Ralston Incident

Fire Behavior Assessment Report

fire burning from bearclover into a dense patch of young pine and Douglas-fir below little oak flat

Prepared 9/16/2006
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Executive Summary

Introduction

Wildfire suppression and wildland fire use 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. The team also collects other information on fire fighter safety, such as convective heat in safety zones as opportunities arise.

This report contains the results of the assessment of fire behavior in relation to fuels, weather and topography, and fire effects to resources in relation to fire behavior for the Ralston Fire Incident.

Objectives

Our objectives were to characterize fire behavior in relation to fuels and topography for a variety of conditions. A key consideration was which sites could be measured safely given access and current fire conditions.

Accomplishments

Fire behavior, pre-fire fuels and post-fire conditions were measured at 16 sites including a variety of conditions. Fuel types included pine-black oak/bearclover, Douglas-fir, canyon live oak, knobcone pine/chaparral, and black oak.

Introduction

Introduction

Wildfire suppression and wildland fire use 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. 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 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. The team also collects other information on fire fighter safety, such as convective heat in safety zones as opportunities arise. (See Appendix A for information on the Fire Behavior Assessment Team).

This report contains the results of the assessment of fire behavior in relation to fuels, weather and topography, and fire effects to resources in relation to fire behavior for the Ralston Fire Incident.

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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

Pre- and post-fire fuels and fire behavior measurements were made at sites throughout the fire. 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. A rapid assessment of fire severity and effects was conducted across the portions of the fire that had burned.

Fire Behavior Measurements and Observations

At each site, sensors were set up to gather information on fire behavior including: rate of spread, fire type, flamelength, and flaming duration. In addition, at some sites, temperature were also measured.

Flamelength and Flaming Duration

Flamelength was determined from video and sometimes supplemented by tree height or char. If crowning occurred above the view of the camera, then tree height was used to estimate the minimum flamelength. If the video camera failed (due to extreme temperatures or trigger malfunction), then char height on tree boles or direct observation were used to estimate flamelength. Flaming duration was based on direct video observation and when temperature was measured, from those sensors as well.

Figure 1. Installing fire behavior sensors at site 12.

Fire Type

Fire type was determined from video as well as post-fire effects at each site. Observations from the video were recorded on transitions to crown fire, including the type of fuel that carried the fire from the surface to crown.

Rate of Spread and Temperature

Rate of spread was determined by video analysis and rate of spread sensors (RASPS) which have a piece of solder attached to a computer chip (buried in the ground) that records the date and time when the solder melts or from thermocouples that measure temperature. The distance and angle between RASPS were measured and the Simard (1977) method of estimating rate of spread using geometry was applied. Temperature was measured using an Omega Nomad sensor with a thermocouple. The sensor was placed in the camera box and the thermocouple hung out of the box at approximately 3’ height.

Vegetation and Fuel Measurements

Vegetation and fuels were inventoried before the fire reached each site and then after. 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.

Crown Fuels and Overstory Vegetation Structure

Tree density, basal area, tree diameters, tree heights and canopy base heights were measured by species for each site. A relaskop was used for overstory and pole plots. Heights were measured with an impulse laser. Diameters were measured with a biltmore stick or in some cases a diameter tape. The Gamma program, based on the Forest Vegetation Simulator (FVS) program was used to calculate canopy bulk density, canopy base height, tree density and basal area.

Surface fuels were inventoried with a Brown's planar intercept. Understory vegetation and live fuels were estimated occularly in a 1 meter wide belt plot along the Brown's transect. The Burgan and Rothermel fuels photo series was used in order to estimate tons per acre of live fuels.

Foliar Moisture and Weather

Live foliage was collected on each plot and oven dried to determine foliar moisture. Weather data was downloaded from the incident remote automated weather stations (RAWS), and the permanent ones at the Foresthill seed orchard, Secret Canyon and Duncan Peak.

Findings

Overall

Fire behavior and post-fire data were collected at 16 sites that burned (Figure 2). Sites were grouped into dominant vegetation types to summarize the data (Table 1). Information for each site. Five vegetation types were sampled including Douglas-fir (8 sites), ponderosa pine-black oak/bearclover (5 sites), black oak (2 sites), ponderosa pine-Douglas-fir (1 site), canyon live oak (1 site), and knobcone pine/chaparral (1 site) (Table 1). Within each of these general types, there was a variety of topography conditions and stand ages.

Two of the Douglas-fir sites with mature forests were steep, and three with moderate slopes. Three of the Douglas-fir sites were on gentle slopes and had various amounts of old-growth trees. Two of these older Douglas-fir sites were adjacent to riparian areas and the other on a flat bench on an upper slope in the American River canyon.

