Fuel treatment effectiveness over 10 years in California forests, USA

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Expansive stand replacing crown fire is the most severe and negatively impacting fire type in many of the coniferous ecosystems within California. The most successful way to change potential fire behavior is to reduce surface fuels, increase the canopy base height and reduce canopy bulk density. This multi-tiered approach breaks the continuity of surface, ladder and crown fuels (i.e., Agee *et al.* 2000; Scott and Reinhardt 2001). Little is known about how long fuel treatments last, or how often they will need to be re-treated to maintain desired levels of reduced fire behavior and effects (Graham *et al.* 2004). This study directly assess how treated fuels change over time.

The most reliable test of fuel treatment effectiveness is to observe what happens when a wildfire encounters a treated area and determine if fire behavior is changed (Pollet and Omi 2002; Finney *et al.* 2005). In the absence of this information and in necessity for fuel treatment planning, it is necessary to "test" fuel treatment effectiveness using fire behavior modeling (i.e., Stephens and Moghaddas 2005; Vaillant *et al.* 2009). Many studies which utilize fire behavior modeling couple data collected to characterize stand characteristics with standard fuels models (Anderson 1982; Scott and Burgan 2005), however there is uncertainty in these results due to the subjective nature of fuel model selection. Agee and Lolly (2006) presented an alternative approach, where they avoided selection of fuel models and the associated uncertainty to compare pre- and post-treatment fire behavior by creating custom fuel models for each site using empirical fuel data. This study explores the use of custom fuel models to model potential fire behavior for assessing fuel treatment effectiveness.

Methods

Objectives

1) Determine the length of time which fuel treatments are effective at reducing undesired fire behavior and effects using:

- ***Forest stand structure***
- ***Understory live fuel loads***
- ***Ground and surface fuel loads***
- ***Potential fire behavior***

2) Quantify the uncertainty associated with use of standard fuel models in predicting potential fire behavior for understanding fuel treatment effectiveness.

3) Quantify the impacts of prescribed-fire only treatments on carbon stocks overtime & compare to simulated values.

