2017 Schaeffer Fire
Sequoia National Forest
An Assessment of Fuels and Fire Behavior

July 24, 2017

Prepared by:

Fire Behavior Assessment Team (FBAT)

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Acknowledgements: We thank the people who dedicate their energy and careers to land and fire management with the Forest Service and other agencies. The firefighters FBAT has had the opportunity to work with on this assignment and others, not only inspire us to continue navigating the difficulties inherent to keeping FBAT operational, but also give us hope that our land management agencies and fire organizations will continue to improve and provide high quality land and fire management into the future.

We thank the CA Central Coast Incident Management Team for supporting FBAT logistically and allowing us to accomplish monitoring work on this fire. We thank the Division Supervisors and other resources we worked with for working with us to access portions of the fire safely. We thank the Sequoia National Forest and Kern River Ranger District, for welcoming FBAT to their unit. A final thanks is to all members and supporters of FBAT, current and past, who have made this program, and the learning which comes from it, possible.

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Introduction

The Schaeffer Fire was first detected during the afternoon of June 24, 2017, at 2.2 miles N/NW of Schaeffer Mountain on the Kern River Ranger District, Sequoia National Forest (Figure 1). This lightning-caused fire started after a winter of very heavy snowpack, and a dry and warm June. Temperatures in the two weeks preceding the fire were much above normal – 15-20 degrees Fahrenheit above normal in the third week of June.

An important feature of this fire is the effect of three (at least partial) stand replacing fires since the mid-1970s: the Flat Fire (1975), Bonita Fire (1977), and the McNally Fire (2002). The McNally Fire was much larger than the Flat or Bonita Fires, and in fact included a reburn of some areas burned by the 1970s fires. The McNally Fire consumed much of the standing and downed dead trees within these older fire footprints (Figure 2).

Post-fire salvage logging and reforestation work has also affected the fuel profile of the Schaeffer Fire area; the past fires resulted in areas of high loadings of dead, standing and downed trees left by the McNally Fire, as well as shrub fields with much less dead woody fuel after being burned both in the 1970s and in 2002.

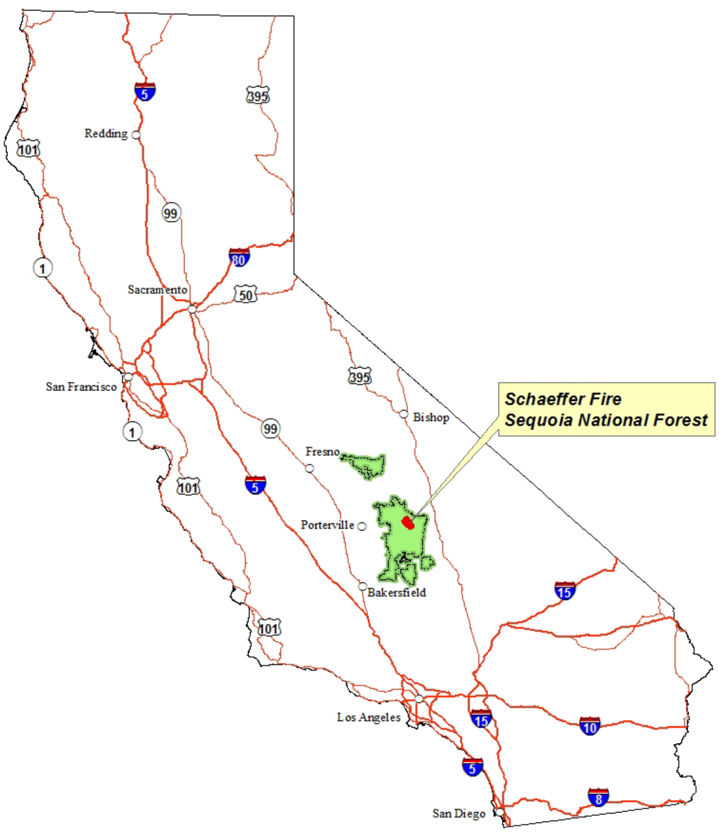

Figure 1. Vicinity map of Schaeffer Fire.

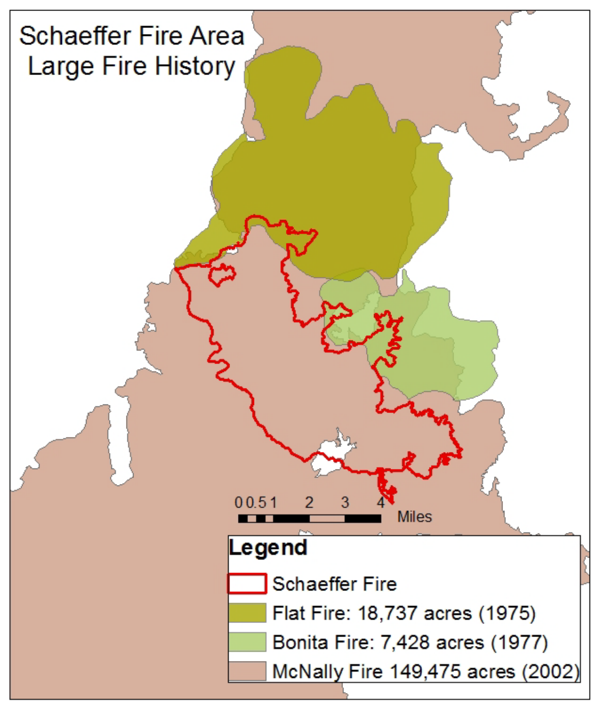

Figure 2. Large Fires which the Schaffer Fire overlapped.