Two of the ponderosa pine-black oak/bearclover sites had young, pole-sized trees. One had a patch of dense, young-mature pine, Douglas-fir and black oak. Two of the sites were dominated by an overstory of mature black oak.

Litter and browsed grass comprised the understory of one of the black oak stand and dense, tall, old deerbrush the second black oak stand.

A variety of fire behavior was measured across the sites. It varied from low intensity surface fire, to intense surface fire with torching, to crown fire. Some of the sites burned as part of the main fire and some as part of burnout operations.

Table 1. Vegetation types assigned to each site and used to group data.

Type		
Black oak	Mature black oak with varied understory of deerbrush or litter and grass.	2
Young ponderosa pine-black oak/bearclover	Plantation and harvested area, with well developed understory of bearclover and scattered or planted young, pole-sized ponderosa pine.	2
Young mature ponderosa pine-black oak/bearclover	Small patch of young mature ponderosa pine and black oak, with some Douglas-fir surrounded by a large open area of dense bearclover and some grass. Some needle draped manzanita bushes at edge of tree patch.	1
Mature ponderosa pine-black oak/bearclover	Ponderosa pine and black oak in the overstory with a well developed layer of bearclover in the understory. Various amounts of grass and mixtures of black oak and pine.	2
Mature Douglas-fir, steep	Moderately dense to dense overstory of Douglas-fir with a sparse understory. Moderate to heavy surface fuels. Some sites had Douglas-fir poles and scattered canyon live oak in the midstory. Slopes steep (>60%).	2
Mature Douglas-fir, moderately steep	Moderately dense to dense overstory of Douglas-fir with a sparse understory. Moderate to heavy surface fuels. Some sites with pockets of Douglas-fir saplings or deerbrush. Slopes moderately steep (34-45%)	3
Old growth Douglas-fir-ponderosa pine, gentle slope	Old growth ponderosa pine, Douglas-fir and black oak stand. Scattered clumps of big leaf maple, and California nutmeg seedlings. Well developed understory of poison oak, grass and patches of starflower.	1
Douglas-fir-big leaf maple	Mature and remnant old growth Douglas-fir with midstory of big-leaf maple and a buckeye. Well developed grass understory. On an alluvial bench next to a perennial stream.	1
Douglas-fir - dogwood	Old growth Douglas-fir with very large Douglas-fir, incense cedar on an alluvial bench next to an ephemeral draw. Scattered dogwood and other moist site indicators including trailplant and false Solomon's seal.	1
canyon live oak	Canyon live oak dominated woodland with sparse understory. Scattered patches of whiteleaf manzanita.	1
Knobcone pine/chaparral	Knobcone pine woodland over a dense understory of old whiteleaf manzanita. Heavy loading of jackstrawed, down knobcone pine logs was present.	1

Figure 2. Map with locations of detailed and rapid assessment sample locations.

(insert pdf file…for better resolution map)

Vegetation, Fuels, Fire Behavior and Effects

Data on pre-fire vegetation structure (tables 2 and 3), pre-fire live fuels (table 4), pre-fire surface fuels (table 5), fire behavior (table 6), post-fire consumption of surface fuels (table 7) and immediate post-fire effects (table 8) were summarized.

Pre-fire Vegetation Structure

Canopy cover for tree, shrub, herb and grass layers varied amongst sites depending upon the vegetation type and stand age (Table 2). The highest tree canopy covers were in the mature Douglas-fir sites (Figure 3). The canyon live oak, knobcone pine/chapparal and younger ponderosa pine-black oak/bearclover sites had the lowest tree canopy covers. Canopy cover varied from moderate to moderately high in the black oak and older Douglas-fir sites (Figure 5). Shrub cover was greatest in the sites with bearclover and the knobcone/chapparal site (Figure 4). One of the black oak sites had a dense patch of deerbrush and the other a sparse understory. The mature Douglas-fir sites had low understory cover.

Figure 3. Mature Douglas-fir at site 14.

