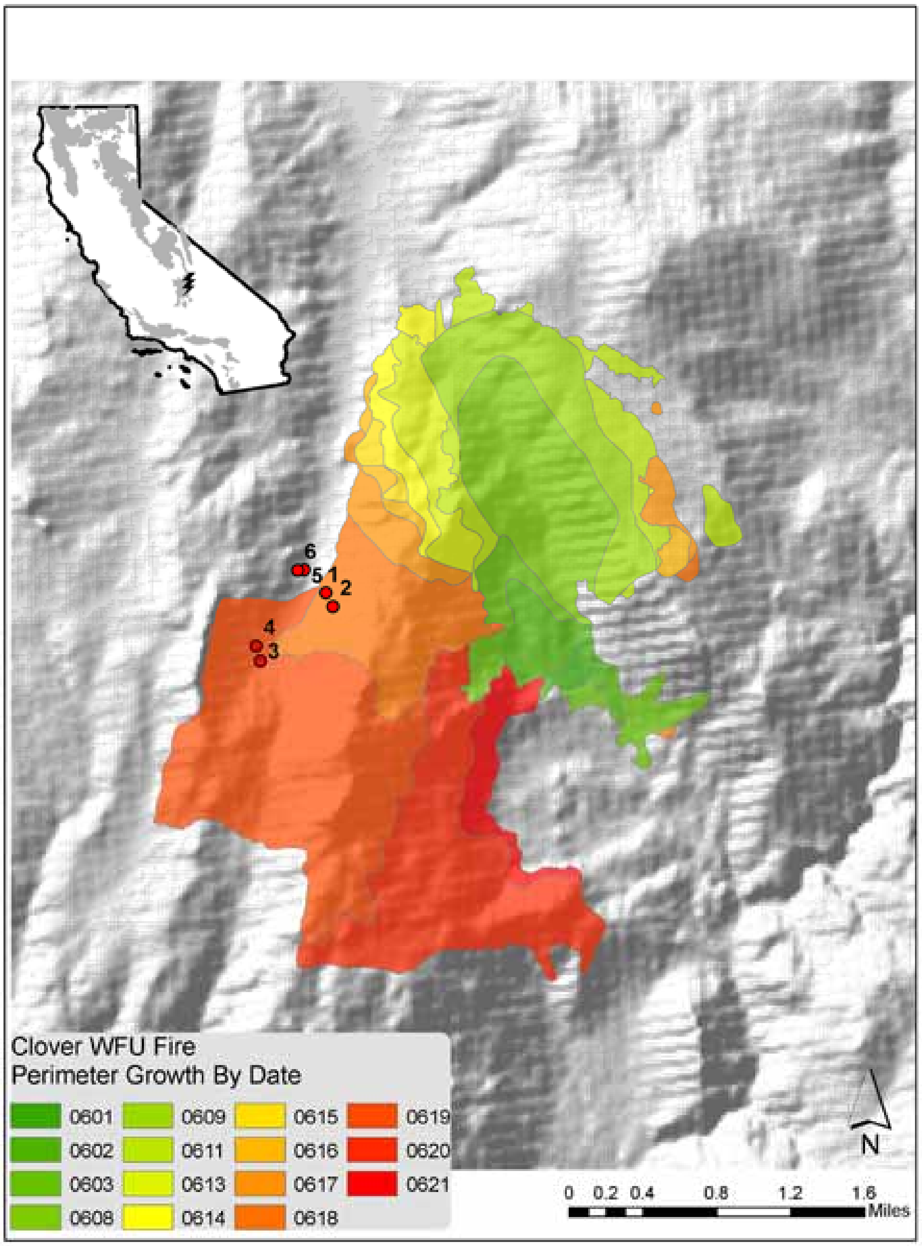


Figure 1: Location of Clover WFU Fire, progression of fire (as of 6/21/2008) and study sites. Although Sites 5 and 6 do not appear to be within the burn perimeter they did burn on 6/19/2008.

Pre- and Post-Vegetation and Fuel Measurements

Vegetation and fuels were inventoried both before the fire reached each site and then again after the fire. Consumption and fire effects (i.e. scorch) were inventoried after burning. Mortality was not determined for trees, since mortality can be delayed for some time after the fire, and is not possible to determine immediately post-fire.

Figure 2: Example of vegetation and fuel data collection at Site 2 in the Clover WFU Fire.

Crown Fuels and Overstory Vegetation Structure

Variable radius plots were used to characterize crown fuels and overstory vegetation structure. A relaskop was used to create individual plots for both pole (>2.5 to 5.9" DBH) and overstory (>6" DBH) trees. When possible a prism factor was selected to include between 5 and 10 trees for each classification. Tree species, status (alive or dead), diameter at breast height (DBH), height, canopy base height and crown classification (dominant, co-dominant, intermediate or suppressed) was collected for each tree before the fire. After the fire maximum char, scorch and torch heights were recorded for each tree. Diameter at breast height was measured with a biltmore stick. Total tree height, canopy base height, char height, scorch height, and torch height were measured with an impulse laser. Canopy Fuels Inventory Processor (CFIP) was used to calculate canopy bulk density, canopy base height, tree density and basal area (Wilson 2008). CFIP is based on the Forest Vegetation Simulator (FVS) program, a forest and growth yield program used throughout the United States.

Understory Vegetation Structure and Loading

Understory vegetation was measured in a one meter wide belt along a 50 ft transect. The transect was 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 class (based on an ocular estimation) were recorded for all understory shrubs, grasses and herbaceous plants. In addition, shrub or grass type and density class were noted to calculate live understory fuel loading following the Burgan and Rothermel (1984) methodology. The resulting loading is also used to calculate consumption of understory fuels.

Surface and Ground Fuel Loading

Surface and ground fuels were measured along the same 50 ft transect as the understory vegetation at each site. Surface (1-hr, 10-hr, 100-hr and 1000-hr time lag fuel classes and fuel height) and ground fuels (litter and duff depths) were measured using the line intercept method (Brown 1974). 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 to determine the fuel bed depth. 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 (van Wagtendonk 1998) and ultimately percent fuel consumption. When applicable duff pins were installed along the transect to better measure duff consumption by the fire. Finally, a rapid assessment of fire severity was completed along the transect to note the effects of fire on the surface and ground fuels.

Fire Behavior Measurements and Observations

At each site, various sensors and a video camera were set up to gather information on fire behavior. The sensors include the capability to capture rate of spread, temperature, duration of heat and wind. The sensors will be described in more detail below. The video camera is used to determine fire type, flame length, variability and direction of rate of spread and flame duration. This information can also be used to calculate fuel consumption by the flaming front. A portable remote automated weather station (RAWS) was used to gather weather information (relative humidity, wind speed, wind direction, temperature and fuel moisture) near the sites. The RAWS was located at H3 at the northern end of the fire in Beck Meadow.

Figure 3: Example of fire behavior equipment set up at the Clover WFU Fire at Site 4.

Rate of Spread and Temperature
Rate of spread was determined by video analysis and rate of spread sensors (MadgeTech 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. In addition, thermocouples attached to Campbell Scientific data loggers were also used for rate of spread. The distance and angle between MadgeTech data loggers or Campbell Scientific data loggers were measured to utilize the Simard (1977) method of estimating rate of spread using geometry.

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 site. For example, sites where there was complete consumption of needles indicate 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 height or char. If crown fire occurred above the view of the camera, then maximum tree height was used to estimate the minimum flame length. Flaming duration was based on direct video observation and when temperature was measured, from those sensors as well.

Wind Speed
Wind speed was measured using and anemometer attached the same Campbell Scientific data logger as one thermocouple at each site. Wind speed can be measured until the anemometer cups melt due to fire activity. At this time it is not possible to determine the wind direction using our sensors alone. However; needle freeze can indicate the direction the fire burned through the plot and can give an indication of wind direction.

Weather
Weather data was downloaded from a portable remote automated weather station (RAWS) placed north of the sites at H3. Data includes relative humidity, temperature, fuel moisture, wind speed and wind direction from 6/18/2008 through 6/21/2008.

Burn Severity Plots
Areas where the 2008 Clover Fire burned over the 1980 Clover Fire, 2004 Crag Fire and the 2006 Broder/Beck Fire were visited to assess difference in burn severity to adjacent areas not previously burned. A total of 10 plots were placed inside the over lapping area burned by the 2008 and 1980 Clover Fires and the adjacent area only burned by the 2008 Clover Fire. The same was completed for the 2004 Crag Fire. The 2006 Broder/Beck Fire overlap was visited but no plots were installed due to a minimal amount of land burning again. The burn severity plots encompassed a 10 m circle. At each plot aspect, slope and elevation were recorded. The burn severity plots measured current overstory cover (noting live or dead using a densitometer), percent scorch, percent torch, and effects of fire severity on understory vegetation and surface and ground fuels. Understory and surface fire severity was ranked on a scale from one to five. With one being very high, two high, three moderate, four low and five unburned. In addition,

four pictures were taken at each plot in each of the cardinal directions. Please see Appendix C for the pictures.