Study Site and Treatments

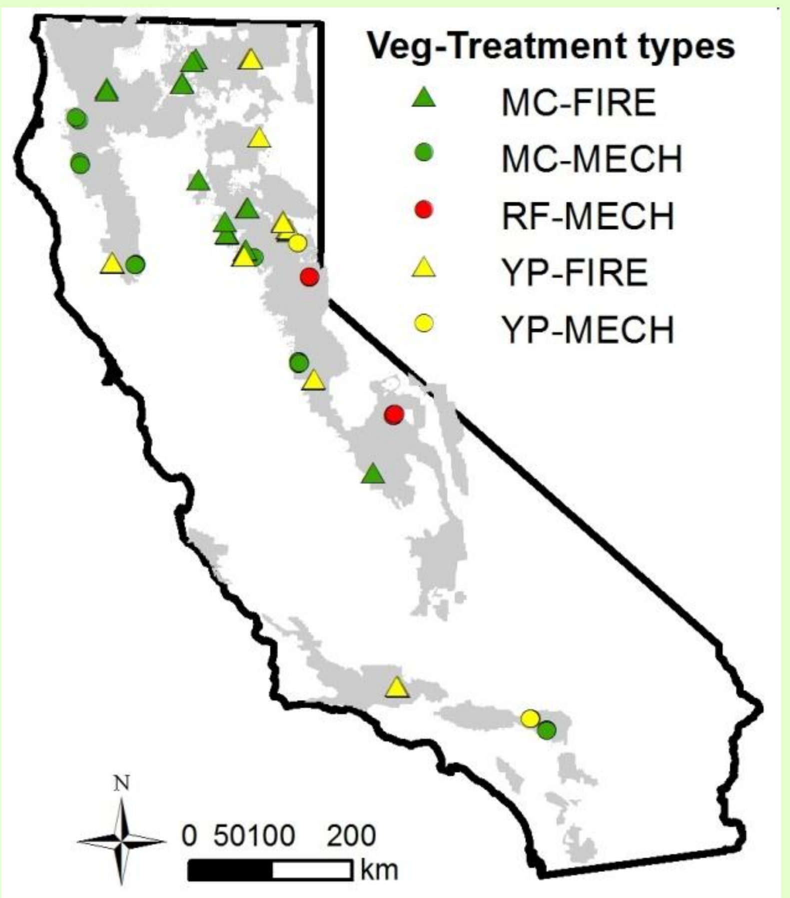

Figure 1. Fuel treatment project locations denoted by Veg-Treatment type. MC = mixed conifer, RF= red fir, YP = Yellow Pine, Fire = fire only treatment, MECH = mechanical treatment.

As part of a long-term fuel treatment effects monitoring project data was collected at 89 permanent plots representing 28 fuel treatment projects on 14 national forests in California from 2001 to 2012. Fuel treatments ranged from prescribed fire only, thinning only, mechanical understory treatments such as mastication, and a combination of thinning plus understory fuel reduction treatments.

Plots were assigned subjectively to three forest types based on dominant tree species, similarities in fuel characteristics, and expected fire behavior. The forest types are mixed conifer (MC), yellow pine (YP) and red fir (RF).

Forest and fuels inventory data was collected before treatments and up to 10 years after treatment (1, 2, 5, 8, and 10 year post treatment intervals) for each plot.

Field Measurements

Stand Characteristics

Trees

- *Overstory trees (> 15 cm DBH, 0.1 ha plot), pole-sized trees (0.025 ha),*
  - ✓ Live - Species, DBH, height to live crown base, total height, and canopy position
  - ✓ Dead - Species, DBH, total height
- *Seedling trees (<2.5 cm DBH, 0.005 ha)*
  - ✓ Tallied by species in height classes

Prescribed fire effects *-measured after burn treatments*

- Bole char, needle scorch, torch height
- Burn severity rating (CBI) for plot

Canopy cover *- 50 or 100 points along transect(s)*

- Moosehorn, site tube (50-100 points)

Figure 2. Field crews using laser to measure tree metrics.

Live and dead fuels

Shrubs *– 1 or 2 50m transect(s)*

- Species, vigor (live/dead), range, average height

Grasses and herbaceous plants *– 5 or 10 1X1m quadrats*

- Species, cover class, vigor, height

Surface fuels *- planar intercept, 2 or 4 15.m transect(s)*

- 1-hr, 10-hr, and100-hr tallied
- 1000-hr fuels diameter recorded
- Max fuel bed depth measured at 10 intervals
- Litter and duff measured at 10 points