The initial response on the Schaeffer fire was a confine/contain strategy, keeping the fire contained within a system of roads, trails, and ridgeline. This strategy was selected to utilize existing roads/trails, minimizing impacts to resources, costs, and exposure to crews from the snag patches covering much of the more remote areas of the fire. Within 3 days, the fire grew to approximately 600 acres. On June 29, the decision was made to insert hand crews on western portion of the fire due to containment trails not being adequate should fire activity increase. Estimated size of fire that evening was over 1,000 acres. On June 30th, the fire grew to 1,467 acres, and the smoke column was much smaller than previous day.

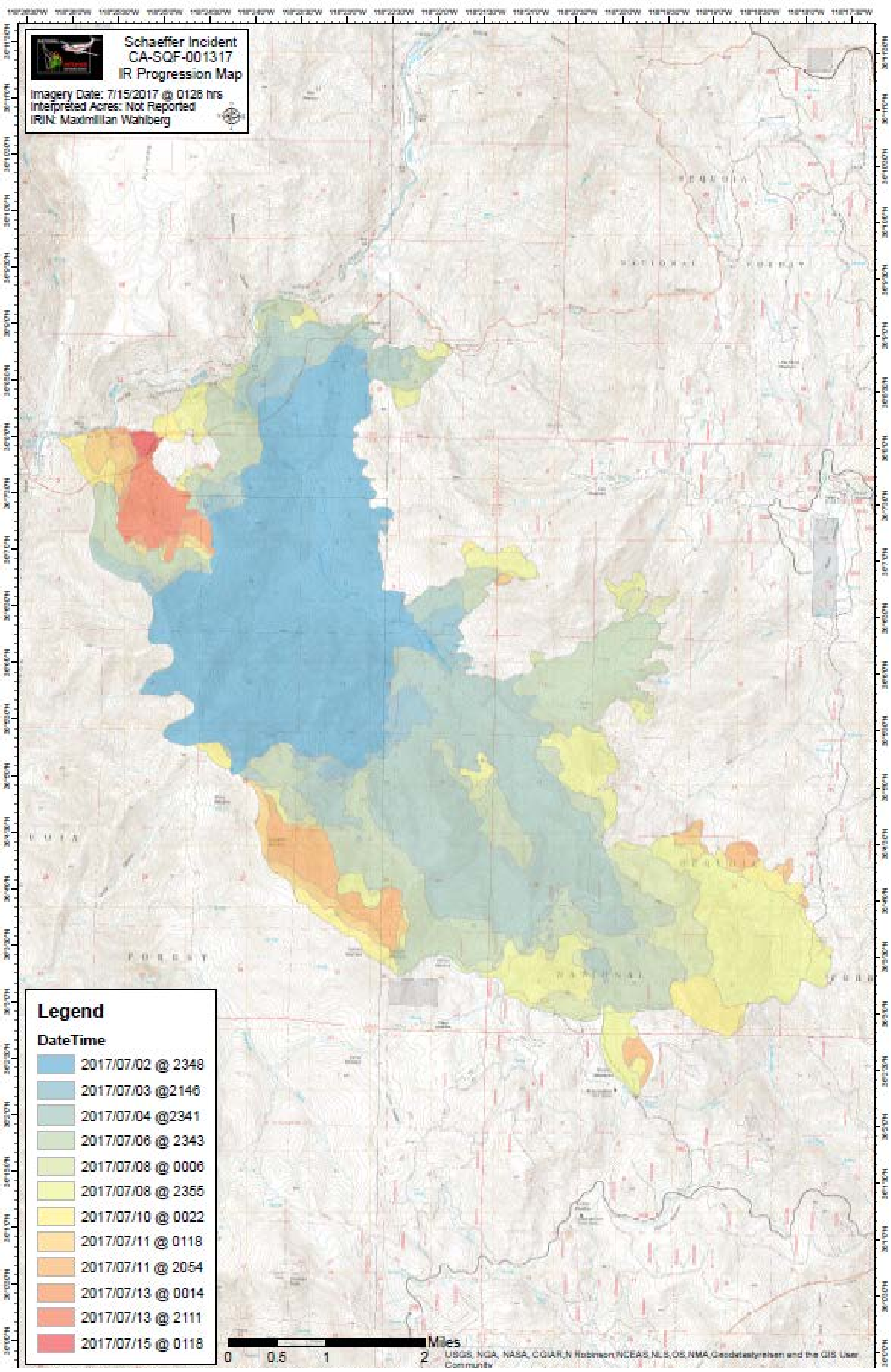

Figure 3. Progression of the Schaeffer Fire

On July 1, the fire made significant runs across Rattlesnake drainage growing to just under 4,000 acres.

