A Fuel Treatment Reduces Potential Fire Severity and Increases Suppression Efficiency in a Sierran Mixed Conifer Forest

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Abstract—*Fuel treatments are being widely implemented on public and private lands across the western U.S. While scientists and managers have an understanding of how fuel treatments can modify potential fire behavior under modeled conditions, there is limited information on how treatments perform under real wildfire conditions in Sierran mixed conifer forests. The Bell Fire started on 9/22/2005 on the Plumas National Forest, CA. This fire burned upslope into a 1-year old, 390-acre mechanical fuel treatment on private land. Prior to impacting the fuel treatment, the main fire ignited spot fires 400 feet into the treated area. Within the treated area, loadings of 1, 10, and 100-hour fuels averaged 5.2 tons per acre. Stand density averaged 73 trees per acre, with a live crown base of 30 feet, and 36% canopy cover. This fuel treatment resulted in: 1) increased penetration of retardant to surface fuels, 2) improved visual contact between fire crews and the IC, 3) safe access to the main fire, and 4) quick suppression of spot fires. This treatment was relatively small and isolated from other fuel treatments but resulted decreased severity, suppression costs, and post fire rehabilitation needs leading to cost savings for local public and private land managers.*

Introduction

Fuel treatments are being widely implemented on public and private lands across the western United States (Stephens 2005). Over 11 million acres of hazardous fuel reduction and landscape restoration activities have been implemented since federal fiscal year 2000 (Healthy Forests Report 2005). The stated goals of these treatments are to: "1) Directly reduce wildfire threats to homes and communities that are adjacent to or within the wildland urban interface (WUI), 2) Treat areas outside of the wildland-urban interface (non-WUI) that are at greatest risk of catastrophic wildland fire. These high priority non-WUI treatments move towards restoring fire to its historical role and 3) Maintain previous treatments to ensure resiliency to catastrophic wildland fire and implement activities that are in line with other long-term management goals" (Healthy Forests Report 2005).

While scientists and managers have an understanding of how fuel treatments can modify potential fire behavior under modeled conditions (Stephens and Moghaddas 2005), there is limited information on how treatments perform under real wildfire conditions in Sierran mixed conifer forests (Fites and Henson 2004). Public land managers are often tasked with designing projects to meet "desired future conditions" for fuel treatments, though there is limited information on what these conditions should be across a broad range of site classes and forest types. While several fires have been documented by fire managers burning or spotting into recently established fuel treatments

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In: Andrews, Patricia L.; Butler, Bret W., comps. 2006. Fuels Management—How to Measure Success: Conference Proceedings. 28-30 March 2006; Portland, OR. Proceedings RMRS-P-41. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

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(Beckman 2001; Hood 1999), relatively few of these events are formally studied to determine the effects of the fuel treatment on fire behavior and severity in Sierran mixed conifer forests.

The purpose of this paper is to document one example of how a fuel treatment influenced fire behavior and enhanced suppression efficiency in a mixed conifer stand within the wildland urban interface. Secondly, this paper quantifies a stand structure which was functioned as an effective fuel treatment under the weather conditions described.

Methods

Study Site

The study area is on the Beckworth Ranger District of the Plumas National Forest, approximately 1 mile south of Highway 89 at Lee Summit. The treatment described was established on private timberlands owned by the Soper-Wheeler Company. The treatment unit is located within the 1.5 mile extended wildland urban interface of Spring Garden, a Community at Risk (Callenberger and Lunder 2006; PCFSC 2005). The parcel is bordered on two sides by untreated National Forest Land (Figure 1, Figure 2). The fuel treatment was established on the north side of a ridge, immediately above the Middle Fork of the Feather River Drainage. The dominant aspect of the treated area is north facing with an average slope of 11 percent. The area within the treatment is classified as a site class II (Dunning 1942). Data available from the timber harvest plan and associated inventory plots were used to establish pre-treatment stand conditions. Post treatment, three 1/10th acre fixed radius plot were established along a transect which ran through the area impacted by spot fires. These plots were measured within 2 months of the fire.

Treatment Prescription

The forest type is Sierran Mixed Conifer forest dominated by Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), incense cedar (*Calocedrus decurrens* [Torr.] Floren.), ponderosa pine (*Pinus ponderosa* Dough. Ex. Laws), sugar pine (*Pinus lambertiana* Dougl.), white fir (*Abies concolor* Gord. & Glend.), and California black oak (*Quercus kelloggii* Newb.) (table 3). Prior to treatment, stand basal area was 258 ft^2 per acre and tree density was 478 trees per acre. Stands were thinned in the summer of 2005 under a selection harvest (CDF 2003) using a leave tree mark. Biomass and sawlog material was removed mechanically using a whole tree harvest system. Sub-merchantable material and tops were chipped at the landing and hauled to a local mill. An average of 2,460 board feet and 8.6 bone dry tons of biomass per acre were removed from the project area (Violett 2005).