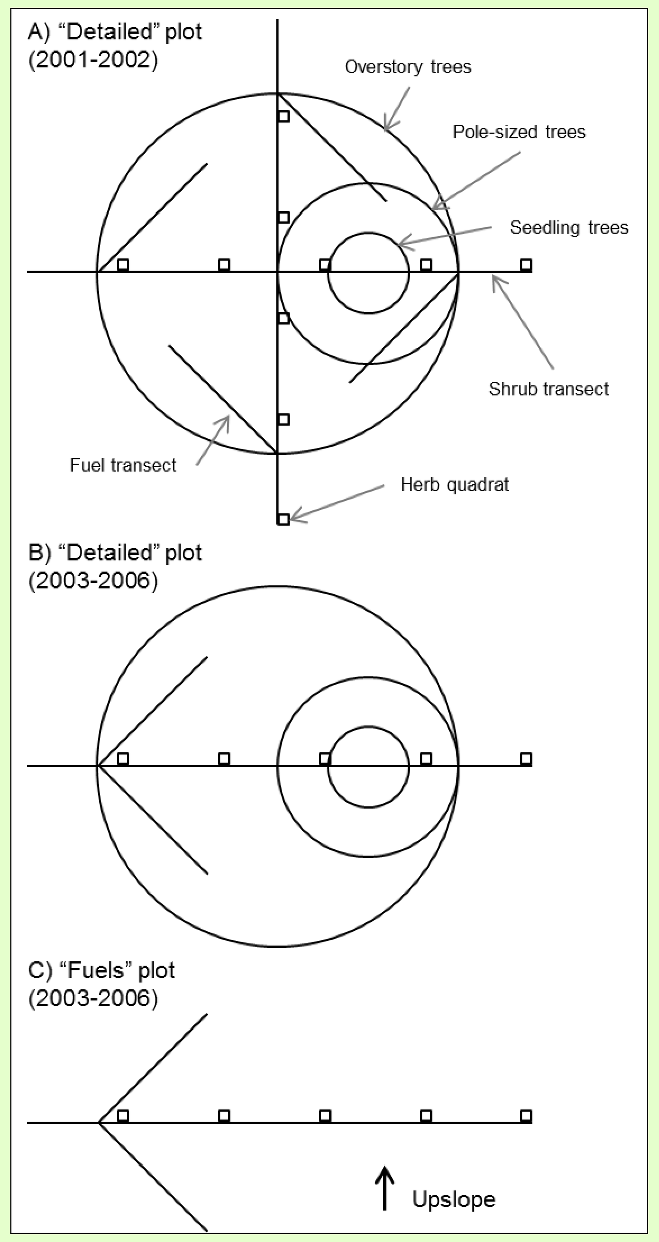

Figure 3. Various plot layouts used during field sampling.

