Effectiveness and longevity of fuel treatments in coniferous forests across California

Managers' Report: Stanislaus National Forest

Prepared by

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Integrating science, technology and fire management.

Wildland Fire Management RD&A

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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.

Big Love (Project 47, Calaveras District)

Project history

The Big Love project had three plots set up pre-treatment using two different plot styles (detailed and fuels 2003). In 2012 plot 3 changed to detailed style plot, making all plot styles the same. For details about the protocol used, please see "Appendix B: Sampling Protocol" at the end of the report. Plots 1 and 3 were in the mixed conifer forest type, and plot 2 was in the yellow pine forest type. Plots were sampled prior to treatment (P00), then 1 yr post (P01), 2 yr post (P02), 5 yr-post (P05), 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 Big Love plots were grouped into the mechanical treatment category.

The Mt. Elizabeth 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.

Plot	2004	2005	2006	2009	2012
1	P00	P01	P02	P05	P08
2	P00	P01	P02	P05	P08
3	P00	P01	P02	P05	P08

Treatment information

Prior treatment: Plots 1 and 3 burned in the Big Tress Co-op underburn in 1997. Plot 2 burned in Big Love Understory burn in 2003.

During the project treatment: All plots were part of the Big Love Hazard Fuel Removal Multi-product timber sale in 2003. This was a thin from below (DBH <18 inch had saw log removal) and biomass/slash removal from 4-10 inch diameter class. Overall project cutting was finished by 10/31/06 and timber was removed offsite by 11/14/06. The landing slash piles were to be burned at some point. Data shows this as being completed before the crews re-read the data in 2005, so we are assuming treatment year to be 2004/2005.

Future treatment: No recent treatments have occurred, although they have been trying to re-treat the area via mastication (not done as of 2012).

Project location map

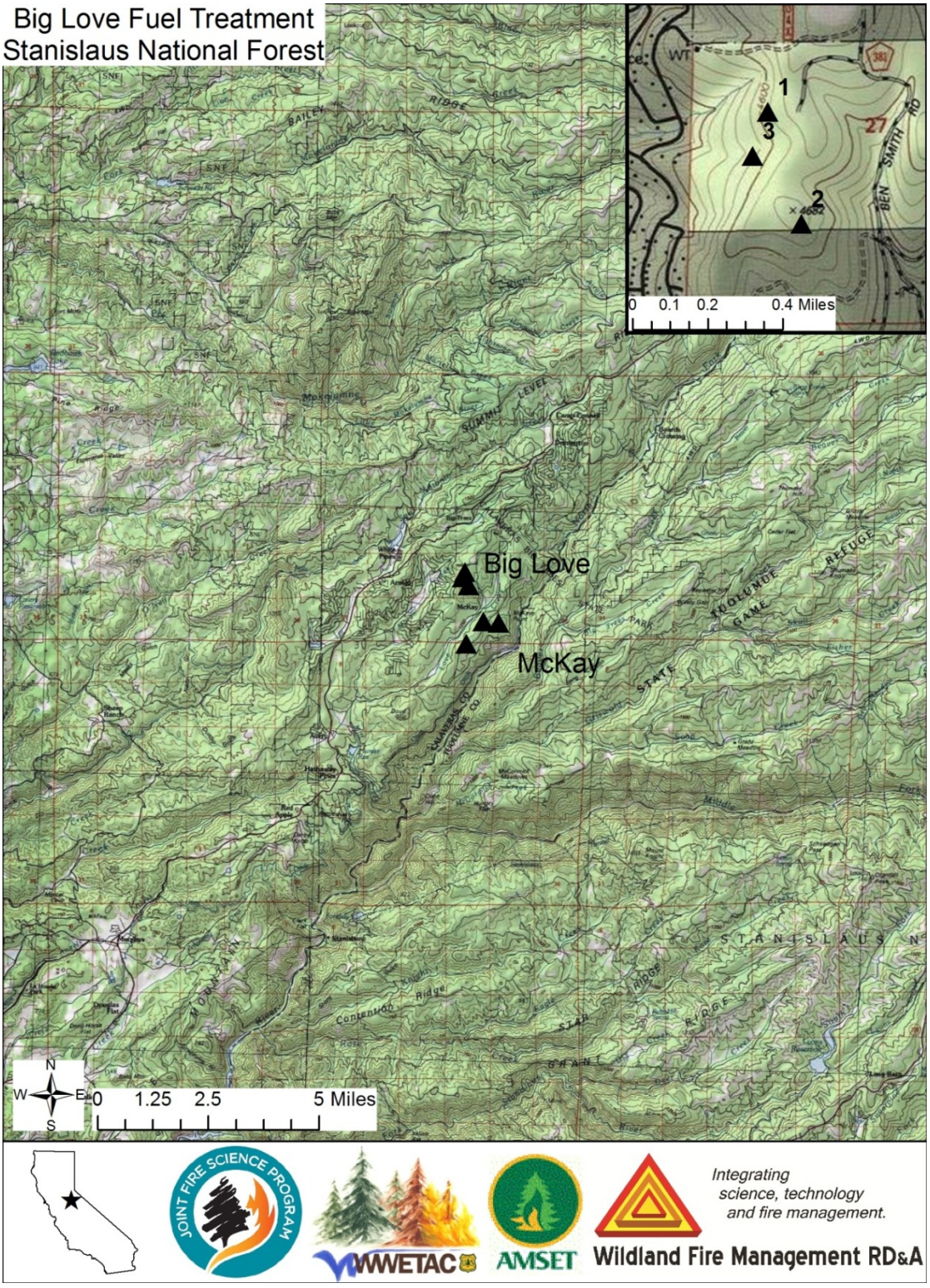

Figure 1. Location map for the Big Love fuel treatment plots, showing general location of plots, and inset displaying increased detail of plot locations.

Driving directions/GPS/plot layout

Driving directions

Plot 1- Take Love Creek Rd. to McKay Rd. From McKay continue north on Love Creek Rd. for 1.1 miles. At an unlabeled junction that has many homeowner "last name" signs, turn left onto an unnamed, unnumbered road (that borders units A and B). Stay right at next unlabeled junction, then immediate left turn (after going uphill about 0.5 miles). Continue uphill for about 0.9 miles to the top of the knoll to a large obvious landing (big enough to be a large parking area). In 2012, a new start tree was established on the right side of the road, labeled with a small tree- size tag, # 1000. The start tree is a large ponderosa pine with DBH of 104 cm with a large scar and swollen base.

Plot 2- Follow directions to Plot 1 to top of knoll. Stay on road that stays on the ridge line (top of knoll) and not the road going downslope. Start tree has placard marker facing away from the Rd, less than 0.3 to 0.5 mile down the road from Plot 1.

Plot 3- See Plot 2 directions. Start tree has placard marker facing away from the road. You can access this plot by taking the lower road (if trees blocking it are clear), or just walk or just walk cross country downslope from the upper road.

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).

Plot	Start tree (DBH and species)	Azimuth °	Distance
1	104 cm ponderosa pine	273	143 m
2	62 cm ponderosa pine	124	132 m
3	62 cm ponderosa pine	338	220 m

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

Plot	Latitude	Longitude
1	38.258305	-120.313174
2	38.25401	-120.31149
3	38.256601	-120.313915

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	164	121	211
2	Detailed 2003	111	69	159
3	Detailed 2003	204	159	249

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.

Figure 2. Example paired photos showing changes over the time steps for Plot 1, CD or main transect line from pre-treatment in 2004 to 8 yr post-treatment in 2012.

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.

