Effectiveness and longevity of fuel treatments in coniferous forests across California

Managers' Report: Inyo National Forest

Prepared by

Nicole Vaillant, Fire Ecologist, nvaillant@fs.fed.us, USDA Forest Service,
Western Wildland Environmental Threat Assessment Center

Erin Noonan-Wright, Fire Application Specialist, enoonan02@fs.fed.us, USDA Forest Service,
Wildland Fire Management Research Development and Applications

Scott Dailey, Fire Ecologist, scottdailey@fs.fed.us, USDA Forest Service,
Adaptive Management Services Enterprise Team

Carol Ewell, Fire Ecologist, cewell@fs.fed.us, USDA Forest Service,
Adaptive Management Services Enterprise Team

Alicia Reiner, Fire Ecologist, alreiner@fs.fed.us, USDA Forest Service,
Adaptive Management Services Enterprise Team

Kevin McCrummen, Biological Science Technician, kmcrummen@fs.fed.us, USDA Forest Service,
Adaptive Management Services Enterprise Team

JFSP Grant 09-1-01-1

Integrating science, technology and fire management.

Wildland Fire Management RD&A

Table of Contents

Background

Longevity of fuel treatment effectiveness to alter potential fire behavior is a critical question for managers preparing plans for fuel hazard reduction, prescribed burning, fire management, forest thinning, and other land management activities. Results from this study will help to reduce uncertainty associated with plan prioritization and maintenance activities. From 2001 to 2006, permanent plots were established in areas planned for hazardous fuel reduction treatments across 14 National Forests in California. Treatments included prescribed fire and mechanical methods (i.e., thinning of various sizes and intensities followed by a surface fuel treatment). After treatment, plots were re-measured at various intervals up to 10 years post-treatment. Very few empirically based studies exist with data beyond the first couple of years past treatment, and none span the breadth of California's coniferous forests. With the data gathered, this research aimed to meet three main objectives:

Objective 1) *Determine the length of time that fuel treatments are effective at maintaining goals of reduced fire behavior, by*

a) measuring effects of treatments on canopy characteristics and surface fuel loads over time, and
b) modeling potential fire behavior with custom fuel models.

Objective 2) *Quantify the uncertainty associated with the use of standard and custom fuel models.*

Objective 3) *Assess prescribed fire effects on carbon stocks and validate modeled outputs.*

This managers' report is meant to compliment the final report to the Joint Fire Science Program and supply project specific information that is not included in the regional assessment. This report includes a summary of Key Findings and Management Implications from the regional study as well as individual Forest-level information for each plot (i.e., project history, map, navigation directions, plot level findings, and plot protocol). For your use, we included a number of supplementary files with the digital version of this report. Included on the thumb drive are the following also described in Appendix A:

- Final report to the JFSP
- FVS Input database for your Forest for all projects (database file)
- Photo pairs for the plots on your Forest (power point file)
- Plot maps for each project on your Forest (pdf file)
- GIS shapefile with the plots on your Forest

All datasets for the regional project were input into the FFI (Feat/FIREMON Integrated) tool (www.frames.gov/partner-sites/ffi/ffi-home/) for future use and comparisons. Please contact Nicole Vaillant (nvaillant@fs.fed.us) for more information on obtaining the FFI data or other questions.

Key Findings

Objective 1- Determine the length of time that fuel treatments are effective at maintaining goals of reduced fire behavior by measuring effects of treatments on canopy characteristics and surface fuel loads over time and modeling potential fire behavior with custom fuel models.

Results have shown initial reductions in surface fuels from fire treatments recover to pre-treatment levels by 10 yr post-treatment. Mechanical treatments continue to have variable effects on surface fuels. With the exception of mechanical treatments in red fir, both treatment types resulted in increased live understory vegetation by 8 yr post-treatment relative to pre-treatment. Mechanical treatment effects on stand structure remains fairly consistent through 8 yr post. Fire-induced delayed mortality contributes to slight decreases in canopy cover and canopy bulk density over time. For both treatment types, overall canopy base height decreases in later years due to in-growth of smaller trees, but it remains higher than pre-treatment. The changes in fuel loads and stand structure are reflected in fire behavior simulations via custom fuel modeling. Surface fire flame lengths were initially reduced as a result of prescribed fire, but by 10 yr post-treatment they exceeded the pre-treatment lengths. Though a low proportion of fire type, initial reductions in potential crown fire returned to pre-treatment levels by 8 yr post-treatment; passive crown fire remained reduced relative to pre-treatment for the duration. Mechanical treatments showed variable and minimal effects on surface fire flame length over time; however the incidence of active crown fire was nearly halved from this treatment for the duration.

Objective 2- Quantify the uncertainty associated with the use of standard and custom fuel models

The Fire and Fuels Extension to the Forest Vegetation Simulator (FFE-FVS) was used to model potential fire behavior for plots treated with prescribed fire to determine the differences in modeled fire behavior using standard and custom fuel models. In general predicted fire behavior from custom versus standard fuel models were similar with mean surface fire flame lengths slightly higher using standard fuel models for all time steps until the 8 yr post-treatment. Similarly, custom fuel models predicted a higher instance of surface fire than standard fuel models with the exception of 8 yr post-treatment.

Objective 3- Assess prescribed fire effects on carbon stocks and validate modeled outputs.

