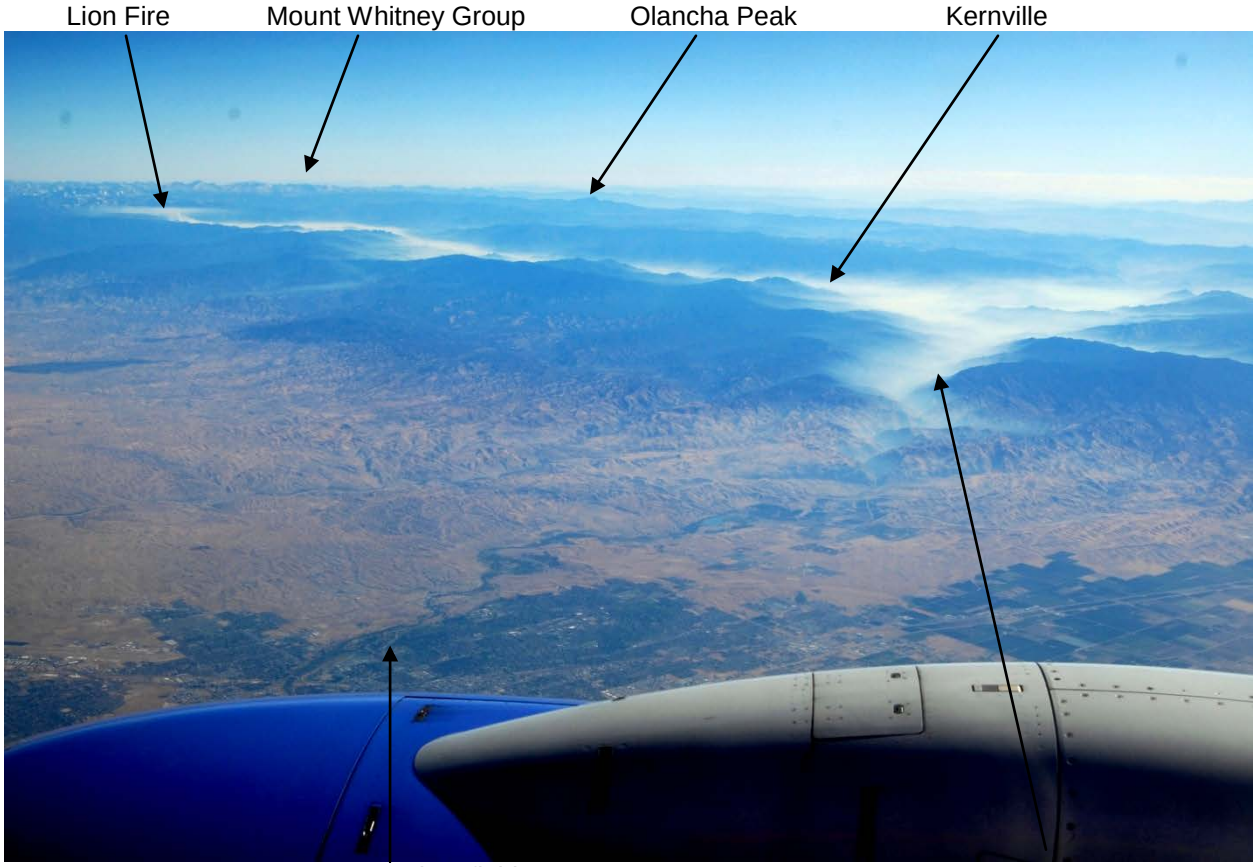
Lion Fire 2011
Sequoia National Forest

Fire Behavior Assessment Report



Picture taken on August 3, 2011 at about 0930 by passenger on a 737 traveling north – view looking northeast from above the San Joaquin Valley

Prepared September 14, 2011 (Draft 2)
Fire Behavior Assessment Team (FBAT)

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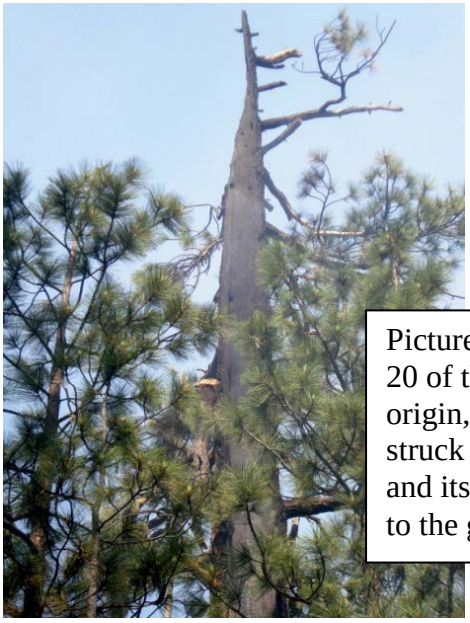


Pictures by Crew 20 of the Lion Fire origin, a lightning struck tree (right) and its top that fell to the ground (left).

Introduction

Wildland fire management is dependent upon good fire behavior and resource effects predictions. Existing prediction models are based upon limited data from wildfire 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 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; the more we know the more we can mitigate hazards and prevent accidents, as well as making steps towards improvement in natural resource management.

This report contains the results of a one week assessment of fire behavior, vegetation and fuel loading and consumption, and fire effects to vegetation and soil resources for Division Z on the Lion Wildfire. The Lion Fire started by lightning on July 8th, 2011 near Lion Meadow on the Sequoia National Forest in the Golden Trout Wilderness on the Western Divide Ranger District. Fire behavior, pre- and post-vegetation and fuel conditions were measured at 10 sites between Lion Meadow and Tamarack Creek between July 16 and 21st and August 7th, 2011. Fuel Moisture samples were gathered and measured in three fire management areas on Division Z. Multiple members of SQF's Crew 20, Crew 2, and Engine 23 assisted and trained with FBAT on fire behavior equipment and fuels/vegetation inventory techniques.

Objectives

Our objectives were to:

1. Characterize fire behavior and quantify fuels for a variety of fuel conditions. A key consideration was which sites could be measured safely given access and current fire conditions.
2. Estimate smoke emissions based on vegetation and fuels measured at the study sites and computed by FOFEM.
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 at the study plots based on immediate post fire measurements.
5. Support efforts by the USFS R5 Air Quality specialists and others to publish a peer reviewed study of the Lion Fire by gathering and summarizing fuel, moisture, fire behavior and consumption data.
6. Cross train and work with some of the SQF Fire Module crewmembers during the field study.
7. Produce a summary report based on preliminary analysis for fire managers and the Sequoia National Forest.

Applications

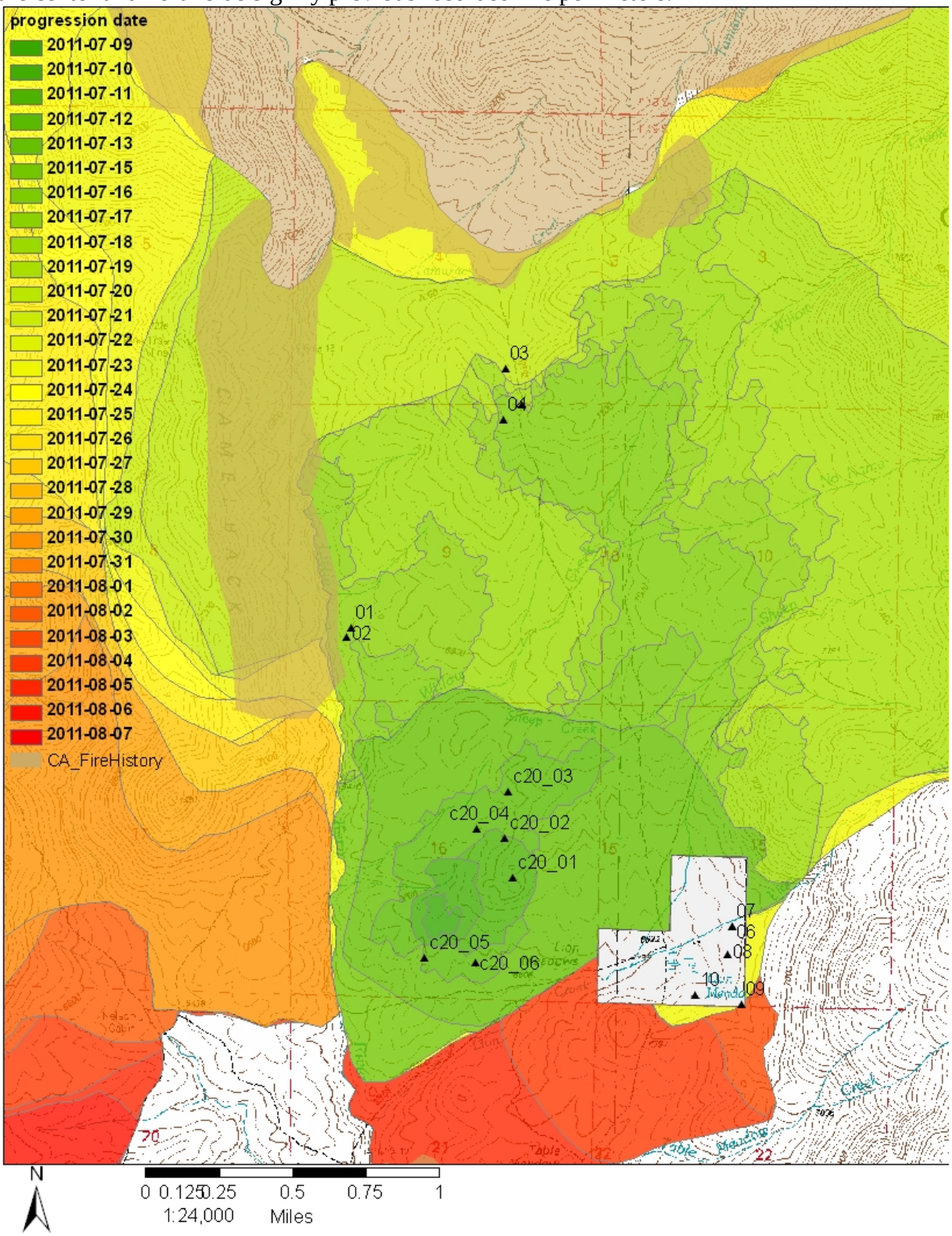
This information will be shared with managers to evaluate the effectiveness of the Lion Fire in meeting land and resource management plan objectives. The information would also prove valuable when shared with: firefighters to improve situational awareness; managers to improve predictions for fire planning; and scientists for improving fire behavior modeling. A publication proposal is being outlined with USFS R5 Air Quality managers to conduct further detailed analysis of the plot and airshed level data in order to develop a more formal publication of the emissions and fuel loading correlations.

Approach/Methods

Pre- and post-fire fuels and fire behavior measurements were taken at 10 sites above and near Lion Meadow between the little Kern River and Tamarack Creek within what was called Division Z of the Lion Fire. The map (Figure 1) also displays recorded fire history perimeters in tan colored polygons (center and N. side) as well as fire progression for the SE side of the fire (mostly Division Z). FBAT attempts to select study sites to represent a variety of fire behavior and vegetation/fuel conditions. Site

selection priorities were also based on safe access and areas that would most likely be burned over within the timeframe that FBAT was at the incident.

Figure 1: Location of FBAT and Crew 20 study sites in Lion Fire, Division Z. Site numbers marked with C20, signify fuel transects measured and calculated by SQF's Crew 20. The tan colored polygons in the center and north side signify previous recorded fire perimeters.



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 recently burned 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 post-burn at Site 5 in Division Z of the Lion Fire.

Crown Fuels and Overstory Vegetation Structure

Variable radius plots were used to characterize crown fuels and overstory vegetation structure. A relaskop (slope corrected tree prism) was used to create individual plots for both pole (>2.5 to 5.9 in. DBH) and overstory (>6 in. 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 (DBH) was measured with a diameter tape. Total tree height, canopy base height, char height, scorch height, and torch height were measured with a laser rangefinder. The Forest Vegetation Simulator program and its Fire and Fuels Extension (FVS-FFE), a forest level growth yield program used throughout the United States, was used to calculate canopy bulk density, canopy base height, tree density and basal area.