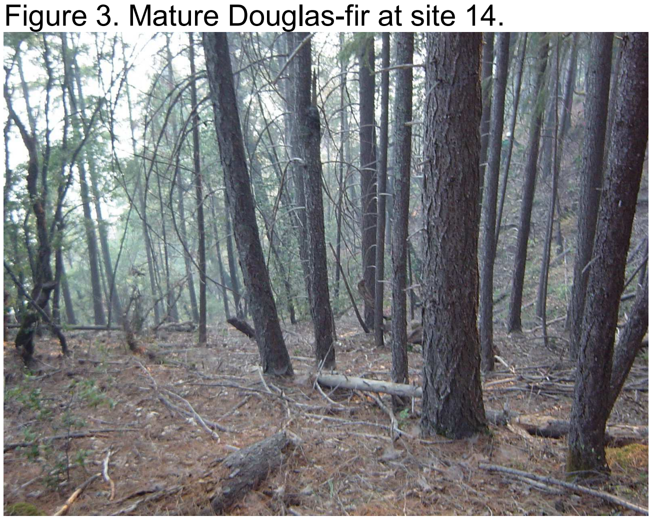

Figure 4. Ponderosa pine-black oak/bearclover, site 4.

Figure 5. Old-growth Douglas-fir site.

Figure 6. Canyon live oak at site 13.

Table 2. Canopy cover by lifeform by site. Canopy cover is based on ocular estimates of cover classes. Moss cover was estimated but was found on only a few sites and on those were less than 10%. It occurred on the boles of hardwoods or in conifer dominated stands, sometimes on the soil surface or rocks.

	Canopy Cover by Lifeform (%)				
Site	**Tree Overstory**	**Seedlings**	**Shrubs**	**Herbs/Ferns**	**Grasses**
Black oak					
11-litter	40-60	1-10	1-10	1	1-10[1]
6b-deerbrush	40-60	1-10	75-100	1	1
Ponderosa pine – black oak / bearclover					
2-young	30 (poles)	1	40-60	1-10	25-50
6a-young	10 (poles)	1-10	75-100	1-10	10-25
4-young,mature	60 in tree patch, 20% overall	1	75-100 outside of tree patch	1-10	10-25
3-mature	20-30	1	75-100	1-10	1
5-mature	50-60	1-10	25-50	25-50	1-10
Mature Douglas-fir					
8-moderate slope	60	Patchy 1-10 & 50-75	1	1-10	10-25
10-mod slope	80-90	1-10	1	1	0
16-mod	80	1	1-10	1	0
14-steep	70	1-10	1-10	1-10	10-25
15-steep	>70	1	0	1	1-10
Douglas-fir with old growth					
12-dogwood	60-70	1-10	1-10	1-10	0
9-maple	50-60	1-10	0	1-10	25-50
1-ponderosa	50-60	1-10	1-10	1-10	25-50
Canyon live oak					
13	30-40	10-15	1	1	1-10
Knobcone pine / chapparal					
7	20-30	1	75-100	1	1

1- browsed

Basal areas varied widely, reflecting the variation in tree cover and stand ages, ranging from 50-340 square feet per acre (Table 3). The greatest basal areas were in the Douglas-fir types and some of the ponderosa pine-black oak/bearcover sites. In the latter site, a dense clump of young mature trees had a high basal area but overall the area had low basal area. Tree densities and quadratic mean diameters varied considerably as well. There were scattered remnant old growth trees at some of the mature Douglas-fir and ponderosa pine-black oak/bearclover sites that is reflected in higher quadratic mean diameters.

Table 3. Pre-fire forest structure calculated using GAMMA, based on algorithms from the Forest Vegetation Simulator.

Site	Basal Area (ft^2/acre)	Trees Density > 1" dbh (no/acre)	Quadratic Mean diameter (inches)
Black oak			
11-litter	145	419	10.3
6b-deerbrush	105	269	8.5
Ponderosa pine – black oak / bearclover			
2-young	120	880	5.0
6a-young	50	552	4.1
4-young,mature	360	393	18.4
3-mature	100	39	23.5
5-mature	280	88	29.0
Mature Douglas-fir			
8-moderate slope	160	134	21.8
10-mod slope	165	688	13.7
16-mod	290	1522	10.1
14-steep	260	546	12.3
15-steep	225	*	14.1
Douglas-fir with old growth			
12-dogwood	340	151	33.7
9-maple	130	128	17.8
1-ponderosa	215	199	45.0
Canyon live oak			
13	90	*	7.5
Knobcone pine / chapparal			
7	60	*	7.8

* data needs more detailed re-examination

Pre-fire Live Fuels

Tree Canopy Fuels Canopy fuels varied amongst sites similarly to vegetation structure because of the diversity of composition and stand age (Table 4). Canopy base heights varied from 2 to >30 feet. The lowest canopy base heights were in the younger stands in the ponderosa pine-black oak/bearclover type. Similarly, stands in this type also had the greatest canopy bulk densities, because the crowns are compact vertically and the bulk densities are calculuated using a vertical moving average. The peak value across the vertical profile is what is used. The mature and 2 of the old-growth Douglas-fir forest sites had moderate to high canopy bulk densities, exceeding 0.2 kg/m^3.