To better understand the impact of prescribed fire on carbon stocks, we estimated aboveground and belowground (roots) carbon stocks using field measurement in FFE-FVS, and simulated wildfire emissions, before treatment and up to 8 yr post-prescribed fire. Prescribed fire treatments reduced total stand carbon by 13%, with the largest reduction in the forest floor (litter and duff) pool and the smallest reduction in the live tree pool. Combined carbon recovery and reduced wildfire emissions allowed the initial carbon source from simulated wildfire emissions and treatment to become a sink by 8 yr post-treatment relative to pre-treatment if both were to burn in a wildfire. In a comparison of field-derived versus FFE-FVS simulated carbon stocks, the total stand, tree, and belowground live carbon pools are highly correlated. However, the variability within the other carbon pools compared was high (up to 212%).

Management Implications

- ✓ Need more long term monitoring.
- ✓ The ability of a fuel treatment to maintain effectiveness in reducing fire behavior and effects depends on the accumulation rates and distribution of fuels, which are used as metrics to judge treatment longevity. Surface and understory fuel loading trends help inform managers' initial treatment and maintenance timelines, priorities, and adaptive management prescriptions.
- ✓ Stand and canopy structure trends help inform both fuel and silviculture integrated objectives and prioritizations.
- ✓ Despite extensive variability between plots, overall trends for treatment-forest combinations exist.
- ✓ Changes to modeled surface fire after prescribed fire treatment included an initial decrease in surface fire flame lengths, then an increase starting around 5 yr post-treatment.
- ✓ Overall, modeled fire behavior in mechanical treatments showed that goals of reduced fire behavior were initially reached, and then began diminishing around 5 to 8 yr post-treatment, with some positive changes still apparent through 8 yr post-treatment.
- ✓ In general, predicted fire behavior from custom versus standard fuel models was similar.
- ✓ Prescribed fire treatments reduced total stand carbon by about 13%, and total stand carbon stocks returned to 97% of pre-treatment levels after 8 yr post-treatment.
- ✓ Although the total stand carbon differences between field-derived and simulated carbon stocks are minimal, the variability within different carbon was great.

Project Websites

Please visit our project website in the next few months to year as reports are finalized and publications become available at http://www.fs.fed.us/adaptivemanagement/pub_reports/JFS_vaillant2.shtml.

The final report and many of our presentations and other deliverables will also be available via the Joint Fire Science Program website at http://www.firescience.gov/JFSP_advanced_search_results_detail.cfm?jdbid=%24%26Z%2F8W%20%20%20%0A.

Acknowledgements

We acknowledge funding for this research from the USFS Region 5 Fire Aviation and Management and Joint Fire Sciences program (JFS 09-01-1-01). This project would have never gotten off the ground without the passion and drive of Jo Ann Fites-Kaufman. We thank the countless number of field crew members over the past 12 years, especially T. Decker and K. McCrummen for serving as crew leads during the past four years. Thank you to all the fire and fuels specialists on all the National Forests in California for providing invaluable insight and information about their fuel treatments.

Mammoth Fuel Break (Project 41, Mammoth District)

Project history

The Mammoth Fuel Break project had six plots set up pre-treatment using two different plot styles (detailed and fuels 2003). For details about the protocol used, please see "Appendix B: Sampling Protocol" at the end of the report. Five plots were treated and continued to be revisited through various post-treatment years, see the "Treatment information" section below for details. Plots were sampled prior to treatment (P00), then 1 yr post (P01), 2 yr post (P02), and 8 yr post (P08) (Table 1).

For analysis at the regional level, plots from all projects were grouped into one of two treatment types (mechanical or prescribed fire) and one of three dominant forest types (yellow pine, red fir, or mixed conifer). All Mammoth Fuel Break plots were grouped into the mechanical treatment category and the red fir forest type.

The Crestview RAWS was used for fire weather and fire behavior simulation modeling.

Table 1. Treatment visits completed by year for each of the plots in the project. ~Indicates that data were not gathered on the plot during that year.

Plot	2003	2004	2005	2011
1	P00	P01	P02	~
2	P00	P01	P02	~
3	P00	P01	P02	P08
4	P00	P01	P02	P08
5	P00	P01	~	~
6	P00	P01	P02	P08

Treatment information

Prior treatment: No past vegetation treatment is known in the area around the plots.

During the project treatment: The fuelbreak work was completed by 2004, and included tree thinning, pruning, mastication, and jackpot or pile burning. Plots 1 and 2 were thinned a second time after the P02 vsist (between 2005 and 2011 site visits), so these plots were considered re-treated, which is outside the scope of this study, and did not have further re-measurements. Plot 5 had obvious impact from fire wood gathering after the P01 read and the data was removed.

Future treatment: There are no plans for future treatments in this area.