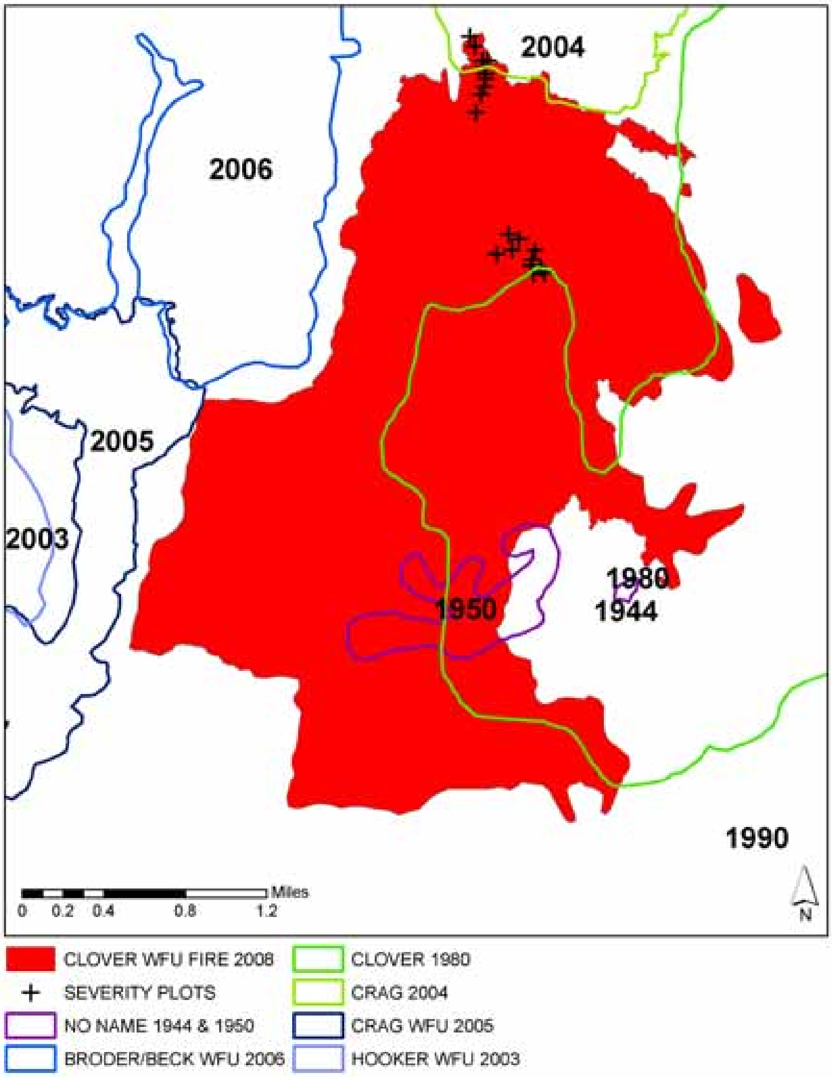


Figure 4: Map of 2008 Clover WFU Fire perimeter (as of 6/21/2008), adjacent fire history and burn severity plot locations in the Crag 2004 and Clover 1980 Fires.

Findings/Results

Pre- and Post-Vegetation and Fuel Measurements

Overstory Vegetation Structure and Crown Fuels

Tree species within the six sites included: ponderosa pine, Jeffrey pine, lodgepole pine, white fir, and juniper. Tree density ranged from 23 to over 500 trees per acre. Canopy cover was between 15 and 66% for the six sites. Pre-fire tree metrics are presented below in Table 1. Due to active fire behavior and adverse terrain the pre-fire tree data was "recreated" after the fire during the post-fire plot re-read for Site 2. Existing scorched needles were used to aid in the determination of the pre-fire canopy base height.

Site	Quadratic Mean Diameter (in)	Basal Area (ft^2/ac)	Tree Density (TPA)	Canopy Base Height (ft)	Canopy Height (ft)	Canopy Cover (%)	Canopy Bulk Density (kg/m^3)	Canopy Fuel (ton/ac)
1	7.0	65	245	1.0	38.0	40.7	0.071	2.4
2	13.9	85	81	4.0	53.9	27.8	0.043	2.9
3	20.2	50	23	11.0	80.3	15.1	0.027	2.2
4	11.4	105	149	4.0	76.2	36.3	0.057	4.3
5	7.9	170	503	1.0	67.5	66.2	0.095	5.8
6	7.3	95	326	1.0	61.5	49.5	0.066	4.8

Table 1: Pre-fire overstory vegetation and crown fuel data by site.

The day after the fire burned through each site additional measurements were gathered (char height, maximum scorch and torch heights, and percentage of the crown scorched and torched) to better assess the fire severity at each site. New canopy metrics are not calculated due to the resilience of some tree species post-fire. It was too soon to assume mortality from scorch alone. However, severity can be assessed from the percentage of scorch and torch for each study site (Table 2).

Site	% Scorch			% Torch		
	Avg.	Min	Max	Avg.	Min	Max
1	33	0	100	35	0	100
2	49	15	100	3	0	10
3	74	20	100	26	0	80
4	8	0	90	92	10	100
5	30	0	100	2	0	10
6	22	0	60	3	0	10

Table 2: Post-fire average, minimum and maximum percent canopy scorch and torch at each site. Values were determined using ocular estimations.

Understory Vegetation Structure and Loading

The understory vegetation was dominated by a shrub component. Very few grasses herbaceous species were found at any of the sites. Dominant shrubs present at the sites included tan oak, mountain mahogany, manzanita, sagebrush and antelope bitter brush. The density of the shrub component varied by site (see Table 3 for loading information). The photographs in Appendix B also show the distribution and density of shrubs for each site.

Pre-Fire								
Site	Grass (ton/ac)	Herb (ton/ac)	Low Shrub (>3ft, ton/ac)		High Shrub (≥3 ft, ton/ac)		Average Fuel Bed Depth (ft)	
			Live	Dead	Live	Dead	Grass & Herb	Shrub
1	--	--	0.05	0.07	14.28	17.85	--	2.29
2	--	<0.01	2.38	0.06	1.64	--	0.52	2.59
3	--	--	0.12	<0.01	--	--	--	1.03
4	--	--	0.71	0.15	--	--	--	1.15
5	<0.01	--	1.00	0.25	--	--	0.49	2.30
6	--	--	<0.01	<0.01	--	--	--	0.82

Table 3: Pre-fire understory fuel loading and fuel bed depth by site (-- none present).

The majority of the understory component was consumed by the fire. Many of the shrubs were burned down to stobs. Again the photographs in Appendix B show the drastic change. Tables 4 and 5 show the post-fire loading and percent consumption from the fire for each site.

Post-Fire								
Site	Grass (ton/ac)	Herb (ton/ac)	Low Shrub (>3ft, ton/ac)		High Shrub (≥3 ft, ton/ac)		Average Fuel Bed Depth (ft)	
			Live	Dead	Live	Dead	Grass & Herb	Shrub
1	--	--	0	0	0	0.49	--	8.20
2	--	0	0	0.04	0	--	0	0.98
3	--	--	0	0	--	--	--	1.64
4	--	--	0	0	--	--	--	0
5	0	--	0	0.15	--	--	0	2.79
6	--	--	<0.01	<0.01	--	--	--	0.82

Table 4: Post-fire understory fuel loading and fuel bed depth by site (-- none present pre-fire).

% Consumption						
Site	Grass (ton/ac)	Herb (ton/ac)	Low Shrub (>3ft, ton/ac)		High Shrub (≥3 ft, ton/ac)	
			Live	Dead	Live	Dead
1	*	*	100	100	100	97
2	*	100	100	37	100	*
3	*	*	100	100	*	*
4	*	*	100	100	*	*
5	100	*	100	38	*	*
6	*	*	0	0	*	*

Table 5: Understory percent consumption by site (* no change).

<u>*Surface and Ground Fuel Loading*</u>

The predominant surface fuels were litter. Site 3 was the only site with a 1000-hr component. The fuel bed depth ranged from a few inches to over a foot. We did not include litter in the calculation of 1-hour fuels but they do contribute to that fuel size class in fire spread and intensity. Pre- and post-fire surface and fuel loading are presented in Tables 6 and 7. Again with active fire behavior and adverse terrain the pre-fuel bed depth was not measured at Site 2.

Pre							
Site	Litter (ton/ac)	Duff (ton/ac)	1-hr (ton/ac)	10-hr (ton/ac)	100-hr (ton/ac)	1000-hr (ton/ac)	Fuel Bed (ft)
1	2.3	11.2	0.2	2.8	--	--	0.2
2	2.3	--	0.3	--	--	--	N/A
3	2.3	18.7	0.2	0.2	0.9	61.0	1.3
4	3.1	18.7	0.1	1.0	1.7	--	0.1
5	3.9	--	--	0.2	--	--	0.1
6	1.6	--	--	3.7	0.9	--	0.3

Table 6: Pre-fire surface and ground fuel loading by site (N/A – no reading taken; -- none present).

Sites 1 through 5 had complete consumption of surface and ground fuels. Site six did not have any consumption along one half of the fuels transect. Unfortunately this was the portion of the transect utilized to gather fuel loading information. Percent consumption for each plot is summarized in Table 8.

Post							
Site	Litter (ton/ac)	Duff (ton/ac)	1-hr (ton/ac)	10-hr (ton/ac)	100-hr (ton/ac)	1000-hr (ton/ac)	Fuel Bed (ft)
1	0.0	0.2	0.0	0.2	--	--	0.0
2	0.0	--	0.0	--	--	--	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.9	0.0
5	0.0	--	--	0.0	--	--	0.0
6	1.6	--	--	3.7	0.9	--	0.3

Table 7: Post-fire surface and ground fuel loading by site (-- none present pre-fire).

% Consumption							**% Change**
Site	Litter (ton/ac)	Duff (ton/ac)	1-hr (ton/ac)	10-hr (ton/ac)	100-hr (ton/ac)	1000-hr (ton/ac)	Fuel Bed (ft)
1	100	98	100	94	*	100	100
2	100	*	100	*	*	*	N/A
3	100	100	100	100	100	100	100
4	100	100	100	100	100	+	100
5	100	100	*	100	*	*	100
6	0	*	*	0	0	*	0

Table 8: Percentage of consumption and change in surface and ground fuels due to the fire (N/A not possible to calculate; * fuel loading was zero both pre- and post-fire; + increase in fuel loading for the given site and metric).

Post-burn ground severity was also measured along each transect at each plot. National Park Service, substrate severity ratings: very high, white ash, some discoloration of soil; high, gray and black ash; moderate, ash and some patches of charred litter or duff; low, charred litter and some unburned litter and duff remain; and unburned.