Understory Vegetation Structure and Loading

Understory vegetation was measured in a one meter wide belt along three 50 foot transects. 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 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. Understory and ground fuel moisture samples were measured in three fire management areas on Division Z. Fuel Moisture data was useful for the First Order Fire Effects Model (FOFEM) emissions estimates and may be useful in future fire behavior analysis.

Surface and Ground Fuel Loading

Surface and ground fuels were measured along the same three 50 foot transects 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. Finally, a rapid assessment of fire severity was completed along the transects to note the effects of fire on the surface and ground fuels.

Fire Behavior Measurements and Observations

At each site, multiple 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, BTUs and wind. The sensors are 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. A portable remote automated weather station (RAWS) was used to gather weather information (relative humidity, wind speed, wind direction, temperature and fuel moisture) for the general area and was located at the western end of Lion Meadow and managed by one of SQF's Wildland Fire Module, Crew 20.

Figure 3: Example of fire behavior equipment set up at the Lion Fire at Site 9 in a white fir dominated area.

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 and Campbell Scientific data loggers were measured to utilize the Simard et al. (1984) 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 tree canopy needles indicate crown fire (not found on Lion Fire study sites).

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.

Site Specific Wind Speed

Wind speed was measured using an anemometer attached the same Campbell Scientific data logger as two thermocouples at each site. Wind speed can be measured until the anemometer cups melt due to fire activity. Wind direction can be obtained from video footage taken facing the colored flagging (serves as a "wind vein") tied to the anemometer pole. 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 in Lion Meadow managed by one of SQF's Wildland Fire Modules, Crew 20. RAWS data includes relative humidity, temperature, wind speed, and wind direction throughout most of the fire's duration.

Findings/Results

Pre- and Post-Vegetation and Fuel Measurements

Overstory Vegetation Structure and Crown Fuels

Tree species within the nine sites included: ponderosa pine, Jeffrey pine, white fir, and a few western white pine, incense cedar, and sugar pine. Overstory-size (>6 inch DBH) tree density ranged from 48 to over 427 trees per acre. Canopy cover estimates were between 23 and 82 percent for the 10 sites. Pre-fire tree metrics calculated in FVS with the Western Sierra variant are presented below in Table 1. Small pole-size trees (<6 inch DBH) were only found and measured on two plots. Overstory tree density and size varied greatly, as represented by the data.

Table 1: Pre-fire overstory vegetation and crown fuel data by site. QMD is the quadratic mean diameter based on tree data collected at the plot scale.

Site	FVS Forest Type	Overstory (>6 in. DBH) trees/acre	Pole-size (<6 in. DBH) trees/acre	QMD (in.)	Basal Area (ft^2/acre)	Height to Live Crown (ft)	Canopy Height (ft)	Canopy Cover (%)	CBD (kg/m^3)
1	Ponderosa pine	172	0	17	278	1	80	69	0.09
2	Ponderosa pine	238	up to 490	14	242	11	75	66	0.13
3	CA mixed conifer	77	0	18	138	13	71	40	0.07
4	CA mixed conifer	427	0	8	162	5	85	46	0.08
5	Ponderosa pine	77	0	18	138	11	79	41	0.03
6 / 7	Ponderosa pine	156	up to 28	24	503	60	181	82	0.05
8	Ponderosa pine	48	0	25	158	27	104	39	0.03
9	CA mixed conifer	41	0	21	96	10	77	23	0.05
10	Ponderosa pine	52	0	24	163	17	89	45	0.03

This FBAT case study does not collect enough data to quantify canopy characteristics on a large spatial scale. Based on the plot level data collected, some generalizations are made about the canopy characteristics overall. 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 is important because it affects crown fire initiation. Continuity of canopies is more difficult to quantify, but clearly patchiness of the canopy will reduce the spread of fire within the canopy stratum. The data summary listed in Table 1 provides a snapshot of some of these characteristics for some areas of Division Z on the Lion Fire. Forest treatments that target height to live crown 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 summarized above, and reaches maximum values of 0.13 kg/m^3 at plot 2. 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 difficult to achieve (Scott and Reinhardt 2001). Fire is a natural process, or treatment method, for reducing canopy fuels. Tree mortality and canopy fuel changes cannot be determined with certainty until one or more years post-fire.

Fire Effects: Tree Canopy Scorch and Torch

Two days after the fire burned through each site (allow for cooling, safety, and smoldering combustion) 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 site. Percentage values were determined using ocular estimations, and heights were measured with a laser rangefinder. 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 or fire effects can be accessed from the percentage of scorch and torch for each study site (Table 2). Note that many trees on many sites had noticeable mistletoe infections. The fire (heat) had scorched (cooked foliage) portions of most tree canopies, but only torched (consumed) portions of a few tree canopies.

Table 2: Overstory tree canopy average, minimum and maximum percent scorch and torch at each site.

Site	% Scorch			% Torch		
	Average	Min	Max	Average	Min	Max
1	95	85	100	1	0	5
2	34	0	85	0	0	0
3	18	3	45	1	0	2
4	51	5	100	6	0	40
5	10	0	40	0	0	0
6 / 7	83	60	99	0	0	0
8	83	55	100	0	0	1
9	35	2	70	0	0	0
10	57	5	98	3	0	15

Understory Vegetation Structure and Loading

The understory vegetation was sparse to patchy, and only plots two and ten (pre-burn) had a large component of the shrubs. Very few grasses or herbaceous species were found at any of the sites. Dominant shrubs present at the sites included, manzanita, ceanothus, and chinquapin species. The shrub density varied by site (see Table 3 for loading information). The majority of the herbaceous and grass understory component was consumed by the fire. Some shrubs were burned down to stobs (shrub stumps). The paired photographs in Appendix A show a sample of the distribution and density of understory flora for each site, as well as illustrate the change post-burn. Tables 3 and 4 list the post-fire loading and percent consumption from the fire for each site.

Table 3: Pre-and post-fire understory vegetation fuel loading and fuel bed depth by site.

N/A: none present pre-burn

	Grass/Herb (ton/ac)		Shrub Pre-Fire (ton/ac)		Shrub Post-Fire (ton/ac)		Mean Fuel Bed Depth Pre-Fire (ft)		Mean Fuel Bed Depth Post-Fire (ft)	
Site	Pre-Fire	Post-Fire	Live	Dead	Live	Dead	Grass/Herb	Shrub	Grass/Herb	Shrub
1	<0.01	0	0.03	0	0	+0.03	0.37	0.57	0	0.52
2	<0.01	0	4.12	<0.01	0.22	+0.81	0.39	1.09	0	0.83
3	<0.01	<0.01	0.11	<0.01	0.03	0.01	0.42	1.27	0.34	1.21
4	<0.01	0	<0.01	0	0	0	0.16	0.41	0	0
5	<0.01	<0.01	1.69	1.11	0.02	0.16	0.42	2.19	0.19	1.56
6 / 7	<0.01	0	0.07	0	0	<0.01	0.70	1.58	0	0.26
8	<0.01	0	1.21	0.13	0.10	0.21	0.79	2.41	0	1.62
9	0	N/A	0	0	N/A	N/A	0	0	N/A	N/A
10	<0.01	<0.01	6.75	1.96	0.47	0.42	0.42	3.35	0.14	3.23

Table 4: Understory percent consumption by site.
N/A: none present pre-burn

Understory Percent Consumption		
Site	**Grass/Herb** (ton/ac)	**Shrub** (ton/ac)
1	100	<1%
2	100	75
3	16	64
4	100	100
5	40	94
6 / 7	100	99
8	100	77
9	N/A	N/A
10	75	90

Surface and Ground Fuel Loading

The predominant surface fuels were litter and duff. All sites had a 1000-hr fuel size component, though it was not captured by fuel transects in site 2. The fuel bed depth ranged from a few inches to up to foot. Litter was not included in the calculation of 1-hour fuels (they are calculated separately), 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 5 and 6. SQF's Crew 20 also measured and calculated fuel loading in part of Division Z (see figure 1), and their fuels data was included below as well. Percent consumption for each plot is summarized in Table 7. All FBAT sites, except 3 and 9, on average, had high percentages (89% or more) to near-complete consumption of surface and ground fuels. Crew 20's 4 sites also had high percentages of consumption. Note that the values presented for total loading per plot are averages of three transects and not a sum of the average values listed for each category on that table.

Table 5: Pre-fire surface and ground fuel loading by site.

Pre-burn Surface Fuel Loading: (tons/acre)								
Site	**Litter**	**Duff**	**1-hr**	**10-hr**	**100-hr**	**1000-hr**	**Total Loading/Plot**	**Fuel Bed Depth(ft)**
1	5.70	33.94	0.02	0.56	1.11	16.76	58.09	0.30
2	5.90	15.97	0.10	0.28	1.48	0	23.73	0.11
3	1.64	5.54	0.22	1.51	1.44	3.23	13.57	0.52
4	3.27	13.59	0.52	0.62	1.44	13.04	32.48	0.36
5	2.39	5.03	0.33	0.82	0.36	10.66	19.60	0.20
6/7	5.01	31.45	0	0.63	2.58	12.42	86.54	0.94
8	4.62	52.91	0.06	1.68	2.58	34.02	95.88	0.51
9	20.08	19.31	0.15	0.93	5.78	72.78	119.03	0.78
10	15.97	15.97	0.12	0.21	0.74	0.64	20.92	0.31
Crew 20 plot 1*	1.04	3.33	0.25	0.24	0.90	0	5.75	~
Crew 20 plot 2*	3.83	12.06	0.01	1.09	0	0	16.99	~
Crew 20 plot 3*	1.54	17.05	0.15	1.33	1.11	11.76	32.94	~
Crew 20 plot 4*	3.12	7.07	1.40	1.97	1.46	33.07	48.09	~
Crew 20 plot 5*	1.17	3.99	0.23	1.44	0.89	0	7.72	~

*SQF Crew 20 used slightly different methods, and each row was also an average of three fuel transects per plot.

Table 6: Post-fire surface and ground fuel loading by site.

Post-burn Surface Fuel Loading (tons/acre)								
Site	Litter	Duff	1-hr	10-hr	100-hr	1000-hr	Total loading/plot	Fuel Bed Depth(ft)
1	0	0	0.01	0.14	0.37	0	0.52	0.02
2	0	0.50	0.01	0.21	0	0	0.72	0.17
3	0	3.02	0.04	0.14	0	0.94	4.13	0.02
4	0.25	2.01	0	0.07	0	1.12	3.46	0.01
5	0	0.50	0.03	0.21	0.36	0.19	1.29	0.10
6/7	0	2.50	0.03	0.21	0	3.71	6.45	0.47
8	0	0	0.01	0.21	0	8.97	9.19	0.24
9	5.19	1.07	0.02	0.12	2.75	12.75	21.91	0.48
10	0.79	0	0.33	0.28	0	0.46	1.86	0.41
Crew 20 plot 2*	0.42	0	0.2	0.12	0	0	0.56	~
Crew 20 plot 3*	0.021	0.42	0.03	0	0.22	1.28	2.16	~
Crew 20 plot 4*	0	0	0.03	0.06	0.22	1.14	1.45	~
Crew 20 plot 5*	0	0	0.01	0.06	0	0	0.07	~

* SQF Crew 20 used slightly different methods, and each row was also an average of three fuel transects per plot. Crew 20 Plot 1 post-burn measurements not yet available.

Table 7: Average consumption and percentage of consumption and change in surface and ground fuels due to the fire.