Project location map

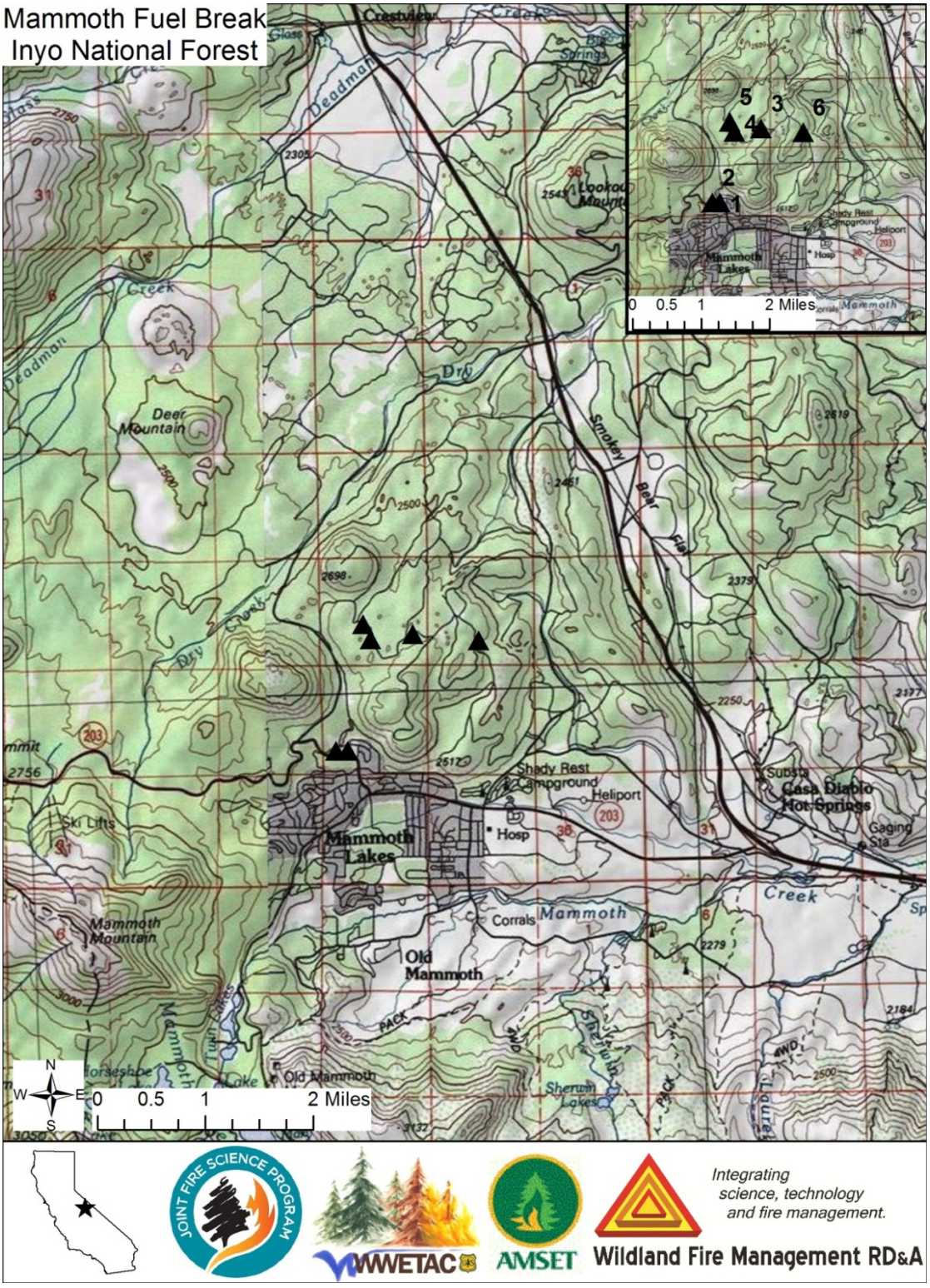

Figure 1. Location map for the Mammoth Fuel Break monitoring plots, showing general location of plots, and inset displaying increased detail of plot locations.

Driving directions/GPS/plot layout

Driving directions

Plot 1- Hwy 395 South to Mammoth lakes. Hwy 203 into Mammoth Lakes turns into Main Street. Go right on Minaret Rd. (2nd stop light you come to). At approximately 4/10 miles, go right on Mammoth Knolls Dr., park in pullout corner. Start tree is an ABMA (red fir) near the stop sign. The plot center is near a large ABMA with tree tag number 42.

Plot 2- Follow same route for Plot 1 until corner of Mammoth Knolls Dr. and Minaret Rd. Continue on Minaret Road past Mammoth Knolls for 0.2 miles. Start tree is a large ABMA in the center of the pullout on the side of the road, next to 25 mph sign. The plot center is near a large ABMA snag (dead) tree.

Plot 3-Follow directions for Plot 1 and continue up Minaret Rd. Take a right onto Mammoth Lakes Scenic Loop Road (3S23). At approximately 1.5 miles turn right onto 3S24 and zero out your odometer, stay right at fork at about 0.2 miles. At 1.1 miles, plot is on the right, pull into turnout on the right. The plot center is next to a large rock about 1 meter tall.

Plot 4- Follow directions for Plot 1 and continue up Minaret Rd. Take a right onto Mammoth Lakes Scenic Loop Road (3S23). At approximately 1.5 miles turn right onto 3S24 and zero out your odometer, stay right at fork at about 0.2 miles. At 0.7 miles park in the pullout on the left. There is an OHV trail on the right and the plot is on the right.

Plot 5- Follow directions for Plot 1 and continue up Minaret Rd. Take a right onto Mammoth Lakes Scenic Loop Road (3S23). At approximately 1.5 miles turn right onto 3S24 and zero out your odometer, stay right at fork at about 0.2 miles. At 0.5 miles the plot is on the right.

Plot 6- Follow directions for Plot 1 and continue up Minaret Rd. Take a right onto Mammoth Lakes Scenic Loop Road (3S23). At approximately 1.5 miles turn right onto 3S24 and zero out your odometer, stay right at fork at about 0.2 miles. At 1.6 miles stay left at 3-way intersection, at 1.9 miles at 4-way intersection take soft right (not hard right) onto 3S48, and at 2.2 miles plot is on the left. The center of the plot is upslope and north east of a large red fir tree (DBH 73 cm).

Table 2. Directions (distance and azimuth) for walking from the "start tree" to each plot. The azimuth takes into account the local declination. Distance and azimuth are approximate as they were recorded by crews walking in from the start tree (usually tagged tree near road edge). ~ Indicates no start tree was designated; see notes in driving directions.