Live Understory Fuels Live understory fuels varied considerably amongst sites (Table 4). The greatest understory loadings were on those sites with dense whiteleaf manzanita (sites 3 and 7) (Figure 7). Site 6b with a dense patch of tall deerbrush also had a substantial shrub load. Sites with bearclover had loadings of 1.5-3 tons/acre of shrub fuels. In addition, bearclover has highly resinous and flammable foliage. Most of the bearclover observed had 5-15% dead foliage and fine stems as well. Sites with denser grass cover had the highest loadings of herb and grass fuels (Figure 8).

Figure 7. Manzanita at Knobcone site 7.

Figure 8. Grassy understory at site 1.

Table 4. Live fuels by site. Crown fuels were calculated using GAMMA, with calculations based on those in the Forest Vegetation Simulator (FVS) for the western Sierra Nevada variant. Understory fuels were calculated using the Burgan and Rothermel (1984) method.

Site	Trees		Understory	
	Canopy Base Height (ft)	**Canopy Bulk Density (kg/m^3)**	**Live & Dead Grass, Herb (tons/acre)**	**Live & Dead Shrub, Seedlings (tons/acre)**
Black oak				
11 - litter	>12	0.33	0.01	<0.1
6b – deerbrush	>15’	.14	<0.01	11-13
Ponderosa pine-black oak/bearclover				
2-young	2	>0.4	0.26	0.7-2.8
6a-young	3	4 trees	0.08	11-13
4-young, mature	3	0.28	0.03	0-2
3-mature	>10	0.18	0.02	66
5-mature	12	0.23	0.07	1.7
Mature Douglas-fir				
8-moderate slope	18	0.13	0.02-0.05	<0.01
10 moderate slope	9	0.29	0	<0.01
16-moderate slope	10	0.32	0	0.03
14-steep	14	0.26	0.44	0.09
15-steep	4	0.16	0.01	<0.01
Douglas fir with old growth				
12-dogwood	32	0.07	0	<0.01
9-maple	7	0.26	0.01	<0.1
1-Ponderosa pine	36	0.30	0.25	0.7
Canyon live oak				
13	0.5	>0.4[1]	0.1	0.2
Knobcone pine/chaparral				
7	8	See footnote 1	0.1	51

1- limited data for estimating canopy bulk density for canyon live oak, may be overestimate. There is no information to base canopy bulk density for knobcone pine

Pre-fire Dead Surface Fuels

The highest dead surface fuel loadings were in the Douglas-fir sites (Table 5). Litter comprised a significant proportion of the surface fuels with estimated loadings of >4 tons/acre at many sites and >7 tons/acre at 8 out of 16 sites. Thousand hour fuels were greatest in the mature and old-growth Douglas-fir sites. A regression formula that applies an average coefficient for all Sierra Nevada species (van Wagtendonk) was used to calculate duff weights and it is likely that some of the values might change considerably if species specific coefficients were used.

Table 5. Pre-fire surface fuels. Sampled using Brown's planar intercept method. Note that the 1 hour surface fuel loadings do not incorporate litter loading. Litter is a significant component of 1-hour fuels and should be added to 1-hour loading if this data is used for fire behavior modeling. *A regression formula that applies an average coefficient for all Sierra Nevada species (van Wagtendonk) was used to calculate duff weights and it is likely that some of the values might change considerably if species specific coefficients were used.*

Site	**Small Surface Fuels (tons/acre)**				**1000 hour fuels (tons/acre)**		**Litter and Duff (tons/acre)**	
	1 hour	10 hour	100 hour	Total	Rotten	Sound	Litter	Duff
Black oak								
11 litter	.1	.5	.6	1.2	.9	3.0	8.9	37.3
6b deerbrush	.1	.3	1.2	1.6	3.2	1.7	12.1	60.3
Ponderosa pine-black oak / bearclover								
2-young	.02	00	.6	.6	0	0	1.2	0
6a-young	.2	0	0	.2	3.2	1.7	4.9	7.4
4-young, mature	0	1.2	0	1.2	.6	0	7.3	39.8
3-mature	.1	.3	.6	1.0	0	0	10.1	26.1
5-mature	.1	0	2.4	2.5	3.1	1.2	4.9	31.4
Mature Douglas-fir								
8-mod. slope	.2	2.6	5.5	8.3	7.2	4.0	7.3	29.2
10-mod. slope	0	.3	3.6	3.9	1.4	0	8.1	60.7
16-mod. slope	.6	3.7	1.2	5.5	2.4	5.5	4.5	33.6
14-steep	.4	2.7	7.4	10.5	14.9	14.9	4.9	31.4
15-steep	.9	3.4	2.5	6.8	5.7	14.7	2.8	42.4
Douglas-fir with old growth								
12-dogwood	0	1.4	3.1	6.9	139.2	5.5	9.7	51.9
9-maple	.1	.6	0	.7	0	27.4	4.9	18.5
1-ponderosa	.0	.5	2.4	2.9	1.4	0	2.2	19.3
Canyon live oak								
13	.1	.6	3.0	3.7	3.1	0	5.7	0
Knobcone pine / chapparal								
7	.1	.3	0	.4	0	13.3	10.5	54.7