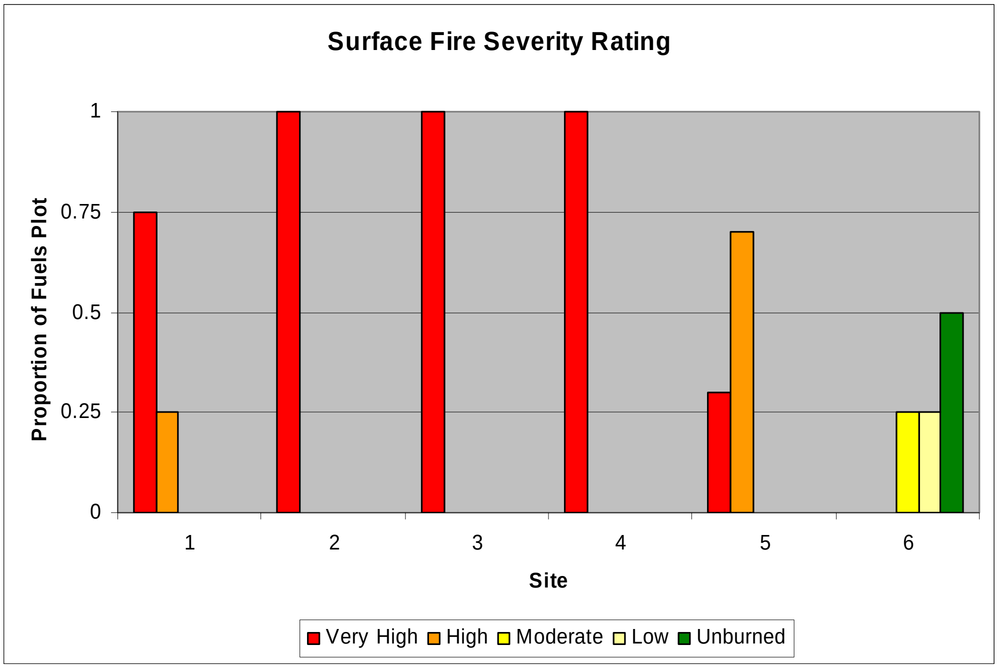


Figure 5: Post-fire surface fire (substrate) severity rating by site.

Fire Behavior Observations and Measurements
All six study sites were above Beck Meadow in the southern portion of the meadow (Figure 1). Sites 1 and 2 were installed and burned on 6/18/2008, Sites 3 and 4 were installed and burned on 6/19/2008, and finally Sites 5 and 6 were installed and burned on 6/20/2008. The wind direction was site specific due to eddying effects from the topography. 6/18/2008 and 6/19/2008 had greater fire behavior and spread than 6/20/2008 from our vantage point affecting the study sites. Below is a site by site description of fuels and fire behavior.

Site 1
Site 1 was located on the lower third of a west facing slope in a north south running drainage. Ponderosa pine, juniper and white fir were the dominant tree species within the site. The understory consisted of fairly continuous patches of mountain mahogany. Fire was established at 13:17 with the maximum temperature at 13:20 (from a rate of spread sensor, 822 ºF). At 14:56 fire activity increased resulting in the maximum temperature of 2088 ºF. Based on temperature sensors fire activity lasted from 13:00 to 16:00 with heavy fuels continuing to 22:30.

Figure 6: Still shot taken from the video footage of fire behavior at Site 1, the anemometer is in view on the left hand side of the photograph.

Site 2
Site 2 was located upslope and south of Site 1. Dominant trees were the same as Site 1, however; the understoy shrub component was less dense. Set up time was limited in due to the proximity of fire to the site location. Fire was established at 12:19 with a peak of1938 ºF occurring at 12:21. Based on temperature sensors fire activity lasted until 17:00.

Figure 7: Still shot taken from the video footage of fire behavior at Site 2 with the melted anemometer in the foreground.

Site 3

Site 3 was south of Sites 1 and 2 on an east facing slope. Dominant trees species included Jeffrey pine, ponderosa pine and white fir. This is the only site with a component of large (1000-hr) dead and downed fuels. Fire was established in the site at 13:12 with a peak temperature of 2003 ºF. Based on temperature sensors fire activity lasted until about 16:00.

Figure 8: Early establishment of fire in Site 3, taken from the video footage.

Site 4

Site 4 was up slope of Site 3 located in a small draw. Site 4 had the same overstory species composition as Site 3, however; the fuel bed was not continuous due to many large rocks. Fire was established at 13:16 with a peak temperature of 1981 ºF occurring at 13:18; duration continued until 21:57. Unfortunately, the camera triggered late for this site and footage is of consumption.

Sites 5 and 6

Sites 5 and 6 were across Beck Meadow from Sites 1 and 2 on an east facing slope. Sites 5 and 6 were also located next to the edge of the 2006 Broder/Beck Fire. Site 6 was just up hill from Site 5. Based on the temperature sensors Site 6 was the first to established fire at 16:09 with a peak temperature of 127 ºF at 16:27. However, based on the video footage fire established in Site 6 just before noon in a large downed log. Minimal data was collected on this site due to technical issues. Fire established in Site 5 at 16:41 with a peak temperature of 1859 ºF at 16:43. Fire duration at Site 5 was short, lasting little more than an hour. It is likely that Site 6 had a similar duration once fire was fully established in the Site because of it's proximity to Site 5.

Figure 9: Still shot taken from the video footage of fire approaching Site 5.

Data Collected from the Sensors

Rate of spread, wind speed, and temperature are all gathered using the MadgeTech and Campbell Scientific data loggers. Appendix D has graphs from three of the Campbell Scientific data loggers and five of the MadgeTech data loggers.

Site	ROS (ch/hr)	Maximum Temperature (ºF)	Duration of Heat (>140ºF)
1	0.5 - 3.7	2087	9 hrs 22 min
2	0.4	1939	5 hrs 24 min
3	2.8 - 9.8	2004	2 hrs 40 min
4	equipment failure	1982	8 hrs 40 min
5	equipment failure	1860	1 hrs 2 min
6	equipment failure	1369	5 hrs 11 min

Table 9: Rate of spread, maximum temperature, and duration of heat from the Campbell Scientific and MadgeTech data loggers.

Fire Behavior Measurements from the Camera Footage

In addition to the temperature sensors, fire behavior data can be taken from the video footage. Table 9 below lists the fire type, flame length, flame angle, rate of spread and duration of active consumption. All values are determined by watching the video footage using photo poles in view of the camera.

Site	Fire Type	Flame Length	Flame Angle (%)	ROS (ch/hr)	Start of Fire	End of Active Consumption
1	Medium intensity surface fire	6’	20 to 35	7 to 8	14:56:38	15:14:01
2	High intensity surface fire coupled with passive crown fire	12’	45	20	12:15:17	12:38:38
3	Low intensity surface fire	4’	10	1	3:24:21*	Longer than tape
4	Crown fire+	N/A	N/A	N/A	13:36:01	N/A
5	Medium to high intensity surface fire with passive crown fire	2’-8’	30	6	16:24:30	16:56:15
6	Low intensity backing surface fire	2”-3”	3	<1	11:51:20	Longer than tape

Table 10: Fire behavior data captured using the camera footage. Site 4 is lacking footage due to a late triggering of the camera. Once the filming started the whole site was on fire.

* not time of day, rather running time on the video footage

\+ fire type based on post-fire fuels data

Weather Observations

A portable remote automated weather station (RAWS) was located at the northern end of Beck meadow. Figures 11 and 12 show temperature, relative humidity, and maximum wind speed for June 18th to 21st.

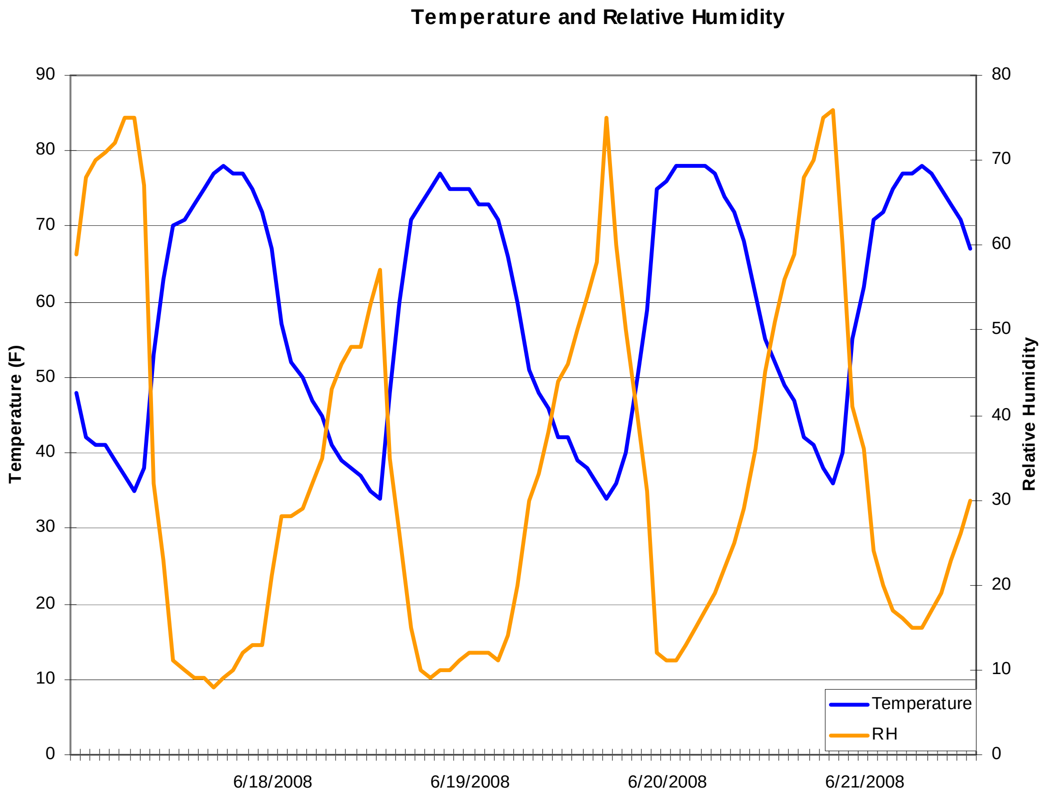


Figure 10: Temperature and relative humidity from the portable RAWS.