Plot	Start tree (DBH and species)	Azimuth °	Distance
1	Red fir, near stop sign	305	195 m
2	Red fir, next to 25 mph sign	31	95 m
3	~	146	25 m
4	~	233	25 m
5	~	144	70 m
6	~	115	22 m

Table 3. GPS coordinates for each plot (decimal degrees, datum NAD 1983, projection NAD_1983_California_Teale_Albers).

Plot	Latitude	Longitude
1	37.654357	-118.987149
2	37.654398	-118.989163
3	37.669946	-118.975922
4	37.669278	-118.983053
5	37.671324	-118.984308
6	37.77897	-118.96474

Table 4. Plot layout line azimuths (degrees). See Appendix A for plot diagrams. CD is the main transect and F1 and F2 are the fuels transects.

Plot	Plot Type	CD	F1	F2
1	Detailed 2003	36	351	81
2	Detailed 2003	65	20	110
3	Detailed 2003	205	160	250
4	Detailed 2003	342	297	27
5	Fuels 2003	284	239	329
4	Fuels 2003	10	325	55

Paired pictures

Below is an example of pictures paired or matched over the time steps the plots were visited. All of the paired pictures are available in the supplied power point file.

Pre-treatment

1 yr post

2 yr post

8 yr post

Figure 2. Example paired photos showing changes over the time steps for Plot 6, fuel line 2 (F2) from pre-treatment in 2003 through 8 yr post-treatment in 2011.

Plot findings

Below are graphs and data tables of key metrics from the data gathered in the field for each plot and time period within the project.

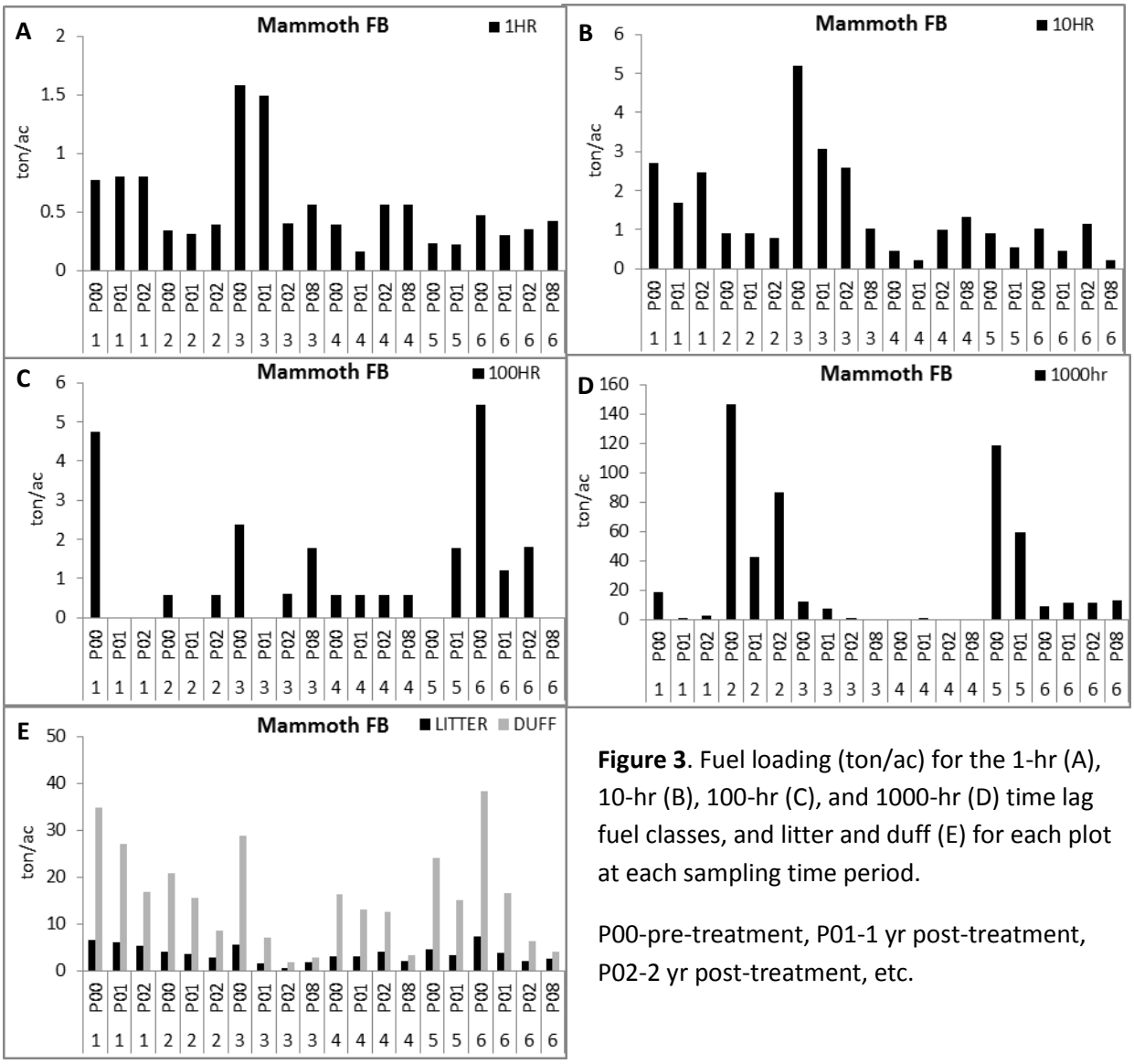

Figure 3. Fuel loading (ton/ac) for the 1-hr (A), 10-hr (B), 100-hr (C), and 1000-hr (D) time lag fuel classes, and litter and duff (E) for each plot at each sampling time period.