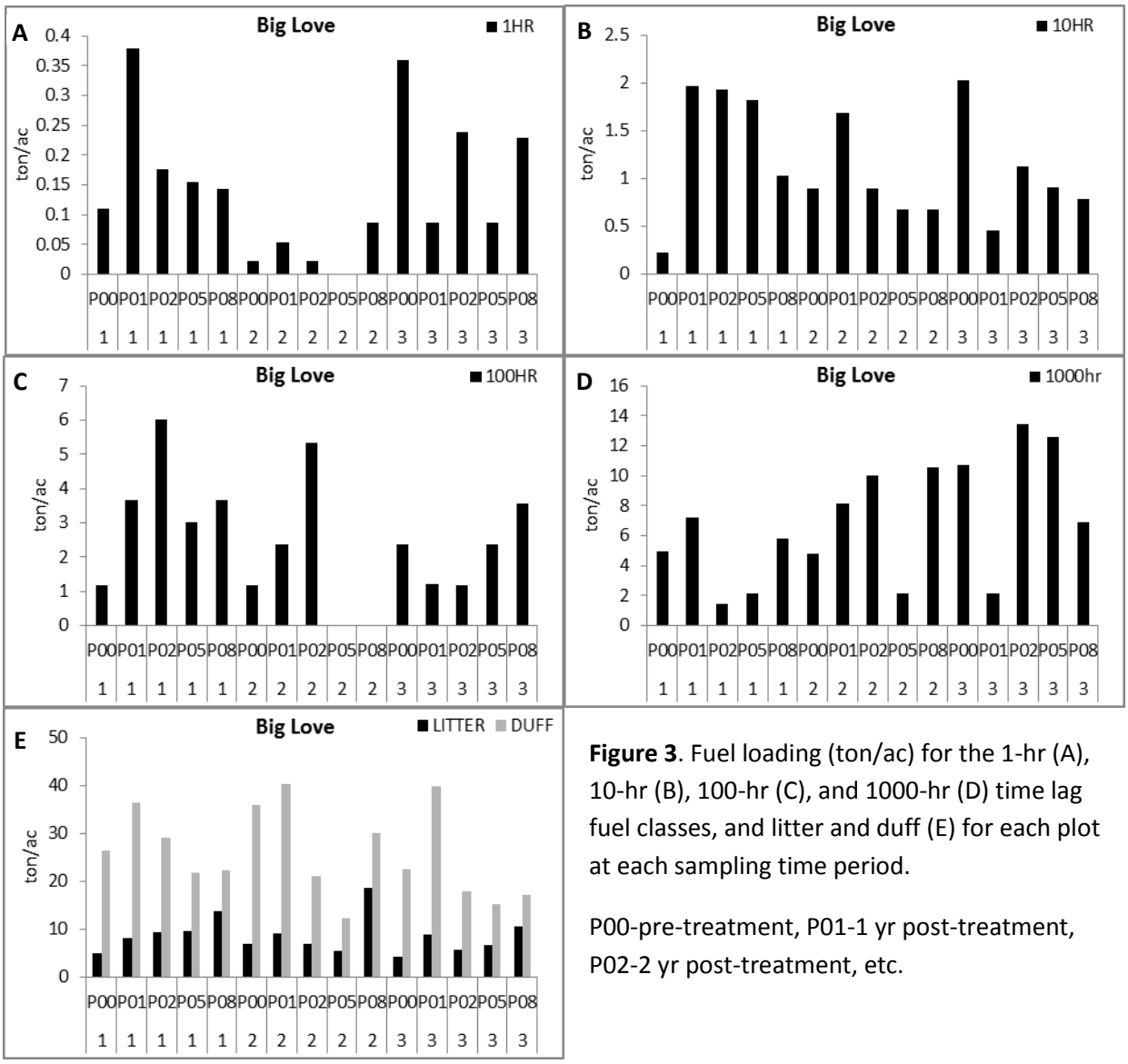

Figure 3. Fuel loading (ton/ac) for the 1-hr (A), 10-hr (B), 100-hr (C), and 1000-hr (D) time lag fuel classes, and litter and duff (E) for each plot at each sampling time period.

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 Big Love fuel treatment project.

Plot	Time period	1-hr	10-hr	100-hr	1000-hr	Litter	Duff
1	P00	0.11	0.2	1.2	4.9	5.1	26.4
1	P01	0.38	2.0	3.7	7.2	8.2	36.4
1	P02	0.18	1.9	6.0	1.5	9.5	29.2
1	P05	0.15	1.8	3.0	2.2	9.6	21.9
1	P08	0.14	1.0	3.7	5.8	13.8	22.2
2	P00	0.02	0.9	1.2	4.8	6.9	35.9
2	P01	0.05	1.7	2.4	8.2	9.1	40.3
2	P02	0.02	0.9	5.3	10.0	6.9	21.2
2	P05	0.00	0.7	0.0	2.1	5.4	12.3
2	P08	0.09	0.7	0.0	10.6	18.7	30.0
3	P00	0.36	2.0	2.4	10.7	4.3	22.6
3	P01	0.09	0.5	1.2	2.1	8.9	39.7
3	P02	0.24	1.1	1.2	13.5	5.8	17.8
3	P05	0.09	0.9	2.4	12.6	6.7	15.2
3	P08	0.23	0.8	3.6	6.9	10.7	17.2

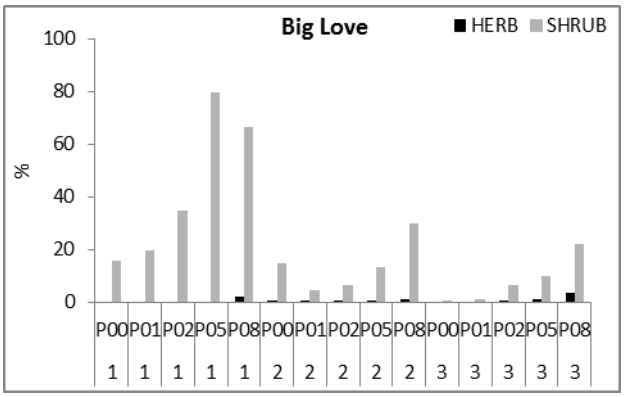

Figure 4. Average herbaceous plant and shrub cover for each plot at each sampling time period.

Table 6. Understory vegetation cover by time period for all the plots in the Big Love fuel treatment project.

Plot	Time period	Herbaceous cover (%)	Shrub cover (%)
1	P00	0	16
1	P01	0	20
1	P02	0	35
1	P05	0	80
1	P08	2	66
2	P00	1	15
2	P01	1	5
2	P02	1	7
2	P05	1	13
2	P08	1	30
3	P00	0	0
3	P01	0	1
3	P02	1	7
3	P05	1	10
3	P08	4	22

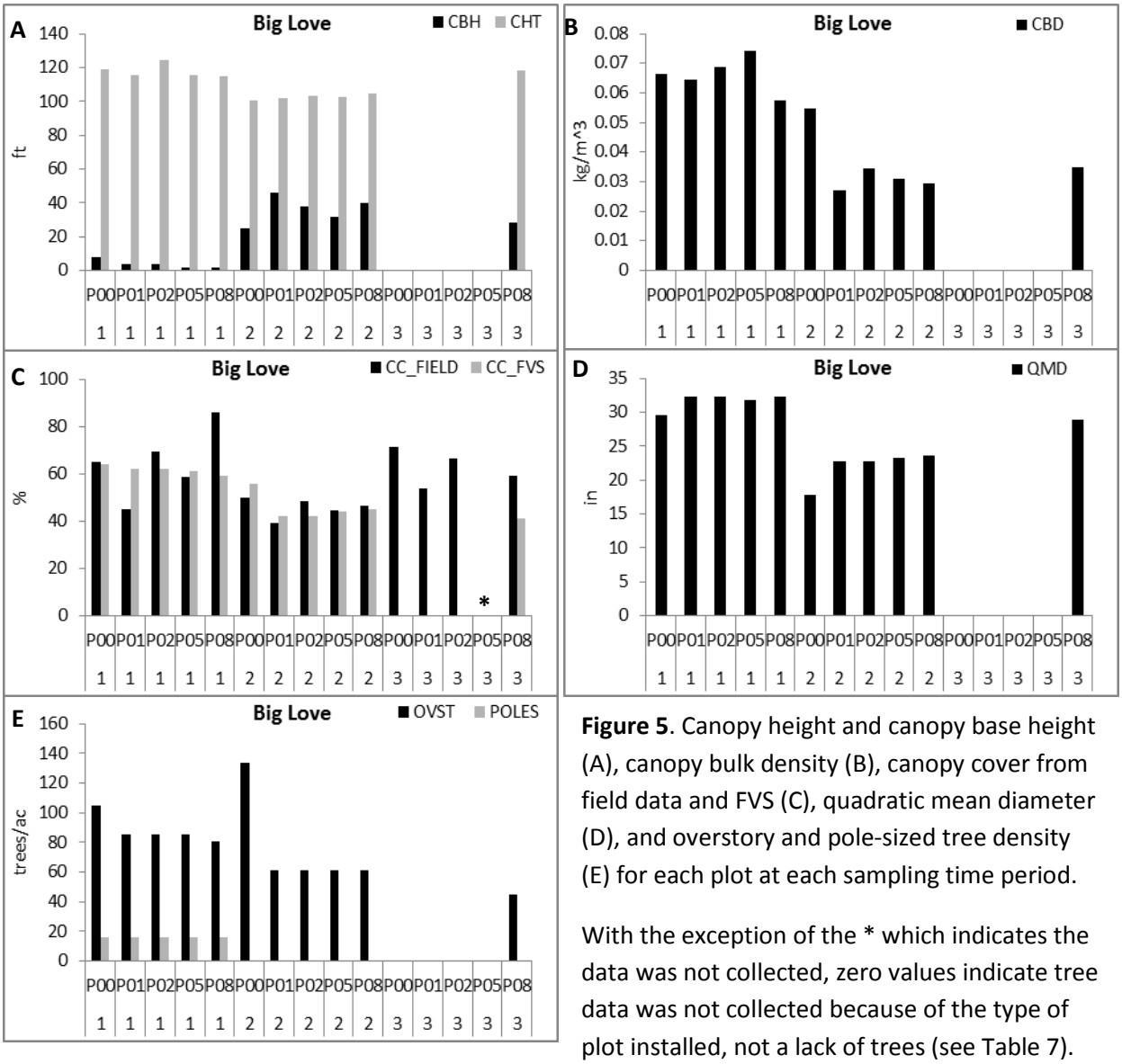

Figure 5. Canopy height and canopy base height (A), canopy bulk density (B), canopy cover from field data and FVS (C), quadratic mean diameter (D), and overstory and pole-sized tree density (E) for each plot at each sampling time period.