Mean Consumption in tons/acre (percent consumed)								Consumption
Site	Litter	Duff	1-hr	10-hr	100-hr	1000-hr	Total loading/plot	Fuel Bed Depth (ft)
1	5.70 (100%)	33.94 (100%)	0.01 (50%)	0.42 (75%)	0.74 (67%)	16.76 (100%)	57.57 (99%)	0.3 (94%)
2	5.90 (100%)	15.47 (97%)	0.09 (90%)	0.07 (25%)	1.48 (100%)	N/A	23.01 (97%)	+0.1
3	1.64 (100%)	2.52 (45%)	0.18 (82%)	1.37 (91%)	1.44 (100%)	2.29 (71%)	9.44 (70%)	0.5 (96%)
4	3.02 (92%)	11.58 (85%)	0.52 (100%)	0.55 (55%)	1.44 (100%)	11.92 (91%)	29.02 (89%)	0.4 (98%)
5	2.39 (100%)	4.53 (90%)	0.30 (91%)	0.62 (75%)	0 (0%)	10.47 (98%)	18.30 (93%)	0.1 (49%)
6/7	5.01 (100%)	28.95 (92%)	+0.03	0.42 (67%)	2.58 (100%)	8.71 (70%)	80.09 (93%)	0.47
8	4.62 (100%)	52.91 (100%)	0.05 (83%)	1.47 (88%)	2.58 (100%)	25.05 (74%)	86.69 (90%)	0.27
9	14.89 (74%)	18.24 (94%)	0.13 (84%)	0.81 (87%)	3.03 (52%)	60.03 (82%)	97.12 (82%)	0.30
10	15.19 (95%)	15.97 (100%)	+0.21	+0.07	0.74 (100%)	0.18 (28%)	19.07 (91%)	+0.10
Crew 20 plot 2*	3.41 (89%)	12.06 (100%)	+0.19	0.97 (89%)	N/A	1.10 (100%)	16.43 (97%)	~
Crew 20 plot 3*	1.52 (99%)	16.63 (98%)	0.12 (80%)	1.33 (100%)	0.89 (80%)	13.07 (91%)	30.78 (93%)	~
Crew 20 plot 4*	3.12 (100%)	7.07 (100%)	1.37 (98%)	1.91 (97%)	1.24 (85%)	39.88 (97%)	46.64 (97%)	~
Crew 20 plot 5*	1.17 (100%)	3.99 (100%)	0.22 (96%)	1.38 (96%)	0.89 (100%)	15.19 (100%)	7.65 (99%)	~

N/A: No change because fuel loading was zero both pre- and post-fire.

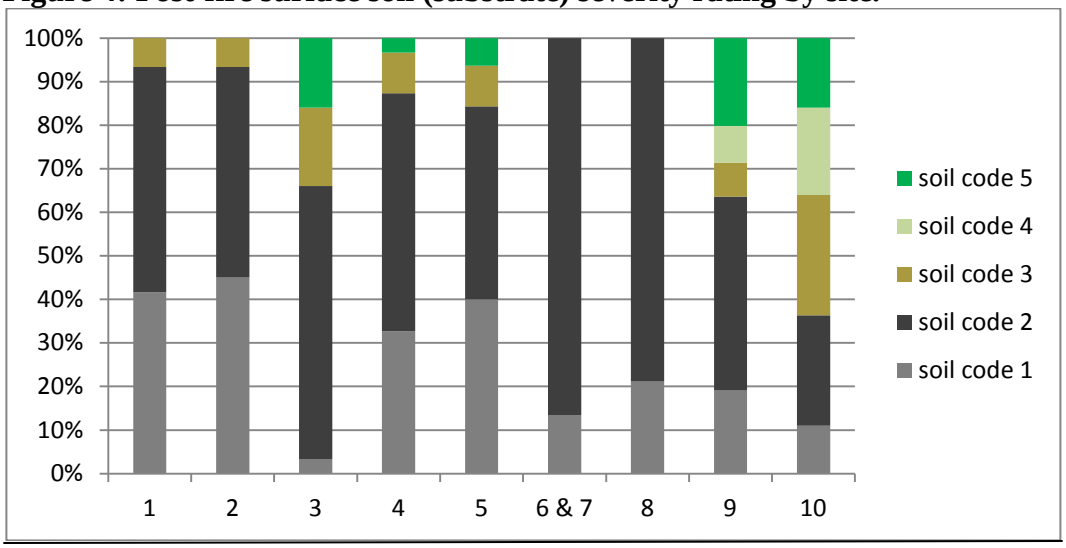
+ increase in fuel loading for the given site and metric; fuel height changed post-burn due to burned branches or logs falling onto the transect during or after the fire passed.

*Crew 20 used slightly different methods, and each row was also an average of three fuel transects per plot.

Soil, Substrate, and Vegetation Burn Severity Rating

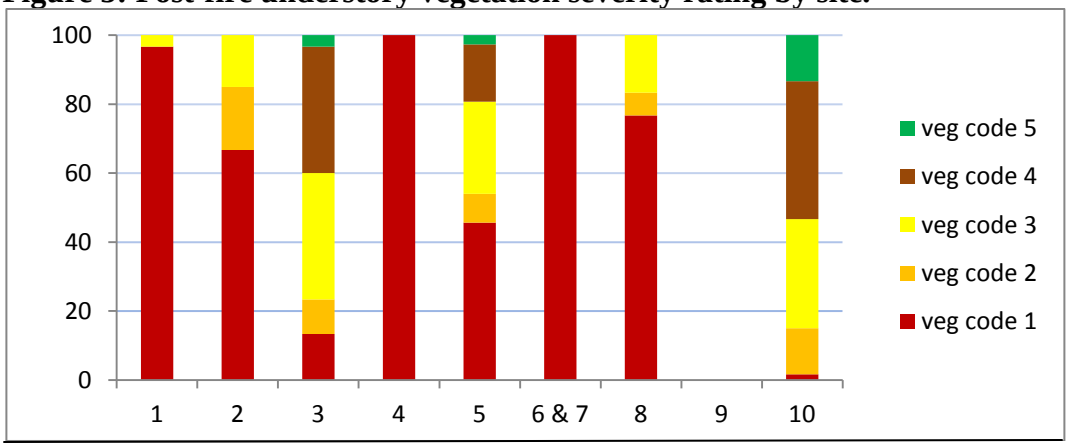
Post-burn soil/substrate and understory vegetation severity was also measured along each transect within a one meter belt width at each plot by ocular estimates. The National Park Service's severity categories were used. The NPS soil/substrate burn severity ratings are: (1) very high, white ash, some discoloration of soil; (2) high, gray and black ash; (3) moderate, ash and some patches of charred litter or duff; (4) low, charred litter and some unburned litter and duff remain; and (5) unburned. See Figure 4.

Figure 4: Post-fire surface soil (substrate) severity rating by site.



National Park Service vegetation burn severity ratings are: (1) mostly burned to stobs; (2) foliage and small diameter branches consumed; (3) foliage scorched, some consumed; (4) some unburned foliage; and (5) unburned. See Figure 5. Previously in this report (see Tables 3 and 4), it mentions the variability of vegetation density, usually being lower amounts on most plots. Vegetation burn severity is only based on the vegetation that was documented pre-burn. For example, plot 4 had less than one percent cover in the transects of understory vegetation pre-burn, and it was all consumed by the fire. Therefore, the table below shows 100 percent vegetation severity code 1, but that only accounts for 1% of the transect area. Site 9 had no understory vegetation pre-burn.

Figure 5: Post-fire understory vegetation severity rating by site.



Site Specific Fuel Moisture Measurements

Fuel moisture samples were collected at plot 1 on July 16, 2011, plot 3 on July 17, 2011, and at plots 8, 9, 10 on July 20, 2011 and were processed at the Sequoia National Forest Peppermint Work Center (Table 8). The driest plots were in open pine stands (plots 1, 3, and 10) while the moister sites were in the dense stands on the east and southeast sides of Lion Meadows. The Manzanita sampled at plot 10 displayed continuing new growth. In general, the calculated fuel moistures fall within the normal range for this area and season on the Sequoia National Forest.

Table 8: Average fuel moisture percentages calculated from site specific fuel moisture samples.

Fuel Moisture Type	Plot 1 Willow Creek	Plot 3 Tamarack Creek	Plot 8 East of Lion Meadow	Plot 9 South East of Lion Meadow	Plot 10 South of Lion Meadow
Litter	4%	6%	4%	8%	4%
Duff	7%	7%	18%	10%	9%
100 Hour Time Lag	12%	10%	8%	9%	7%
1,000 Hour Time Lag	-	12%	21%	14%	13%
Manzanita New	-	-	-	-	57%
Manzanita Old	-	-	-	-	52%

Smoke Emissions - First Order Fire Effects Model (FOFEM)

For several of the following model estimations, FOFEM (version 5.9) was forced to reduce fuel loading to the maximum the model would allow because fuel reduction observed at the plots was greater than model algorithms' capabilities. Fuel moisture inputs were reduced to less than actual field observations in order to force the model to reduce more fuels in order to be closer to measured quantities. More work is needed to test the FOFEM use with the Lion data set to find improved emission estimates. Summary of the particulate matter emissions, based on pre-burn dead fuel loading site measurements, is below (Table 9) and detailed results of FOFEM are in Appendix C. Emission amounts are pounds per acre.

Table 9. FOFEM emissions summary based on site's dead and downed loading data. Shrub and herbaceous fuel loadings were included in the analysis for FBAT sites 1 through 10.

Emission Type (lbs/ac)	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6/7	Site 8	Site 9	Site 10
PM-10	2,370	824	422	1,209	565	2,111	4,064	4,437	1,637
PM-2.5	2,009	699	357	1,024	479	1,789	3,444	3,761	1,387
CH4 – Methane	1,211	411	213	616	285	1,078	2,078	2,256	836
CO – Carbon Monoxide	26,445	8,833	4,601	13,429	6,169	23,541	45,373	49,061	18,251
C02 – Carbon Dioxide	127,670	65,657	28,925	68,277	38,307	114,314	216,749	264,678	88,515
NOX – Nitrous Oxide	37	54	19	25	24	34	59	119	26
SO2 – Sulfur Dioxide	98	46	21	52	28	89	168	199	68
Crew 20 Plots									
PM-10	206	558	1,324	1,778	276				
PM-2.5	175	473	1,122	1,506	233				
CH4 – Methane	104	280	678	904	139				
CO – Carbon Monoxide	2,260	6,042	14,833	19,661	3,011				
C02 – Carbon Dioxide	12,958	40,673	67,797	105,577	18,439				
NOX – Nitrous Oxide	7	29	14	47	11				
SO2 – Sulfur Dioxide	9	29	53	80	14				

Fire Behavior Observations and Measurements

All nine study sites were above Lion Meadows between the Little Kern River, Tamarack Creek, and Table Meadow Creek. Sites 1 and 2 were installed and burned on 7/16/2011. Sites 3 to 5 were installed on 7/17/2011 and burned on 7/18/11. Site 5 and 8 only measured vegetation and fuels, not fire behavior characteristics. Sites 6 to 10 were installed close to Lion Meadow between July 18th and 20th and were burned on July 20th and 21st. The wind direction recorded at each study plot was site specific due to eddying effects from the topography. Below is a site by site description of fuels and fire behavior. The still shots captured from the video include vertical poles for scale that have 1 foot gradients.

Site 1

Site 1 was located on the lower third of the west facing slope in Little Kern River drainage. Ponderosa pine was the dominant tree species with other mixed conifer species present at the site. The understory consisted of manzanita, ceanothus, and chinquapin shrub species and minor amounts of herbs and grass. Fire was established at the first sensor at 14:07 on July 16th with the maximum temperature at 1,012ºC (from a rate of spread sensor, 1,854ºF). Based on temperature sensors fire activity lasted from 14:00 to 15:40 with heavy fuels continuing to smolder beyond that time.

Figure 6: Fire establishment at Site 1.