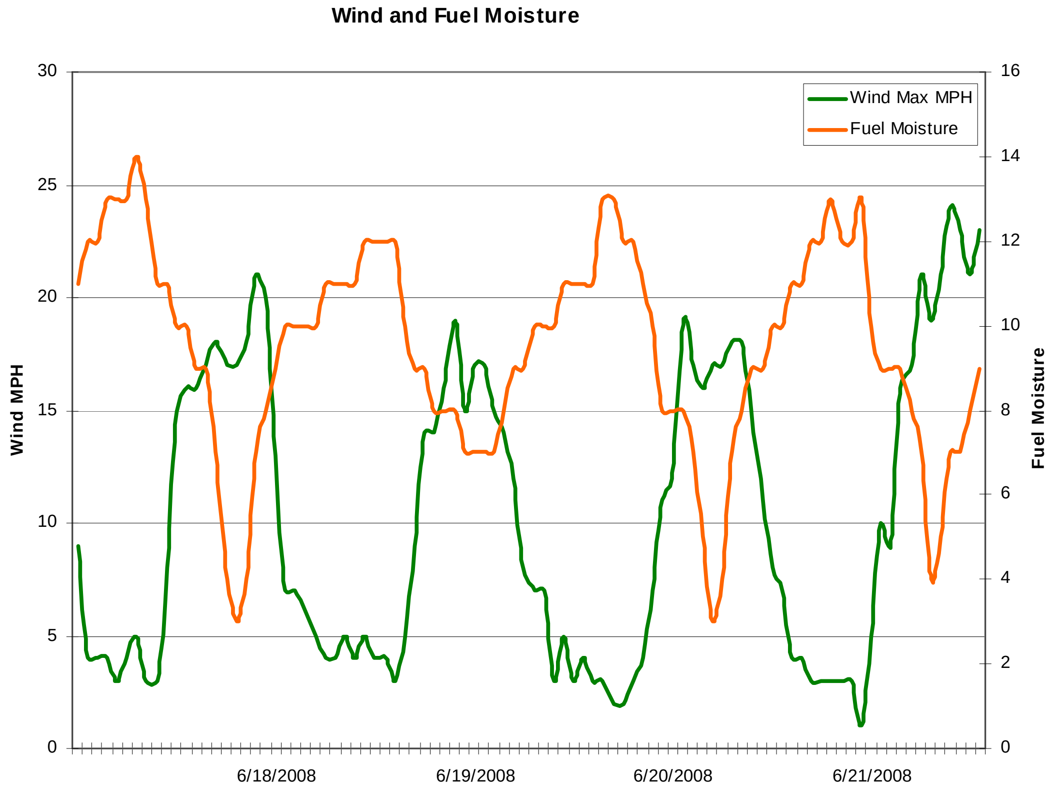


Figure 11: Maximum wind speed and fuel moisture from the portable RAWS.

Burn Severity Plots

The 2008 Clover WFU Fire burned into three older fire perimeters during the time we were in the field (6/18 to 6/22). Those past fires include the 2006 Broder/Beck Fire, 2004 Crag Fire, and the 1980 Clover Fire (Figure 4). A total of 10 rapid burn severity plots were completed in the 2004 Crag and 1980 Clover Fires and 10 in the land just adjacent (still within the 2008 Clover WFU Fire). No plots were completed in the 2006 Broder/Beck burn area because the overlapping area burned was very slight. Fire only burned into the 2006 fire perimeter by a few feet in a couple of places along the border. Where fire did enter it was carried by needle cast.

2004 Crag Fire
Based on the burn perimeters (Figure 4), area re-burned in the Crag Fire was limited. In the area burned by both fires the intensity was less the farther away the plots were from the edge of the 2004 Crag Fire and 2008 Clover WFU Fire.

Plot	Elevation (ft)	Slope (%)	Aspect (deg)	Tree Cover (%)		Scorch (%)	Torch (%)
				Live	Dead		
Area burned in 2004 and 2008							
1	8122	22	270	35	0	5	0
2	8092	15	230	0	0	0	0
3	8060	25	240	0	40	80	0
4	8101	30	294	0	16	0	100
5	8155	30	240	0	45	50	40
Adjacent area only burned in 2008							
6	8153	40	239	0	15	0	100
7	8148	35	264	0	42	0	100
8	8119	25	252	0	10	0	100
9	8094	20	240	0	9	50	50
10	8066	25	270	0	45	40	10

Table 11: Burn severity plot details and overstory tree severity for plots 1-10.

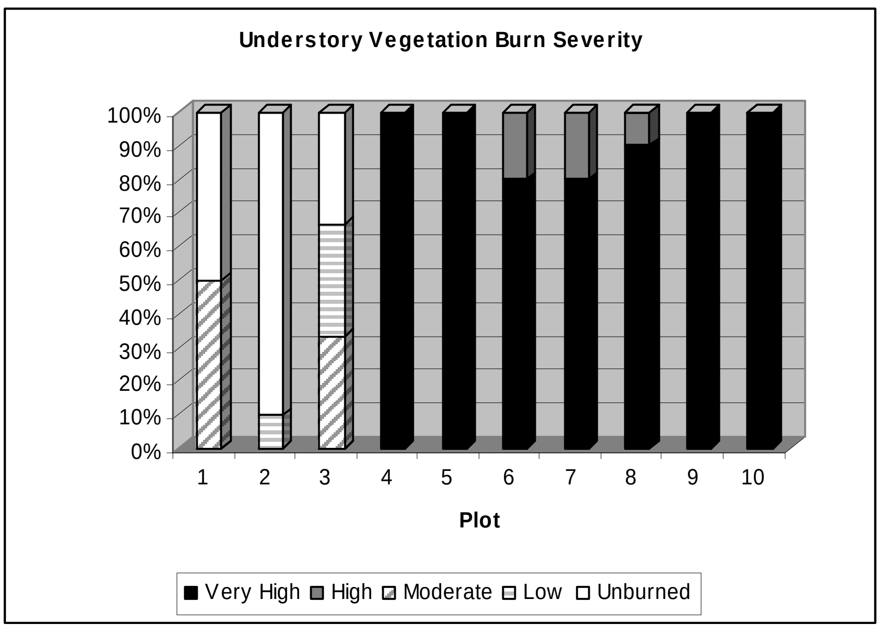


Figure 12: Understory vegetation burn severity rankings for plots 1-10.

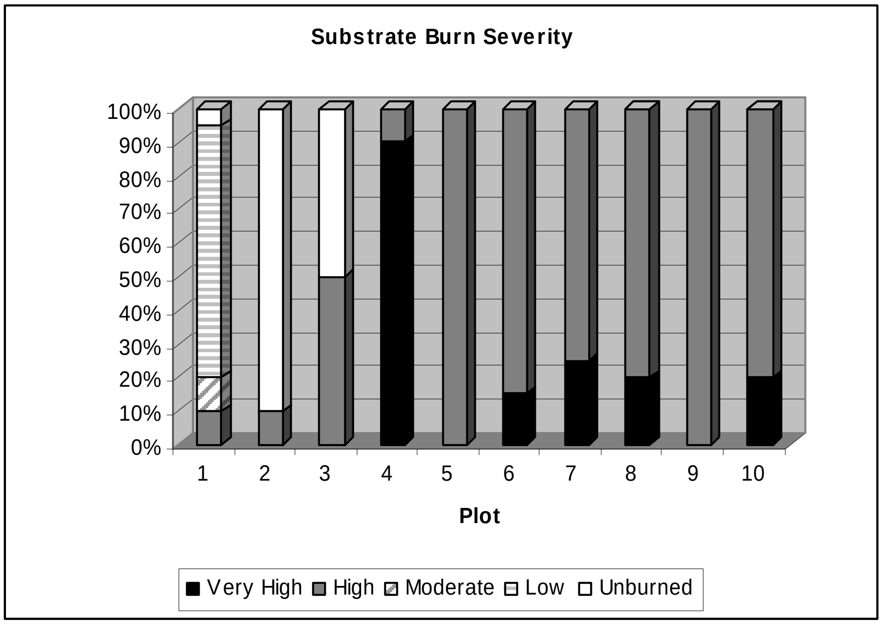


Figure 13: Substrate burn severity rankings for plots 1-10.

1980 Clover Fire

A large area of the 1980 Clover Fire re-burned during the Clover WFU Fire of 2008. The severity seemed to be unchanged no matter the location of the burn severity plots. It was challenging finding the edge between the two fire events and two plots might not have occurred in the 1980 Clover Fire perimeter (Figure 4).

Plot	Elevation (ft)	Slope (%)	Aspect (deg)	Tree Cover (%)		Scorch (%)	Torch (%)
				Live	Dead		
			Area burned in 1980 and 2008				
11	7833	40	90	0	0	0	100
12	7861	25	70	0	6	0	100
13	7896	35	110	0	21	0	100
			Area possibly burned in 1980 and 2008				
14	8047	35	64	0	4	0	100
15	8038	50	62	0	4	0	100
			Adjacent area only burned in 2008				
16	8015	50	306	0	28	0	100
17	8034	25	30	0	23	20	80
18	8086	20	56	0	22	30	70
19	7974	5	68	0	5	20	80
20	7924	50	38	0	2	3	97

Table 12: Burn severity plot details and overstory tree severity for plots 11-20.

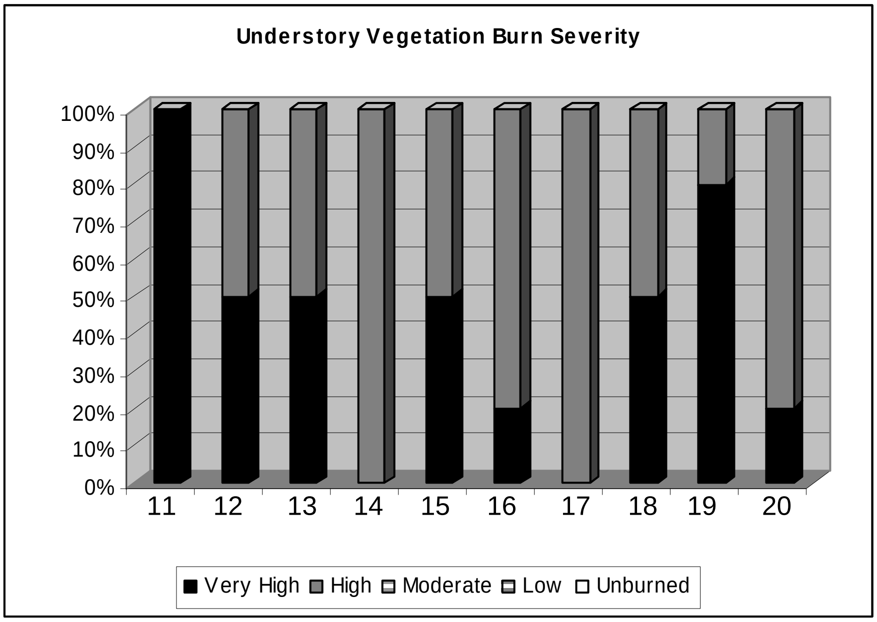


Figure 14: Understory vegetation severity rankings for plots 11-20.