With the exception of the * which indicates the data was not collected, 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 Big Love fuel treatment 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	65	64	119.0	8.0	0.066	29.6	105	16
1	P01	45	62	115.6	4.0	0.065	32.2	85	16
1	P02	70	62	124.8	4.0	0.069	32.2	85	16
1	P05	59	61	115.8	2.0	0.074	31.7	85	16
1	P08	86	59	114.8	2.0	0.058	32.4	81	16
2	P00	50	56	100.8	25.0	0.055	17.8	134	0
2	P01	39	42	101.6	46.0	0.027	22.8	61	0
2	P02	48	42	103.4	38.0	0.035	22.8	61	0
2	P05	44	44	102.3	32.0	0.031	23.3	61	0
2	P08	47	45	104.9	40.0	0.030	23.7	61	0
3	P00	72	*	*	*	*	*	*	*
3	P01	54	*	*	*	*	*	*	*
3	P02	67	*	*	*	*	*	*	*
3	P05	*	*	*	*	*	*	*	*
3	P08	59	41	118.3	28.0	0.035	28.9	45	0

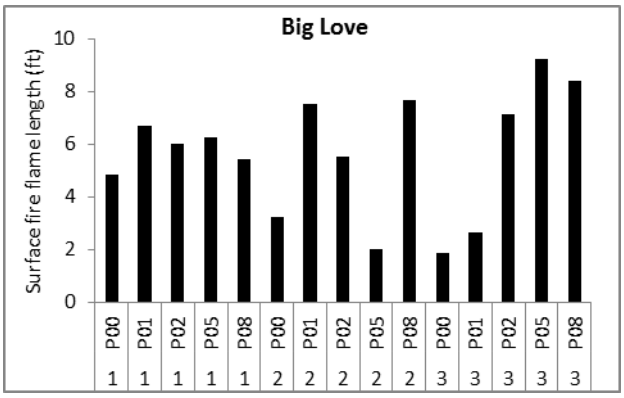

Figure 6. Surface fire flame length from custom fuel models using NEXUS for each plot at each sampling time period under 90th percentile fire weather conditions.

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 Big Love fuel treatment 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	4.85	Surface
1	P01	6.68	Passive crown
1	P02	6.01	Passive crown
1	P05	6.25	Passive crown
1	P08	5.41	Passive crown
2	P00	3.22	Surface
2	P01	7.51	Surface
2	P02	5.51	Surface
2	P05	2.01	Surface
2	P08	7.69	Surface
3	P00	1.88	*
3	P01	2.63	*
3	P02	7.15	*
3	P05	9.21	*
3	P08	8.38	Surface

McKay (Project 16, Calaveras District)

Project history

The McKay project had three plots set up pre-treatment using the detailed 2001 plot style. For details about the protocol used, please see "Appendix B: Sampling Protocol" at the end of the report. Plot 2 was unable to be found by the field crew in 2011, potentially due to post-treatment tillage mentioned below, so no data is available for Plot 2 for the 8 yr post-treatment time step. Plots were sampled prior to treatment (P00), then 1 yr post (P01), 2 yr post (P02), and 8 yr post (P08) (Table 9).

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). For this project all plots were grouped into the mechanical treatment type and mixed conifer forest type.

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

Table 9. Treatment visits completed by year for each of the plots in the project. ~ Indicates the data was not collected for that plot and year.

Plot	2001	2004	2005	2011
1	P00	P01	P02	P08
2	P00	P01	P02	~
3	P00	P01	P02	P08

Treatment information

Prior treatment: All plots were inside the McKays II Underburn in 1994. The plots border the 2001 Darby fire perimeter, but records show the plots were outside the perimeter (other side of the road).

During the project treatment: All plots were part of the Big Love Hazard Fuel Removal Multi-product (meaning saw log removal and biomass treatment) project. Cutting occurred from 5/10/04 to 7/18/04. Chipping was complete by 7/19/04 for the whole McKay unit, with chips moved offsite. Three landing piles were created, which were covered by 10/4/04 to be burned one day. The tillage (plow the soil/reduce compaction on skid roads, landings, temporary roads) was complete by November 2006, but no evidence of this occurring in the plots was found based on 2011 pictures.

Future treatment: None known.

Project location map

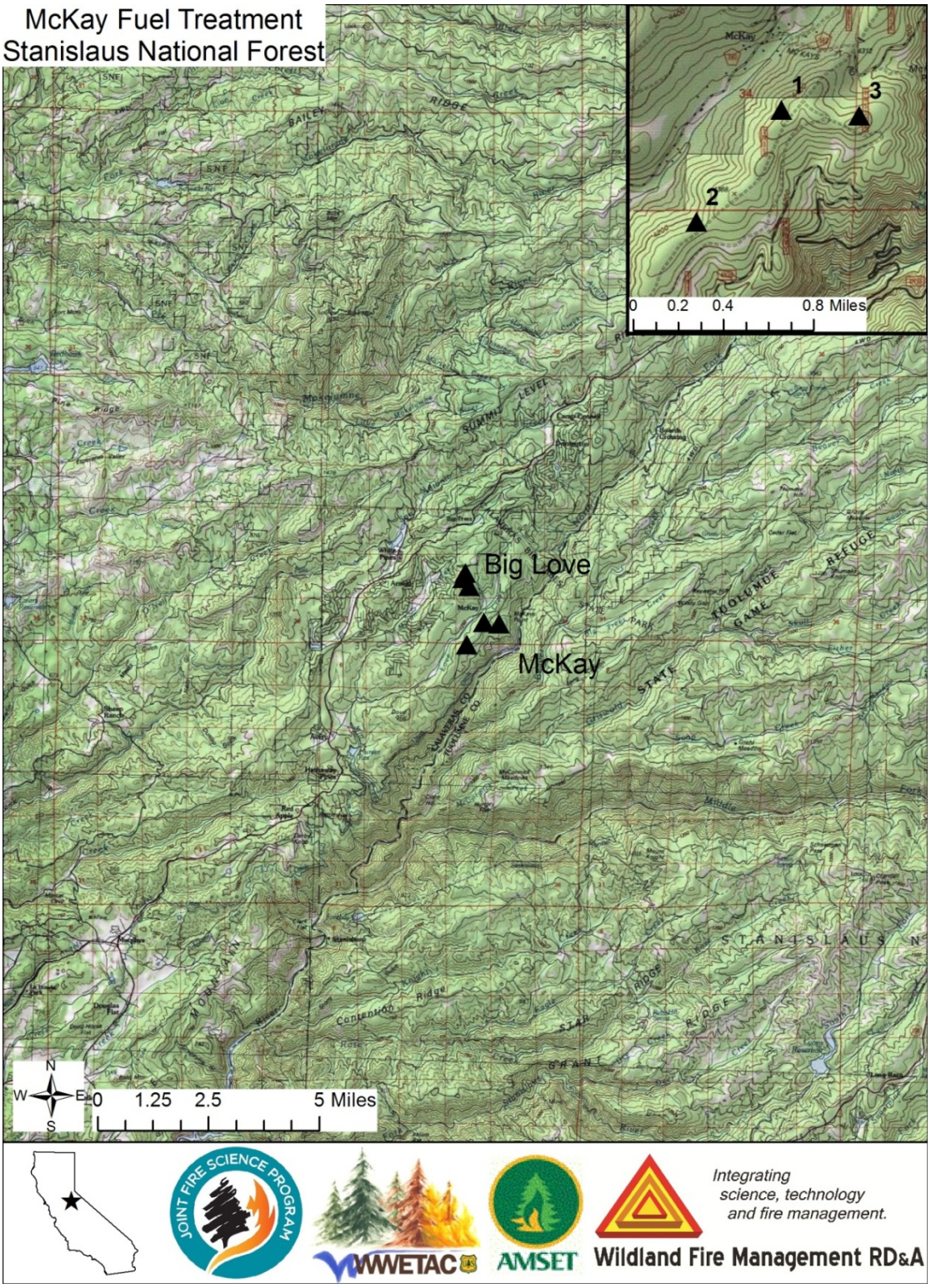

Figure 7. Location map for the McKay fuel treatment plots, showing general location of plots, and inset displaying increased detail of plot locations.

Driving directions/GPS/plot layout

Driving directions

Plot 1- Take Hwy 4 East to Love Creek Rd going NE turn right onto 5N35 (just outside of McKay). In about ½ mile you will reach an intersection (4 way with 5N35, 5N35A, and 5N36) in order to stay on 5N35 go right. From this intersection, the start tree is in ½ mile. The start tree is a ponderosa pine on south side of 5N35. Start tree placard is a piece of scrap metal painted yellow with AMSET and the plot info hand stamped onto it. Also see notes under plot 3.

Plot 2- Follow Hwy 4 East. Take Hwy 4 East to Love Creek Rd going NE turn right onto 5N35 (just outside of McKay). In about ½ mile you will reach an intersection (4-way with 5N35, 5N35A, and 5N36) in order to stay on 5N35 go right. From this intersection, the start tree is in 1.2 miles. The start tree is a 56 cm ponderosa pine on north side of 5N35. Also see notes under plot 3.

Plot 3- Follow the directions to the 4-way intersection mentioned in plot 1. To stay on 5N35, stay right. Road climbs a very steep section. Beyond the steep section, you will come to an unmarked intersection. This is where you would go right for plots 1 and 2, and left for plot 3. Turn left, go 0.1 miles to landing area. Pass by the landing to the right, to an unmarked intersection. Turn left and go down 0.2 miles to the start tree on the left (west side) adjacent to a skid trail running upslope towards plot 3. Start tree is within 2m of road edge. Using the topo map, plot 3 is located on a relatively prominent knoll near the end of a small ridge which extends to the E/SE of the main SW to NE running ridge.