Site 2

Site 2 was located slightly down slope and south of Site 1. Dominant trees and understory were the same as Site 1. This site had a minimal component of large (1000-hr) dead and downed fuels, as compared to other sites. Fire was established at 15:07 with a peak of 1,166 ºC (2,131 ºF) and heat duration of about 3 minutes recorded. Based on temperature sensors fire activity lasted until 17:11, with some fuels continuing to smolder. Unfortunately, the video camera trigger did not function at the correct time for this site, so no fire behavior picture is available. See appendix A and D for vegetation pictures.

Site 3

Site 3 was on an east facing slope and south of Tamarack Creek. Dominant trees species included ponderosa pine and white fir. Fire was established in the site at 12:57 with a peak temperature of 749 ºC (1,380 ºF). Based on temperature sensors fire activity lasted until about 16:41 and continued with smoldering.

Figure 7: Fire establishment in Site 3.

Site 4

Site 4 was slightly south of Site 3 and south of Tamarack Creek. Site 4 had the same overstory species composition as Site 1 and 2, meaning ponderosa pine dominated. Fire was established by 15:33 with a peak temperature of 1,025 ºC (1,877 ºF); with heat duration continuing until 17:30 followed by smoldering stages.

Figure 8: Consumption and spread at Site 4.

Sites 6/7

Sites 6 and 7 are just east of Lion Meadow on private property (with boys camp) with higher fuel loadings. Due to management operations, the priority was for site protection of that area. Starting at 18:07 at one sensor, plot 6 had a high intensity surface fire of 3-6 ft flame lengths, and up to 9 ft on occasion. Starting at 17:31, plot 7's fuel consumption occurred with primarily a surface fire of 1-2 ft flame lengths, and the minimal brush torched with about 10-15 ft flames. Both fire types lead to bole char and scorching of trees. Both plots were in a narrow strip of land utilized to buffer the private property and cabins from future fire damage.

Figure 9: Site 6 burned on July 20, 2011 starting at about 18:06.

Figure 10: Consumption at Site 7, on July 20, 2011 starting at about 17:43.

Site 9

Site 9 was SE of Lion Meadow in the white fir dominated forest type, close to Table Meadow Creek. Similar to sites 6 to 8, sites 9 and 10 were part of fire management operational area to create a strip of consumed fuels to buffer the private property and its infrastructure from Lion fire damage. The fuel loading was very heavy with occasional pockets of sparse fuels and sandy soils. Starting at one sensor at 19:06, fire intensity was both low and high, primarily with flame lengths of 3 to 5 feet, and occasionally 5 to 8 feet.

Figure 11: Consumption and smoldering at Site 9 on July 21, 2011. Note the silhouette of the anemometer (at 6ft) and heat flux sensor (box at 4ft height) in the left side foreground.

Site 10

Site 10 was South of Lion Meadow close to Table Meadow Creek in the ponderosa pine dominated forest type with significant, though sometimes patchy, manzanita understory. Similar to Site 9, this site was in the buffer zone of consumed fuel for structure protection. This site burned mostly at night, starting at 20:50 on video and 21:08 with heat duration at one sensor, and continued to past the length of the video with smoky combustion and smoldering.

Figure 12: Site 10 burned on July 21, 2011 mostly at night. Note the silhouette of the anemometer (at 6ft) on the left side foreground.

Data Collected from the Sensors

Rate of spread, wind speed, and temperature are all gathered using fire proofed data loggers (MadgeTech and Campbell Scientific) at each of the below listed plots. See Table 10.

Table 10: Rate of spread, wind speed, max temperatures, and duration of heat from the Campbell Scientific and MadgeTech data loggers.

Plot No. Date and Time of Main Heat Pulse	Rate of Spread ft/second	Rate of Spread ft/hr (chains/hr)	Max Wind Speed (10 second mean) mph	Max Temp at 6 Inches Above Litter ºC	Max Temp at 12 Inches Above Litter ºC	Heat Duration above 80ºC
1	0.154	554 (8.1)	0.25	995		34 min
16-Jul-11	1.171	4,212 (63.8)		700		5 min 51 sec
14:07 to 15:38	0.193	684 (10.4)		1012		29 min
				860	810	83 sec
2			13	154		~ 10 seconds
16-Jul-11	0.093	324 (4.9)		271		~ 3 min
15:07 to 17:11	1.240	4,464 (67.6)		200		20 sec
	0.113	396 (6.0)		912	1166	~2 min
3	0.008	29 (0.4)	3	191		30 sec
18-Jul-11	0.309	1,116 (16.9)		262		1 min 36 sec
12:57 to 16:41	sensor heat damaged	~	~	~	~	~
	0.001	3.6 (0.05)		749	647	5 min 10 sec
4	0.212	763 (11.6)	3.75	1025		2 hour
18-Jul-11	sensor damaged or failed	~	~	~	~	~
15:33 to at least 17:30				480		12 min
6	0.400	1,440 (21.8)	8.5	830		6 min 32 sec
20-Jul-11			~	1016	~	34 min 28 sec
18:07 to at least 18:30						
	0.541	1,944 (29.5)		861	814	50 min 51 sec
7	0.036	126 (1.9)	3.75	565.1		8 min 26 sec
20-Jul-11			~	809	~	24 min 36 sec
17:31 to at least 18:34	0.067	238 (3.6)		560		40 min
				323	435	2 min 45 sec
9	0.102	367 (5.6)	2.25	79.3		2 sec
20-Jul-11			~	949	~	46 min 46 sec
19:06 to at least 19:53	sensor damaged or failed					
				40.6	38.9	
10	0.043	155 (2.3)	sensor damaged or failed	556		9 min 6 sec
21-Jul-11				481		8 min 16 sec
21:08 to at least 21:28	0.029	104 (1.6)		580		29 min 40 sec
	sensor damaged or failed					

Heat Flux Sensor

FBAT chose to retest a couple of heat flux sensors on a few plots on a trial basis. FBAT is working at a longer term goal of being able to measure both radiant and convective heat during wildfires. Background information is below, and is followed by example data from plot 9 at the Lion Fire. See picture above for Site 9 with the heat flux sensor silhouette (ammo box size), which is located at about 4 feet above the litter layer.

We used a Medtherm 64 Series Heat Flux Transducer. We used a Campbell Scientific CR10X datalogger to log temperature from the Type K thermocouples (rated -200 ° C to + 1350 °C (-328 °F to + 2462° F) placed at 6 and 12 inches above the litter layer (see Figure 14) and the Medtherm data (see Figure 13), collected at two second intervals.

The transducer used is on two basic sensor types, the Gardon type sensor, standard in ranges from 5 to 4000 BTU / (ft^2*sec), and the Schmidt-Boelter thermopile type sensor, standard in the 0.2 to 4 BTU / (ft^2*sec) ranges. In both type sensors heat flux is absorbed at the sensor surface and is transferred to an integral heat sink that remains at a different temperature than the sensor surface. The difference in temperature between two selected points along the path of the heat flow from the sensor to the sink is a function of the heat being transferred, and a function of the net absorbed heat flux.

Gardon gages absorb heat in a thin metallic circular foil and transfer the heat radially (parallel to the absorbing surface) to the heat sink welded around the periphery of the foil. The electro-magnetic field (EMF) output is generated by a single differential thermocouple between the foil center temperature and foil edge temperature. This measurement is indicated as 'T' on the below figure.

Schmidt-Boelter gages absorb the heat at one surface and transfer the heat in a direction normal to the absorbing surface. The EMF output is generated by a multijunction thermopile responding to the difference in temperature between the surface and a plane beneath the surface. The Schmidt-Boelter thermopile sensor is always used below 5 Btu/ (ft^2*sec). This measurement is indicated as 'R' on the below figure.

Figure 13: Heat flux graph of portion of temperatures measured at plot 6, near the private cabins by Lion Meadow.

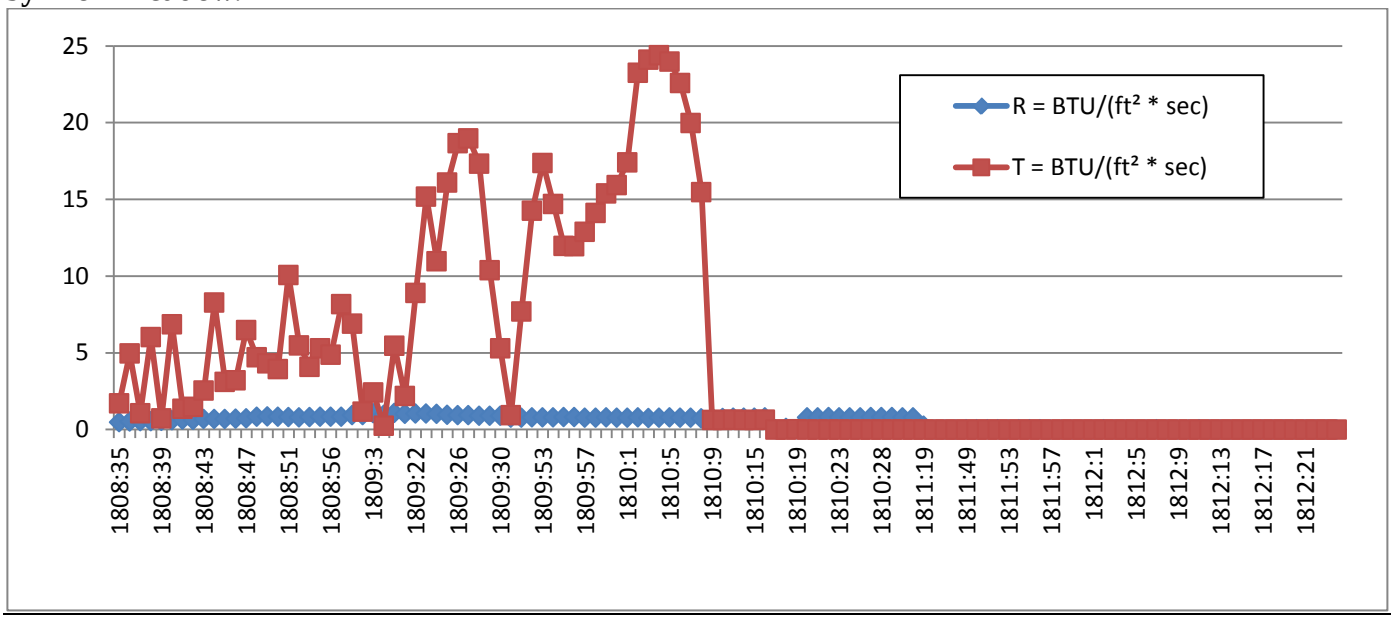
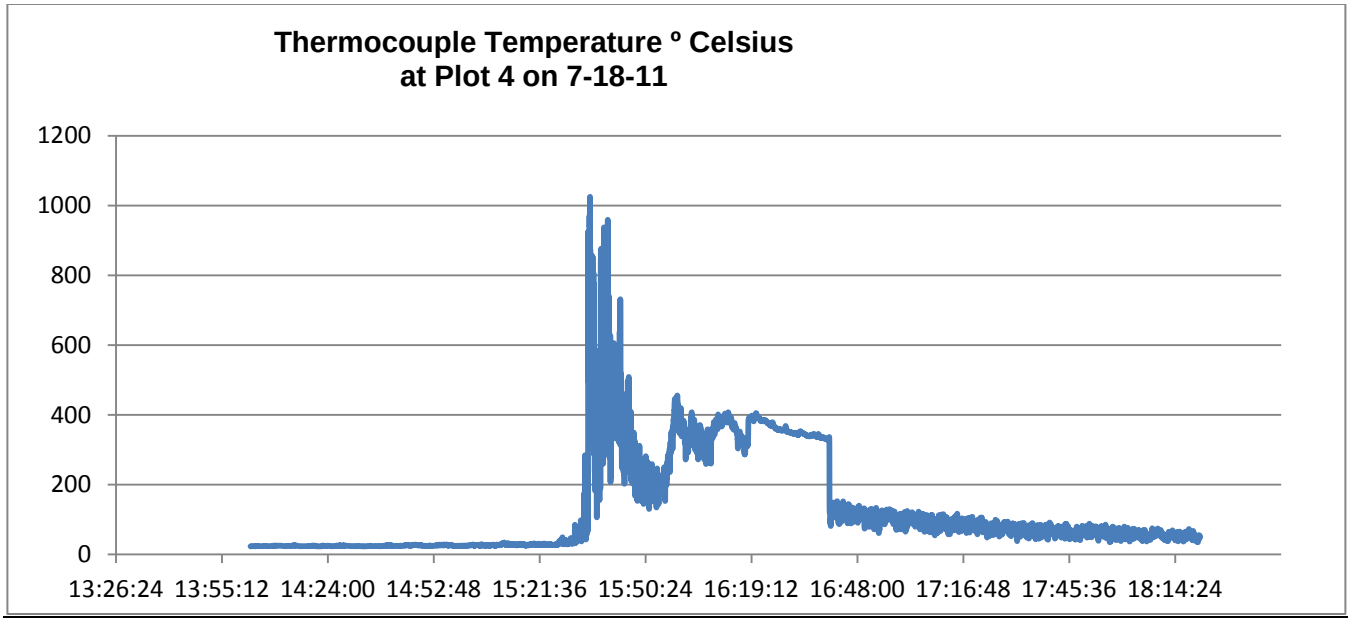


Figure 14: Thermocouple temperature graph of portion of temperatures measured at plot 4, south of Tamarack Creek.