Fuelbed depths were greatest at the Douglas-fir sites, reflecting the higher 10, 100 and 1000 hour fuel loadings. Litter depths exceeded 1.5 inches on most sites and 2 inches on 7 out of the 16 sites (Table 6). Duff depths were greatest in the Douglas-fir types.

Table 6. Fuel depths by site.

Fuel Depths			
Site	**Duff (inches)**	**Litter (inches)**	**Fuel bed (feet)**
Black oak			
11-litter	0.4	2.2	0.04
6b-deerbrush	1.0	3.0	0.3
Ponderosa pine – black oak / bearclover			
2-young	0	0.7	0.04
6a-young	0.1	1.2	0.40
4-young, mature	0.8	1.8	0.15
3-mature	0.2	2.5	0.10
5-mature	0.8	1.2	0.35
Mature Douglas-fir			
8-mod slope	0.4	1.8	0.98
10-mod slope	1.8	2.0	0.38
16-mod slope	1.0	1.08	1.23
14-steep	0.8	1.2	0.67
15-steep	1.8	0.7	2.83
Douglas-fir with old growth			
12-dogwood	1.0	2.4	1.39
9-maple	0.4	1.2	0.77
1-pondoerosa	0.59	0.54	0.04
Canyon live oak			
13	0.0	1.4	0.16
Knobcone pine / chapparal			
7	1.0	2.6	2.78

Fire Behavior

A variety of fire behavior was measured but most of it was surface fire (Table 7). The time of day the site burned was a key factor in the observed and measured fire behavior in addition to the topography and fuels. Sites that had heavier surface fuels, high shrub cover or ladder fuels burned with the greatest intensity (Figure 9). The one site that burned as a crown fire, site 10, had moderately high surface fuels, high canopy fuels and was on a steep slope near the ridgetop. It burned during the day when temperatures were greatest, humidities lowest and ridgetop winds the greatest. All sites with bearclover had high fuel consumption and some moderately intense surface fire when they burned in the afternoon

(Figure 10). Other sites burned under cooler conditions with less wind later in the day and although they had high surface fuel consumption, the fires were surface (Figure 11).

Figure 9. Transition to passive crown fire or group torching at site 4.

Figure 10. Intense surface fire through bearclover at site 4. Firewhirls were evident in some of the video footage.

Figure 11. Surface fire at a mature Douglas-fir site, site 15.

Figure 12. Surface fire through canyon live oak stand at site 13, part of burn operation.

Associated Weather and Fuel Moisture

We are in the process of downloading weather data from three nearby weather stations (RAWS) and processing the weather data gathered from the fire RAWS. This information will be added after it is synthesized.

Although we collected live fuel moisture samples several times, our equipment malfunctioned and we were unable to obtain values that were reasonable.

Table 7. Fire behavior measurements and observations by site.

Site/Plot	Slope %	Fire Type	Type of Burn	Fame Length (feet)	Rate of Spread (chains/hr)	Flame Duration Across Site
Black Oak						
11-Litter	53%	Low intensity surface night burn	Backing, burnout	.5’ to 1’	2 to 5	1 hour
6b- Deerbrush	34%	Medium intensity surface, partial torching	Backing	3’ to 5’	1 to 10	> 1.5 hours end of tape
Ponderosa pine-black oak/bear clover						
2-young	30%	Medium surface intensity	Backing	.5’ to 3’	10 to 15	1.3 hours
6a-young	34%	Medium intensity surface, partial torching	Backing	3’ to 5’	1 to 10	>1.5 hours end of tape
4-young, mature	37%	High intensity surface, torching	Head	1’ to 15’	10 to 30	4 hours
3-mature	37%	Low intensity surface	Backing	0’ to 2’	1.5 to 5	>1.5 hours end of tape
5-mature	15%	Low intensity surface	Backing	.5 to 1.5’	1.5 to 5	3 hours
Mature Douglas-fir						
8b-moderate slope	28%	High intensity surface,	Backing, burnout	No data see footnote	No data see footnote	No data see footnote
10 moderate slope	34%	High intensity torching, crowning	Head	>60	No data see footnote	No data see footnote
16- moderate slope	45%	Low intensity surface night burn	Backing	.5 to 1’	.5	>1.5 hours end of tape
14-steep	62%	Medium intensity surface,	Backing	1’ to 3’	10 to 12	>1.5 hours end of tape
15-steep	64%	Medium intensity surface night burn	Too slow to see, only in background		1 in video	>1.5 hours end of tape