On July 2, with the high probability of a long duration incident and challenging terrain, a Type 2 team was ordered to assist the Forest in managing the incident. About this point in time, the incident response evolved from a confine/contain strategy to a more direct, aggressive strategy with crews and aviation resources using direct and indirect suppression tactics. On July 4, the fire saw significant growth with majority of fire activity towards the SE of fire, totaling 8,400 acres. On July 5, fire activity was less than the previous burning period, with precipitation beginning around 1600. From July 6th -9th, moderate fire activity was observed, however smoke in nearby communities continued to be challenging. Precipitation as well as high RH continue to aid suppression actions. From July 10th -12th, the fire experienced low fire activity. Smoke concerns in surrounding communities started to decrease. The perimeter was approximately 16,031 acres on July 19th, with a containment at 94% (Figure 3).

The McNally Fire greatly affected the fuels in which the Schaeffer Fire burned. The McNally Fire burned over 150,700 acres, with over 73,000 of those acres falling into moderate to high fire severity categories (Figure 4). The higher severity area from the McNally Fire which fell inside the Schaeffer Fire was previously mostly tree-shaded area. After burning in the McNally Fire, high and moderate severity areas and lower elevations became shrub-dominated (e.g., manzanita, whitethorn, and chinquapin). Only small patches have regenerated with trees, mostly due to replanting efforts. Many areas at higher elevations remain more forested, with only subtle vegetation changes. The overstory areas remaining in the lower severity areas are populated with species such as Jeffrey pine, white fir, and red fir. The historic fire return interval of Jeffrey pine is 9-12 years. White fir is a common associate, which can be become codominant in the absence of fire. The upper elevations are populated with red fir, which are fairly fire tolerant and have a historic fire return interval of 10-65 years (FEIS).