P00-pre-treatment, P01-1 yr post-treatment, P02-2 yr post-treatment, etc.

Table 5. Fuel loading (ton/ac) for the 1-hr, 10-hr, 100-hr, and 1000-hr time lag fuel classes, and litter and duff by time period for all the plots in the Mammoth Fuel Break project.

Plot	Time period	1-hr	10-hr	100-hr	1000-hr	Litter	Duff
1	P00	0.77	2.7	4.7	18.4	6.6	34.7
1	P01	0.80	1.7	0	1.1	6.1	27.2
1	P02	0.80	2.5	0	2.7	5.4	16.7
2	P00	0.35	0.9	0.6	146.8	4.0	20.8
2	P01	0.31	0.9	0	42.6	3.5	15.5
2	P02	0.39	0.8	0.6	86.8	2.8	8.7
3	P00	1.58	5.2	2.4	11.9	5.5	28.8
3	P01	1.49	3.1	0	7.2	1.6	7.1
3	P02	0.40	2.6	0.6	0.7	0.6	1.8
3	P08	0.56	1.0	1.8	0	1.8	2.8
4	P00	0.39	0.4	0.6	0	3.1	16.2
4	P01	0.16	0.2	0.6	1.0	2.9	13.1
4	P02	0.56	1.0	0.6	0	4.1	12.6
4	P08	0.56	1.3	0.6	0	2.0	3.2
5	P00	0.24	0.9	0	118.9	4.6	24.1
5	P01	0.23	0.6	1.8	59.6	3.4	15.0
6	P00	0.48	1.0	5.4	9.3	7.4	38.3
6	P01	0.30	0.5	1.2	11.4	3.7	16.5
6	P02	0.35	1.2	1.8	11.1	2.1	6.4
6	P08	0.42	0.2	0	13.0	2.5	4.0

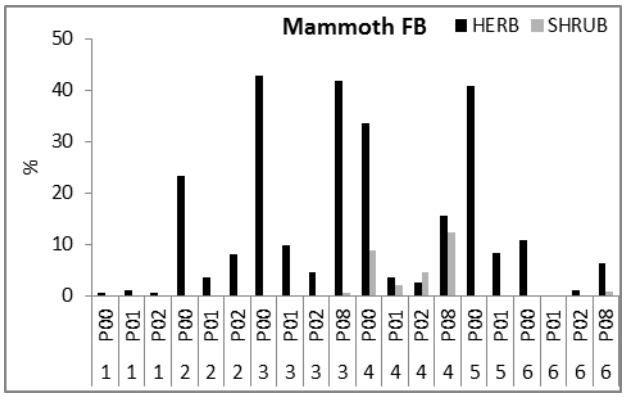

Figure 4. Average herbaceous plant and shrub cover for each plot at each sampling time period.

Table 6. Understory vegetation cover by time period for all the plots in the Mammoth Fuel Break project.

Plot	Time period	Herbaceous cover (%)	Shrub cover (%)
1	P00	<1	0
1	P01	1	0
1	P02	<1	0
2	P00	23	0
2	P01	3	0
2	P02	8	0
3	P00	42	0
3	P01	10	0
3	P02	5	0
3	P08	41	<1
4	P00	34	9
4	P01	4	2
4	P02	3	5
4	P08	16	12
5	P00	41	0
5	P01	8	0
6	P00	11	0
6	P01	<1	<1
6	P02	<1	1
6	P08	<1	<1