Table 7. continued.

Site/Plot	Slope %	Fire Type	Type of Burn	Fame Length (feet)	Rate of Spread (chains/hr)	Flame Duration Across Site
Douglas-fir with old growth						
12-dogwood	10%	High intensity surface, night burnout	Head	6’ to 8’	No data see footnote	No data see footnote
9-fir-maple	3%	Low intensity surface	Head	0’ to 1’	1/8	1.5 hours end of tape
1-Ponderosa pine	70%	Low intensity surface	Backing	1’ to 2’	1	>1.5 hours end tape
Canyon live oak						
13	62%	Low intensity Surface night burn	Head	.5 to 1’	.5	No data see footnotes
Knobcone pine/chapparal						
7	30%	High intensity surface	Backing, burn out	10’ to 15’	1.5 to 3	Camera tripped mid burn

#8 Camera triggered late due to firing direction, fire never entered camera view.
#10 High intensity crown fire, rate of spread sensors failed due to extreme heat. Unknown flame lengths, camera out of alignment.
#12 High intensity surface fire, rate of spread sensors failed due to extreme heat. Unknown flame lengths, camera failure.
#13 Unknown duration, camera triggered late.
#14 Long duration of fire in plot due to percentage of 1,000 hour fuels.

Post-fire Consumption and Immediate Effects

The fire effects that we measured and observed post-fire are immediate. It is not possible to determine tree mortality or mortality of understory plants that may resprout so soon after the fire. Paired, pre- and post-fire photos and descriptions of conditions of individual sites are in Appendix B. Here, overall effects are described.

Overall the sites burned with low to moderate intensity but had high dead and live surface fuel consumption (Table 8). Effects to live vegetation depended upon stand structure and the conditions (weather) they burned under. Sites that burned in the day when conditions were drier and hotter generally displayed consumption of live understory plants (Table 9). Most of the species that were recorded at the sites have characteristics, such as the ability to sprout, that make it likely that they will regrow from below ground rhizomes, burls, roots, tubers or bulbs post-fire. Two of the sites burned in a very patchy pattern, reflecting at least in part the conditions in which they burned, site 1 and 9. It could also be that there was higher soil moisture and a prevalence of lighter surface fuels.

The effects to the tree layers varied considerably amongst sites (Table 8). Those that had lower canopy base heights or moderate canopy base heights and intense surface fire had moderate to high crown scorch. Those that had tall trees had little crown scorch. The only site that had extensive crown consumption was site 10 that burned as a crown fire.

Figure 13. Post-fire along plot transect at site 5, showing effects of low intensity fire.

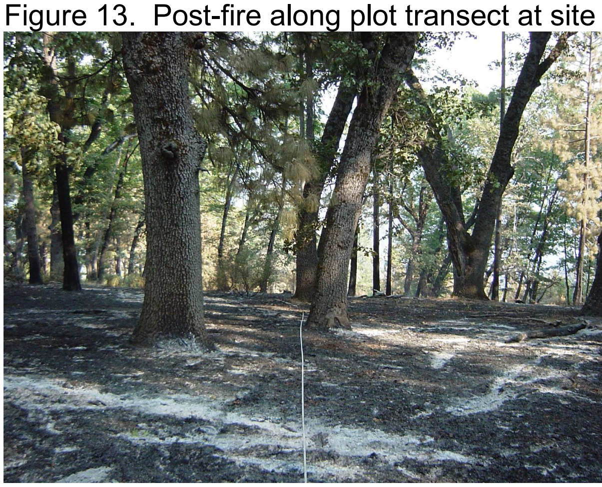

Figure 14. Post-fire photo at site 7, knobcone/chaparral, showing very high consumption of manzanita.

Table 8. Surface and ground fuel consumption by site.