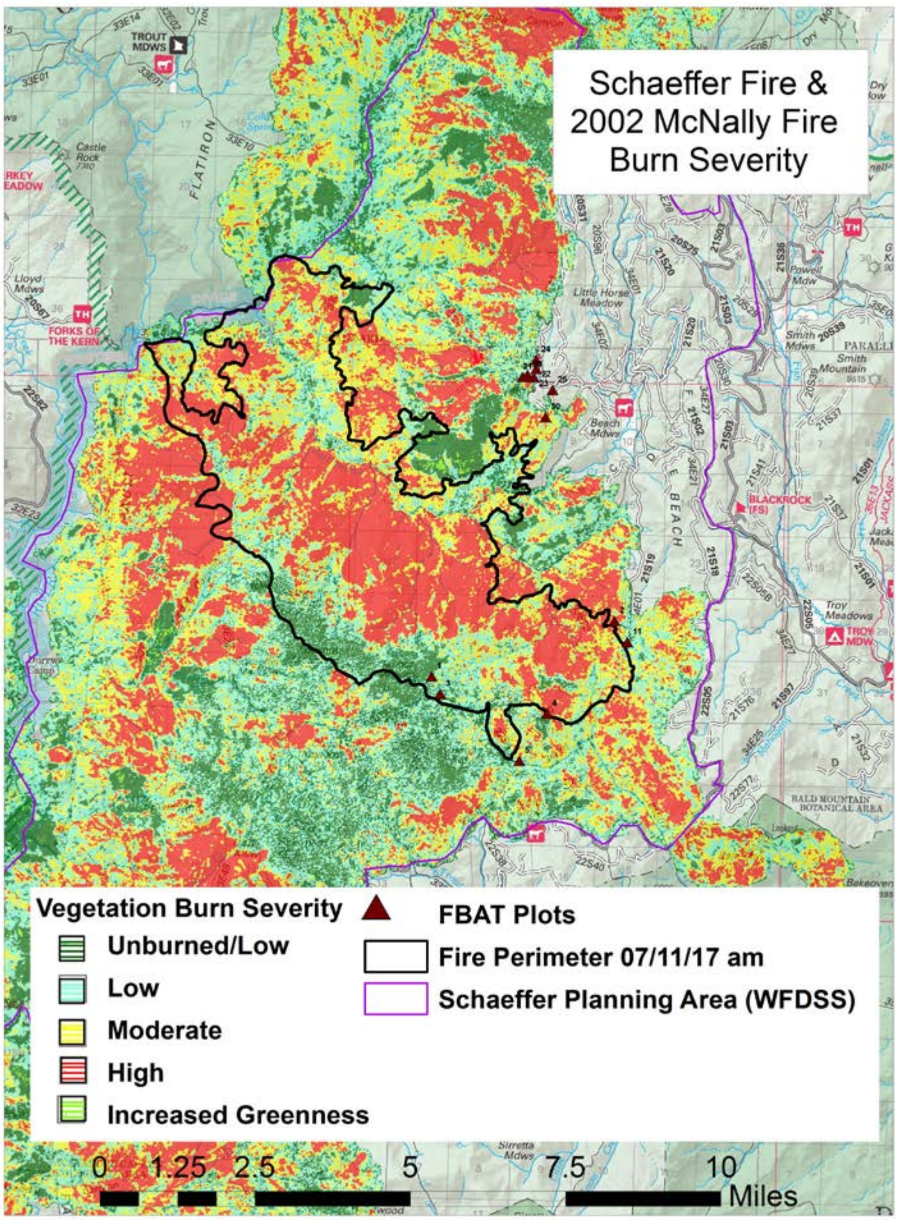

Figure 4. McNally burn severity map with Schaeffer perimeter and FBAT plots. Burn severity data is from Monitoring Trends in Burn Severity (http://www.mtbs.gov/documents_references.html).

Decades of fire suppression have given rise to ecosystems with heavy fuel accumulations which have contributed to uncharacteristically large, severe wildfires on our National Forests.

One of the largest concerns is emissions from wildfires, which are largely uncontrollable.

In the late 1800s and early 1900s, the Forest Service came out with multiple policies that favored suppression of all wildfires. However, by reducing the amount of fire that forests usually experience, change began to occur in many forest types across the western U.S. Tree stands became denser, which led to stands which being over-crowded. When trees grow too close together, they compete for water, light and space and can become weakened, and are more easily killed by insects and disease. The Southern Sierra Nevada are currently experiencing large amounts of tree die-off, which are due partly to overly crowded forests. This condition is partly the result of having less fire on the landscape. Overly dense stands with high amounts of fuels easily leads to fires which burn much more intensely. Additionally, dead trees are a hazard to firefighters

Part of the solution to overly dense stands prone to die-off, uncharacteristically large, severe wildfires and associated large smoke events is to use fire as a tool to reduce fuels, reduce future large smoke impacts and increase forest resiliency against fire and disease. Fire is an integral part of California's ecosystem processes and is as much a part of the environment as precipitation, flooding, predation, herbivory and nutrient cycling (Sugihara et al. 2006). Sugihara et al. 2006 also state that fire maintains a mosaic of different vegetation, and ***reduces fuel accumulations***. Decades of fire suppression have played a role in increasing fuel accumulations which have contributed to uncharacteristically large, severe wildfires on our National Forests. One of the larger concerns about these fires is smoke, which is largely uncontrollable. Wildfires tend to be larger in scale than prescribed fires, and have greater air quality impacts. Wildfires may occur during times of unfavorable atmospheric conditions compounding this impact. However, the long-term benefits of wildfires are reduction in fuels, and potentially increased forest resilience.

Part of the solution to overly dense stands prone to die-off, uncharacteristically large, severe wildfires and associated large smoke events, is to use fire as a tool to reduce fuels, reduce future large smoke impacts and increase forest resiliency against fire and disease.

Smoke, an integral part of wildland fires, and can negatively affect some portions of the population. When population centers are located in airsheds with wildlands that are susceptible to wildfire, we should expect that smoke will be a regular occurrence. Some public health experts have suggested that indoor portable air cleaners could be used as a public health response to smoke events. The smoke from the Schaeffer fire never reached 'hazardous' levels. Unhealthy levels were only reached in some locations for a matter of hours, generally in the mornings before inversions lifted. The smoke production from the Schaeffer Fire would have been higher had the McNally fire not burned because McNally Fire consumed a large quantity of fuel. Overall fuel loadings in the McNally fire area are lower as compared to areas which have not seen fire in over 30 years. The levels of smoke on the Schaeffer Fire showcase how landscape fuels reduction through fire can lower smoke emissions of wildfires.

One of the goals in the USFS PSW Region Ecological Restoration's Leadership Intent is to "increase forest resilience through treatments (including prescribed fire and thinning) and wildfire, resulting in resource benefits to approximately 9 million acres on national forest system lands" (Forest Service 2011). Despite a real need to restore and maintain forest ecosystems using fire as a tool, land and fire managers must balance somewhat conflicting wildland fire objectives including costs, risk to firefighters, infrastructure and communities as well as anticipated smoke impacts.

Figure 5. Fire burning with low intensity in the Schaeffer fire near trees charred by the 2002 McNally fire which lowered surface fuels.

While balancing these multiple objectives, how do we continue to return fire as an ecosystem process? This is a difficult question given the many important factors land and fire managers must address such as limiting firefighter risk, reducing impacts to communities and infrastructure, and keeping costs down. In the Forest Service, we are also surrounded by a historic culture as an agency to puts fires out. We pride ourselves in a job well done, and since the early 1900s we have viewed firefighter's job is to put fires out quickly. Utilizing fires to create fire resilient ecosystems will at times include resource benefit objectives so that large areas are treated to reduce fuels, and therefore, future smoke impacts. This change will not be 'business as usual' and will involve patience and different tactics than are commonly used.