Fuel loading & canopy characteristics

Mechanical Treatments

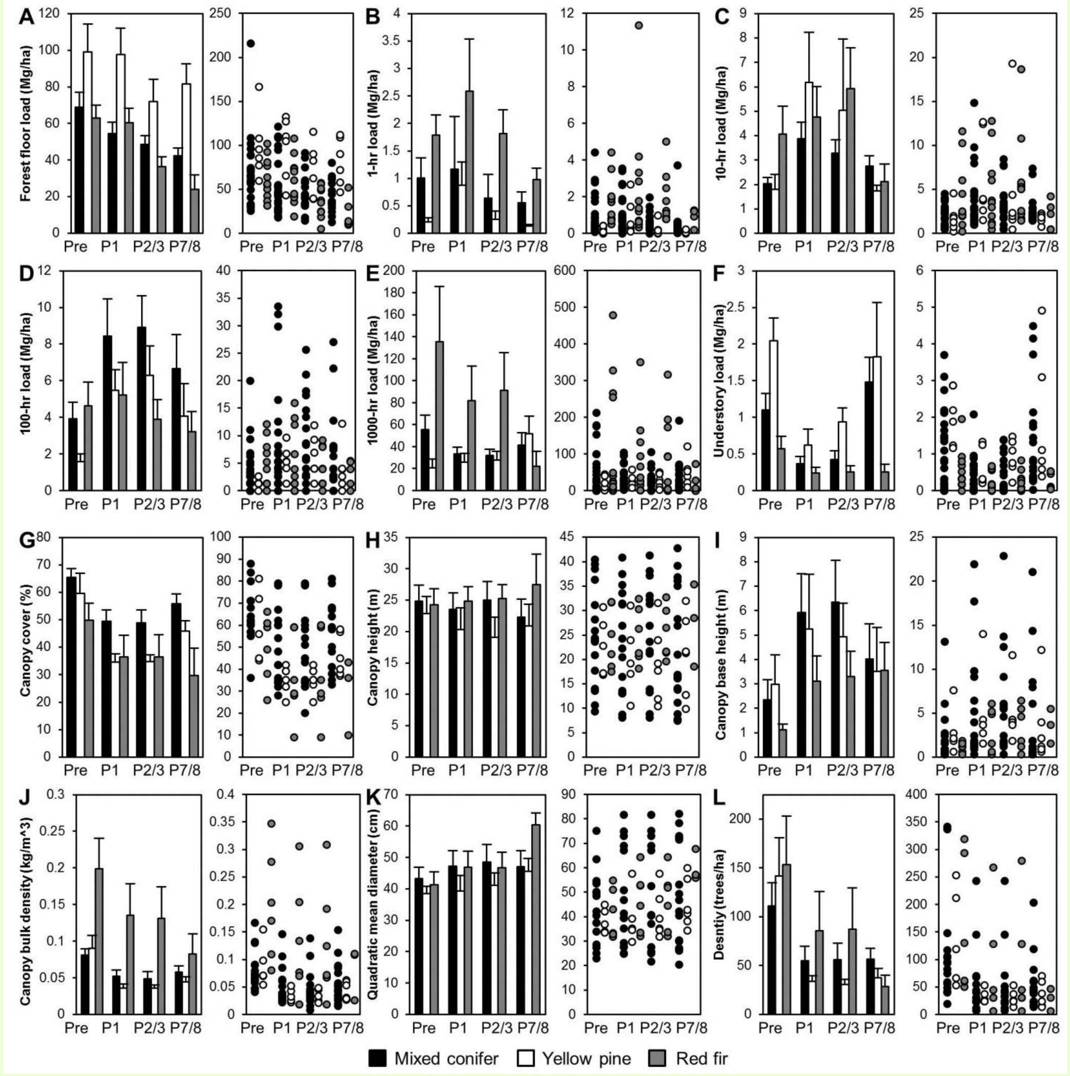

Figure 4. Bar charts showing mean and standard error paired with scatter plots showing dispersion of data for mechanical treatments Both are grouped by vegetation type.