General Fire Information

The Bell fire was reported at 12:13 on September 22nd 2005 (Table 1). The fire was accidentally ignited by railroad activity along the tracks immediately downhill and below the project area (Figure 1). Relative humilities and peak wind speeds averaged 18 percent and 10 miles per hour, respectively, during the burning period between 12:00 to 16:00 (Table 2).

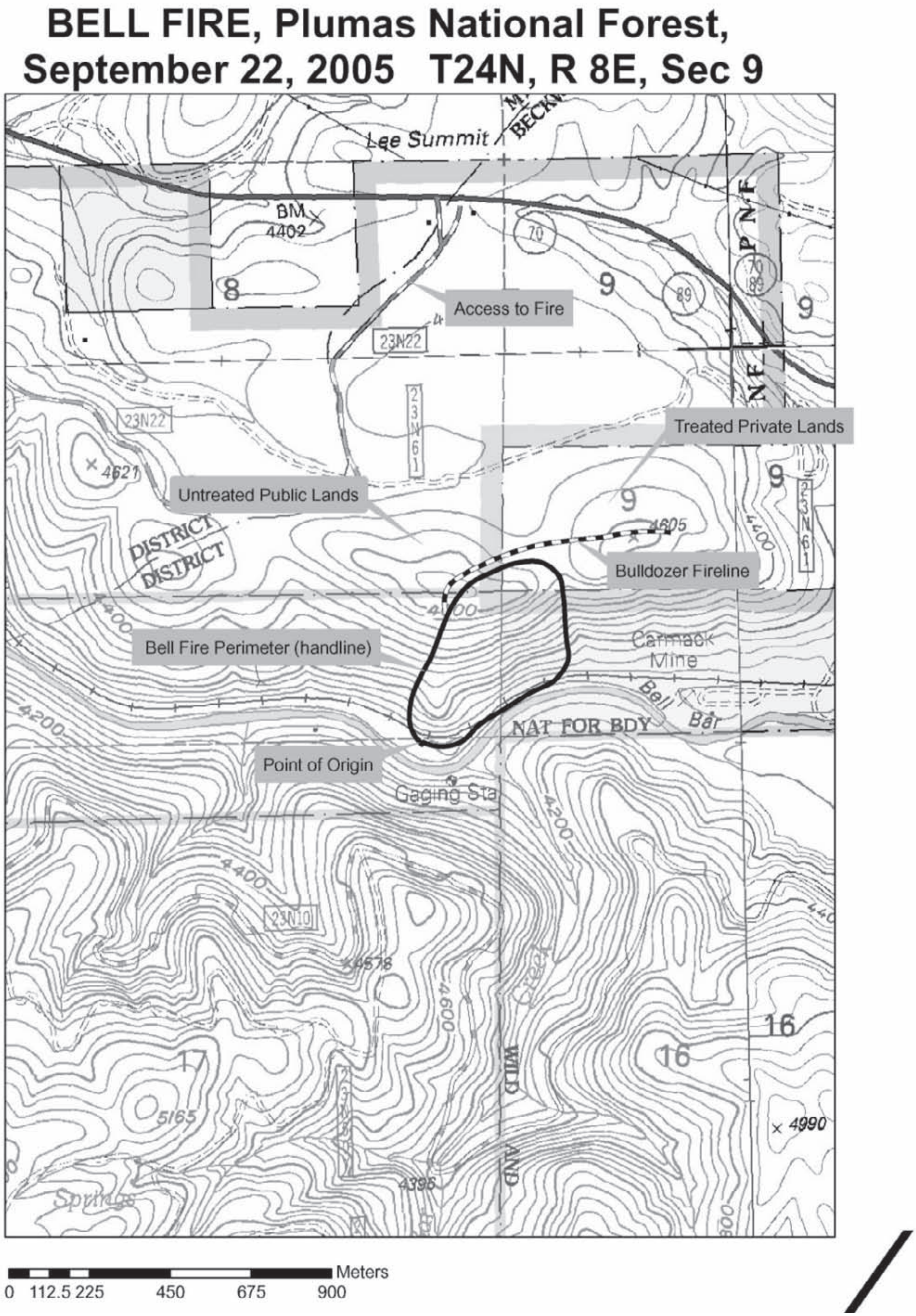

Figure 1—Location of treated area and fire perimeter

Figure 2—Treated stands (foreground) and untreated stands on public land (background). Property line follows edge of thinned area

Table 1—General fire information

Fire Name	Bell Fire
Location	Plumas National Forest, Beckworth Ranger District: T 24N, R 8E, Section 9
Elevation	4,125 ft to 4,605 ft
Burning Index on day of fire	61
Energy Release Component on day of fire	57
Report Date and Time	09/22/2005 at 12:13
Contain Date and Time	09/22/2005 at 19:00
Control Date	09/24/2005 at 18:00
Cause	Ignition from railroad activity
Final Size	35 acres

Table 2—Weather parameters during active burn period on 09/22/2005. Weather taken from Quincy remote access weather station (#40910).