Fire Behavior Measurements from the Video Camera Footage

In addition to the temperature and heat sensors, fire behavior data can be obtained from the video footage. Table 11 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 2 had no wildfire video coverage due to video trigger problems, and as mention previously sites 5 and 8 only measured vegetation and fuels, not fire behavior. Subtle differences are found between the fire behavior measurements between the video camera and the other sensors (Table 10).

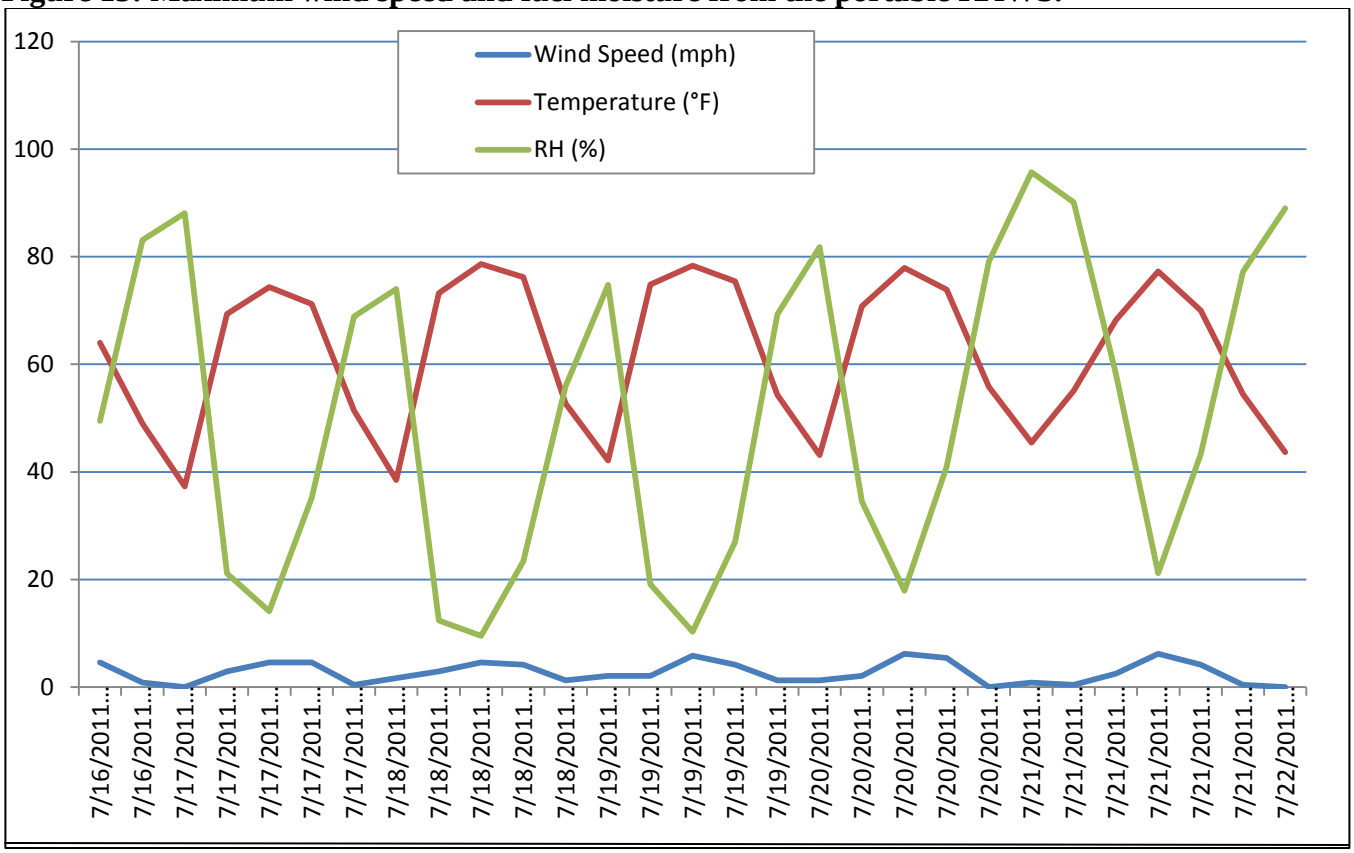
Table 11: Fire behavior data based on the video camera footage.

Site	Fire Type	Flame Length (ft)	Flame Angle (%)	ROS (ch/hr)	Approx. Start of Fire	End of Active Consumption
1	Surface	1+		1 to 2	14:00	12:01+
3	Surface	1 to 2	20 to 40%	1 to 2	12:47	14:08+
4	Surface and some torching	1+, 2 to 4 in pockets, ½ tree height	variable	1 to 2	15:14	15:54+
6	Surface	3 to 6	100 to 200%+	N/A	18:12	18:34 foreground consumed
7	Surface	1 to 2	100%	N/A	17:30	(see Site 6, very close by)
9	Surface	3 to 5, & occasional 5 to 8	75 to 200%	3 to 5	18:19	after 19:33, foreground consumed
10	Surface	1 to 2	up to 10%	1 to 2	20:50	21:05 foreground consumed

Weather Observations

A portable remote automated weather station (RAWS) was set up and managed by SQF's Crew 20 at the western end of Lion meadow. Figure 15 illustrates the wind speed, temperature, and relative humidity trends for the time period overlapping the days the plots had wildfire, if data was available.

Figure 15: Maximum wind speed and fuel moisture from the portable RAWS.



Additional Observations:

Depending upon your natural resource management focus, the following notes were made. These are for Division Z only, east of the Little Kern River, when FBAT was on the incident.

- SQF archeologist, Linn Gassaway, observed and recorded the notable trails that were used as fire containment, control, and access points and corridors as well as historic trail blazed trees.
- In multiple places during FBAT's July and August visits in Division Z understory plant recovery was observed very quickly after the fire, such as grass, oak, chinquapin, lupine, and other species resprouting. Potentially, following a very high precipitation year like 2010 to 2011, the understory had the resources to resprout faster than dryer years (usually seen the following season). Thunderstorm precipitation may have assisted in a faster resprouting rate as well.
- Higher vegetation severity areas are found within the fire perimeter, as well as some areas of crown fire, but were not captured by FBAT study sites, partly due to safe access and timing.
- This FBAT report did not highlight the fire spread pathway (management burning or "natural" spread) between the study sites.
- A BAER study was conducted of the soil burn severity; see that report for further details.
- AMSET is coordinating a wildfire interactions study about the recent fire perimeters that the Lion Fire bumped into.

Summary/Accomplishments

Our objectives were to:

1. Characterize fire behavior and quantify fuels for a variety of fuel conditions. A key consideration was which sites could be measured safely given access and current fire conditions.
2. Estimate smoke emissions based on vegetation and fuels measured at the study sites and computed by FOFEM.
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 at the study plots based on immediate post fire measurements.
5. Support efforts by the USFS R5 Air Quality specialists and others to publish a peer review study of the Lion Fire by gathering and summarizing fuel, moisture, fire behavior, and consumption data.
6. Cross train and work with some of the SQF Fire Module crewmembers during the field study.
7. Produce a summary report based on preliminary analysis for fire managers and the Sequoia National Forest.

Ten sites were successfully measured and burned over in the area between Lion Meadow, the Little Kern River, and Tamarack Creek in Division Z of the Lion Fire from July 16 to 21, 2011. Smoke emissions were estimated using FOFEM based on dead and down fuel loading measurements at the study sites. Fuel moisture samples were gathered and measured in three fire operational areas on Division Z. Multiple members of SQF Crew 20, Crew 2, and Engine 23 assisted with and trained on the fire behavior equipment and fuels/vegetation inventory techniques. This report presents multiple characteristics to compare fuel and fire behavior between the plots and illustrates some variable fire behavior, though largely surface fire spread.

This information will be shared with managers to evaluate the effectiveness of the Lion Fire in meeting land and resource management plan objectives. The information would also prove valuable when shared with: firefighters to improve situational awareness; managers to improve predictions for fire planning; and scientists for improving fire behavior modeling. A publication is being outlined with USFS R5 Air Quality managers to conduct further detailed analysis of the plot and airshed level data in order to develop a more formal publication of the information. FOFEM use with study site data will be further explored for improvements.

This report will be distributed to Lion Fire personnel, the Sequoia National Forest, the Inyo National Forest, Sequoia and Kings Canyon National Park, and USFS Fire and Air Quality Management.

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Special thanks and appreciation to Sequoia National Forest's Crew 20 under Aaron Woodyard, Crew 2, Springville Hotshots, the Incident Command Team (Paul Gibbs, Robert Sanders, Joe Loehner, Jack Medina, Pricilla Summers and others), Engine 23, the Helicopter 522 Crew, and other staff who were supportive and helped with study site establishment, gear hauling, and logistics. Thanks to past FBAT members and assistance who helped build our FBAT program to its current worth, as well as thanks to Nicole Vaillant, Scott Dailey, and Tiffany Norman for analysis contributions.

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

Figure A1: Paired pre- and post- fire photographs from site 1.

Figure A2: Paired pre- and post- fire photographs from site 2.

Figure A3: Paired pre- and post- fire photographs from site 3.

Figure A4: Paired pre- and post- fire photographs from site 4.

Figure A5: Paired pre- and post- fire photographs from site 5.

Figure A6: Paired pre- and post- fire photographs from site 6/7.

Figure A7: Paired pre- and post- fire photographs from site 8.

Figure A8: Paired pre- and post- fire photographs from site 9.

Figure A9: Paired pre- and post- fire photographs from site 10.