Prescribed Fire Treatments

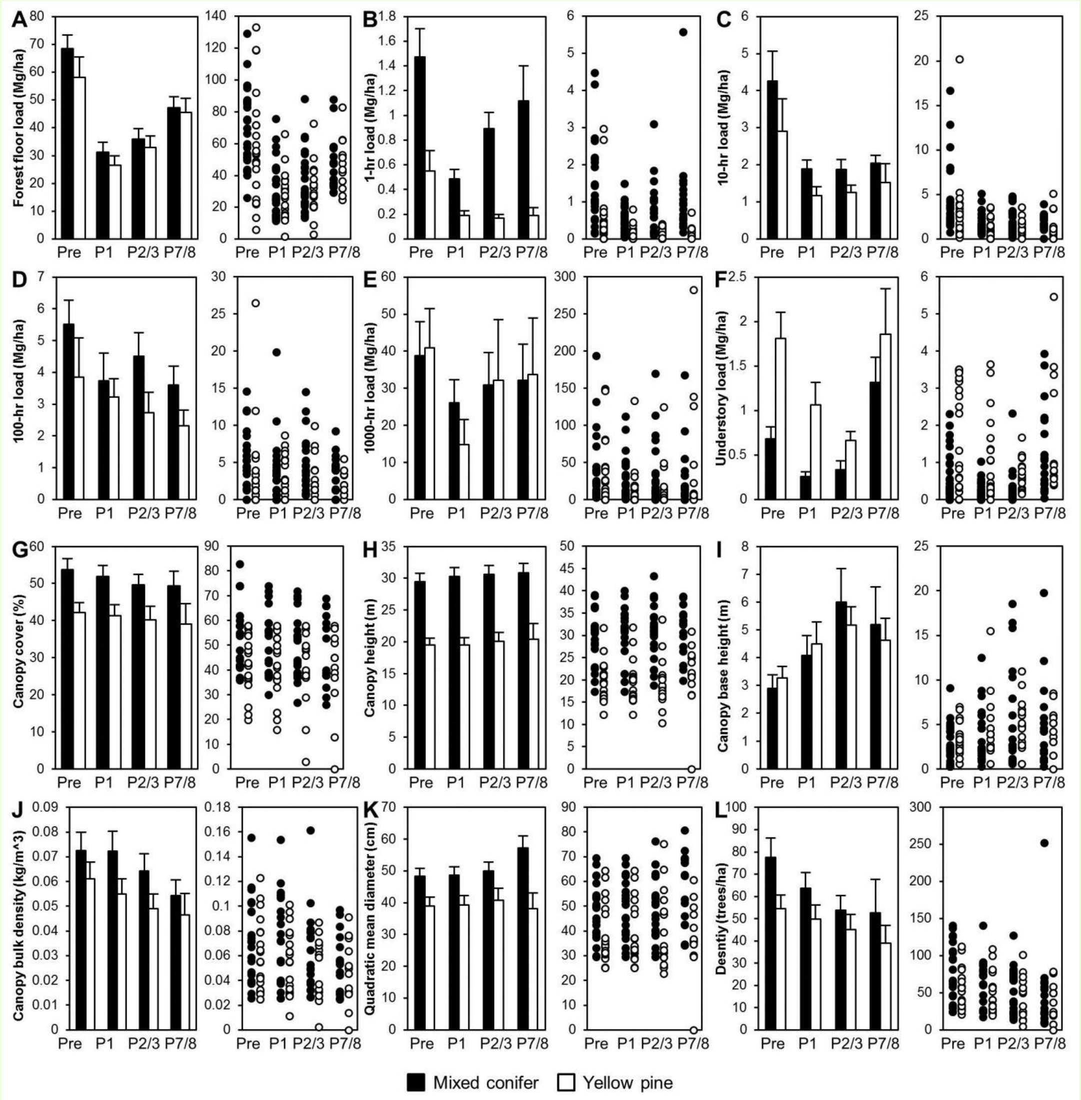

Figure 5. Bar charts showing mean and standard error paired with scatter plots showing dispersion of data. Both are grouped by vegetation type.

Chronoseries of Masticated Plots

Pre-treatment | 1-year post | 2-year post | 8-year post | 10-year post

Prescribed Fire & Carbon Stocks

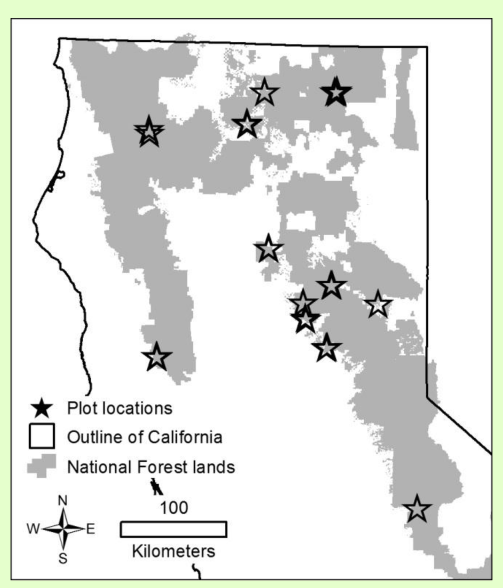

Figure 6. Prescribed-fire treatment plots used in analysis of carbon pools

A subset of the this data (25 plots from 12 projects) which was treated with prescribed fire was used to study how prescribed fire treatments affect carbon stocks over time. And to assess the accuracy of modeling carbon stocks into the future by comparing field-derived values to those modeled with FFE-FVS.