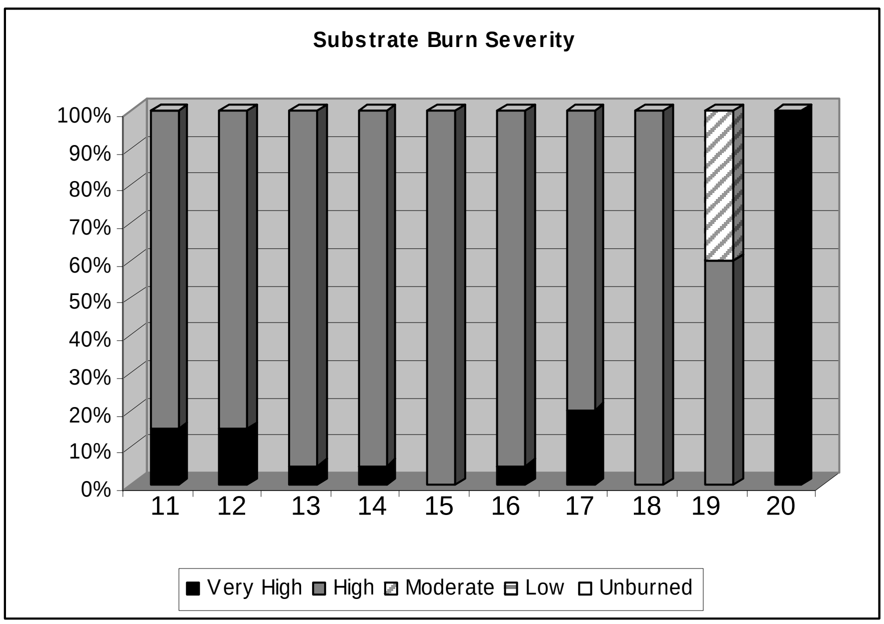


Figure 15: Substrate burn severity rankings for plots 11-20.

Summary/Accomplishments

Our objectives were to:

1. Characterize fire behavior in relation to fuels and weather for a variety of fuel conditions. A key consideration was which sites could be measured safely given access and current fire conditions.
2. Assess fire severity in areas where the Clover WFU Fire re-burned past fire areas.
3. Assess high severity gaps for Fisher habitat.
4. Create a report on our finding for the fire and local forest.

Six sites were successfully visited and burned over in the area surrounding Beck Meadow in the northern portion of the Clover WFU Fire from 6/18/2008 through 6/21/2008. Fire behavior between the plots was variable.

We completed 20 burn severity plots in areas burned again by the Clover WFU Fire. The goal was to assess the effectiveness of old fire areas to act as treatments to reduce future fire intensity and severity. Time since fire seems to play a large role in the ability of the 2008 Clover WFU Fire to enter old burn areas.

We completed a few plots and mapped a couple of high severity gaps for Fisher habitat. The information gathered is in Appendix E.

We will distribute this report to both the Clover WFU Fire personnel and the Sequoia National Forest.

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

We are a unique module that specializes in measuring fire behavior on active wildland fire use fires, prescribed fires and wildland fires. We utilize fire behavior sensors and special video camera set-ups to measure direction and variation in rate of spread, fire type (e.g. surface, passive or active crown fire behavior) in relation to fuel loading and configuration, topography, fuel moisture, weather and operations. We measure changes in fuels from the fire and can compare the effectiveness of past fuel treatments or fires on fire behavior and effects. We are prepared to process and report 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 verifying or testing 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 and more often one or more division supervisor qualified persons. The team can vary in size, depending upon availability and needs of order, from 5 to 12 persons. Our lead fire overhead is Mike Campbell, Division Supervisor. We have extensive experience in fire behavior measurements during wildland fires, wildland fire use fires and prescribed fires. We have worked safely and effectively with over 16 incident management teams.

We can be ordered from ROSS, where we are set up as "TEAM- FIRE BEHAVIOR ASSESSMENT – FITES". We can be requested by the following steps: 1) Overhead, 2) Group, 3) Squad, and 4) in Special Needs box, "Requesting –Fire Behavior Assessment Team- Fites' Team out of CA-ONCC 530-226-2800.
You can also contact us directly by phone to notify us that you are placing an order, to speed up the process. You can reach Jo Ann at 530-478-6151 or cell (only works while on travel status) at 530-277-1258. Or you can reach Mike Campbell at 530-288-3231 or cell (only works while on travel status) 530-701-3644. Or you can reach us through Tahoe NF dispatch, who has our home phone numbers as well (530-478-6111). Do not assume that we are not available if you call dispatch and we are already on a fire. We have and can work more than one fire simultaneously and may be ready for remobilization.

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

F**igure 16:** Paired pre- and post-fire photographs from Site 1.

Figure 17: Paired pre- and post-fire photographs from Site 2.

Figure 18: Paired pre- and post-fire photographs from Site 3.

Figure 19: Paired pre- and post-fire photographs from Site 4.

Figure 20: Paired pre- and post-fire photographs from Site5.

Figure 21: Paired pre- and post-fire photographs from Site 6.

Appendix C:
Burn Severity Plot Photographs

All photographs are in the same order top left is facing north, top right east, bottom left south and bottom right west.

Area burned by both the 2004 Crag Fire and 2008 Clover WFU Fire

Figure 22: Pictures from burn severity plot 1.

Figure 23: Pictures from burn severity plot 2.

Figure 24: Pictures from burn severity plot 3.

Figure 25: Pictures from burn severity plot 4.

Figure 26: Pictures from burn severity plot 5.

Area adjacent to the 2004 Crag Fire burned by the 2008 Clover WFU Fire

Figure 27: Pictures from burn severity plot 6.

Figure 28: Pictures from burn severity plot 7.

Figure 29: Pictures from burn severity plot 8.

Figure 30: Pictures from burn severity plot 9.

Figure 31: Pictures from burn severity plot 10.

Area burned by both the 1980 Clover Fire and 2008 Clover WFU Fire

Figure 32: Pictures from burn severity plot 11.

Figure 33: Pictures from burn severity plot 12.

Figure 34: Pictures from burn severity plot 13.

Area burned by both the 1980 Clover Fire and 2008 Clover WFU Fire or just the 2008 Clover WFU Fire (we are not sure)

Figure 35: Pictures from burn severity plot 14.

Figure 36: Pictures from burn severity plot 15.

Area adjacent to the 1980 Clover Fire burned by the 2008 Clover WFU Fire

Figure 37: Pictures from burn severity plot 16.

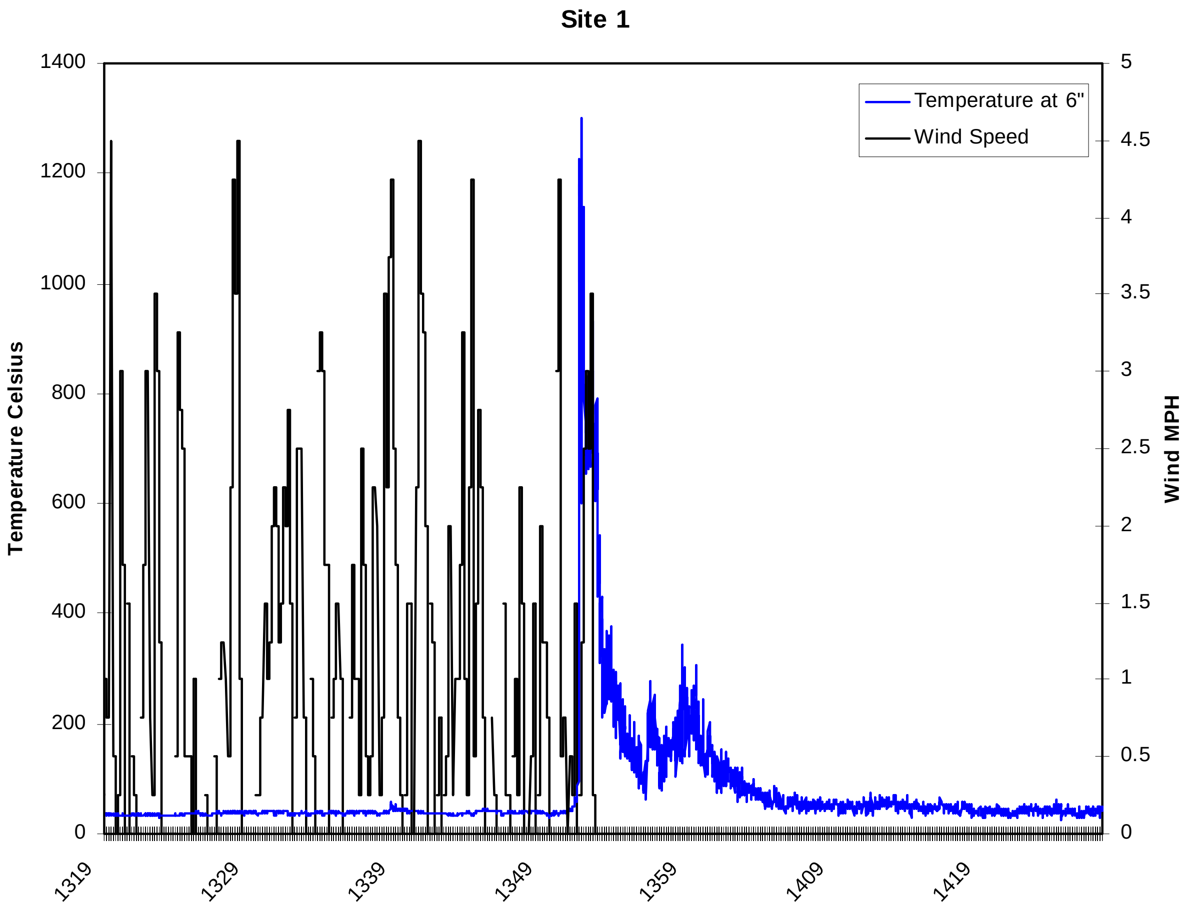
Figure 38: Pictures from burn severity plot 17.

