Changes in Forest Structure and Fire Behavior on the Unc Mesa Restoration Project

Results from a stem-map inventory and physics based fire behavior modeling

Background

Ponderosa pine (*Pinus ponderosa*) forests within the Uncompahgre National Forest, like much of the western United States, have undergone a shift from a historical mosaic pattern of individual trees, clumps, and openings that exhibited a variety of tree sizes to a more dense, homogeneous forest structure. These changes have resulted in an increased concern over the potential for altered ecological functions, such as increased potential for crown fires. In response to this shift in forest structure, restoration treatments seeking to enhance structural complexity and mitigate undesirable fire behavior, such as those as part of the Uncompahgre Plateau Collaborative Forest Landscape Restoration Project, have started to be implemented. However, due to traditional views of stand management and spatially-inexplicit stand dynamics and fire behavior models the implications of structural complexity are not fully understood or evaluated.

Study Objective

This case study assessment utilized a 10 acre stem-map plot within unit #1 of the Unc Mesa restoration project in order to evaluate the treatment's impact on forest structure and fire behavior. The analysis evaluated pre- and post-treatment changes in traditional forest inventory metrics, forest spatial arrangement, and simulated fire behavior using WFDS, a model that considers the spatial arrangement of trees on wind and fire behavior.

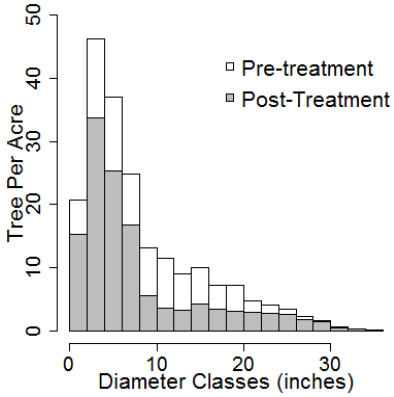
Forest Structure Changes

This site is typical of the more productive ponderosa pine stands on the west slope of the Rocky Mountains in Colorado with a site index of 90 feet (base age 100). Prior to treatment, the stand was dominated by 2-8" DBH trees, with a moderate to high stocking level 204 trees per acre (TPA) and 135 ft^2 of basal area (BA) per acre, but areas that exceeded 500 TPA. Following treatment, the resulting changes occurred:

- Both TPA and BA per acre were reduced by ~40% without impacting the distribution of tree diameters.
- Although surface fuel loading saw only a slight reduction (13%), canopy bulk density was reduced by 40%.

Table 1. Stand structure and diameter class distribution pre- and post-treatment.

	Pre	Post
TPA	203	126
QMD (in)	10.8	10.5
BA (ft^2/acre)	135	77
Mean - CBH (ft)	20	22.3
Mean - HT (ft)	64.6	83.7
Canopy Bulk Density (lbs/ft^3)	0.013	0.008
Surface load (tons/acre)	5.4	4.7
Species	87% PIPO 6% POTR	87% PIPO 7% POTR



Structure Change Summary

- The treatment in the Unc Mesa restoration project reduced stem density and basal are by approximately 40%, without significantly altering the distribution of tree sizes or species composition.
- Along with a vertical shift up in mean tree height and canopy base height, there was a 40% reduction in canopy bulk density. However, surface fuels were only marginally reduced
- Stand continuity was reduced and the variability in forest structures was increased by breaking up large clumps of trees.

Fire Behavior Implications

- Disruptions in stand continuity and alterations to the fuels complex resulted in predicted reductions in all measures of fire behavior tested.
- Moderate canopy consumption levels were predicted across both wind scenarios, however active fire behavior is still expected.

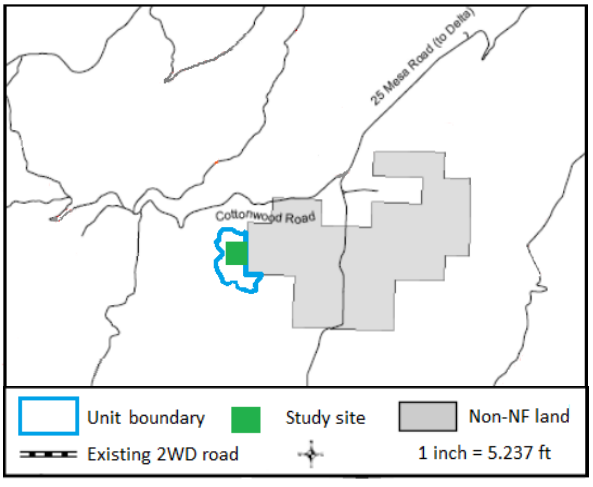


Figure 1. Map of Unc Mesa unit #1 and 10 acre study

Forest Spatial Arrangement Changes

Most forest restoration projects within dry mixed conifer systems seek to enhance the variation in stand-level forest structures. Here forest structure is described as the allocation of aerial cover to single trees, clumps of trees, and openings and the distribution of tree clump sizes from single trees to clumps containing more than 15 trees. Prior to treatment, 86% of trees were contained in clumps of >15 trees which accounted for more than 40% of the stand area. Following treatment, the resulting changes occurred:

- The area occupied by clumps was reduced by 15% and redistributed mostly to openings, reducing stand continuity and increasing the size of openings.
- The variation in stand-level forest structures was increased by breaking up clumps of >15 trees and redistributing them into each of the small clump sizes.