Table 10. 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).

Plot	Start tree (DBH and species)	Azimuth °	Distance
1	85 cm ponderosa pine	205	75 m
2	56 cm ponderosa pine	360	40 m
3	123 cm ponderosa pine	334	140 m

Table 11. GPS coordinates for each plot (decimal degrees, datum NAD 1983, projection NAD_1983_California_Teale_Albers).

Plot	Latitude	Longitude
1	38.24216	-120.305466
2	38.23493	-120.312393
3	38.241815	-120.299093

Table 12. Plot layout line azimuths (degrees). See Appendix A for plot diagrams. Where AB and CD are the main transects and F1, F2, F3, and F4 are the fuels transects.

Plot	Plot type	AB	CD	F1	F2	F3	F4
1	Detailed 2001	260	170	282	362	92	182
2	Detailed 2001	211	116	343	76	170	251
3	Detailed 2001	290	200	278	8	88	198

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.

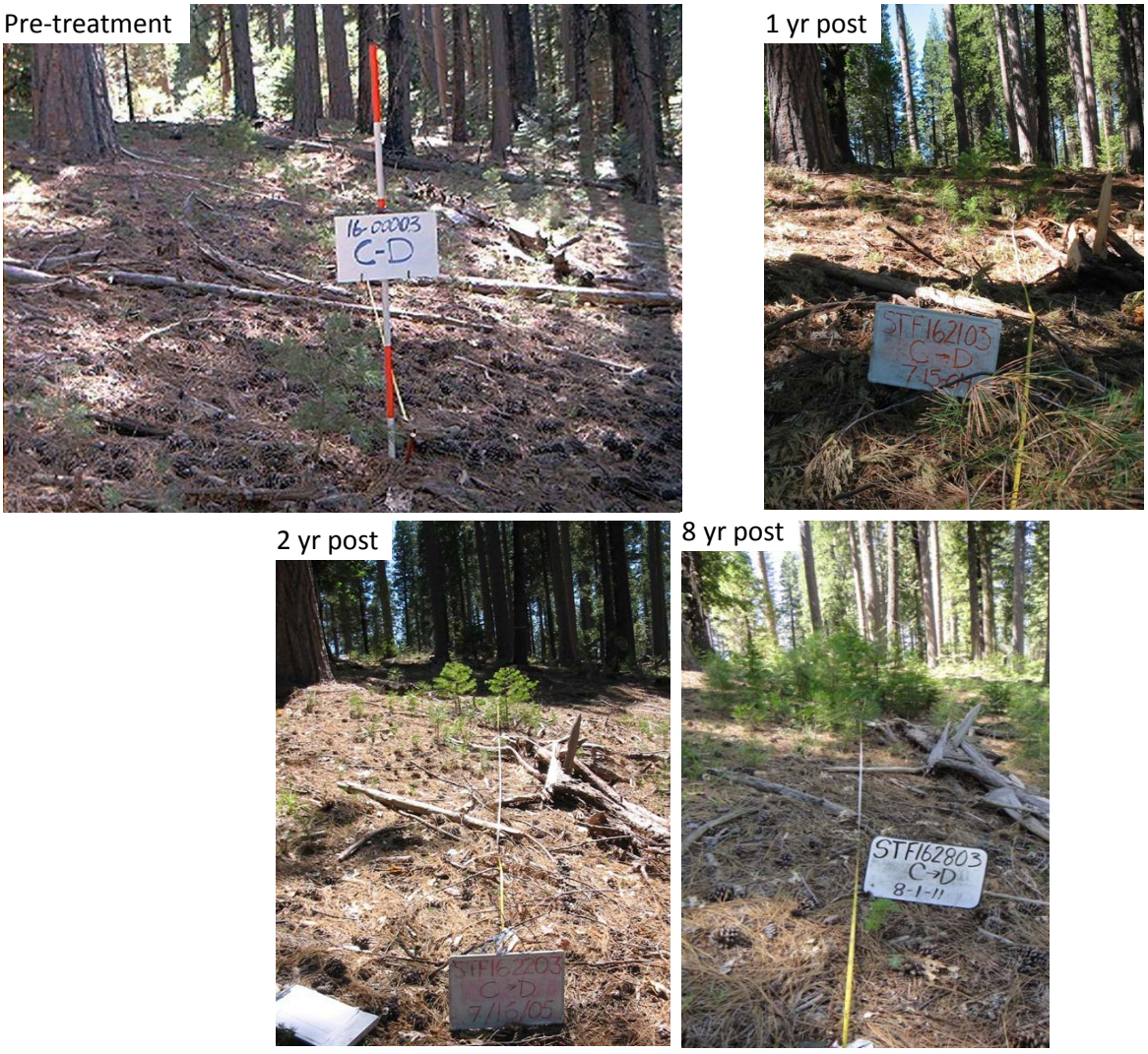

Figure 8. Example paired photos showing changes over the time steps for Plot 3 on the CD or main transect line from pre-treatment in 2001 through 8 yr post-treatment in 2011.

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.

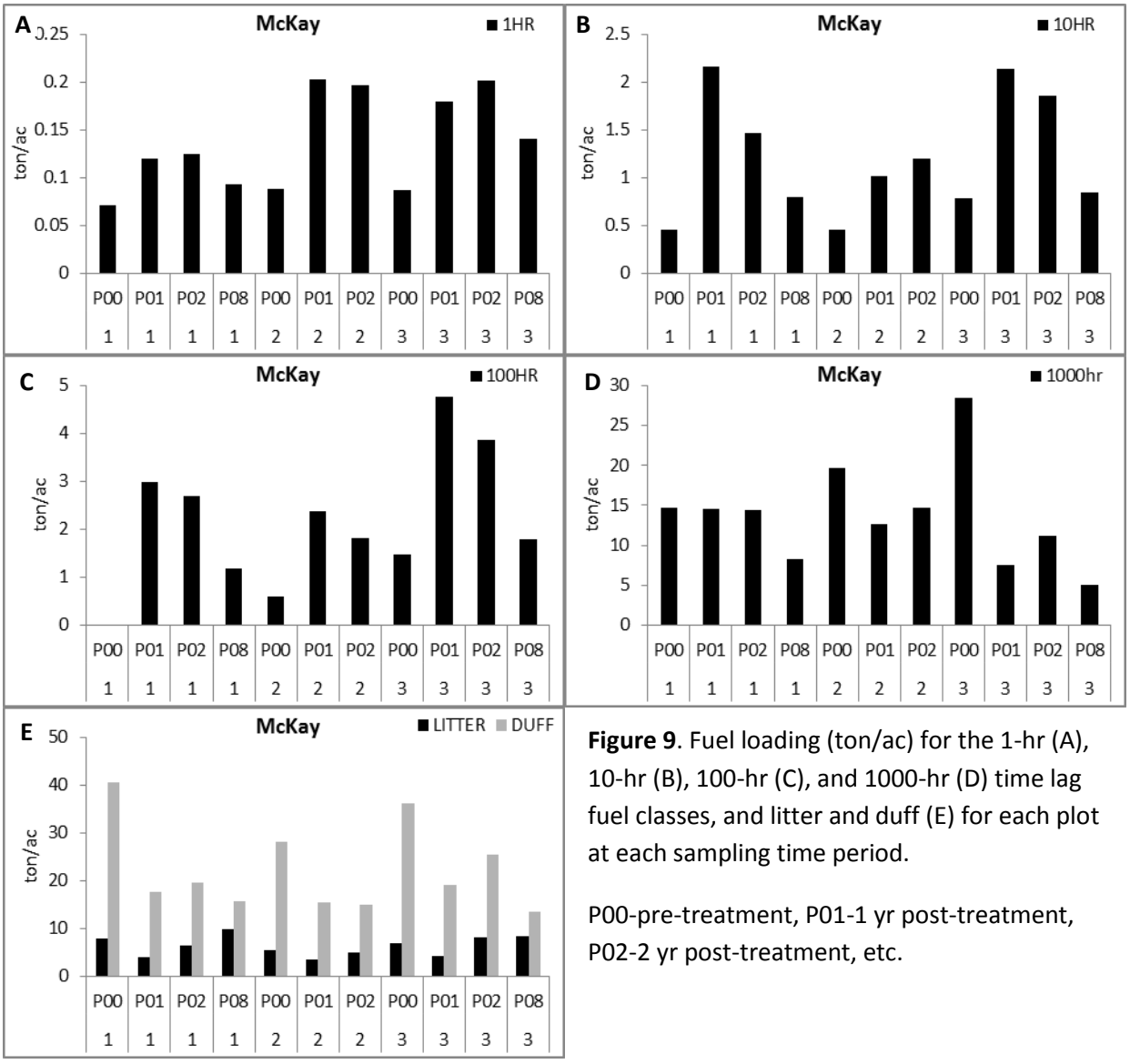

Figure 9. Fuel loading (ton/ac) for the 1-hr (A), 10-hr (B), 100-hr (C), and 1000-hr (D) time lag fuel classes, and litter and duff (E) for each plot at each sampling time period.