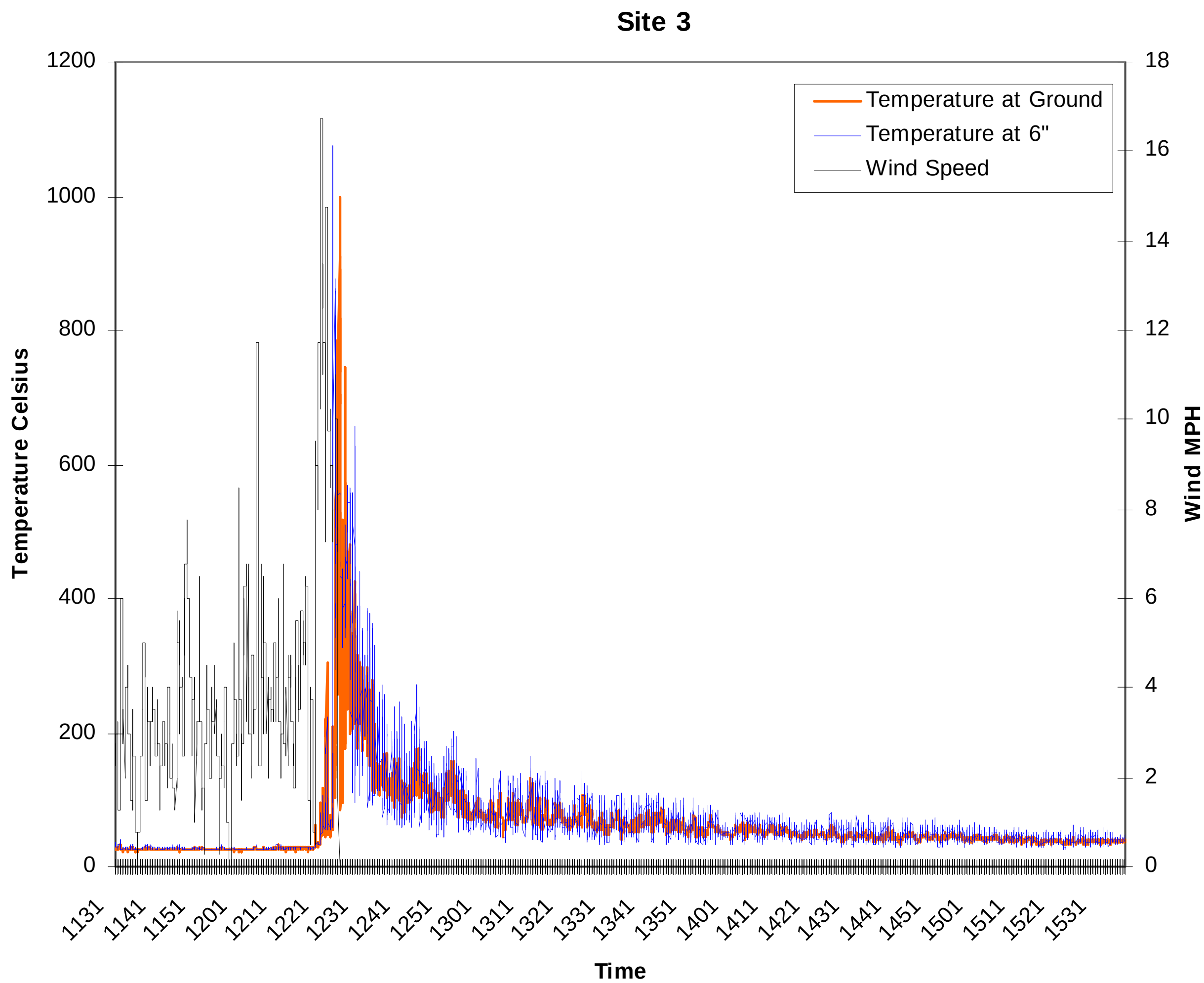
Figure 39: Pictures from burn severity plot 18.

Figure 40: Pictures from burn severity plot 19.

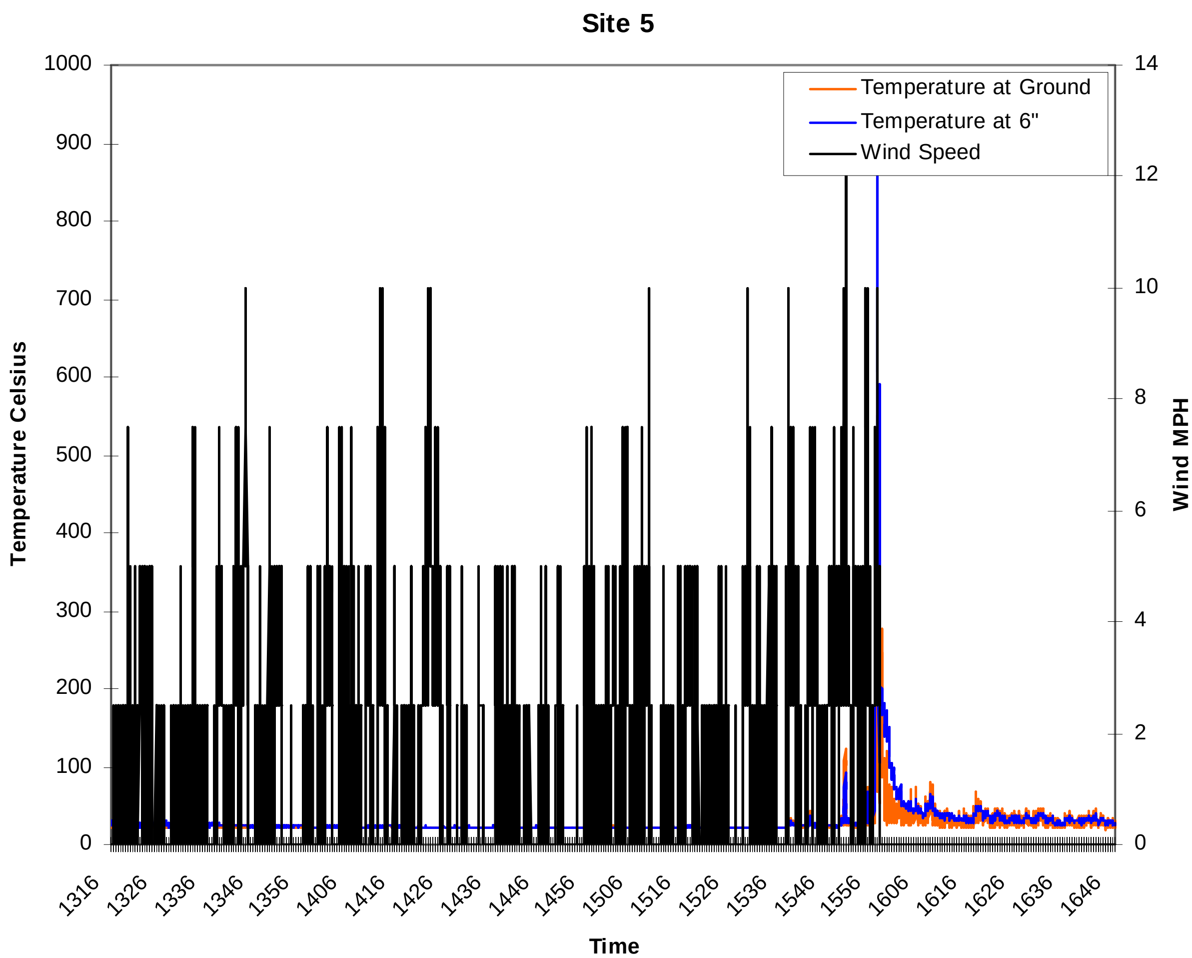
Figure 41: Pictures from burn severity plot 20.

Appendix D:
Data Logger Outputs

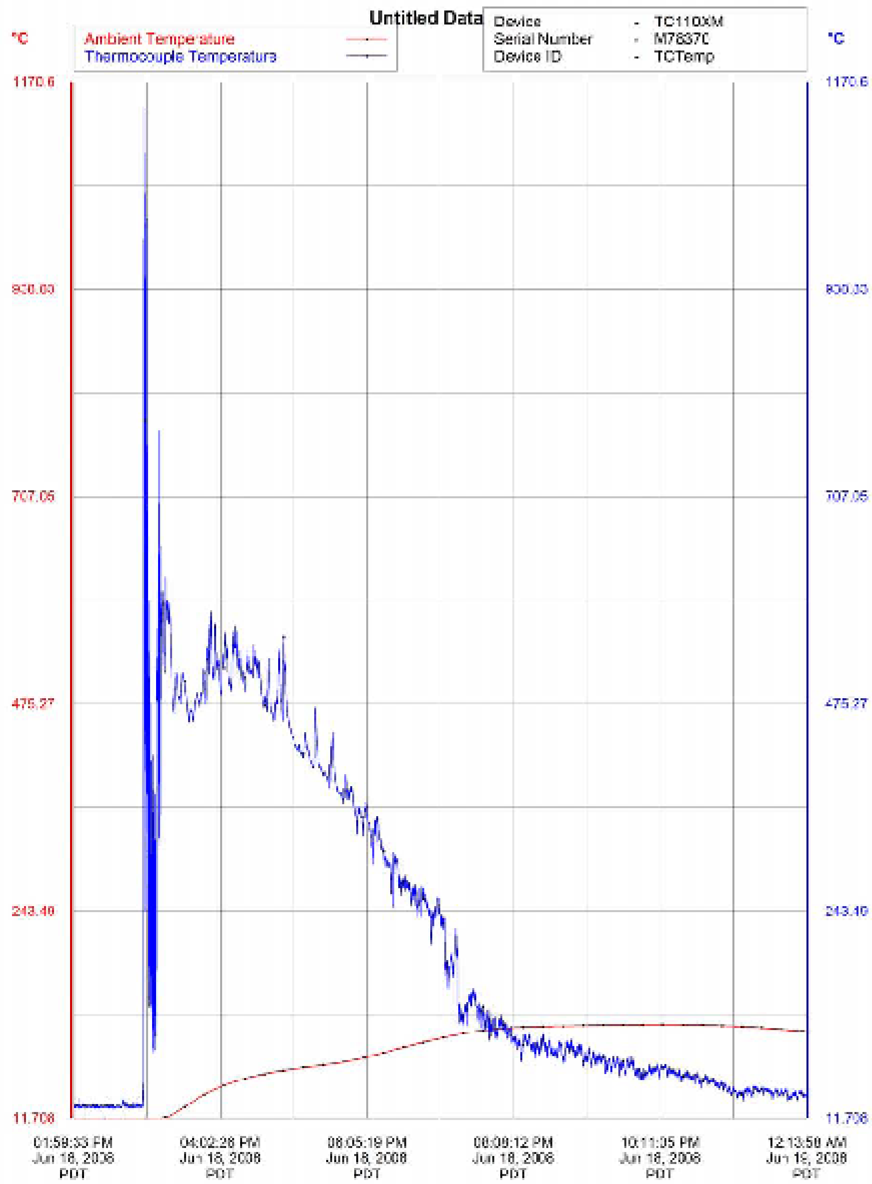




Site 3
Temperature at Ground
Temperature at 6"
Wind Speed
Temperature Celsius
Wind MPH
Time
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12
14
16
18
1131
1141
1151
1201
1211
1221
1231
1241
1251
1301
1311
1321
1331
1341
1351
1401
1411
1421
1431
1441
1451
1501
1511
1521
1531