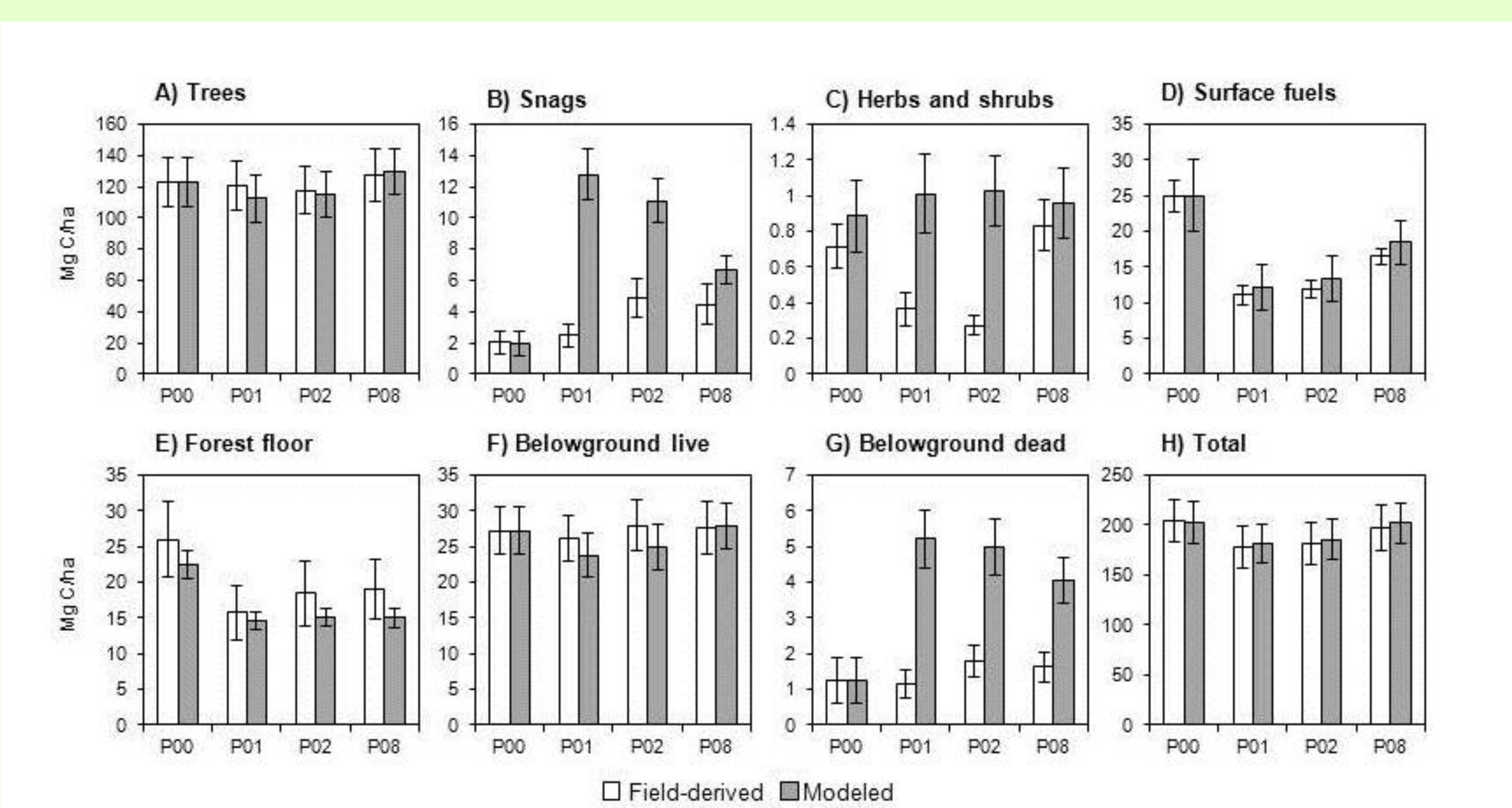

Figure 7. Means and standard errors of various carbon pools from field-derived measurements versus FFE-FVS model output by time since treatment. (P00, P01, P02, P08 = pre-treatment, 1-year, 2-years, and 8-years post-treatment, respectively)

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Evaluation of Custom Versus Stylized Fuel Models

Fuel treatment effectiveness is often evaluated using fire behavior modeling systems which use surface fuel models to generate surface flame lengths and fire type. How surface fuels models are characterized, either using one of the 53 fuel models or developing custom fuel models, can affect predicted fire behavior. We evaluated two methods to characterize surface fuels using FFE-FVS; measured loads were used to 1) develop custom fuel models and 2) select a standard fuel model.