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

Table 13. Fuel loading (ton/ac) for the 1-hr, 10-hr, 100-hr, and 1000-hr time lag fuel classes, and litter and duff for by time period for all the plots in the McKay fuel treatment project.

Plot	Time period	1-hr	10-hr	100-hr	1000-hr	Litter	Duff
1	P00	0.07	0.5	0.0	14.6	7.8	40.7
1	P01	0.12	2.2	3.0	14.5	4.0	17.6
1	P02	0.13	1.5	2.7	14.4	6.3	19.6
1	P08	0.09	0.8	1.2	8.3	9.8	15.7
2	P00	0.09	0.5	0.6	19.6	5.4	28.0
2	P01	0.20	1.0	2.4	12.6	3.5	15.5
2	P02	0.20	1.2	1.8	14.6	4.9	15.1
3	P00	0.09	0.8	1.5	28.5	6.9	36.1
3	P01	0.18	2.1	4.8	7.6	4.3	19.1
3	P02	0.20	1.9	3.9	11.1	8.2	25.4
3	P08	0.14	0.8	1.8	5.0	8.4	13.4

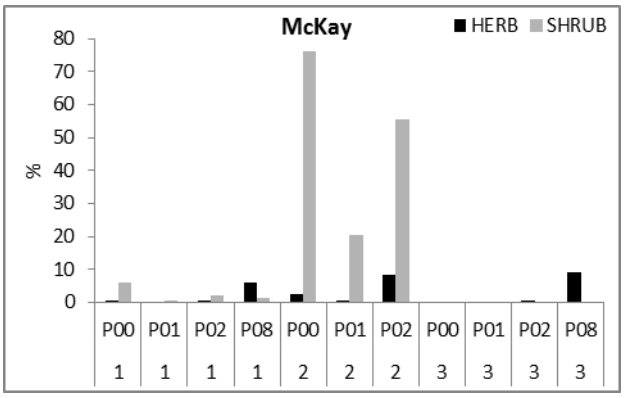

Figure 10. Average herbaceous plant and shrub cover for each plot at each sampling time period.

Table 14. Understory vegetation cover by time period for all the plots in the McKay fuel treatment project.

Plot	Time period	Herbaceous cover (%)	Shrub cover (%)
1	P00	0	6
1	P01	0	0
1	P02	0	2
1	P08	6	1
2	P00	3	76
2	P01	0	20
2	P02	8	56
3	P00	0	0
3	P01	0	0
3	P02	0	0
3	P08	9	0

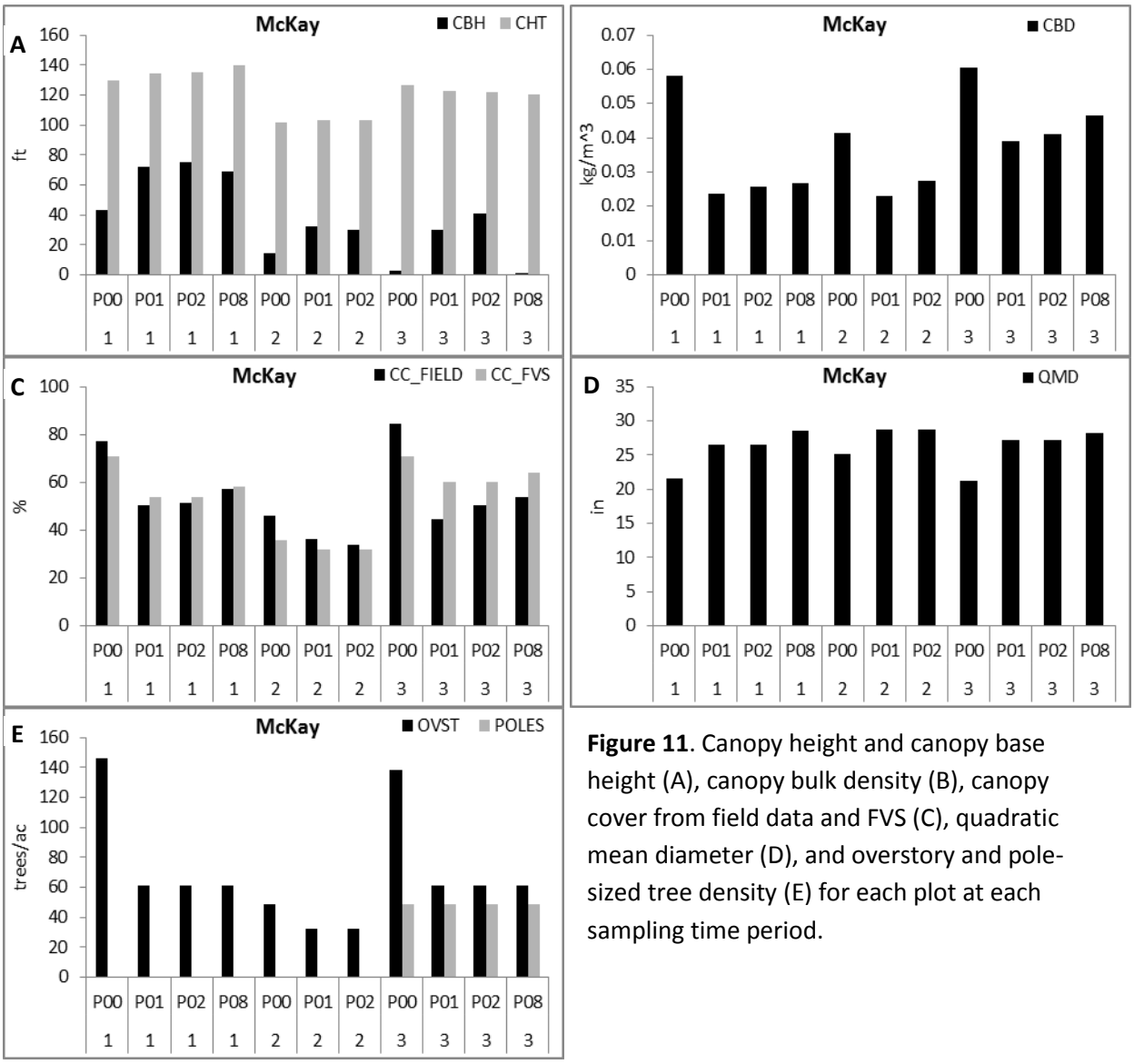

Figure 11. Canopy height and canopy base height (A), canopy bulk density (B), canopy cover from field data and FVS (C), quadratic mean diameter (D), and overstory and pole-sized tree density (E) for each plot at each sampling time period.

Table15. Canopy characteristics by time period for all the plots in the McKay fuel treatment project.

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	77	71	129.4	43.0	0.058	21.5	146	0
1	P01	51	54	134.1	72.0	0.024	26.5	61	0
1	P02	51	54	135.3	75.0	0.026	26.5	61	0
1	P08	57	58	140.2	69.0	0.027	28.5	61	0
2	P00	46	36	102.1	14.0	0.041	25.1	49	0
2	P01	36	32	103.2	32.0	0.023	28.8	32	0
2	P02	34	32	102.9	30.0	0.027	28.8	32	0
3	P00	85	71	126.5	3.0	0.060	21.2	138	49
3	P01	45	60	122.9	30.0	0.039	27.2	61	49
3	P02	50	60	121.8	41.0	0.041	27.2	61	49
3	P08	54	64	120.8	1.0	0.047	28.2	61	49

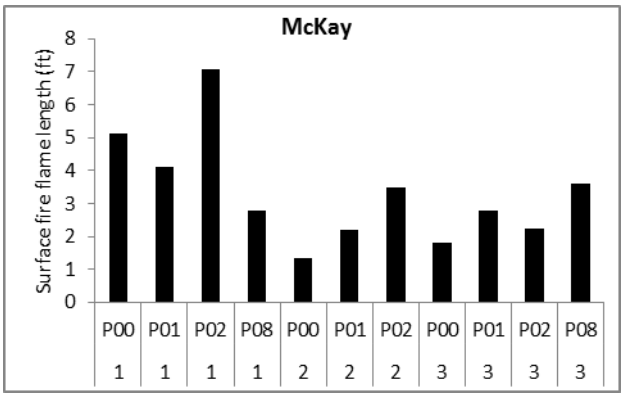

Figure 12. Surface fire flame length from custom fuel models using NEXUS for each plot at each sampling time period under 90th percentile fire weather conditions.

Table 16. 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 McKay fuel treatment project.

Plot	Time period	Surface fire flame length (ft)	Type of fire
1	P00	5.11	Surface
1	P01	4.12	Surface
1	P02	7.08	Surface
1	P08	2.8	Surface
2	P00	1.36	Surface
2	P01	2.19	Surface
2	P02	3.47	Surface
3	P00	1.82	Passive crown
3	P01	2.8	Surface
3	P02	2.24	Surface
3	P08	3.62	Passive crown

Wrights Creek (Project 28, Mi-Wok District)

Project history

The Wrights Creek project had three plots set up pre-treatment using the detailed 2001 plot style. For details about the protocol used, please see "Appendix B: Sampling Protocol" at the end of the report. Plots 1 and 2 were treated and continued to be revisited. Plots were sampled prior to treatment (P00), then 1 to 2 yr post (P01, P02), 3 to 5 yr post (P03, P04, P05), 7 to 8 yr post (P07, P08), and then 10 yr post (Table 17).