Analysis of forest spatial arrangement, changes in cover and clumping.

	Pre-treatment		Post-treatment	
Aerial cover (%)				
Single tree	3.7		4.4	
Clumps	41.1		26.6	
Openings	55.2		69.0	
Clump Size Composition	**% TPA**	**% BA acre^{-1}**	**% TPA**	**% BA acre^{-1}**
Single Tree	1.8	4.4	3.9	11.6
Small (2-4 trees)	4.7	8.9	10.5	18.4
Medium (5-9 trees)	3.5	3.7	10.1	15.2
Large (10-15 trees)	3.7	7.5	7.7	12.5
Very large (15+ trees)	86.3	75.5	67.7	41.9

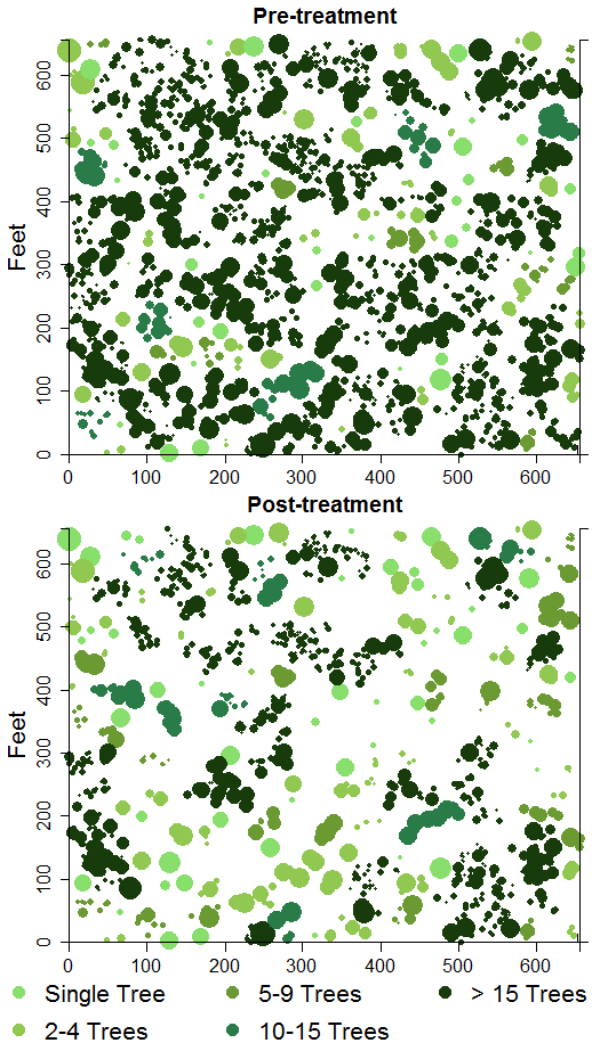


Figure 2. Stem-map of sampled area. Trees sized to

Fire Behavior Changes

Beyond increasing stand-level forest structural variability, often forest restoration treatments seek to reduce fire behavior and effects. Prior to treatment, under the high wind speed the stand exhibited canopy consumption, fireline intensities, and rates of spread consistent with extreme fire behavior. Following treatment, all metrics of fire behavior simulated were reduced with the exception of fire rate of spread under our lower wind scenario. The extreme wind scenario tested found reductions of 33%, 22%, and 55% for canopy consumption, fire rate of spread and fireline intensity. The moderate wind scenario found no effect of treatment on the rate of fire spread but reduced canopy consumption and intensity by 21% and 46%, respectively. Overall, the treatment reduced potential fire severity and behavior, with moderate levels of canopy consumption predicted for both wind speeds following treatment. However, based on the rate of spread and fireline intensity there remains considerable potential for extreme fire behavior that may limit fire operations.

Table 2. Pre- and post-treatment fire behavior predictions from Wildland-Urban Interface Fire Dynamics Simulator model runs under high and moderate wind speed scenarios.

Open Wind Speed (mph)	Rate of Spread (ch/hr)		Fireline Intensity (kW/m)		Canopy Consumption (%)	
	Pre	Post	Pre	Post	Pre	Post
9	157	154	35,335	19,256	67.3	46.5
30	321	250	108,460	37,118	80.3	52.9

This is part of a broader project funded by the Joint Fire Sciences Program project 13-1-04-53 and USDA National Fire Plan, spanning 8 study sites across the Southern Rocky Mountains and Colorado Plateau. Additional study methods, details, summaries and videos of pre- and post-treatment fire behavior can be found at (Create Host Site). Project conducted by:

Wade Tinkham, Justin Ziegler, & Chad Hoffman of Colorado State University and Mike Battaglia of USDS-FS RMRS