Time	Relative Humidity	Dry Bulb Temperature	10-hour Fuel Moisture	Fuel Temperature	Peak Windspeed	Wind Direction
	Percent	*°F*	*Percent*	*°F*	*mi/hr*	*degrees*
12:00	25	74	8.9	74	6	260
13:00	18	85	8.7	103	6	144
14:00	15	86	8.0	101	14	224
15:00	14	85	7.5	98	13	243
16:00	17	82	7.2	93	17	267
17:00	21	79	7.1	81	12	256
18:00	23	75	7.0	78	11	256
19:00	31	67	7.0	63	7	259

Results

Post Treatment Stand Structure

Mechanical treatments resulted in a relatively open stand with vertical and horizontal separation of ladder and crown fuels (Figure 2). Treatments reduced the percent species composition of white fir (Table 3). Treatments raised the average height to crown base and reduced canopy cover, basal area, and overall stand density (Table 4). Though surface fuels were not treated, residual 1, 10 , and 100 hour fuels combined averaged 5.3 tons per acre (Table 5). Fuel depth average 1.4 inches (Table 5). There was no evidence of brush on the plots at the time of measurement.

Predicted and Actual Fire Behavior

The fire moved quickly up a steep hill from the point of origin to the ridgeline which was also the boundary of the fuel treatment. At the ridgeline, flame lengths from torching trees were observed as high as 30 feet above the tree canopy. Trees on the slope between the ridgeline and the point of origin generally had over 75% scorch. This level of scorch was observed on trees over 20 inches in diameter. From the point the fire impacted the fuel

Table 3—Percent species composition of conifers and hardwoods before and after treatment[a].

Species	Pretreatment	Post Treatment
	- - - - - - - - - *Percent*	- - - - - - - - -
Douglas-fir	21	41
Incense cedar	18	21
Ponderosa pine	19	20
Sugar pine	10	12
White fir	29	6
Black oak	2	na

[a]Note: pre and post treatment data collected within the same stand but from different plots

Table 4—Post treatment vegetation structure

	Live Trees	**Basal area per acre**	**Height to live crown base**	**Tree Height**	**Canopy Cover**	**Quadratic Mean Diameter**	**Stand Density Index**
	Trees per acre	*Ft^2/acre*	*- - - - - - -Feet*	*- - - - - - -*	*Percent*	*Inches*	
Post Treatment Average	73.3	103.3	30.1	72.5	36.3	15.6	130.3
Post Treatment Range	40 to 130	73.2 to 154.3	24.9 to 40.2	59.0 to 84.0	25 to 48	11.9 to 18.3	105.5 to 171.1

Table 5—Post treatment fuel characteristics

	Litter & Duff	**All 1, 10, and 100 hour fuels**	**1,000 hour sound**	**1,000 hour rotten**	**Fuel Depth**	**Cover of Brush**
	- - - - - - - - - - - - - - -	*Tons per acre*	*- - - - - - - - - - - - - - -*		*Inches*	*Percent*
Average	73	5.3	1.9	0.6	1.4	0
Range	19.5 to 110.5	1.3 to 8.3	0.9 to 2.8	0.0 to 0.9	0.5 to 2	0

treatment and approximately 200 feet into the fuel treatment, the level of scorch decreased. Similar patterns of scorch were observed in the Cone Fire at Blacks Mountain Experimental Forest (Skinner and others in press).

Up to four spot fires were ignited within the fuel treatment area. These fires ignited directly in activity fuels left after the harvest. Predicted flame lengths and mortality for these spot fires are shown in table 6. Observed flame lengths on these spot fires was less than 2 feet and there was little evidence of scorch on trees larger than 10 inches DBH.