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). For this project, all plots were grouped into the prescribed fire treatment type and yellow pine forest type.

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

Table 17. Treatment visits completed by year for each of the plots in the project.

Plot	2002	2005	2006	2009	2012
1	P00	P01	P02	P05	P08
2	P00	P03	P04	P07	P10

Treatment information

Prior treatment: The 1950 Wrights Creek Fire perimeter encompassed all three plot areas. Plots 1 and 2 were thinned in the Stand Clearcut (EA/RH/FH) and Wrights Creek II Multiprod on 5/5/1995.

During the project treatment: Plot 2 was burned in the fall of 2002, and Plot 1 was burned on 6/25/05 under the Wrights Creek NEPA process.

Future treatment: The southernmost plot (Plot 1) is included in the "Two mile" project which has largely concluded it final NEPA stage (in 2012). The "Two mile" project is proposed to include thin/biomass/shred/burn. Implementation timeframe is unknown at this time.

Project location map

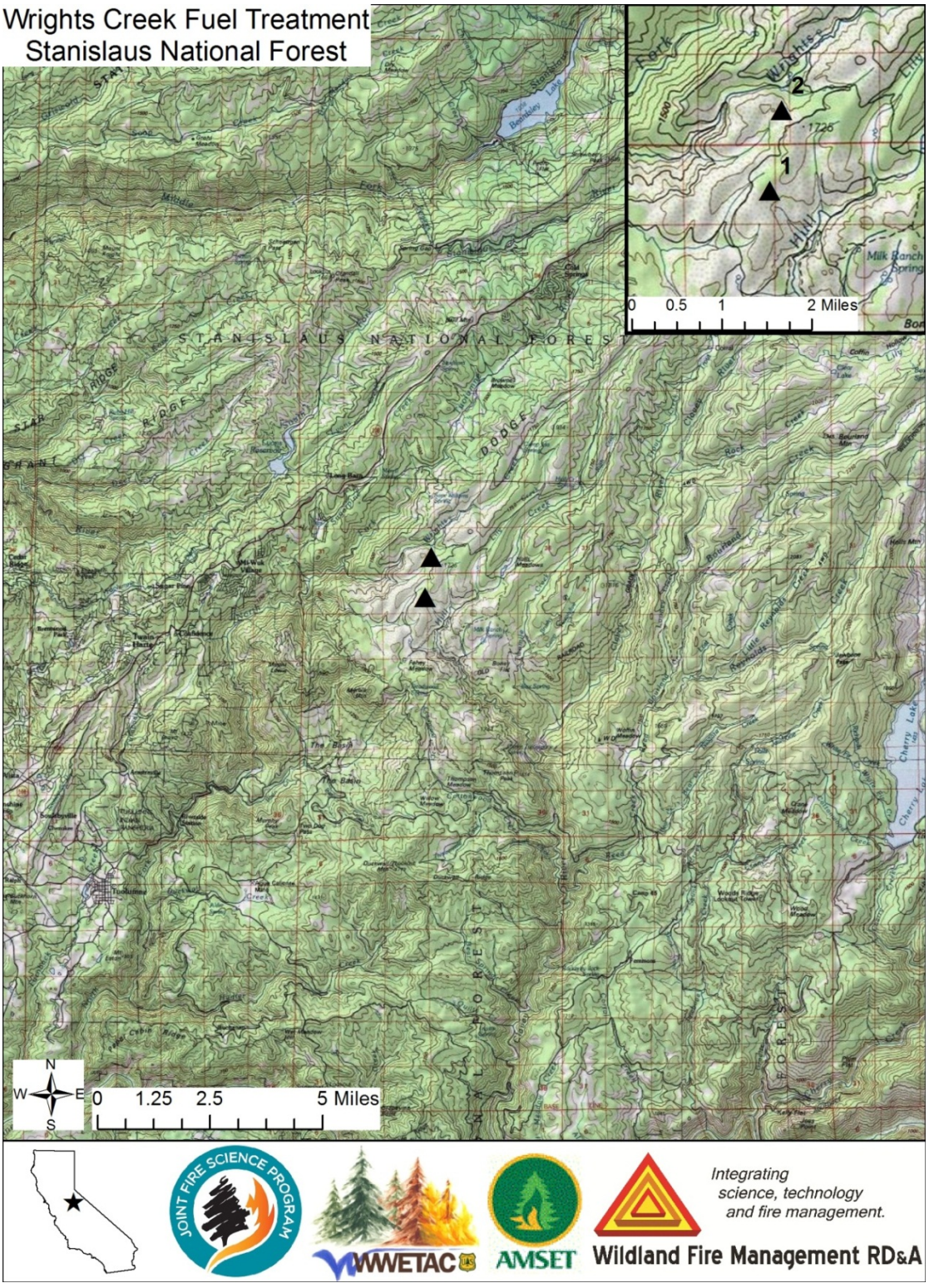

Figure 13. Location map for the Wrights Creek fuel treatment plots, showing general location of plots, and inset displaying increased detail of plot locations.

Driving directions/GPS/plot layout

Driving directions

Plot 1- From 3N01 (31 Rd), turn onto 3N07 (start odometer here), drive 2.55 miles SW on 3N07 to 2N55. Turn left on 2N55 (reset odometer here) pass unmarked ridge road on left at 0.3 miles. The start tree is on the left (north) side of the road about 2 m off the road at 0.6 to 0.7 miles.

Plot 2- Travel on Hwy 108 to Long Barn Rd., then left on Merril Springs Rd (3N07). Travel about 6.3 miles to 2N42Y, which is about 1 mile after Fayhe Cabin (old historic cabin by road side). Turn right on 2N24Y, go less than 0.5 mile and turn right on 3242Y and go 0.1 miles to "Caution" signs that face the road that mark a different study site area. Near the caution sign is the start tree with a placard not facing the road.

Table 18. 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).

Plot	Start tree (DBH and species)	Azimuth °	Distance
1	64 cm ponderosa pine	305	111 m
2	35 cm ponderosa pine	56	194 m

Table 19. GPS coordinates for each plot (decimal degrees, datum NAD 1983, projection NAD_1983_California_Teale_Albers).

Plot	Latitude	Longitude
1	38.055468	-120.105654
2	38.068382	-120.103207

Table 20. Plot layout lines azimuths (degrees). See Appendix A for plot diagrams. Where AB and CD is the main transect and F1, F2, F3, and F4 are the fuels transects.

Plot	Plot type	AB	CD	F1	F2	F3	F4
1	Detailed 2001	143	211	280	10	100	192
2	Detailed 2001	68	331	201	291	14	101

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.

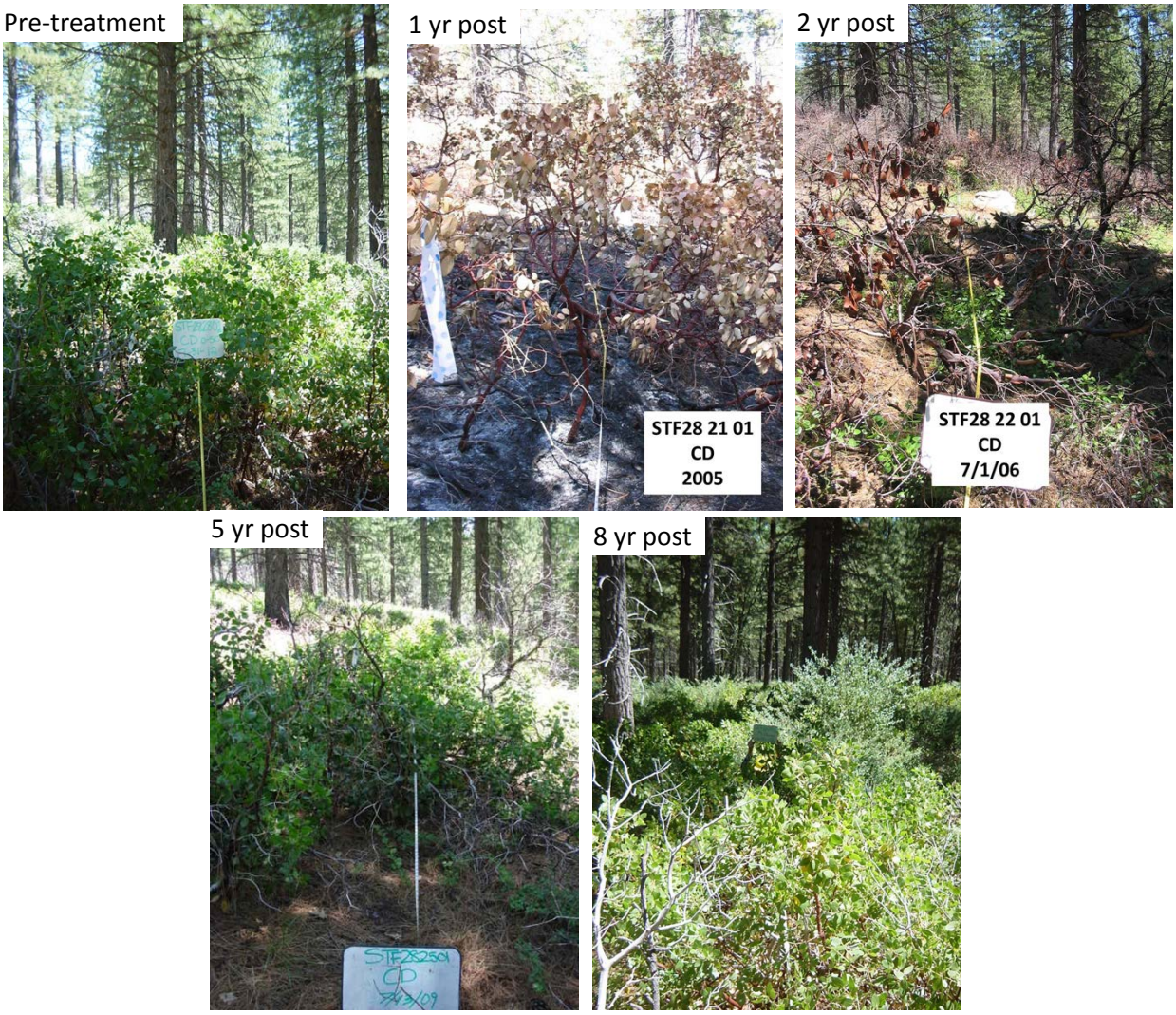

Figure 14. Example paired photos showing changes over the time steps for Plot 1 on the CD or main transect line from pre-treatment in 2002 through 8 yr post-treatment in 2012.