Approach and Methods

FBAT selects study sites to represent a variety of fire behavior and vegetation/fuel conditions. Plot selection priorities are also based on safe access and areas that would most likely be burned over within the timeframe that FBAT can be at the incident. Thirteen plots were installed on the Schaeffer fire within Divisions Q, R, and H (Figure 6). For each plot, pre- and post-vegetation and fuel measurements were recorded by measuring dead fuels, understory vegetation structure and loading, and overstory vegetation structure and crown fuels. Detailed field methods are located at the end of this report (Appendix A).

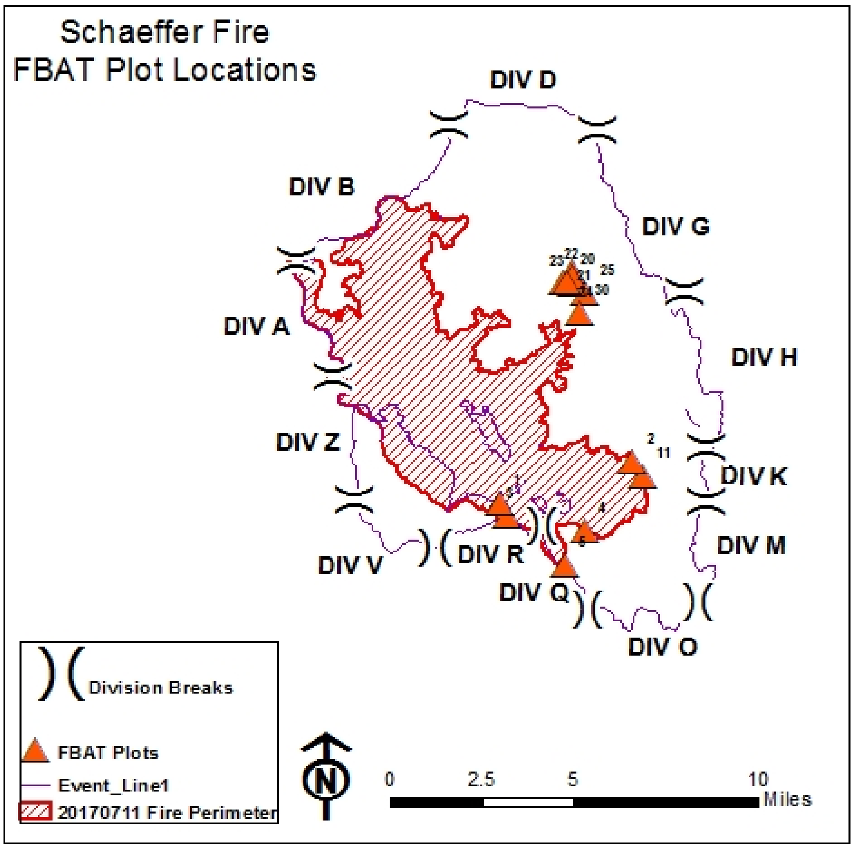

Figure 6. Map of Divisions and FBAT Plot locations.

Results

Fuels

Pre-fire data were collected at 13 plots, with the help of the Sequoia and Summit Wildland Fire Modules. One plot burned and post-fire fuels were reassessed at this plot. The 13 plots represented different severity levels of the McNally Fire.

Total fuel loadings (including duff, litter, downed woody fuels and live herb, grass and shrub fuels) found in plots ranged from 4 to 99 tons/acre. Some of the *highest* litter and duff fuel loadings were in the plots which were located just *outside* the McNally Fire (Table 1). The two plots which were located in *high severity areas* of the McNally Fire had some of the **lowest** litter and duff loadings. Areas of the McNally fire which burned with low to moderate severity levels had a variety of litter and duff loadings. Given the variability in the litter and duff loadings, it is hard to discern any definite trends in litter and duff loadings. The plot with the highest shrub loading (e.g., manzanita) was outside of the McNally fire area.

Canopy base height, canopy bulk density, and canopy continuity are key characteristics of forest structure that affect the initiation and propagation of crown fire (Albini 1976, Rothermel 1991). Canopy base height (CBH), or the bottom of the tree canopy fuels, is important because it affects crown fire initiation. As stated in Scott and Reinhardt (2001), "Defined in terms of its consequences to crown fire initiation, CBH is the *lowest* height above the ground at which there is sufficient canopy fuel to propagate fire vertically through the canopy." Canopy Bulk Density (CBD) is the mass of canopy fuel available per unit canopy volume (Scott and Reinhardt 2001). CBD for the plots ranged from 0.009 kg/m^3 (no trees measured over 6 inches DBH) to 0.226 kg/m^3 (where there was 34 trees/acre (all over 6 inch DBH). Trees per acre ranged from 6 (low-moderate McNally fire severity area) to 270 (outside the McNally fire footprint). Additional tree characteristics calculated by FVS-FFE are in Appendix C.

Table 1. Stand characteristics and fuel loadings, McNally burn severity, slope and aspect for plots*.