Appendix B: Fuel Moisture Data collected from within the Lion Fire

Location on Lion Fire	Date Sampled	Time/Date in Oven	Plot #	Fuel Type	Fuel Moisture	Average per fuel type/plot	Fuel Type Average
Willow Creek	7/16/2011	7/17/11 1800	1	Litter	6		
				Litter	5		
				Litter	3	4	Litter
				Duff	7		
				Duff	6		
				Duff	9	7	Duff
				100 Hour	25		
				100 Hour	11		
				100 Hour	7		
				100 Hour	10		
				100 Hour	12		
				100 Hour	10		
				100 Hour	11	12	100 Hour
Tamarack Creek	7/17/2011	7/17/11 1800	3	Litter	8		
				Litter	5		
				Litter	6	6	Litter
				Duff	8		
				Duff	7		
				Duff	6	7	Duff
				100 Hour	9		
				100 Hour	10		
				100 Hour	9		
				100 Hour	9		
				100 Hour	13		
				100 Hour	8	10	100 Hour
				1,000 Hour	12		
East of Lion Meadows	7/20/2011	7/20/11 1800	8	Litter	4		
				Litter	3		
				Litter	4	4	Litter
				Duff	12		
				Duff	6		
				Duff	35	18	Duff
				100 Hour	9		
				100 Hour	7		
				100 Hour	9		
				100 Hour	6		
				100 Hour	8	8	100 Hour
				1,000 Hour	40		
				1,000 Hour	13		
				1,000 Hour	11	21	1,000 Hour

Location on Lion Fire	Date Sampled	Time/Date in Oven	Plot #	Fuel Type	Fuel Moisture	Average per fuel type/plot	Fuel Type Average
East of Lion Meadows	7/20/2011	7/20/11 1800	9	Litter	8		
				Duff	10		
				100 Hour	8		
				100 Hour	11	9	100 Hour
				1,000 Hour	16		
				1,000 Hour	13	14	1,000 Hour
South of Lion Meadows	7/20/2011	7/20/11 1800	10	Manzanita - old	51		
				Manzanita - old	52	52	Manzanita - old
				Manzanita - new	53		
				Manzanita - new	62	57	Manzanita - new
				Litter	4		
				Litter	6		
				Litter	3	4	Litter
				Duff	10		
				Duff	14		
				Duff	4	9	Duff
				100 Hour	5		
				100 Hour	7		
				100 Hour	10	7	100 Hour
				1,000 Hour - rotten	22		
				1,000 Hour	12		
				1,000 Hour	14	13	1,000 Hour

Appendix C: Detailed results of FOFEM consumption and emissions modeling

Below are detailed results of FOFEM consumption and emissions modeling based on site fuel loading and fuel moisture measurements. For several of the following runs the First Order Fire Effects Model (FOFEM version 5.9) was forced to reduce fuel loading to the maximum the model would allow because fuel reduction observed at the plots was greater than model algorithms capabilities. Fuel moistures inputs were reduced to less than actual field observations in order to force the model to reduce more fuels.

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TITLE: Results of FOFEM model execution on date: 8/26/2011

FUEL CONSUMPTION CALCULATIONS

Region: Pacific_West
Cover Type: SAF/SRM - SAF 245 - **Pacific Ponderosa Pine - Site 1**
Very Heavy Fuel Load - Willow Creek
Fuel Type: Natural
Fuel Reference: FOFEM 021

FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture (%)
Litter	5.70 u	5.70	0.00	100.0	999	
Wood (0-1/4 inch)	0.02 u	0.02	0.00	100.0	999	
Wood (1/4-1 inch)	0.56 u	0.56	0.00	100.0	999	3.0
Wood (1-3 inch)	1.11 u	1.11	0.00	100.0	999	
Wood (3+ inch) Sound	15.08 u	13.39	1.69	88.8	999	1.0
3->6	7.54	7.54	0.00	100.0		
6->9	4.07	3.85	0.22	94.5		
9->20	2.41	1.64	0.77	68.0		
20->	1.06	0.36	0.70	33.9		
Wood (3+ inch) Rotten	1.68 u	1.64	0.04	97.6	999	1.0
3->6	0.84	0.84	0.00	100.0		
6->9	0.45	0.45	0.00	100.0		
9->20	0.27	0.27	0.00	99.5		
20->	0.12	0.08	0.04	66.3		
Duff	33.94 u	26.96	6.98	79.4	2	10.0
Herbaceous	0.01 u	0.01	0.00	100.0	22	
Shrubs	0.03 u	0.02	0.01	60.0	23	
Crown foliage	0.00 u	0.00	0.00	0.0	37	
Crown branchwood	0.00 u	0.00	0.00	0.0	38	
Total Fuels	58.13	49.41	8.72	85.0		

'u' Preburn Load is User adjusted

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in)	1.7	Equation: 6
Mineral Soil Exposed (%)	94.6	Equation: 10

Emissions -- lbs/acre	flaming	smoldering	total
PM 10	35	2335	2370
PM 2.5	30	1979	2009
CH 4	9	1202	1211
CO	75	26370	26445
CO 2	20334	107336	127670
NOX	37	0	37
SO2	11	87	98

	Consumption tons/acre	Duration hour:min:sec
Flaming:	5.72	00:01:00
Smoldering:	43.69	02:24:30
Total:	49.41	
Unit Average Combustion Efficiency:	0.70	
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TITLE: Results of FOFEM model execution on date: 8/26/2011

FUEL CONSUMPTION CALCULATIONS

Region: Pacific_West
Cover Type: SAF/SRM - SAF 245 - **Pacific Ponderosa Pine - Site 2 Heavy Fuel Load - Willow Creek**
Fuel Type: Natural
Fuel Reference: FOFEM 021

FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture (%)
Litter	5.90 u	5.90	0.00	100.0	999	
Wood (0-1/4 inch)	0.10 u	0.10	0.00	100.0	999	
Wood (1/4-1 inch)	0.28 u	0.28	0.00	100.0	999	3.0
Wood (1-3 inch)	1.48 u	1.48	0.00	100.0	999	
Wood (3+ inch) Sound	0.00 u	0.00	0.00	0.0	999	1.0
3->6	0.00	0.00	0.00	0.0		
6->9	0.00	0.00	0.00	0.0		
9->20	0.00	0.00	0.00	0.0		
20->	0.00	0.00	0.00	0.0		
Wood (3+ inch) Rotten	0.00 u	0.00	0.00	0.0	999	1.0
3->6	0.00	0.00	0.00	0.0		
6->9	0.00	0.00	0.00	0.0		
9->20	0.00	0.00	0.00	0.0		
20->	0.00	0.00	0.00	0.0		
Duff	15.97 u	12.69	3.28	79.4	2	10.0
Herbaceous	0.01 u	0.01	0.00	100.0	22	
Shrubs	4.12 u	2.47	1.65	60.0	23	
Crown foliage	0.00 u	0.00	0.00	0.0	37	
Crown branchwood	0.00 u	0.00	0.00	0.0	38	
Total Fuels	27.86	22.93	4.93	82.3		

'u' Preburn Load is User adjusted

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in)	1.7	Equation: 6
Mineral Soil Exposed (%)	94.6	Equation: 10

Emissions -- lbs/acre	flaming	smoldering	total
PM 10	52	772	824
PM 2.5	44	655	699
CH 4	13	398	411
CO	111	8722	8833
CO 2	30154	35503	65657
NOX	54	0	54
SO2	17	29	46

	Consumption tons/acre	Duration hour:min:sec
Flaming:	8.48	00:37:00
Smoldering:	14.45	01:05:45
Total:	22.93	
Unit Average Combustion Efficiency:	0.78	
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TITLE: Results of FOFEM model execution on date: 8/26/2011

FUEL CONSUMPTION CALCULATIONS

Region: Pacific_West
Cover Type: SAF/SRM - SAF 243 - **Sierra Nevada Mixed Conifer - FOFEM 081 - Site 3 - Lightest Fuel Load - Willow Creek**
Fuel Type: Natural
Fuel Reference: FOFEM 081

FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (t/acre)		Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture (%)
Litter	1.64	u	1.64	0.00	100.0	999	
Wood (0-1/4 inch)	0.22	u	0.22	0.00	100.0	999	
Wood (1/4-1 inch)	1.51	u	1.51	0.00	100.0	999	3.0
Wood (1-3 inch)	1.44	u	1.34	0.10	93.3	999	
Wood (3+ inch) Sound	2.91	u	1.06	1.84	36.6	999	1.0
3->6	1.45		0.75	0.71	51.4		
6->9	0.78		0.23	0.56	28.9		
9->20	0.47		0.08	0.39	16.3		
20->	0.20		0.01	0.19	7.3		
Wood (3+ inch) Rotten	0.32	u	0.22	0.11	66.9	999	1.0
3->6	0.16		0.14	0.02	88.2		
6->9	0.09		0.05	0.04	59.1		
9->20	0.05		0.02	0.03	35.7		
20->	0.02		0.00	0.02	16.5		
Duff	5.54	u	4.40	1.14	79.4	2	10.0
Herbaceous	0.01	u	0.01	0.00	100.0	22	
Shrubs	0.11	u	0.07	0.04	60.0	23	
Crown foliage	0.00	u	0.00	0.00	0.0	37	
Crown branchwood	0.00	u	0.00	0.00	0.0	38	
Total Fuels	13.70		10.47	3.23	76.4		

'u' Preburn Load is User adjusted

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in) 2.1 Equation: 6
Mineral Soil Exposed (%) 94.6 Equation: 10

Emissions -- lbs/acre	flaming	smoldering	total
PM 10	18	404	422
PM 2.5	15	342	357
CH 4	5	208	213
CO	38	4563	4601
CO 2	10352	18573	28925
NOX	19	0	19
SO2	6	15	21

	Consumption tons/acre	Duration hour:min:sec
Flaming:	2.91	00:02:30
Smoldering:	7.56	00:33:15
Total:	10.47	
Unit Average Combustion Efficiency:	0.75	
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TITLE: Results of FOFEM model execution on date: 8/26/2011

FUEL CONSUMPTION CALCULATIONS

Region: Pacific_West
Cover Type: SAF/SRM - SAF 243 - **Sierra Nevada Mixed Conifer - FOFEM 081 - Site 4 Heavy Fuel Load - Tamarack Creek**
Fuel Type: Natural
Fuel Reference: FOFEM 081

FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture (%)
Litter	3.27 u	3.27	0.00	100.0	999	
Wood (0-1/4 inch)	0.52 u	0.52	0.00	100.0	999	
Wood (1/4-1 inch)	0.62 u	0.62	0.00	100.0	999	3.0
Wood (1-3 inch)	1.44 u	1.44	0.00	100.0	999	
Wood (3+ inch) Sound	11.74 u	8.21	3.52	70.0	999	1.0
3->6	5.87	5.36	0.50	91.4		
6->9	3.17	1.99	1.18	62.8		
9->20	1.88	0.71	1.16	38.1		
20->	0.82	0.14	0.68	17.4		
Wood (3+ inch) Rotten	1.30 u	1.18	0.13	90.3	999	1.0
3->6	0.65	0.65	0.00	100.0		
6->9	0.35	0.34	0.01	96.8		
9->20	0.21	0.15	0.06	72.3		
20->	0.09	0.03	0.06	37.0		
Duff	13.59 u	10.80	2.79	79.4	2	10.0
Herbaceous	0.01 u	0.01	0.00	100.0	22	
Shrubs	0.01 u	0.01	0.00	60.0	23	
Crown foliage	0.00 u	0.00	0.00	0.0	37	
Crown branchwood	0.00 u	0.00	0.00	0.0	38	
Total Fuels	32.50	26.05	6.45	80.2		

'u' Preburn Load is User adjusted

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in)	2.1	Equation: 6
Mineral Soil Exposed (%)	94.6	Equation: 10

	Emissions -- lbs/acre flaming	smoldering	total
PM 10	24	1185	1209
PM 2.5	20	1004	1024
CH 4	6	610	616
CO	51	13378	13429
CO 2	13823	54454	68277
NOX	25	0	25
SO2	8	44	52

	Consumption tons/acre	Duration hour:min:sec
Flaming:	3.89	00:01:15
Smoldering:	22.16	01:11:00
Total:	26.05	
Unit Average Combustion Efficiency:	0.71	
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TITLE: Results of FOFEM model execution on date: 8/26/2011

FUEL CONSUMPTION CALCULATIONS

Region: Pacific_West
Cover Type: SAF/SRM - SAF 243 - **Sierra Nevada Mixed Conifer - FOFEM 081 - Site 5 Light Fuel Load - Tamarack Creek**
Sierra Nevada Mixed Conifer - FOFEM 081
Fuel Type: Natural
Fuel Reference: FOFEM 081

FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (t/acre)		Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture (%)
Litter	2.39	u	2.39	0.00	100.0	999	
Wood (0-1/4 inch)	0.33	u	0.33	0.00	100.0	999	
Wood (1/4-1 inch)	0.82	u	0.82	0.00	100.0	999	3.0
Wood (1-3 inch)	0.36	u	0.35	0.01	98.4	999	
Wood (3+ inch) Sound	9.59	u	4.20	5.39	43.8	999	1.0
3->6	4.80		2.90	1.90	60.5		
6->9	2.59		0.93	1.66	35.9		
9->20	1.54		0.31	1.22	20.3		
20->	0.67		0.06	0.61	8.9		
Wood (3+ inch) Rotten	1.07	u	0.79	0.28	74.0	999	1.0
3->6	0.53		0.50	0.03	94.4		
6->9	0.29		0.20	0.09	68.8		
9->20	0.17		0.07	0.10	43.1		
20->	0.07		0.01	0.06	19.9		
Duff	5.03	u	4.00	1.03	79.4	2	10.0
Herbaceous	0.01	u	0.01	0.00	100.0	22	
Shrubs	1.69	u	1.01	0.68	60.0	23	
Crown foliage	0.00	u	0.00	0.00	0.0	37	
Crown branchwood	0.00	u	0.00	0.00	0.0	38	
Total Fuels	21.29		13.91	7.38	65.3		

'u' Preburn Load is User adjusted

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in)	2.1	Equation: 6
Mineral Soil Exposed (%)	94.6	Equation: 10

Emissions -- lbs/acre	flaming	smoldering	total
PM 10	23	542	565
PM 2.5	20	459	479
CH 4	6	279	285
CO	49	6120	6169
CO 2	13398	24909	38307
NOX	24	0	24
SO2	8	20	28

	Consumption tons/acre	Duration hour:min:sec
Flaming:	3.77	00:01:00
Smoldering:	10.14	00:45:30
Total:	13.91	
Unit Average Combustion Efficiency:	0.75	
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TITLE: Results of FOFEM model execution on date: 8/26/2011

FUEL CONSUMPTION CALCULATIONS

Region: Pacific_West
Cover Type: SAF/SRM - SAF 245 - **Pacific Ponderosa Pine - Site 6 / 7**
Very Heavy Fuel Load - East Side of Lion Meadows
Fuel Type: Natural
Fuel Reference: FOFEM 021

FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture (%)
Litter	5.01 u	5.01	0.00	100.0	999	
Wood (0-1/4 inch)	0.00 u	0.00	0.00	0.0	999	
Wood (1/4-1 inch)	0.63 u	0.63	0.00	100.0	999	3.0
Wood (1-3 inch)	2.58 u	2.58	0.00	100.0	999	
Wood (3+ inch) Sound	11.18 u	9.71	1.47	86.8	999	1.0
3->6	5.59	5.59	0.00	100.0		
6->9	3.02	2.74	0.27	90.9		
9->20	1.79	1.13	0.66	63.1		
20->	0.78	0.24	0.54	31.0		
Wood (3+ inch) Rotten	1.24 u	1.20	0.04	97.0	999	1.0
3->6	0.62	0.62	0.00	100.0		
6->9	0.34	0.34	0.00	100.0		
9->20	0.20	0.19	0.00	97.9		
20->	0.09	0.05	0.03	61.6		
Duff	31.45 u	24.98	6.47	79.4	2	10.0
Herbaceous	0.01 u	0.01	0.00	100.0	22	
Shrubs	0.07 u	0.04	0.03	60.0	23	
Crown foliage	0.00 u	0.00	0.00	0.0	37	
Crown branchwood	0.00 u	0.00	0.00	0.0	38	
Total Fuels	52.17	44.17	8.00	84.7		

'u' Preburn Load is User adjusted

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in) 1.7 Equation: 6
Mineral Soil Exposed (%) 94.6 Equation: 10

	Emissions flaming	-- lbs/acre smoldering	total
PM 10	32	2079	2111
PM 2.5	27	1762	1789
CH 4	8	1070	1078
CO	69	23472	23541
CO 2	18776	95538	114314
NOX	34	0	34
SO2	11	78	89

	Consumption tons/acre	Duration hour:min:sec
Flaming:	5.28	00:01:30
Smoldering:	38.89	02:14:15
Total:	44.17	
Unit Average Combustion Efficiency:	0.71	
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TITLE: Results of FOFEM model execution on date: 8/26/2011

FUEL CONSUMPTION CALCULATIONS

Region: Pacific_West
Cover Type: SAF/SRM - SAF 245 - **Pacific Ponderosa Pine - Site 8**
Extremely Heavy Fuel Loading - East of Lion Meadows
Fuel Type: Natural
Fuel Reference: FOFEM 021

FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (t/acre)		Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture (%)
Litter	4.62	u	4.62	0.00	100.0	999	
Wood (0-1/4 inch)	0.06	u	0.06	0.00	100.0	999	
Wood (1/4-1 inch)	1.68	u	1.68	0.00	100.0	999	3.0
Wood (1-3 inch)	2.58	u	2.58	0.00	100.0	999	
Wood (3+ inch) Sound	30.62	u	29.05	1.57	94.9	999	1.0
3->6	15.31		15.31	0.00	100.0		
6->9	8.27		8.27	0.00	100.0		
9->20	4.90		4.38	0.51	89.5		
20->	2.14		1.09	1.06	50.7		
Wood (3+ inch) Rotten	3.40	u	3.37	0.03	99.1	999	1.0
3->6	1.70		1.70	0.00	100.0		
6->9	0.92		0.92	0.00	100.0		
9->20	0.54		0.54	0.00	100.0		
20->	0.24		0.21	0.03	87.7		
Duff	52.91	u	42.03	10.88	79.4	2	10.0
Herbaceous	0.01	u	0.01	0.00	100.0	22	
Shrubs	1.21	u	0.73	0.48	60.0	23	
Crown foliage	0.00	u	0.00	0.00	0.0	37	
Crown branchwood	0.00	u	0.00	0.00	0.0	38	
Total Fuels	97.09		84.13	12.96	86.6		

'u' Preburn Load is User adjusted

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in)	1.7	Equation: 6
Mineral Soil Exposed (%)	94.6	Equation: 10

	Emissions -- lbs/acre flaming	smoldering	total
PM 10	56	4008	4064
PM 2.5	48	3396	3444
CH 4	15	2063	2078
CO	119	45254	45373
CO 2	32547	184202	216749
NOX	59	0	59
SO2	18	150	168

	Consumption tons/acre	Duration hour:min:sec
Flaming:	9.15	00:05:00
Smoldering:	74.98	03:42:15
Total:	84.13	
Unit Average Combustion Efficiency:	0.70	
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TITLE: Results of FOFEM model execution on date: 8/26/2011

FUEL CONSUMPTION CALCULATIONS

Region: Pacific_West
Cover Type: SAF/SRM - SAF 243 - **Sierra Nevada Mixed Conifer - FOFEM 081 - Site 9 Heaviest Fuel Loading - Southeast of Lion Meadows**
Fuel Type: Natural
Fuel Reference: FOFEM 081

FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (t/acre)		Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture (%)
Litter	20.08	u	20.08	0.00	100.0	999	
Wood (0-1/4 inch)	0.15	u	0.15	0.00	100.0	999	
Wood (1/4-1 inch)	0.93	u	0.93	0.00	100.0	999	5.0
Wood (1-3 inch)	5.78	u	5.78	0.00	100.0	999	
Wood (3+ inch) Sound	65.50	u	50.51	14.99	77.1	999	5.0
3->6	16.38		16.38	0.00	100.0		
6->9	16.38		15.74	0.64	96.1		
9->20	16.38		12.26	4.11	74.9		
20->	16.38		6.14	10.24	37.5		
Wood (3+ inch) Rotten	7.28	u	6.63	0.64	91.2	999	5.0
3->6	1.82		1.82	0.00	100.0		
6->9	1.82		1.82	0.00	100.0		
9->20	1.82		1.79	0.03	98.1		
20->	1.82		1.21	0.61	66.5		
Duff	19.31	u	15.34	3.97	79.4	2	10.0
Herbaceous	0.00	u	0.00	0.00	0.0	22	
Shrubs	0.00	u	0.00	0.00	0.0	23	
Crown foliage	0.00	u	0.00	0.00	0.0	37	
Crown branchwood	0.00	u	0.00	0.00	0.0	38	
Total Fuels	119.03		99.43	19.60	83.5		

'u' Preburn Load is User adjusted

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in)	2.1	Equation: 6
Mineral Soil Exposed (%)	94.6	Equation: 10

	Emissions -- lbs/acre flaming	smoldering	total
PM 10	114	4323	4437
PM 2.5	97	3664	3761
CH 4	30	2226	2256
CO	242	48819	49061
CO 2	65969	198709	264678
NOX	119	0	119
SO2	37	162	199

	Consumption tons/acre	Duration hour:min:sec
Flaming:	18.55	00:25:15
Smoldering:	80.88	02:44:00
Total:	99.43	
Unit Average Combustion Efficiency:	0.73	
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TITLE: Results of FOFEM model execution on date: 8/26/2011

FUEL CONSUMPTION CALCULATIONS

Region: Pacific_West
Cover Type: SAF/SRM - SAF 245 - **Pacific Ponderosa Pine - Site 10**
Heavy Fuel Loading - South of Lion Meadows
Fuel Type: Natural
Fuel Reference: FOFEM 021

FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture (%)
Litter	15.97 u	15.97	0.00	100.0	999	
Wood (0-1/4 inch)	0.12 u	0.12	0.00	100.0	999	
Wood (1/4-1 inch)	0.21 u	0.21	0.00	100.0	999	3.0
Wood (1-3 inch)	0.74 u	0.74	0.00	100.0	999	
Wood (3+ inch) Sound	0.58 u	0.37	0.21	64.0	999	1.0
3->6	0.29	0.25	0.04	86.4		
6->9	0.16	0.08	0.07	54.4		
9->20	0.09	0.03	0.06	31.6		
20->	0.04	0.01	0.03	14.2		
Wood (3+ inch) Rotten	0.06 u	0.06	0.01	86.9	999	1.0
3->6	0.03	0.03	0.00	100.0		
6->9	0.02	0.02	0.00	91.2		
9->20	0.01	0.01	0.00	63.1		
20->	0.00	0.00	0.00	31.0		
Duff	15.97 u	12.69	3.28	79.4	2	10.0
Herbaceous	0.01 u	0.01	0.00	100.0	22	
Shrubs	6.75 u	4.05	2.70	60.0	23	
Crown foliage	0.00 u	0.00	0.00	0.0	37	
Crown branchwood	0.00 u	0.00	0.00	0.0	38	
Total Fuels	40.41	34.21	6.20	84.7		

'u' Preburn Load is User adjusted

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in) 1.7 Equation: 6
Mineral Soil Exposed (%) 94.6 Equation: 10

	Emissions -- lbs/acre flaming	smoldering	total
PM 10	25	1612	1637
PM 2.5	21	1366	1387
CH 4	6	830	836
CO	53	18198	18251
CO 2	14441	74074	88515
NOX	26	0	26
SO2	8	60	68

	Consumption tons/acre	Duration hour:min:sec
Flaming:	4.06	00:01:00
Smoldering:	30.15	01:10:45
Total:	34.21	
Unit Average Combustion Efficiency:	0.71	
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TITLE: Results of FOFEM model execution on date: 8/26/2011

FUEL CONSUMPTION CALCULATIONS

Region: Pacific_West
Cover Type: SAF/SRM - SAF 245 - **Pacific Ponderosa Pine - Crew 20 Plot 1**
Fuel Type: Natural
Fuel Reference: FOFEM 021

FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture (%)
Litter	1.04 u	1.04	0.00	100.0	999	
Wood (0-1/4 inch)	0.25 u	0.25	0.00	100.0	999	
Wood (1/4-1 inch)	0.24 u	0.24	0.00	100.0	999	3.0
Wood (1-3 inch)	0.90 u	0.62	0.28	68.8	999	
Wood (3+ inch) Sound	0.00 u	0.00	0.00	0.0	999	1.0
3->6	0.00	0.00	0.00	0.0		
6->9	0.00	0.00	0.00	0.0		
9->20	0.00	0.00	0.00	0.0		
20->	0.00	0.00	0.00	0.0		
Wood (3+ inch) Rotten	0.00 u	0.00	0.00	0.0	999	1.0
3->6	0.00	0.00	0.00	0.0		
6->9	0.00	0.00	0.00	0.0		
9->20	0.00	0.00	0.00	0.0		
20->	0.00	0.00	0.00	0.0		
Duff	3.33 u	2.65	0.68	79.4	2	10.0
Herbaceous	0.00 u	0.00	0.00	0.0	22	
Shrubs	0.00 u	0.00	0.00	0.0	23	
Crown foliage	0.00 u	0.00	0.00	0.0	37	
Crown branchwood	0.00 u	0.00	0.00	0.0	38	
Total Fuels	5.76	4.79	0.97	83.2		

'u' Preburn Load is User adjusted

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in)	1.7	Equation: 6
Mineral Soil Exposed (%)	94.6	Equation: 10

Emissions -- lbs/acre	flaming	smoldering	total
PM 10	7	199	206
PM 2.5	6	169	175
CH 4	2	102	104
CO	14	2246	2260
CO 2	3814	9144	12958
NOX	7	0	7
SO2	2	7	9

	Consumption tons/acre	Duration hour:min:sec
Flaming:	1.07	00:01:00
Smoldering:	3.72	00:18:45
Total:	4.79	
Unit Average Combustion Efficiency:	0.74	
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TITLE: Results of FOFEM model execution on date: 8/26/2011

FUEL CONSUMPTION CALCULATIONS

Region: Pacific_West
Cover Type: SAF/SRM - SAF 245 - **Pacific Ponderosa Pine - Crew 20 Plot 2**
Fuel Type: Natural
Fuel Reference: FOFEM 021

FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture (%)
Litter	3.82 u	3.82	0.00	100.0	999	
Wood (0-1/4 inch)	0.01 u	0.01	0.00	100.0	999	
Wood (1/4-1 inch)	1.09 u	1.09	0.00	100.0	999	3.0
Wood (1-3 inch)	0.00 u	0.00	0.00	0.0	999	
Wood (3+ inch) Sound	0.00 u	0.00	0.00	0.0	999	1.0
3->6	0.00	0.00	0.00	0.0		
6->9	0.00	0.00	0.00	0.0		
9->20	0.00	0.00	0.00	0.0		
20->	0.00	0.00	0.00	0.0		
Wood (3+ inch) Rotten	0.00 u	0.00	0.00	0.0	999	1.0
3->6	0.00	0.00	0.00	0.0		
6->9	0.00	0.00	0.00	0.0		
9->20	0.00	0.00	0.00	0.0		
20->	0.00	0.00	0.00	0.0		
Duff	12.06 u	9.58	2.48	79.4	2	10.0
Herbaceous	0.00 u	0.00	0.00	0.0	22	
Shrubs	0.00 u	0.00	0.00	0.0	23	
Crown foliage	0.00 u	0.00	0.00	0.0	37	
Crown branchwood	0.00 u	0.00	0.00	0.0	38	
Total Fuels	16.98	14.50	2.48	85.4		

'u' Preburn Load is User adjusted

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in) 1.7 Equation: 6
Mineral Soil Exposed (%) 94.6 Equation: 10

	Emissions -- lbs/acre flaming	smoldering	total
PM 10	28	530	558
PM 2.5	24	449	473
CH 4	7	273	280
CO	60	5982	6042
CO 2	16323	24350	40673
NOX	29	0	29
SO2	9	20	29

	Consumption tons/acre	Duration hour:min:sec
Flaming:	4.59	00:06:15
Smoldering:	9.91	00:49:45
Total:	14.50	
Unit Average Combustion Efficiency:	0.76	
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TITLE: Results of FOFEM model execution on date: 8/26/2011

FUEL CONSUMPTION CALCULATIONS

Region: Pacific_West
Cover Type: SAF/SRM - SAF 245 - **Pacific Ponderosa Pine - Crew 20 Plot 3**
Fuel Type: Natural
Fuel Reference: FOFEM 021

FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture (%)
Litter	1.54 u	1.54	0.00	100.0	999	
Wood (0-1/4 inch)	0.15 u	0.15	0.00	100.0	999	
Wood (1/4-1 inch)	1.33 u	1.33	0.00	100.0	999	3.0
Wood (1-3 inch)	1.11 u	1.11	0.00	100.0	999	
Wood (3+ inch) Sound	10.58 u	7.89	2.70	74.5	999	1.0
3->6	5.29	5.07	0.23	95.7		
6->9	2.86	1.96	0.90	68.5		
9->20	1.69	0.72	0.97	42.4		
20->	0.74	0.15	0.59	19.7		
Wood (3+ inch) Rotten	1.18 u	1.09	0.09	92.3	999	1.0
3->6	0.59	0.59	0.00	100.0		
6->9	0.32	0.32	0.00	99.4		
9->20	0.19	0.15	0.04	78.4		
20->	0.08	0.03	0.05	41.5		
Duff	17.05 u	13.54	3.51	79.4	2	10.0
Herbaceous	0.00 u	0.00	0.00	0.0	22	
Shrubs	0.00 u	0.00	0.00	0.0	23	
Crown foliage	0.00 u	0.00	0.00	0.0	37	
Crown branchwood	0.00 u	0.00	0.00	0.0	38	
Total Fuels	32.94	26.65	6.29	80.9		

'u' Preburn Load is User adjusted

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in)	1.7	Equation: 6
Mineral Soil Exposed (%)	94.6	Equation: 10

	Emissions flaming	-- lbs/acre smoldering	total
PM 10	13	1311	1324
PM 2.5	11	1111	1122
CH 4	3	675	678
CO	28	14805	14833
CO 2	7537	60260	67797
NOX	14	0	14
SO2	4	49	53

	Consumption tons/acre	Duration hour:min:sec
Flaming:	2.12	00:01:45
Smoldering:	24.53	01:20:15
Total:	26.65	
Unit Average Combustion Efficiency:	0.69	
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TITLE: Results of FOFEM model execution on date: 8/26/2011

FUEL CONSUMPTION CALCULATIONS

Region: Pacific_West
Cover Type: SAF/SRM - SAF 245 - **Pacific Ponderosa Pine - Crew 20 Plot 4**
Fuel Type: Natural
Fuel Reference: FOFEM 021

FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture (%)
Litter	3.12 u	3.12	0.00	100.0	999	
Wood (0-1/4 inch)	1.40 u	1.40	0.00	100.0	999	
Wood (1/4-1 inch)	1.97 u	1.97	0.00	100.0	999	3.0
Wood (1-3 inch)	1.46 u	1.46	0.00	100.0	999	
Wood (3+ inch) Sound	29.76 u	23.07	6.70	77.5	999	1.0
3->6	14.88	14.40	0.49	96.7		
6->9	8.04	5.99	2.05	74.5		
9->20	4.76	2.24	2.52	47.1		
20->	2.08	0.44	1.65	21.0		
Wood (3+ inch) Rotten	3.31 u	3.07	0.23	93.0	999	1.0
3->6	1.65	1.65	0.00	100.0		
6->9	0.89	0.89	0.00	99.6		
9->20	0.53	0.43	0.10	81.5		
20->	0.23	0.10	0.13	43.6		
Duff	7.07 u	5.62	1.45	79.4	2	10.0
Herbaceous	0.00 u	0.00	0.00	0.0	22	
Shrubs	0.00 u	0.00	0.00	0.0	23	
Crown foliage	0.00 u	0.00	0.00	0.0	37	
Crown branchwood	0.00 u	0.00	0.00	0.0	38	
Total Fuels	48.09	39.71	8.38	82.6		

'u' Preburn Load is User adjusted

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in)	1.7	Equation: 6
Mineral Soil Exposed (%)	94.6	Equation: 10

Emissions -- lbs/acre	flaming	smoldering	total
PM 10	45	1733	1778
PM 2.5	38	1468	1506
CH 4	12	892	904
CO	95	19566	19661
CO 2	25936	79641	105577
NOX	47	0	47
SO2	15	65	80

	Consumption tons/acre	Duration hour:min:sec
Flaming:	7.29	00:03:30
Smoldering:	32.42	01:29:45
Total:	39.71	
Unit Average Combustion Efficiency:	0.73	
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TITLE: Results of FOFEM model execution on date: 8/26/2011

FUEL CONSUMPTION CALCULATIONS

Region: Pacific_West
Cover Type: SAF/SRM - SAF 245 - **Pacific Ponderosa Pine - Crew 20 Plot 5**
Fuel Type: Natural
Fuel Reference: FOFEM 021

FUEL CONSUMPTION TABLE

Fuel Component Name	Preburn Load (t/acre)	Consumed Load (t/acre)	Postburn Load (t/acre)	Percent Reduced (%)	Equation Reference Number	Moisture (%)
Litter	1.17 u	1.17	0.00	100.0	999	
Wood (0-1/4 inch)	0.23 u	0.23	0.00	100.0	999	
Wood (1/4-1 inch)	1.44 u	1.44	0.00	100.0	999	3.0
Wood (1-3 inch)	0.89 u	0.71	0.18	79.2	999	
Wood (3+ inch) Sound	0.00 u	0.00	0.00	0.0	999	1.0
3->6	0.00	0.00	0.00	0.0		
6->9	0.00	0.00	0.00	0.0		
9->20	0.00	0.00	0.00	0.0		
20->	0.00	0.00	0.00	0.0		
Wood (3+ inch) Rotten	0.00 u	0.00	0.00	0.0	999	1.0
3->6	0.00	0.00	0.00	0.0		
6->9	0.00	0.00	0.00	0.0		
9->20	0.00	0.00	0.00	0.0		
20->	0.00	0.00	0.00	0.0		
Duff	3.99 u	3.17	0.82	79.4	2	10.0
Herbaceous	0.00 u	0.00	0.00	0.0	22	
Shrubs	0.00 u	0.00	0.00	0.0	23	
Crown foliage	0.00 u	0.00	0.00	0.0	37	
Crown branchwood	0.00 u	0.00	0.00	0.0	38	
Total Fuels	7.72	6.71	1.01	87.0		

'u' Preburn Load is User adjusted

FIRE EFFECTS ON FOREST FLOOR COMPONENTS

Duff Depth Consumed (in)	1.7	Equation: 6
Mineral Soil Exposed (%)	94.6	Equation: 10

	Emissions flaming	-- lbs/acre smoldering	total
PM 10	11	265	276
PM 2.5	9	224	233
CH 4	3	136	139
CO	23	2988	3011
CO 2	6279	12160	18439
NOX	11	0	11
SO2	4	10	14

	Consumption tons/acre	Duration hour:min:sec
Flaming:	1.77	00:02:00
Smoldering:	4.95	00:20:15
Total:	6.71	
Unit Average Combustion Efficiency:	0.75	
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Appendix D: About the Fire Behavior Assessment Team (FBAT)

The Fire Behavior Assessment Team (FBAT) operates under the management of Adaptive Management Services Enterprise Team (AMSET) of the USFS. This module specializes in measuring fire behavior and fuels on active wildland and prescribed fires. We utilize fire behavior sensors and fire-proof video cameras 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, topography, fuel moisture, and weather. 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 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 by the BAER Teams. We can be name requested by the following steps: 1) Overhead, 2) Group, 3) and Squad. You can also contact us directly by phone to notify us that you are placing an order, in order to 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 Scott Dailey at 530-575-7057 (cell) or via the Tahoe NF dispatch (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. Our web page is below and has links to most of our Incident Summary Reports.

FBAT leaving plot 2 at the Lion Fire, Adaptive Management Services Enterprise Team (AMSET)
http://www.fs.fed.us./adaptivemanagement/projects/FBAT/FBAT.shtml