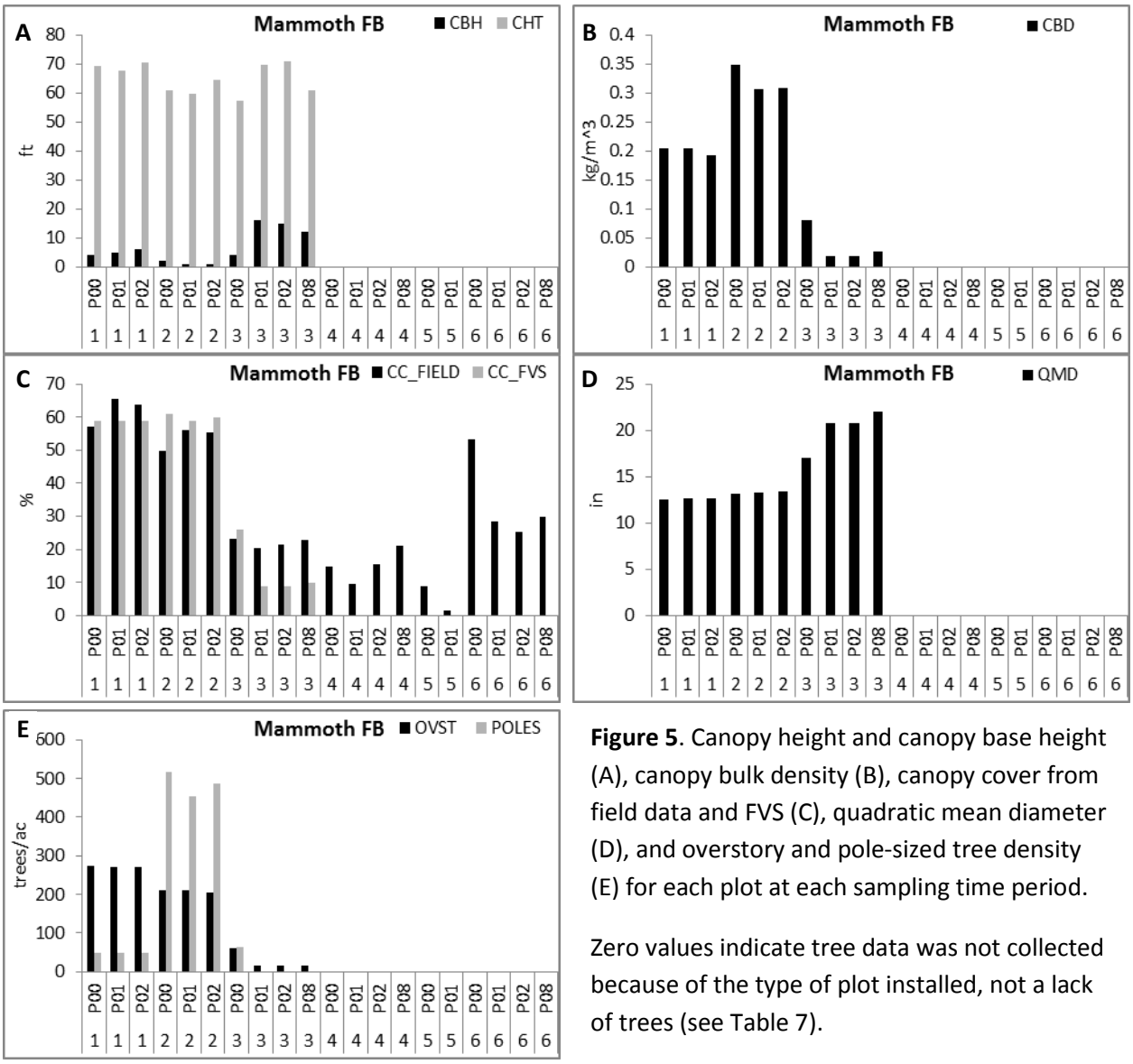

Figure 5. Canopy height and canopy base height (A), canopy bulk density (B), canopy cover from field data and FVS (C), quadratic mean diameter (D), and overstory and pole-sized tree density (E) for each plot at each sampling time period.

Zero values indicate tree data was not collected because of the type of plot installed, not a lack of trees (see Table 7).

Table 7. Canopy characteristics by time period for all the plots in the Mammoth Fuel Break project.
* Indicates the data was not collected for the given plot and time period.

Plot	Time period	Canopy cover (%) - field	Canopy cover (%) - FVS	Canopy height (ft)	Canopy base height (ft)	Canopy bulk density (kg/m^3)	Quadratic mean diameter (in)	Overstory (trees/ac)	Pole-sized (trees/ac)
1	P00	57	59	69.1	4.0	0.204	12.6	275	49
1	P01	66	59	67.7	5.0	0.205	12.7	271	49
1	P02	64	59	70.3	6.0	0.193	12.7	271	49
2	P00	50	61	60.9	2.0	0.348	13.7	210	518
2	P01	56	59	59.6	1.0	0.306	13.7	210	453
2	P02	55	60	64.4	1.0	0.309	13.4	206	486
3	P00	23	26	57.5	4.0	0.081	17.0	61	65
3	P01	21	9	69.8	16.0	0.019	20.8	16	0
3	P02	21	9	70.8	15.0	0.019	20.8	16	0
3	P08	23	10	60.9	12.0	0.027	22.1	16	0
4	P00	15	*	*	*	*	*	*	*
4	P01	10	*	*	*	*	*	*	*
4	P02	16	*	*	*	*	*	*	*
4	P08	21	*	*	*	*	*	*	*
5	P00	9	*	*	*	*	*	*	*
5	P01	2	*	*	*	*	*	*	*
6	P00	53	*	*	*	*	*	*	*
6	P01	29	*	*	*	*	*	*	*
6	P02	25	*	*	*	*	*	*	*
6	P08	30	*	*	*	*	*	*	*

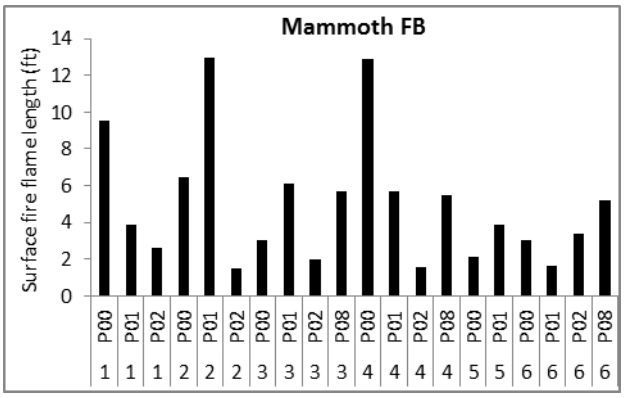

Figure 6. Surface fire flame length from custom fuel models using NEXUS for each plot at each sampling time period under 90th percentile fire weather conditions.

Table 8. Surface fire flame length (modeled in NEXUS with custom fuel models) and type of fire for 90th percentile fire weather conditions for all the plots in the Mammoth Fuel Break project.
* Indicates the tree data was not collected and fire type was not modeled.