Plot	McNally Burn Severity	Slope (%)	Aspect (deg.)	Canopy Bulk Density (kg/m³)	Trees per acre	Live Fuels (t/a)	1, 10 & 100-hour fuels (t/a)	1000-hour fuels (t/a)	Litter and Duff (t/a)	Total Fuels (t/a)
1	low	15	335	**	**	0.51	5.5	38.1	13.9	58.0
2	high	25	294	0	0	2.91	1.3	14.2	3.6	22.0
3	low/mod	5	350	**	**	0.04	0.8	21.4	6.0	28.2
4	mod/high	20	45	0.009	73	0.46	4.6	4.2	1.0	10.3
5	mod	40	190	0.045	24	0.79	0.4	25.1	11.8	38.1
11	mod-high	5	70	0.050	29	0.16	3.6	8.2	13.3	25.3
20	low-mod	15	15	0.226	34	0.01	3.0	0	5.1	8.1
21	low-mod	40	80	0.028	6	0.68	0.6	1.5	1.0	3.8
22	outside	10	109	0.061	121	0.03	2.2	1.2	20.9	24.3
23	outside	40	195	0.141	52	0.18	0.3	1.5	5.9	7.9
24	outside	5	18	0.311	270	0.58	0.5	10.9	18.1	30.1
25	outside	5	200	0.062	12	22.96	2.7	19.0	54.2	98.9
30[1]	high	5	230	N/A	N/A	0.81	2.1	12.6	1.4	16.9

* Note: plots are not numbered consecutively. Live fuels are grasses, herbs and shrubs. Total fuels is the sum of live fuels, 1-, 10-, 100-, and 1000-hour fuels, litter and duff.
**No tree data was collected on these plots.
[1] Plot 30 trees were "candle" snags (short, dead trees with tops broken off). FVS does not calculate tree metrics for dead trees.

Fuel Moistures

Foliage moisture was measured on four occasions at three locations: Alder Creek (at intersection of Sherman Pass Rd., 5 July (*Ceanothus* and *Arctostaphylos);* knoll at west end of Lion Meadows Rd. July 5 and 11 (*Ceanothus* and *Arctostaphylos);* and Danner Meadow July 7: (*Ceanothus*, A*rctostaphylos*, and *Chrysolepis)* (Appendix B: Fuel Moistures). Moistures were generally 100 to 150. The live fuel moistures which were lower than 100 were manzanita and old growth (leaves older than 1 year) chinquapin leaves. The new growth (this year's leaves) had higher moistures. These live fuel moistures are fairly typical for this elevation for this time of year, and the live shrub fuels did not readily burn in the fire unless wind, slope and other fuels aided combustion.

Figure 7. Plot 3 burned with mainly moderate severity with unburned patches interspersed

Burn Severity

Due in part to the fact that the fire was controlled at a smaller size than originally anticipated, most plots did not burn. The one plot which did burn showed moderate to low severity, meaning that damage from the fire was low/moderate (Figure 7). The fire burned very near some plots, but went out before reaching them, evidence of the fact that the burn was patchy in places, leaving some areas unburned. Patchiness in a fire can be beneficial ecologically, leaving a mosaic pattern for wildlife habitat and trees and other vegetation to serve as seed sources for burned areas.

Fire Behavior and Weather Observations

This season, in order to collect more data points than is possible with fully measured and instrumented plots, FBAT began to obtain observational data on weather, fuels and fire behavior as well. In the observational data, as wind gusts increased, flame length increased as well (Figure 8). FBAT was not able to gather as much rate of spread data as flame length data because observers were often not in the immediate vicinity of the fire, where slower rates of spread are more readily documented.

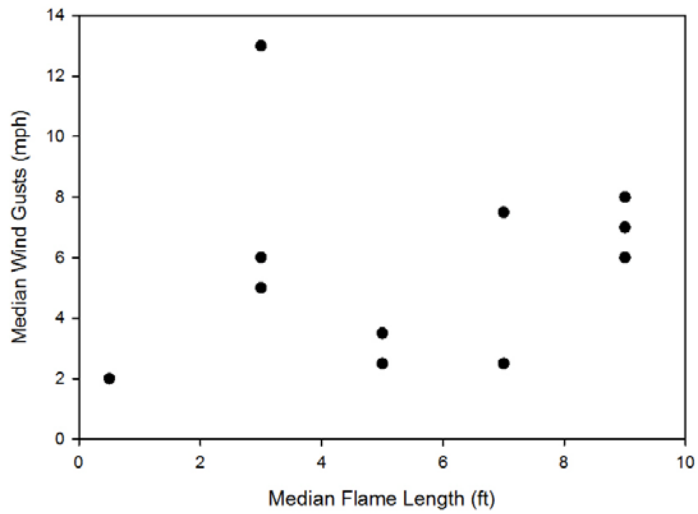

Figure 8. Graph of median flame length (feet) versus median wind gusts (miles per hour)