Preliminary results suggest that the two methods are significantly different when comparing pre-treatment flame lengths with severe and moderate conditions; and post 2-year for severe conditions. Custom fuel models produced higher flame lengths and more crown fire compared to standard fuel models for pre and post 8-yr time periods. One could conclude a different outcome of fuel treatment effectiveness due to the method used to characterize surface fuel loads.

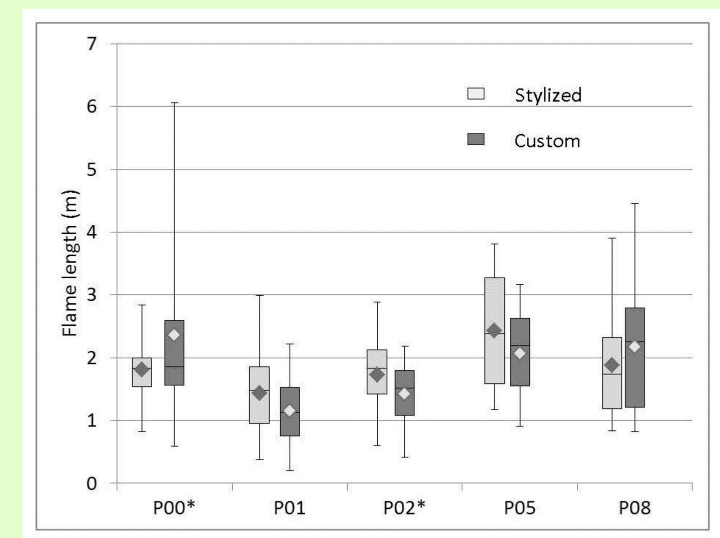

Figure 8. Boxplots of predicted surface flame lengths (m) modeled with maximum momentary gust speed and standard or custom fuel models by time since treatment.

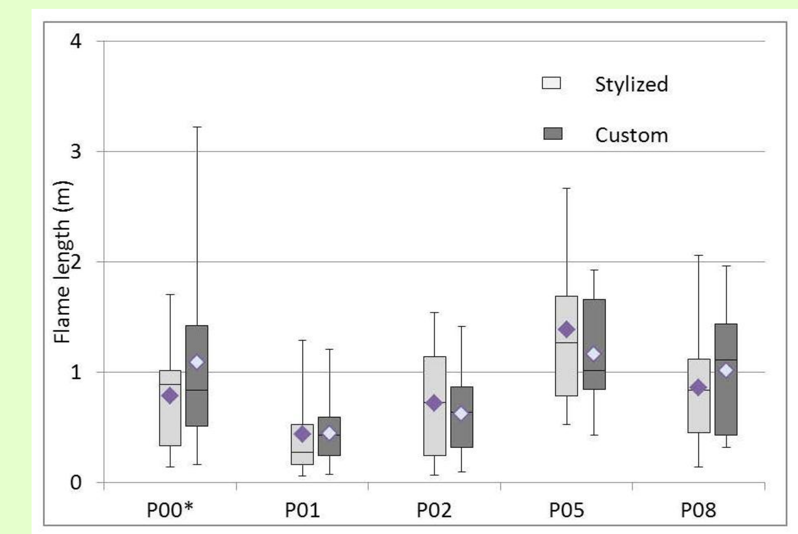

Figure 10. Boxplots of predicted surface flame lengths (m) modeled with maximum 1-minute wind speed and standard or custom fuel models by time since treatment