Site	% Site Burned	Soil Severity (NPS rating)	Duff Consumption (%)	Litter Consumption (%)	Surface Fuels Consumption			
					1- hour	10- hour	100- hour	1,000 hour
Black oak								
11- litter	90%	2-3	90%	90%	90%	60%	20%	60%
6b – deerbrush	100%	1-2	95%	95%	100%	100%	100%	100%
Ponderosa pine-black oak/bearclover								
2 – young	100%	1-2	95%	95%	100%	100%	100%	50%
6a – young	95%	3	95%	95%	100%	100%	100%	50%
4 – young & mature	100%	1-3	95%	95%	100%	100%	100%	90%
3 – mature	100%	2	100%	100%	100%	100%	100%	na
5 – mature	100%	2	95%	95%	70%	70%	70%	80%
Mature Douglas-fir								
8b – moderate slope	95%	1-3	95%	95%	100%	100%	100%	90%
10 moderate slope	100%	1-2	95%	100%	100%	100%	100%	90%
16 – moderate slope	80%	2-4	70%	80%	90%	90%	80%	70%
14 – steep	95%	1-3	70%	90%	100%	100%	100%	60%
5 – steep	90%	2-4	70%	90%	90%	80%	80%	80%
Douglas fir with live oak%								
12 – dogwood	100%	1	100%	100%	100%	100%	100%	90%
9 – maple	65%	3-5	10%	10%	25%	25%	25%	30%
1 – Ponderosa pine	60%	3-5	50%	50%	50%	50%	50%	60%
canyon live oak								
13	80%	3-4	50%	50%	80%	80%	80%	80%
Knobcone pine/chaparral								
7	100%	1-2	90%	90%	100%	100%	90%	90%

1 – National Park Service, substrate severity ratings: 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 severity, charred litter and some unburned litter and duff remain; 5 – unburned.

Note: the average percent burned of our plots does not necessarily represent the overall average area burned within the fire perimeter. It is a limited sample where sites are located where they are most likely to burn.

Table 9. Summary of immediate post fire effects per site. Mortality is not included, since survival cannot be determined immediately post-fire. Trees that are scorched can survive. Data below shows **torch, where needles are consumed**, and **scorch, where needles are brown** but not consumed. Results below are based upon a rapid analysis of measured crown scorch and torch. Detailed data by individual tree was recorded but not summarized quantitatively.

Site	% Site burned	Understory scorch or consumption (%)[1]		Midstory (pole trees)		Overstory Tree Severity	
		Grass/ herb	Shrubs /seedlings	Scorch (% crown)	Torch (% crown)	Scorch (% crown)	Torch (% crown)
Black Oak							
11-litter	95%	100% cons.[2]	100% scorch, white fir cons.	90%	0	5-20%	0
6b-deerbrush	100%	100% cons.	80-100% scorch-deerbrush & seedlings, 100% cons. bearclover	100%	0	0	0
Ponderosa pine-black oak/bearclover							
2-young	100%	90-100% cons.	Bearclover-100% cons. to stobs, manzanita-30% scorch and remainder leaves cons. and some fine branches	90%	0	na	na
6a-young	100%	100% cons.	100% to stobs	100% scorch	0	80%	0
4-young, mature	100%	100% cons.	100% to stobs	na	na	100%	20-100% on 3 trees
3-mature	100%	100% cons.	100% cons. leaves & some 1 hr stems remain	na	na	90-100%	½ trees 100% torch[3]
5-mature	100%	100% cons.	bearclover cons. to stobs	na	na	Black oak-10%, ponderosa pine 80%	0

1- applies to burned patches and not unburned.
2- cons. refers to consumed.
3- one black oak fallen over and mostly consumed.
4- site could have burned more after we measured post-fire conditions since it was still burning in a mosaic in vicinity.
5- clump of black oak sprouts next to large black oak tree that burned and fell over were completely consumed.
6- some trees may have been entirely consumed but we were unable to locate the tree plot rebar. This will be revisited later with a metal detector.

Table 9. continued.