Plot	Time period	Surface fire flame length (ft)	Type of fire
1	P00	9.54	Active crown
1	P01	3.86	Conditional crown
1	P02	2.62	Conditional crown
2	P00	6.47	Active crown
2	P01	12.97	Active crown
2	P02	1.46	Active crown
3	P00	3.00	Conditional crown
3	P01	6.10	Surface
3	P02	1.98	Surface
3	P08	5.69	Surface
4	P00	12.89	*
4	P01	5.66	*
4	P02	1.59	*
4	P08	5.51	*
5	P00	2.13	*
5	P01	3.89	*
6	P00	3.04	*
6	P01	1.64	*
6	P02	3.40	*
6	P08	5.21	*

Appendix A: Description of Supplied Files

For your use we included a number of supplementary files with the digital version of this report (see the supplied thumb drive).

Final report to the JFSP

We included a digital version of the Final Report we submitted to the Joint Fire Science Program for the entire regional assessment.

FVS input database

For each Forest we included an FVS-ready database with all the plots from all the projects (*.mdb). The database includes two different StandInit and TreeInit tables depending on the plot types within the Forest; separate StandInit and TreeInit tables were created for the "detailed" plots and the "fuels" plots. We did this so one would not assume there was tree data available for all plots when it might not have been sampled. The fuel loading data was collected on all plots and is included by size class in both StandInit tables. For the detailed plots, the tree data collected is within the TreeInit table. For the fuels plots, a "dummy" tree list (a single white fir seedling) was created so the plots can be run through FVS, but caution should be used with these because of the lack of real tree data. If data was missing it is represented as a blank in the data tables.

Photo pairs

Most of the photos taken for each plot is included in the supplied Power Point file (*.pptx). Photos were taken along the main transect line(s) and fuel lines each time the plot was visited.

Plot maps

In addition to the imbedded maps in this report, we have supplied PDF versions of the project maps.

GIS shapefile

We supplied a GIS file with all the plots for the Forest.

Appendix B: Sampling Protocol

Data collection protocol (inclusive of all plot layouts)

Plot information naming example

1. Forest name: *"Tahoe NF"*
2. Forest ICS code: *"TNF"*
3. Project name: "Jaybird"
4. Project number: pre-determined for tracking purposes
5. Status: P00=pre-treatment, P01=1st year post, P02=2nd year post, etc.
6. Plot number: *"1"*
7. Surveyors: *"last name, first initial"*
8. Date: *"5/8/09"*
9. Notes: general notes about the area, treatment, anything that stands out

Shrub transect(s) (50 m)

Collect shrub information (for any shrubs that intersect the transect tape) along the length of the transect(s): transect, species, status (live/dead), shrub range in decimeters (dm, distance along transect, i.e. 0.6-0.9 m=3 dm), average height (cm).

Herbs (1x1 m quadrats)

Collect herbaceous species information for all plants rooted in the quadrat. Record the transect, frame, life form (fern, forb, grass, vine, other, unknown), status (live/dead), average height (cm), species (if you know it), and cover class (1=0-5%; 2= 6-25%; 3= 26-50%; 4=51-75%; 5=76-95%; 6=96-100%). Also please take general botany notes for the plot, such as species observed in the plot overall but not captured in the quadrats, and general observations about how much of the plot has weeds or herbaceous plant dominance.

Seedlings (<2.5 cm DBH)

Tally seedlings by species code, status (live/dead), and height class (15=1-15 cm; 30=16-30 cm; 60=31-60 cm; 100=61-100 cm; 200=101-200 cm; 300=201-300 cm, etc.).

Pole-sized trees (>2.5 to <15 cm DBH, and > 4.5 ft (1.37 m) tall)

Live poles: tag #, species, DBH (cm), status (live/dead), partial crown height (m), total tree height (m), canopy class (D=dominant, CD=codominant, I=intermediate, S=suppressed).

Dead poles: tag#, species, DBH (cm), status (live/dead), total tree height (m), decay class (1 newly dead thru 5 long dead).

Overstory trees (>15 cm DBH and > 4.5 ft (1.37 m) tall)

Live trees: tag #, species, DBH (cm), status (live/dead), partial crown height (m), total tree height (m), canopy class (D, CD, I, S).

Dead trees: tag#, species, DBH (cm), status (live/dead), total tree height (m), decay class (1 newly dead thru 5 long dead).

Canopy cover

Collect and record canopy cover, using the moosehorn (canopy sight tube) along the main transects (AB and/or CD) every 1m, starting at 1m and ending at 50m. The moosehorn should be held at the meter mark on the tape, standing on the side of the shrub transect opposite to the side where the herb quadrats are being place. Count the number of hits or intersections, out of 25, where canopy overlaps the grid intersections.

Fuel loading

Each planar fuel transect is 50 ft in length and information is gathered to characterize surface and ground fuels and fuel bed depth.

Surface fuels (1, 10, 100, 1000-hr)

Record the project, plot, transect and tallies for small fuel classes (1, 10, 100-hr), and take notes on the **dominant trees or shrub species** contributing to the fuel load for each transect.

Tally: 1-hr (>0.25”) from 0-6 ft, 10-hr (0.25-<1”) from 0-6 ft, 100-hr (1-<3”) from 0-12 ft.

Record the species, diameter (cm), and status (rotten/sound) for each 1000-hr (> 3’) from 0-50 ft.

Ground fuels (litter/duff/chips)

Measure and record litter and duff depth (thickness) measurements to the nearest 1 cm (measure thickness of each layer, not depth from surface). Starting at 1 foot, take 10 readings, one every 5 ft on each transect: (1 ft, 5 ft, 10 ft… 45 ft). Duff begins where the litter layer organic materials have begun to decompose, and duff ends where the composition is greater than 50% mineral soil. If a sampling spot lands exactly on a log, rock, or other obstruction, take the reading immediately adjacent to the obstruction. If you hit bare soil, your reading will be 0.