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.

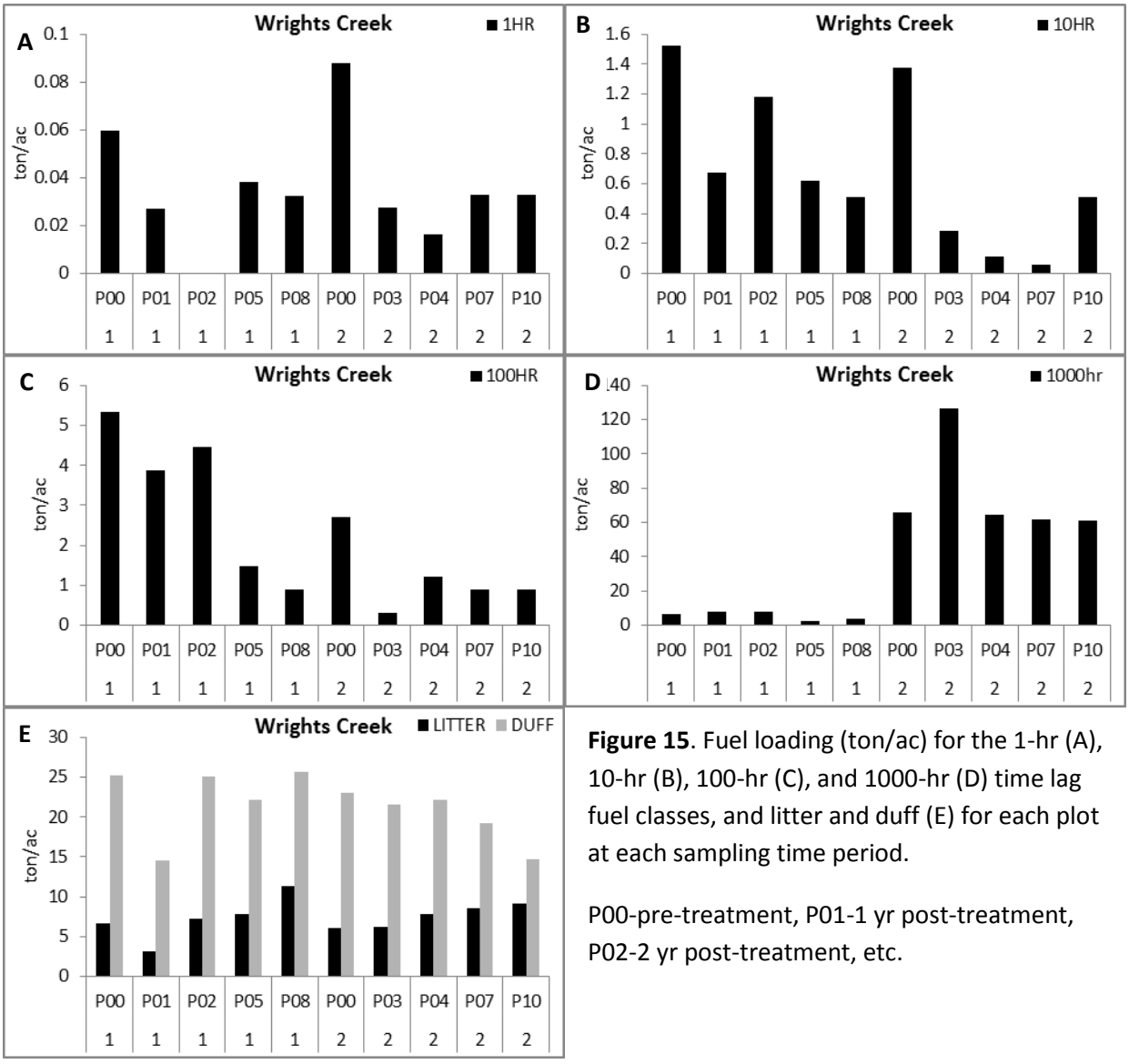

Figure 15. Fuel loading (ton/ac) for the 1-hr (A), 10-hr (B), 100-hr (C), and 1000-hr (D) time lag fuel classes, and litter and duff (E) for each plot at each sampling time period.

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

Table 21. Fuel loading (ton/ac) for the 1-hr, 10-hr, 100-hr, and 1000-hr time lag fuel classes, and litter and duff for by time period for all the plots in the Wrights Creek fuel treatment project.

Plot	Time period	1-hr	10-hr	100-hr	1000-hr	Litter	Duff
1	P00	0.06	1.5	5.3	6.6	6.7	25.2
1	P01	0.03	0.7	3.9	7.5	3.2	14.6
1	P02	0.00	1.2	4.5	8.1	7.2	25.1
1	P05	0.04	0.6	1.5	2.6	7.8	22.2
1	P08	0.03	0.5	0.9	3.4	11.3	25.6
2	P00	0.09	1.4	2.7	65.5	6.1	22.9
2	P03	0.03	0.3	0.3	126.3	6.2	21.6
2	P04	0.02	0.1	1.2	64.5	7.8	22.2
2	P07	0.03	0.1	0.9	62.0	8.5	19.2
2	P10	0.03	0.5	0.9	61.0	9.1	14.7

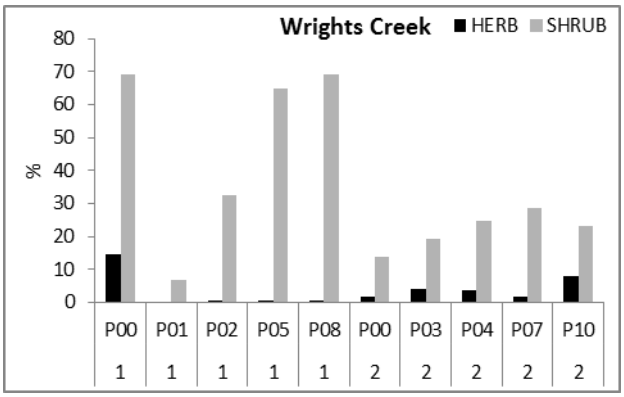

Figure 16. Average herbaceous plant and shrub cover for each plot at each sampling time period.

Table 22. Understory vegetation cover by time period for all the plots in the Wrights Creek fuel treatment project.

Plot	Time period	Herbaceous cover (%)	Shrub cover (%)
1	P00	15	69
1	P01	0	7
1	P02	0	33
1	P05	0	65
1	P08	1	69
2	P00	2	14
2	P03	4	19
2	P04	4	25
2	P07	2	29
2	P10	8	23