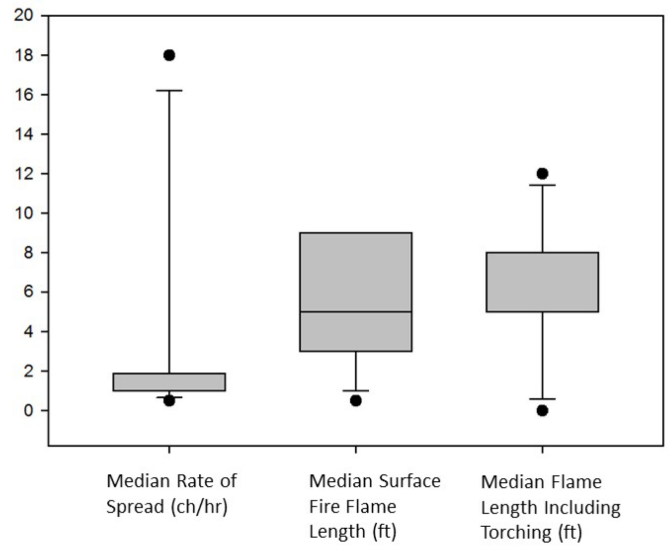

Figure 9. Boxplots of median rate of spread (ch/hr), median surface fire flame length and flame length including the length of trees torching (feet).

In general, most fire behavior was relatively mild on the Schaeffer fire, except a few intense uphill runs on days when the weather was hotter and dryer and when thunderstorms were in the area. Thunderstorms can produce gusty and erratic winds as they develop and dissipate, fanning the fire in sometimes unpredictable directions. Rates of spread documented by FBAT on the Schaeffer Fire were between 0 and 18 chains/hour (1 chain = 66 feet), with most rates of spread between 1 and 2 chains per hour (Figure 9). Surface fire flame lengths documented by FBAT were between 0 and 9 feet, and only approached 13 feet when tree crown fuels were involved (torching). Timelapse video taken by FBAT during the Schaeffer Fire can be viewed here: https://www.fs.fed.us/adaptivemanagement/amset_videos.php

Summary

The Schaeffer fire, which burned within the 2002 McNally Fire generally had lower fuels, fire behavior and smoke production than we would have expected from a fire burning in an area which hadn't seen fire within the past two decades. FBAT data on the Schaeffer fire showed lower fuels inside the McNally fire than the few plots which fell outside the McNally. The levels of smoke on the Schaeffer Fire showcased how landscape fuels reduction through fire can lower smoke emissions of wildfires. Smoke levels never attained hazardous levels and only spiked into unhealthy ranges for portions of several days. Politically and culturally accepting fire as a tool to reduce fuels, future smoke impacts and to create resilient forests will allow us to foster resilient, healthy ecosystems and communities.

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Appendix A: Vegetation and Fuel Measurements

Vegetation and fuels were inventoried both before the fire reached each plot, and then again after the fire passed by and cooled at burnt plots. Most plots within decent day hike access were marked with rebar to provide options for long term monitoring.

Overstory Vegetation Structure and Crown Fuels

Variable radius sub-plots were used to characterize crown fuels and overstory vegetation structure. A relaskop (slope-correcting tree prism) was used to create nested plots for both pole (>1 to 5.9 in diameter at breast height (DBH)) and overstory (>6 in DBH) trees. A basal area prism factor was selected to best include a target of between 8 and 12 trees for each size classification (if the site contained multiple size classes). Tree species, status (alive or dead), DBH, height, canopy base height, and crown classification (dominant, co-dominant, intermediate or suppressed), and injury/damage codes were collected for each tree before the fire. Tree height measurements were completed with a laser rangefinder; DBH was measured with a diameter tape.

Post-fire bole char, crown scorch and torch heights and percentages were recorded for each tree. Trees were assumed to be alive if any green needles were present. Changes in canopy base height were estimated from heights of scorch and torch on tree branches, or if necessary from percent of scorch rather than the maximum heights because uneven scorch values occurred at times.

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

Understory Vegetation Structure and Loading

Understory vegetation was measured in a one meter wide belt along three 50-foot transects before and after the fire. Species, average height and percent cover (based on an ocular estimation) were recorded for all understory shrubs, grasses and herbaceous plants. Biomass of live woody fuels (shrubs and seedlings) and live herbaceous fuels (grasses, herbs, subshrubs) were estimated using coefficients developed for the Behave Fuel Subsystem (Burgan and Rothermel 1984), but calculations were done on a spreadsheet (Scott 2005).

Surface and Ground Fuel Loading

Surface and ground fuels were measured along the same three 50-foot transects as the understory vegetation at each plot. Surface fuel loadings (litter, 1-hr, 10-hr, 100-hr and 1000-hr time lag fuel classes and fuel height) were measured using the line intercept method (Brown 1974, Van Wagner 1968). One and 10-hr fuels were tallied from 0 to 6 ft, 100-hr from 0 to 12 ft and 1000-hr from 0 to 50 ft. Maximum fuel height was recorded in 6 ft intervals from 0 to 6 ft, 6 to 12 ft and 12 to 18 ft. Litter and duff depths were measured at 1 and 6 ft. All measurements were taken both pre- and post-fire. The measurements were used to calculate surface and ground fuel loading with basal area weighted species specific coefficients (van Wagtendonk *et al.* 1996; 1998); and ultimately percent fuel consumption.