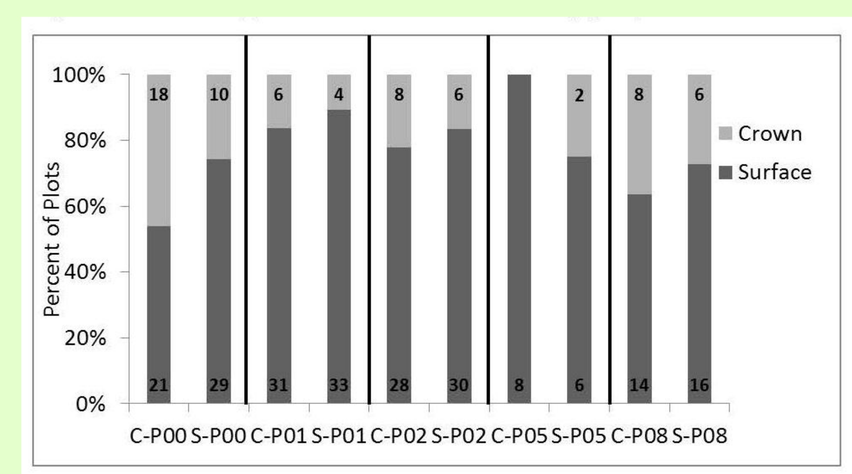

Figure 9. Percent of plots by predicted fire type modeled with maximum momentary gust speed by time since treatment.

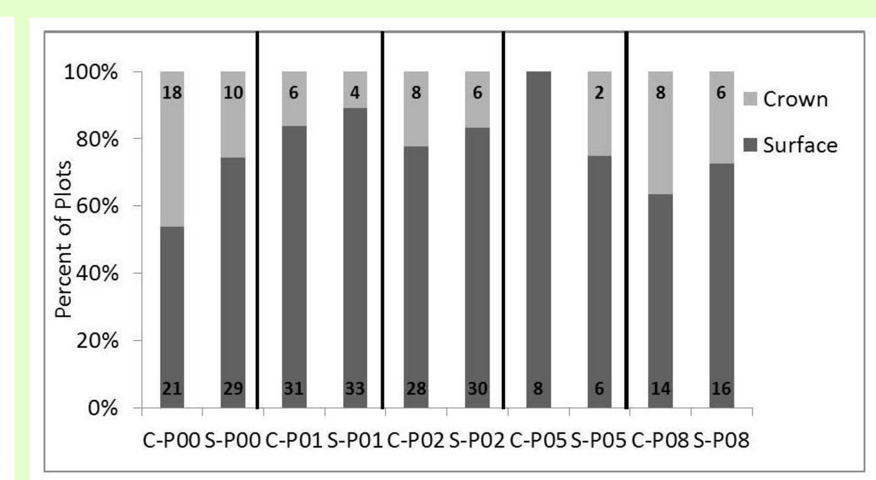

Figure 11. Percent of plots by predicted fire type modeled with maximum 1-minute wind speed by time since treatment.

"C-" denotes custom fuel models used and "S-" denotes standard fuel models; P00, P01, P02, P08 = pre-treatment, 1-year, 2-years, and 8-years post-treatment, respectively)

Chronoseries of Burned Plots

Pre-treatment | 1-year post | 2-year post | 8-year post | 10-year post

Lessons Learned and Suggestions for Future Monitoring

Anybody who has done long-term, repeated measures, monitoring will run into some issues in the field that can create a large headache when collating and checking the data. Below we have some suggestions from our lessons learned during this study.

Plot and transect relocation: every visit verify driving directions and update as needed. For the plots: 1) make a map noting rebar locations, 2) bring GPS coordinates, and 3) bring data and photos to help locate plots and rebar within.

Trees: to help improve tree measurement accuracy and consistency: 1) map the trees, 2) always bring previous years data, and 3) emphasize appropriate sampling techniques. At the end of the field season input and validate all data. Check for species changes and anomalies for growth and changes in status.

Litter and Duff: we recommend measuring them together as 'forest floor' and assigning a percentage to each to minimize sample error.

Fuel bed depth: we found that it is imperative to refresh field crews annually on the true definition of fuel bed depth.

Grass/herb: we recommend trying to visit plots at the peak of flowering for the majority of species to aid in identification of plants.

Photos: print the previous years' photos and take them into the field for direct comparison.

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