Site	% Site burned	Understory scorch or consumption (%)[1]		Midstory (pole trees)		Overstory Tree Severity	
		Grass/ herb	Shrubs /seedlings	Scorch (% crown)	Torch (% crown)	Scorch (% crown)	Torch (% crown)
Mature Douglas-fir							
8-moderate slope	100%	100% cons.	100% cons. in upper plot with heavy woody fuels, 100% scorch in regeneration patch closer to draw	na	na	80-90%	0
10 moderate slope	100%	100% cons.	100% cons.	na	100%	Most trees torched, a few trees 100% scorch	80%
16-moderate slope	70-80%	100% cons.	100% cons.	5-20% scorch	0	0-40%	0
14-steep	100%	100% cons.	100% cons., poison oak 90% scorch	0-15%	na	15-40%	0
15-steep	100%	100% cons.	100% cons.	100% if not torched	80-100%	Mature trees – 100%, large trees (>30" dbh) 30-40%	One tree 90%
Douglas-fir with old growth							
12-dogwood	100%	100% cons.	100% cons.	na	na	2-15%	0
9-maple	30-40%[4]	Little change, scorch & consumed in unburned patches	Some Douglas-fir seedlings scorched, rest unchanged	na	na	Conifer overstory 0%,hard-wood midstory 20-40%	0
1-with ponderosa pine	25	40% scorch, 60% cons.	100% scorch (except nutmeg)	60-90% maple	100% black oak[5]	0	0, except one large black oak[5]
Canyon live oak							
13	70%	100% cons.	100% scorch	na	na	60-80%	0
Knobcone pine/chapparal							
7	100%	100% cons.	100% cons. to stobs of <1' ht (all 1, 10 and much of 100hr size stems on manzanita)	100% for trees remaining[6]	See footnote[6]	na	na

Appendix A

About the Fire Behavior Assessment Team

We are a unique module that specializes in measuring fire behavior on active fires of all kinds including wildland fire use fires, prescribed fires or wildfires. 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 ma uch 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 includes 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 wildfires, wildland fire use fires and prescribed fires, having 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) 559-967-7806. 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

Plot	Topograpy	Aspect	Slope	Description	Type
1	bench on upper slope	330		old growth ponderosa pine and Douglas-fir, with bigleaf maple, black oak in the midstory. California nutmeg in the understory. Poison oak and grassy understory with scattered herbs, including patches of starflower.	**flat, old growth Douglas-fir - Pine**
2	lower edge of ridge	120		ponderosa pine/bearclover, at edge of plantation. Scattered grass	**ponderosa pine-black oak/bearclover**
3	along nose of broad ridge	175		mature ponderosa pine and black oak, with bearclover and patches of white leaf manzanita.	**ponderosa pine-black oak/bearclover**
4	along nose of broad ridge	160	20	young ponderosa pine and black oak, with bearclover and patches of white leaf manzanita	**ponderosa pine-black oak/bearclover**
5	ridgetop	110	15	open black oak with scattered ponderosa pine, with bearclover and scattered grass	**ponderosa pine-black oak/bearclover**
6a	at the head of a draw, just below the ridge	107	34	bearclover with a clump of young ponderosa pine	**ponderosa pine-black oak/bearclover**
6b	at the head of a draw, just below the ridge	107	34	patch of black oak with dense, tall decadent deerbrush in the understory.	**black oak/deerbrush**
7	point of ridge above canyon	211	30	knobcone pine with dense whiteleaf manzanita. Heavy loading of jackstrawed dead knobcone pine logs.	**knobcone pine/chaparral**
8a	small sidelope on ridgetop above ephemeral draw	26	28	mature Douglas-fir with little understory	**moderate slope, mature Douglas-fir**
8b	small sidelope on ridgetop above ephemeral draw	13	34	open, mature Douglas-fir overstory with dense patch of Douglas-fir saplings	**moderate slope, mature Douglas-fir**
9	in ephemeral draw on the top of a ridge	289	3	Open Douglas-fir with bigleaf maple , black oak and grassy understory	**Douglas-fir- maple**
10	ridgetop at edge of canyon	2	48	young mature Douglas-fir with sparse understory	**moderate slope, mature Douglas-fir**
11	upper 1/3 of slope	222	53	mature black oak with some grass. Some cattle trampling that broke up continuity of black oak litter.	**black oak/litter**
12	on bench above ephermal draw, midslope	135	10	Douglas-fir old growth with scattered dogwood and understory herbs indicating moist soils (trail plant and false solomon's seal)	**old growth Douglas-fir-dogwood**
13	lower 1/3 of slope	211	62	open canyon live oak with scattered white leaf manzanita, sparse grass and regeneration of ponderosa pine and black oak	**canyon live oak**
14	ridgtop or upper 1/3 slope at edge of canyon. Adjacent to small draw	61	62	young mature Douglas-fir with scattered canyon live oak	**mature Douglas-fir, steep**
15	upper 1/3 of slope at edge of canyon	21	64	young mature Douglas-fir, one remnant sugar pine	**mature Douglas-fir, steep**
16	ridgtop or upper 1/3 slope at edge of canyon.	10	45	dense mature Douglas-fir with scattered black oak	**moderate slope, mature Douglas-fir**