If there was mastication/chipping completed, record the depth of the chipped materials as well.

Fuel bed depth

Measure and record the height of the **tallest** downed and dead woody fuel for ten 5 ft collection point intervals (0-5 ft, 5-10 ft, 10-15 ft, up to 45-50 ft) along the planar transect. Measure from the **base of the litter layer to the top of the fuel particle**; measure to the nearest whole cm. If you do not have any dead and downed fuels, your measure will be based on the maximum litter depth in that interval.

Photos

Avoid people and gear in the photos. Line up with the photos supplied from previous plot visits to the best of your ability. Use a photo board to document the photo location within the photos, matching the plot naming protocol example above. **Always take the photos in a portrait orientation (up and down) with the transect tape in the bottom middle of the image**. Photos were only taken from 0 to 50 ft for each fuels transect (labeled F1, F2, etc.), from C to D (and A to B if applicable) for the shrub transect, and one general picture of the plot (this one will not have an old photo to match).

2003 detailed plot specifics

Shrub transects (50 m)

There is one transect (CD) for these plots. It **should** be contour to the slope.

Herb quadrats

There are five quadrats for these plots. They are located from 9-10 m, 19-20 m, 29-30 m, 39-40 m, and 49-50 m along the uphill side of CD transect.

Seedlings

This is a circular plot starting at the pole/seedling origin rebar (at 33.92 m on transect CD) extending out and around 3.99 m in all directions.

Pole-sized trees

This is a circular plot starting at the pole/seedling origin rebar (at 33.92 m on transect CD) extending out and around 8.92 m in all directions.

Overstory trees

This is a circular plot starting from the origin (at 25 m on transect CD) extending out and around 17.85 m in all directions.

Canopy cover

A total of 50 canopy cover readings will be measured. They will start at 1 m and continue every meter until the end of the transect CD (50 m).

Fuel loading

There are two 50 ft fuel transects for this layout. They both start at 7.15 m along the CD transect and have a rebar labeled “F1/F2 0ft”. F1 extends uphill at a 45º angle toward the center of the plot, F2 extends downhill at a 45º angle toward the center of the plot.

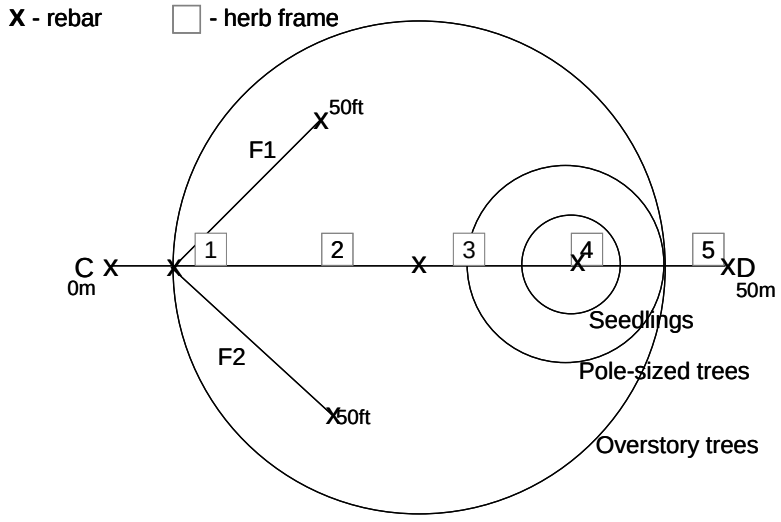

Figure 7. Plot layout diagram for the detailed plots installed from 2003 to 2006.

2003 fuels plot specifics

Starting in 2012 tree data was collected on Fuels '03 plots that were visited. You need to establish the pole/overstory and seedling rebar and tag all pole & overstory trees and gather data on all size classes!

Shrub transect

There is one transect (CD) for these plots. It **should** be contour to the slope.

Herb quadrats

There are 5 quadrats for these plots. They are located from 9-10 m, 19-20 m, 29-30 m, 39-40 m, and 49-50 m along the uphill side of CD transect.

Canopy cover

A total of 50 canopy cover readings will be measured. They will start at 1 m and continue every meter until the end of the transect CD (50 m).

Fuel loading

There are two 50 ft fuel transects for this layout. They both start at 7.15 m along the CD transect and have a rebar labeled "F1/F2 0 ft". F1 extends uphill at a 45º angle toward the center of the plot, F2 extends downhill at a 45º angle toward the center of the plot.

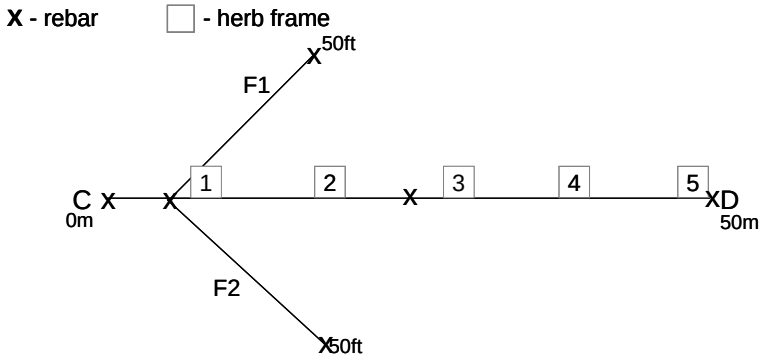

Figure 8. Plot layout diagram for the fuels plots installed from 2003 to 2006.