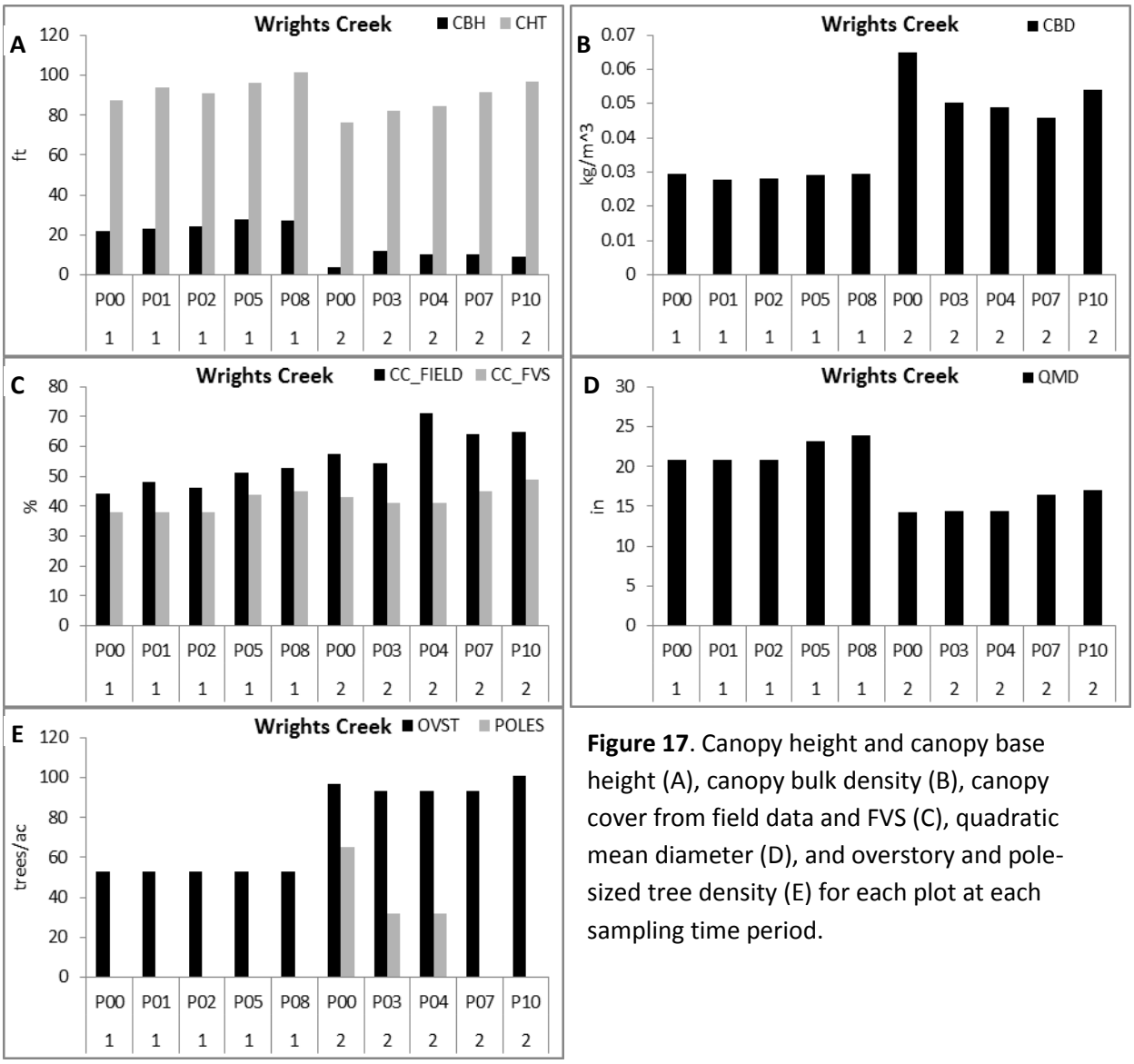

Figure 17. Canopy height and canopy base height (A), canopy bulk density (B), canopy cover from field data and FVS (C), quadratic mean diameter (D), and overstory and pole-sized tree density (E) for each plot at each sampling time period.

Table23. Canopy characteristics by time period for all the plots in the Wrights Creek fuel treatment project.

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	44	38	87.2	22.0	0.029	20.8	53	0
1	P01	48	38	93.8	23.0	0.028	20.8	53	0
1	P02	46	38	90.7	24.0	0.028	20.8	53	0
1	P05	51	44	96.5	28.0	0.029	23.2	53	0
1	P08	53	45	101.3	27.0	0.029	23.9	53	0
2	P00	57	43	76.4	4.0	0.065	14.2	97	65
2	P03	54	41	82.2	12.0	0.050	14.5	93	32
2	P04	71	41	84.8	10.0	0.049	14.5	93	32
2	P07	64	45	91.4	10.0	0.046	16.4	93	0
2	P10	65	49	96.9	9.0	0.054	17.0	101	0

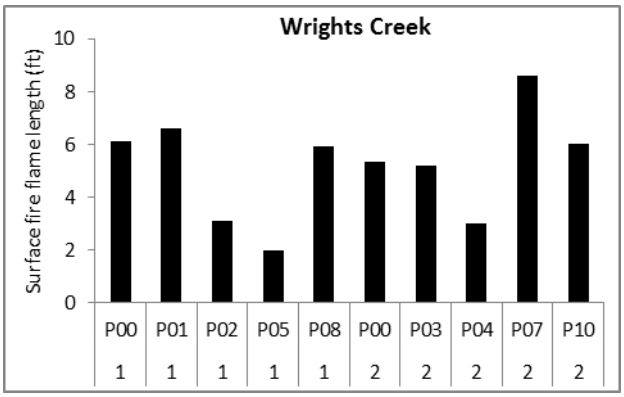

Figure 18. Surface fire flame length from custom fuel models using NEXUS for each plot at each sampling time period under 90th percentile fire weather conditions.

Table 24. 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 Wrights Creek fuel treatment project.

Plot	Time period	Surface fire flame length (ft)	Type of fire
1	P00	6.10	Surface
1	P01	6.59	Surface
1	P02	3.08	Surface
1	P05	1.99	Surface
1	P08	5.91	Surface
2	P00	5.31	Passive crown
2	P03	5.17	Surface
2	P04	3.01	Surface
2	P07	8.62	Surface
2	P10	6.01	Passive crown

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).

2001 detailed plot specifics

Shrub transects (50 m)

There are two perpendicular transects (AB and CD) for these plots. They **should** be contour and up/down slope, but they **might** be shifted.

Herb quadrats

There are 10 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 **left hand side** looking from 0 to 50 m for both the AB and CD transects.

Seedlings

This is a circular plot starting at the pole/seedling origin rebar (at 33.92m 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 33.92m 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 100 canopy cover readings will be measured. They will start at 1m and continue every meter until the ends of each transect (50 m). This is to be done along **both** transect AB and CD.

Fuel loading

There are four 50 ft fuel transects for this layout. They start at 7.15 m and 42.85 m along the AB and CD transects extending out at a 45º angle. See the diagram for number convention and general layout.

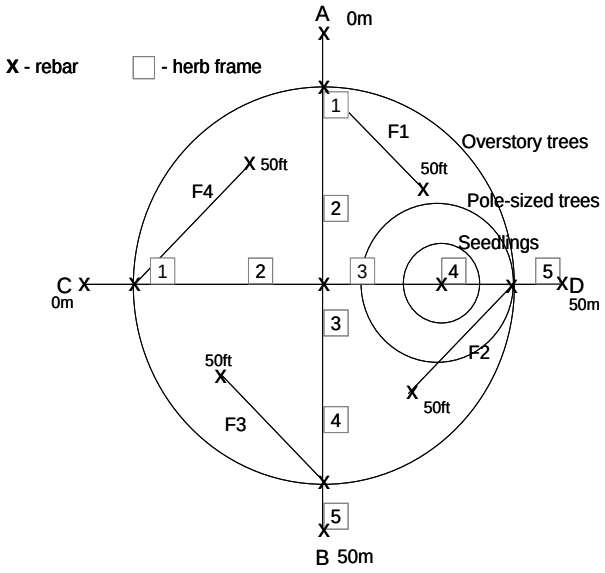

Figure 19. Plot layout diagram for the detailed plots installed in 2001 and 2002.

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.

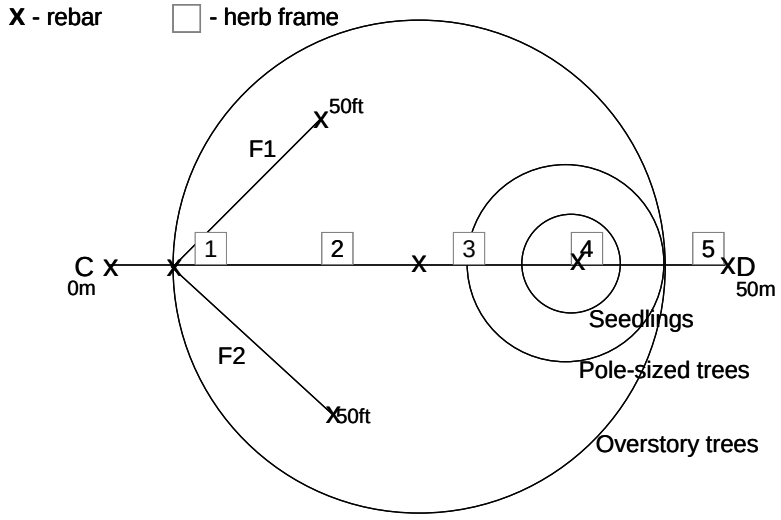

Figure 20. Plot layout diagram for the detailed plots installed from 2003 to 2006.

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.

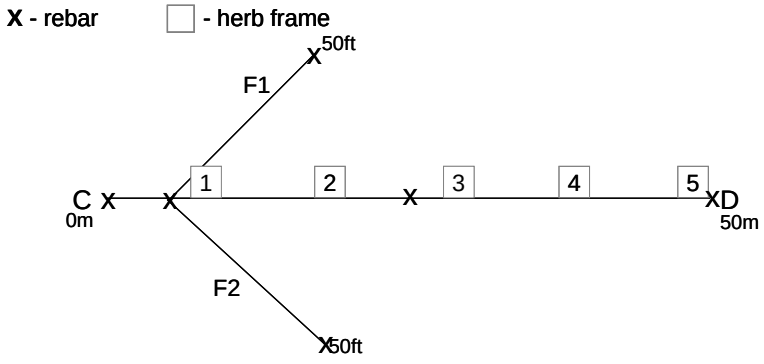

Figure 21. Plot layout diagram for the fuels plots installed from 2003 to 2006.