Appendix B: Fuel Moistures Collected on the Schaeffer Fire

Date	Location	Sample Type	Fuel Moisture
7/5/2017	Lion Meadows*	Greenleaf manzanita, branch tips & leaves	105
7/5/2017	Lion Meadows	Greenleaf manzanita leaves only	99
7/5/2017	Lion Meadows	Greenleaf manzanita leaves only	103
7/5/2017	Lion Meadows	whitethorn, branch tips & leaves	132
7/5/2017	Lion Meadows	whitethorn leaves only	139
7/5/2017	Lion Meadows	whitethorn leaves only	148
7/5/2017	Lion Meadows	whitethorn, branch tips & leaves	140
7/5/2017	Alder Creek*	Greenleaf manzanita, branch tips & leaves	162
7/5/2017	Alder Creek	Greenleaf manzanita, branch tips & leaves	135
7/5/2017	Alder Creek	Greenleaf manzanita, branch tips & leaves	152
7/5/2017	Alder Creek	whitethorn, branch tips & leaves	171
7/5/2017	Alder Creek	whitethorn, branch tips & leaves	162
7/5/2017	Alder Creek	whitethorn, branch tips & leaves	155
7/8/2017	Danner Meadow	Manzanita, new growth	124
7/8/2017	Danner Meadow	Manzanita, new growth	147
7/8/2017	Danner Meadow	Manzanita, old growth	111
7/8/2017	Danner Meadow	whitethorn old growth	138
7/8/2017	Danner Meadow	whitethorn new growth	149
7/8/2017	Danner Meadow	whitethorn new growth	134
7/8/2017	Danner Meadow	chinquapin old growth	77
7/8/2017	Danner Meadow	chinquapin new growth	206
7/8/2017	Danner Meadow	chinquapin old growth	80
7/11/2017	Lion Meadows*	manzanita leaves	125
7/11/2017	Lion Meadows	manzanita twigs & leaves	134
7/11/2017	Lion Meadows	whitethorn leaves	136
7/11/2017	Lion Meadows	whitethorn twigs & leaves	164
7/11/2017	Lion Meadows	whitethorn twigs & leaves	164
7/11/2017	Lion Meadows	manzanita twig &leaves	146

*Lion Meadows was at the knoll off the west end of Lion Meadows Rd.
*Alder Creek was where the creek intercepted Sherman Pass Rd.

Appendix C: Plot tree data outputs

Table AC: Pre- and post-fire overstory vegetation and crown fuel data by plot estimated by FVS-FFE (Western Sierra variant). QMD is the quadratic mean diameter based on tree data collected at the plot scale.

Plot	Overstory (>6 in DBH) trees/acre	Pole-size (<6 in DBH) trees/acre	QMD (in)	Basal Area (ft^2/acre)	Canopy Cover (%) (FVS calculated)	Canopy Height (ft)	Canopy Base Height (ft)	CBD (kg/m^3)
4	0	73	5	10	5	43	9	0.009
5	24	0	32	137	30	42	14	0.045
11	29	0	19	58	19	34	9	0.050
20	34	0	33	204	31	21	3	0.226
21	6	0	41	55	14	25	3	0.028
22	46	75	9	49	19	18	2	0.061
23	52	0	22	141	42	20	4	0.141
24	59	211	10	142	38	10	1	0.311
25	12	0	29	55	7	23	4	0.062
30*	n/a	0	n/a	n/a	0	n/a	n/a	0

* Plot 30 trees were “candle” looking snags (short, dead trees with tops broken off), and FVS doesn’t calculate tree metrics for dead trees.

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

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

FBAT is a team focused on the collection of fuels and active fire behavior data on wildland fire incidents. FBAT functions in collaboration with land managers and interested research groups. In coordination with incident management, sites are placed opportunistically ahead of the fire accounting for current and expected fire behavior, safe access, and fire management tactics. The FBAT team is made up of members who train with FBAT in the spring, and are called as needed when fires occur. FBAT has started to work with Wildland Fire Modules which train on FBAT methods as well, and are ordered to fires to help with FBAT data collection and equipment. FBAT has no based funding, but is funded intermittently by units which benefit from FBAT data and products.

Since 2003, The FBAT program has built a rich dataset and library of products for fire and fuels managers; fire training and safety; and fuel, fire, and smoke scientific communities. FBAT video has been utilized by the Wildland Firefighter Apprenticeship Program and USFS PSW ecological restoration video series; and FBAT data and program information were shared with the **JFSP crown fire behavior knowledge synthesis project** (p. 41) and a **PSW Research Station project** that estimated carbon stocks and emissions in CA and evaluated FOFEM.

We can be ordered through ROSS to wildland fire incidents. Please contact Alicia Reiner at 530-559-4860 or Carol Ewell at 209-283-4563. The FBAT web page has links to most FBAT Incident Summary Reports: https://www.fs.fed.us/adaptivemanagement/projects_main_fbat.php