The actions taken for suppression of the fire are based on discussions with on-scene personnel (Craggs 2006) and summarized here. Hand crews hiked into the base of the fire along the railroad tracks, anchored their fireline and continued constructing line up the east and west fire flanks. The Incident Commander (IC) and two bulldozer transports could access the main fire from Highway 89, along a dirt road, and directly through the treated area. From this point, the IC could also easily locate established spot fires. Due to relatively low rates of spread and flame lengths, the decision was made to line spot fires using the bulldozer. After lining the spot fires, the bulldozers then cut a line between the approaching fire front, the untreated USFS land, and the treated private property. The dozer line between the main fire and untreated USFS land was completed prior to the main fire reaching the ridge. When the fire reached the main ridge and the fuel treatment, torching stopped though direct scorch still occurred within the first 200 feet of the treatment. Finally a water tender and "pumpkin" were brought forward into the treated area and used in conjunction with engines to extinguish and mop up the spot fires. Mop up continued the next day.

Table 6—Predicted fire behavior and mortality

	Flame Length	Torching Index	Crowning Index	Predicted Mortality Trees 1 to 10 inches	Predicted Mortality Trees 10 to 20 inches	Predicted Mortality Trees 20 to 30 inches
	Feet	*- - - Miles Per Hour- - -*		*- - - - - - - - - - - DBH - - - - - - - - - - - -*		
Predicted	3.2	>40	>40	60	14	5

During the active suppression period, aerial retardant was being delivered to the area between the main fire and both the private treated area and the untreated US Forest Service property. Based on visual observations, substantially more retardant reached surface fuels in the treated area than on the untreated USFS lands. Within untreated areas, retardant was evident on upper foliage of dominant and co-dominant trees where it would not help slow the spread of surface fire.

Discussion

The treatments utilized principles of fuel reduction including thinning from below and use of whole tree harvest (Skinner and Agee 2005). While no further treatment of activity fuels generated by the harvest were completed, residual, post treatment fuel loads and arrangement resulted in observed flame lengths in spot fires was less than 2 feet. These low flame lengths in conjunction with relatively high crown base heights resulted in limited observed scorch in spot fire areas at the time of measurement. Spot fires were easily lined and allowed to burn out while suppression resources were concentrated on the main fire flanks.

In terms of suppression tactics, the treated area established a safe access point which could be use to move equipment and other resources towards the head of the main fire. Had this area not been in place, crews would have likely had to hike in an additional ¼ to ½ mile. This would have resulted in the use of indirect suppression methods, leading to increased suppression intensity than the direct control methods utilized. The relative openness of the stand allowed the Incident Commander (IC) to maintain visual contact with equipment and personnel. In addition, greater penetration and coverage of aerial retardant to surface fuels was observed in the treated areas adjacent to un-treated areas. In untreated areas, retardant primarily ended up in the upper tree crowns were it was less effective at containing and reducing surface fire spread. The overall results of this treatment were decreased suppression intensity and increased suppression effectiveness. This in turn resulted in decreased damage to the stand due to suppression activities and direct scorch. In turn, these factors decreased the relative total cost of suppression and follow up rehabilitation.

Conclusion

It is important to emphasize that fuel treatments are not designed to stop all fires the purpose of this work is not to make this assertion. Fuel treatments are typically designed decrease flame lengths, fire spread, and ideally, reduce landscape level fire severity (Stratton 2004; Finney 2001). Often, they are to be used in conjunction with suppression resources (Agee and others 2000). This is an important point to bring out when communicating the potential effectiveness of fuel treatments with the public. Not all fuel treatments will work all the time in all vegetation types or weather conditions. Breaking up vertical and horizontal continuity of live and dead fuels in this particular case reduced passive crown fire within treated areas. Decreased flame lengths and visual contact in treated areas allowed more direct suppression methods to be employed. It is difficult to say how big the fire would have been without treatments in place or if in indirect methods were used but based on discussions with personnel on-scene, suppression intensity and cost were decreased by these treatments. If the fire had become established in the un-treated areas, suppression intensity, cost, and follow up rehabilitation would have likely been higher.

Fire managers should be able to easily document their direct experiences with fire behavior within established fuel breaks. Fire fighters are often the only ones to witness “real time” fire behavior within fuel treatments- their direct observations and experiences are critical in determining when fuel treatments work and don’t work, and how they can be modified to be more effective in the future. This is imperative considering the limited funds available for establishing fuel treatments in comparison to the number of acres that need treatment. If documented and available for public access, these observations may inform the research community of sites for possible future studies of fire behavior as well as inform and refine current hypothesis used for these studies. This information will help provide the necessary feedback for changing and improving practices through adaptive management.

Acknowledgments

Thanks to Paul Violett and the Soper-Wheeler Company for allowing access to their land and records for this study. Special thanks to Larry Craggs, Fire Management Officer, and Ryan Southwick, Dozer 2 Operator both from the Mount Hough Ranger District on the Plumas National Forest. Their eyewitness experiences on this fire were essential in conveying the story of what happened as seen by the folks who were there as it burned.

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