Site 5
Temperature Celsius
1000
900
800
700
600
500
400
300
200
100
0
Wind MPH
14
12
10
8
6
4
2
0
Temperature at Ground
Temperature at 6"
Wind Speed
1316
1326
1336
1346
1356
1406
1416
1426
1436
1446
1456
1506
1516
1526
1536
1546
1556
1606
1616
1626
1636
1646
Time



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Ambient Temperature
Thermocouple Temperature
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Serial Number - M78370
Device ID - TCTemp
°C
°C
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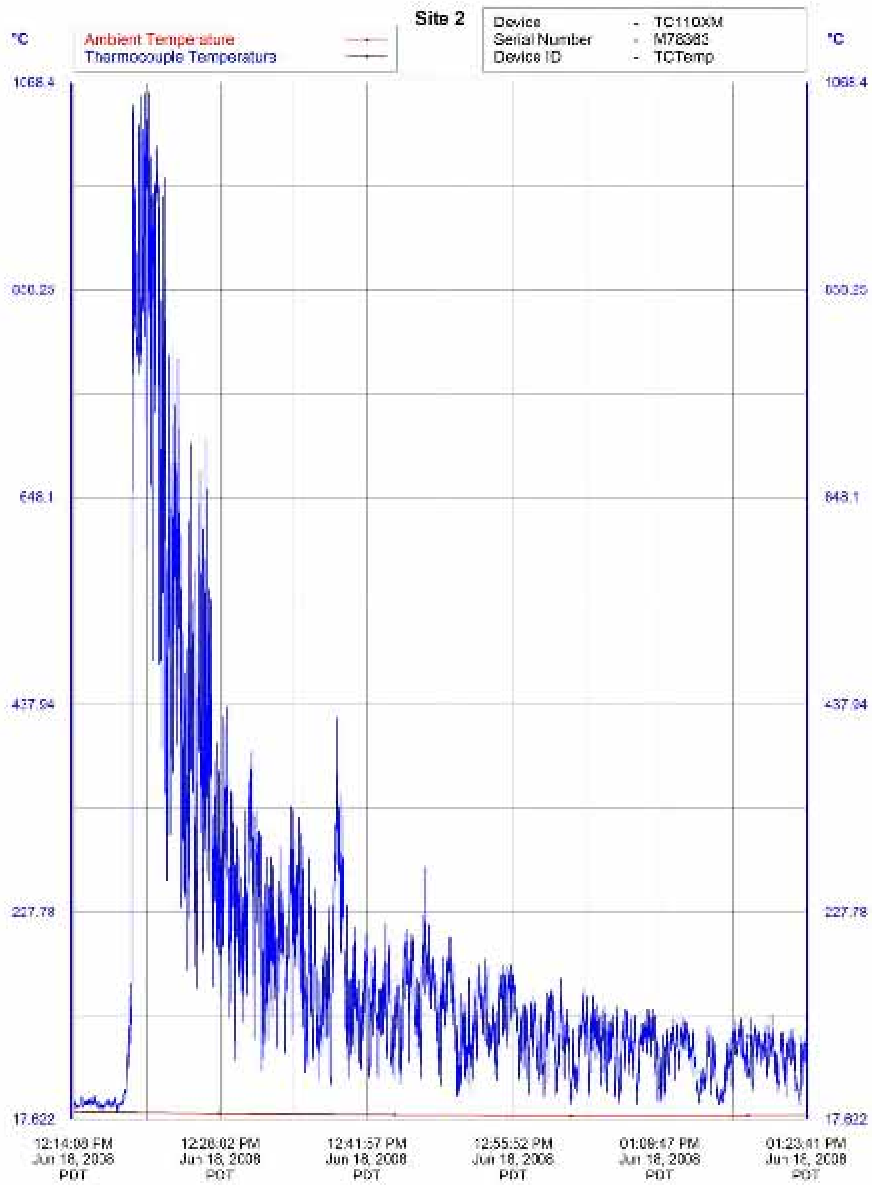
707.05
475.27
243.49
11.708
01:59:33 PM Jun 18, 2008 PDT
04:02:26 PM Jun 18, 2008 PDT
06:05:19 PM Jun 18, 2008 PDT
08:08:12 PM Jun 18, 2008 PDT
10:11:05 PM Jun 18, 2008 PDT
12:13:58 AM Jun 19, 2008 PDT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°C
Ambient Temperature
Thermocouple Temperature
Device - TC110XM
Serial Number - M78363
Device ID - TCTemp
°C
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648.1
437.94
227.78
17.622
12:14:08 PM Jun 18, 2008 PDT
12:28:02 PM Jun 18, 2008 PDT
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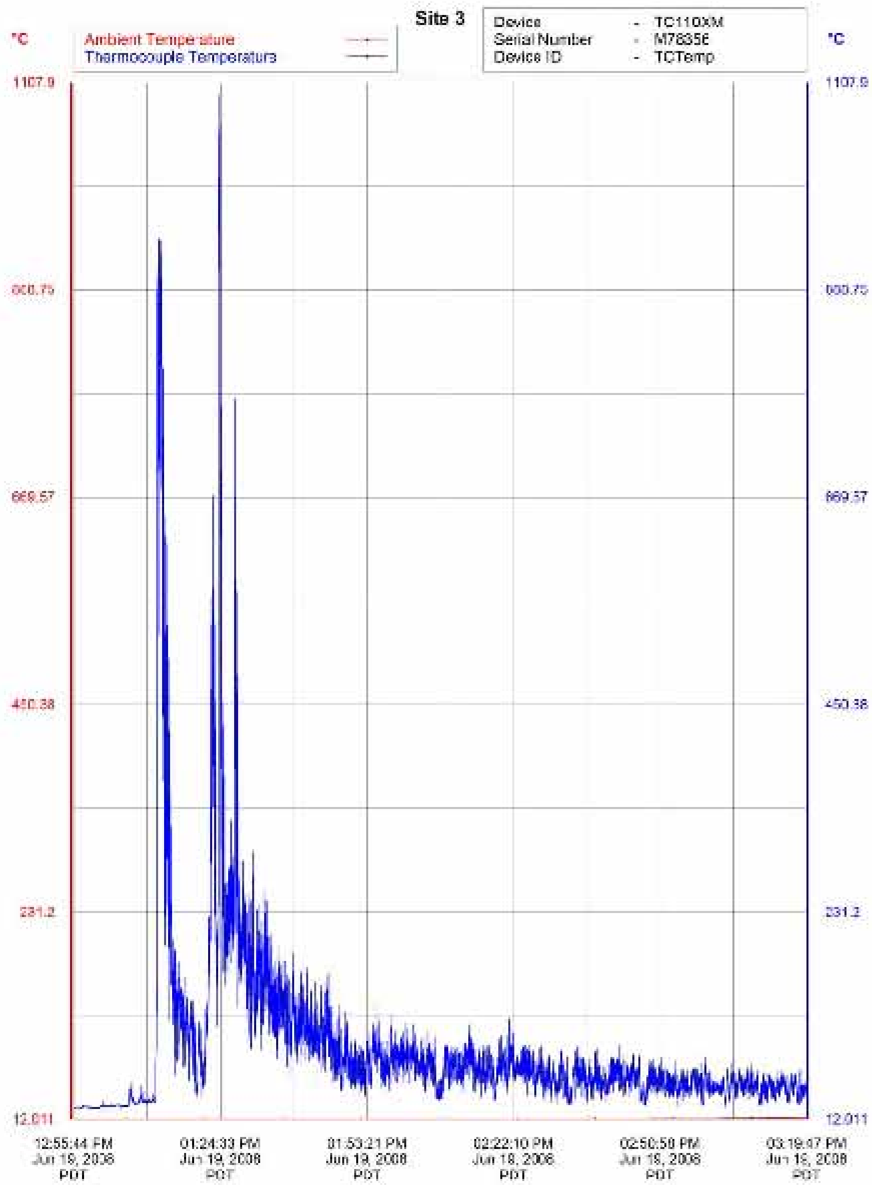
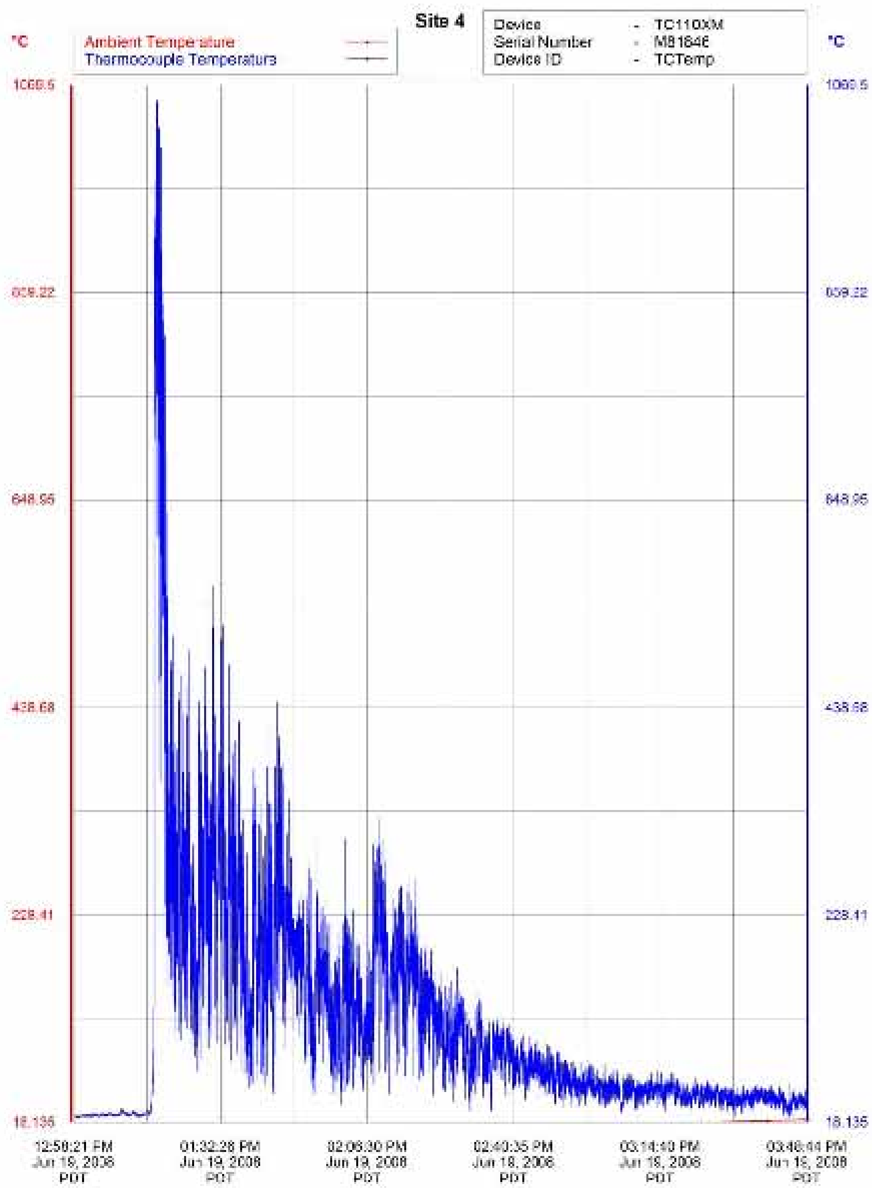
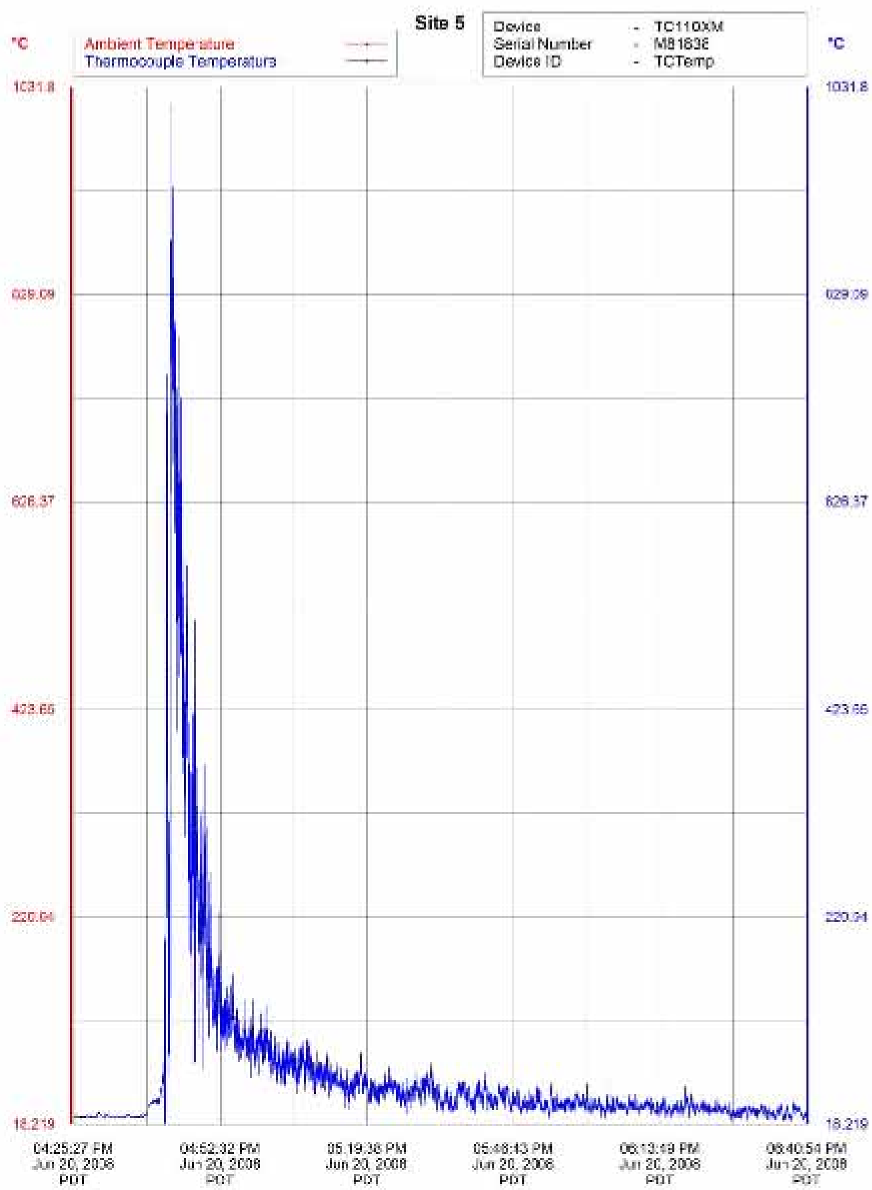
12:55:52 PM Jun 18, 2008 PDT
01:09:47 PM Jun 18, 2008 PDT
01:23:41 PM Jun 18, 2008 PDT



