Changes in Forest Structure and Fire Behavior on the Long John Restoration Project

CFRI-TB-1604

Background

Ponderosa pine (*Pinus ponderosa*) forests within the Pike and San Isabel 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 denser, 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 Front Range 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 the Long John 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.

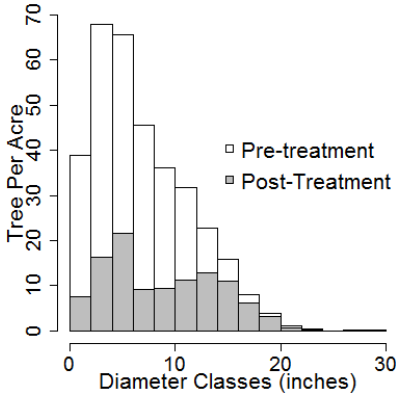
Forest Structure Changes

This site is typical of the more productive ponderosa pine stands along the Front Range of the Rocky Mountains in Colorado with a site index of 75 feet (base age 100). Prior to treatment, the stand was dominated by 2-6" DBH trees, with a moderate to high stocking level 288 trees per acre (TPA) and 126 ft^2 of basal area (BA) per acre, but areas in excess of 600 TPA. Following treatment, the resulting changes occurred:

- Both TPA and BA per acre were reduced by ~60%, while causing only small shifts in the overall distribution of tree diameters.
- Although there was no detectable change in surface fuel loading, canopy bulk density was reduced by 47%.

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

	Pre	Post
TPA	288	99
QMD (in)	9.0	10.6
BA (ft^2/acre)	126	68
Mean - CBH (ft)	14	17
Mean - HT (ft)	35	42
Canopy Bulk Density (lbs/ft^3)	0.016	0.007
Surface load (tons/acre)	7.1	7.1
Species	86% PIPO 13% PSME	86% PIPO 11% PSME



Structure Change Summary

- The Long John restoration treatment project reduced stem density and basal are by approximately 60%, smaller diameter trees (< 6") were preferentially removed leading to a small increase in quadratic mean diameter.
- Along with a vertical shift up in mean tree height and canopy base height, there was a 47% reduction in canopy bulk density.
- Stand continuity was reduced and the variability in forest structures was increased by breaking up large clumps of trees.

Fire Behavior Implications

- The stand's high crown base height resulted in minimal canopy consumption under all scenarios.
- Due to high surface fuel loading the stand is expected to have a fireline intensity and rate of spread consistent with extreme fire behavior across both wind scenarios.

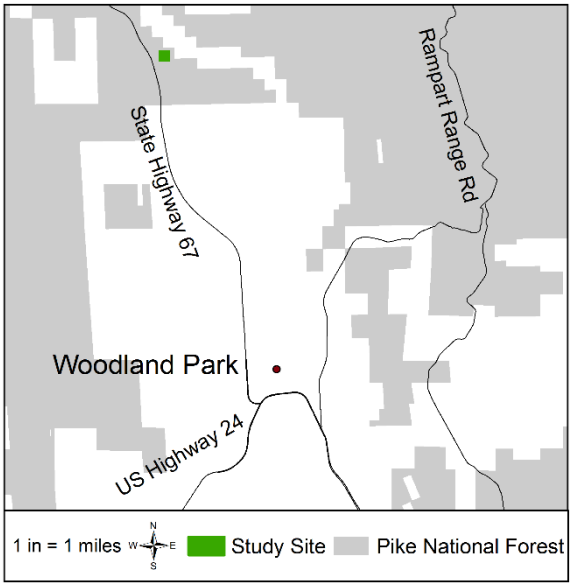


Figure 1. Map of Long John 10 acre study site.

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, 99% of trees were contained in clumps of >15 trees which accounted for more than 50% of the stand area. Following treatment, the resulting changes occurred:

- The area occupied by clumps was reduced by 26% 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.

Table 2. Analysis of forest spatial arrangement, changes in cover and clumping.

	Pre-treatment		Post-treatment	
Aerial cover (%)				
Single tree	3.1		6.6	
Clumps	50.5		24.3	
Openings	46.4		69.1	
Clump Size Composition	**% TPA**	**% BA acre^{-1}**	**% TPA**	**% BA acre^{-1}**
Single Tree	0.1	0.2	9.9	5.7
Small (2-4 trees)	0.3	0.9	24.2	16.8
Medium (5-9 trees)	0.1	0.3	14.8	13.1
Large (10-15 trees)	0.0	0.0	11.5	14.8
Very large (15+ trees)	99.4	98.6	39.6	49.6

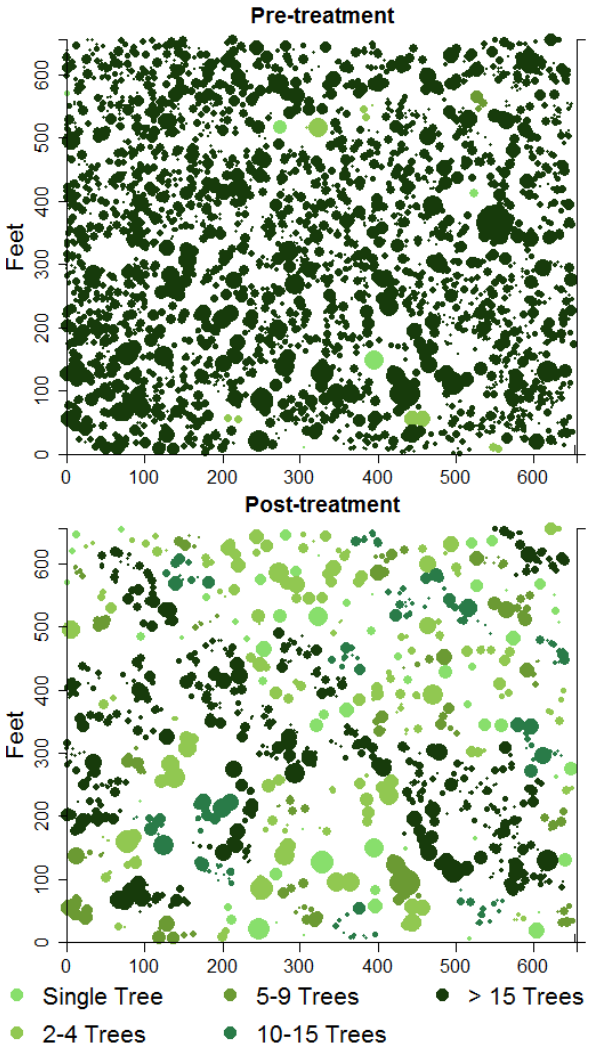


Figure 2. Stem-map of sampled area. Trees sized to represent crown area.

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 fire behavior consistent with a high intensity fast spreading surface fire but only consumed crowns of understory trees. Following treatment there was a slight reduction to canopy consumption and ~10% reduction in fireline intensity under the high wind scenario, but no change to rate of spread. Due to increased surface winds following treatment, both rate of spread and fireline intensity saw ~30% increases in the moderate wind scenario. Overall, the treatment had limited effect on fire behavior as the stand already exhibited limited crown fire potential. However, based on the rate of spread and fireline intensity there remains conditions unsafe for direct attack considerable, limiting fire operations.

Table 3. 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	41	56	2,909	3,815	4.5	4.3
30	75	77	5,621	5,165	5.0	3.7

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 (cfri.colostate.edu). Project conducted by:

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

Contact Chad Hoffman with any questions:
C.Hoffman@colostate.edu