Site 3
°C
Ambient Temperature
Thermocouple Temperature
Device - TC110XM
Serial Number - M78356
Device ID - TCTemp
°C
1107.9
888.75
669.57
450.38
231.2
12.011
12:55:44 PM Jun 19, 2008 PDT
01:24:33 PM Jun 19, 2008 PDT
01:53:21 PM Jun 19, 2008 PDT
02:22:10 PM Jun 19, 2008 PDT
02:50:58 PM Jun 19, 2008 PDT
03:19:47 PM Jun 19, 2008 PDT



Site 4
°C
Ambient Temperature
Thermocouple Temperature
Device - TC110XM
Serial Number - M81846
Device ID - TCTemp
°C
1069.5
859.22
648.95
438.68
228.41
18.135
12:58:21 PM Jun 19, 2008 PDT
01:32:28 PM Jun 19, 2008 PDT
02:06:30 PM Jun 19, 2008 PDT
02:40:35 PM Jun 19, 2008 PDT
03:14:40 PM Jun 19, 2008 PDT
03:48:44 PM Jun 19, 2008 PDT



Site 5
°C
Ambient Temperature
Thermocouple Temperature
Device - TC110XM
Serial Number - M81836
Device ID - TCTemp
°C
1031.8
829.09
626.37
423.65
220.94
18.219
04:25:27 PM Jun 20, 2008 PDT
04:52:32 PM Jun 20, 2008 PDT
05:19:38 PM Jun 20, 2008 PDT
05:46:43 PM Jun 20, 2008 PDT
06:13:49 PM Jun 20, 2008 PDT
06:40:54 PM Jun 20, 2008 PDT

Appendix E:
High Severity Gaps for Fisher Habitat

Gap ID	Plot #	UTM E	UTM N	Comments
1	1	397401	400032	~750 TPA, PICO, 12-20 in DBH, 40-60ft tall, torched
1	2	397836	3999173	~250 TPA, PICO, 8-12 in DBH, 25-30 ft tall, torched
1	3	397943	3998967	~300 TPA, PICO, 16-20 in DBH, 55-65 ft tall, torched
1	4	397997	3998721	~250 TPA, PICO, 8-20 in DBH, 25-30 ft tall, torched
1	5	398030	3998407	~300 TPA, 4-12 in DBH, 30-65 ft tall, torched, shrubs too
1	6	398122	3998248	~250 TPA, PICO, JUOC, ABCO, mountain mahogany (30%) cover, all torched, less severe than other plots
1	7	398156	3998146	Edge of severity along PCT. Mostly unburned litter, 50% brush, 3 trees, no scorch
2	1	????	????	Edge of Gap along the PCT
2	2	????	????	Edge of Gap along the PCT

Notes Gap 1:
Plot points are all along the PCT and are 1/50 of an acre in size. The area of severity runs along the PCT about 1.3 miles. The gap extends up both sides of the canyon to at least the upper 1/3 of the slope. Estimated gap size >500ac. Severity is higher along the saddle and is less along the upper edge of the fire.

Notes Gap 2:
The two GPS points are along the northern edge of the fire where it crosses the PCT. I am trying to get them from the GPS, but am having technical difficulties. The gap is an area of high severity in the bowl uphill of the PCT between the two points. The severity lessens when the fire approaches and entered the 2004 Crag Fire. We installed 10 burn severity plots in this gap.

General Notes:
There were many gaps in the fire especially after the fire grew on 6/18/2008. We only had access along the PCT and Beck Meadow. From the ground the burn pattern is a mosaic of different severities. However, I would say the number and size of the high severity gaps is larger than in the adjacent 2006 Broder/Beck Fire. The adjacent 2004 Crag Fire also had visible large high severity gaps as with the 2008 Clover WFU Fire. If there is interest in future work walking and mapping the gaps or using satellite burn severity imagery please contact Nicole Vaillant nvaillant@fs.fed.us.

Fire Behavior Assessment Team
Adaptive Management Enterprise Team
www.fs.fed.us/adaptivemanagement