Changes in Forest Structure and Fire Behavior on the Bluewater Forest Restoration Project

CFRI-TB-1609

Background

Ponderosa pine (*Pinus ponderosa*) forests within the southern Rocky Mountains of New Mexico, 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 Zuni Mountain Collaborative Forest Landscape Restoration Program, 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 utilized a 10 acre stem-map plot within the Bluewater Forest 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.

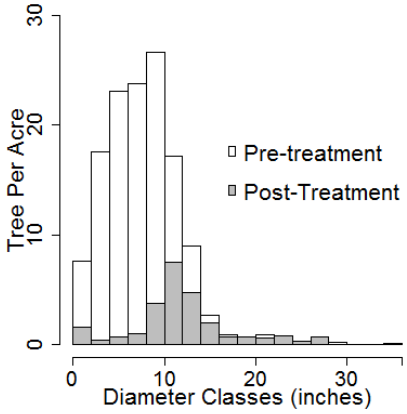
Forest Structure Changes

This site is typical of many ponderosa pine stands within the southern Rocky Mountains in New Mexico with a site index of 50 feet (base age 100). Prior to treatment, the stand was dominated by 6-12" DBH trees, with a moderate stocking level of 132 trees per acre (TPA) and 84 ft^2 of basal area (BA) per acre, but areas that approached 600 TPA. Following treatment, the resulting changes occurred:

- Both TPA and BA per acre were reduced by ~70% without impacting the distribution of tree diameters.
- The stand experienced a significant shift in vertical structure and reductions to surface fuel loading (47%) and canopy bulk density (60%).

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

	Pre	Post
TPA	132	26
QMD (in)	10.8	15.3
BA (ft^2/acre)	84	33
Mean - CBH (ft)	13	15
Mean - HT (ft)	30	41
Canopy Bulk Density (lbs/ft^3)	0.008	0.002
Surface load (tons/acre)	1.1	1.1
Species	81% PIPO 11% PIED	88% PIPO 9% PIED



Structure Change Summary

- The Bluewater forest restoration treatment reduced both stem density (81%) and basal area (61%).
- There was a significant shift in the stand's vertical structure, with a 77% reduction in canopy bulk density but no detectable change in surface fuel loading.
- Both small trees and less substantial species were removed in favor of retaining ponderosa pine which shifted the distribution of tree sizes and substantially increased the stand's QMD.
- The stand shifted toward a spatial arrangement dominated by single trees and small clumps that are indicative of historic patterns within the region.

Fire Behavior Implications

- The stands low canopy and surface fuel loading resulted in predictions of minimal canopy consumption and fire line intensity.
- The treatment exhibited no detrimental effects on stand fire behavior or effects under high wind conditions.

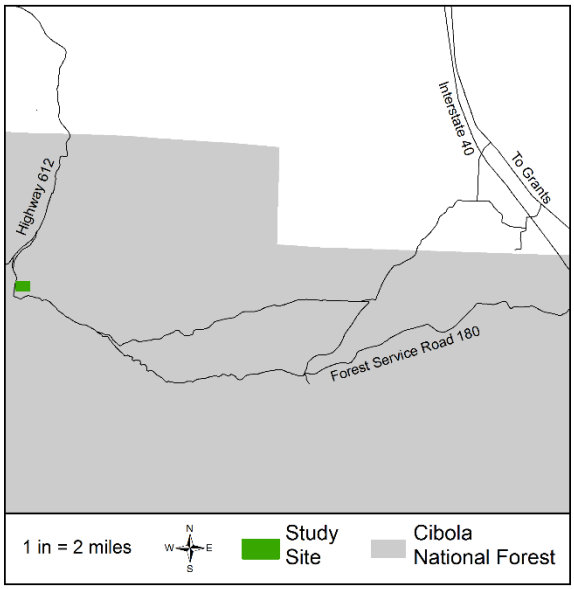


Figure 1. Map of Bluewater 10 acre study site.

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, ~70% of trees and basal area in the plot were contained in very large clumps of >15 trees. Following treatment, the resulting changes occurred:

- The area occupied by clumps was reduced by 12% and redistributed to stand openings, this reduction in stand continuity increased the size and number of openings throughout the stand.
- The variation in stand-level forest structures shifted from favoring very large clumps of trees to favoring single trees and small clumps, similar to observed historic forest patterns throughout the region.

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

	Pre-treatment		Post-treatment	
Aerial cover (%)				
Single tree	7.6		5.4	
Clumps	15.9		3.5	
Openings	76.5		91.1	
Clump Size Composition	**% TPA**	**% BA acre^{-1}**	**% TPA**	**% BA acre^{-1}**
Single Tree	3.9	10.0	26.3	37.6
Small (2-4 trees)	9.2	12.2	48.2	46.1
Medium (5-9 trees)	6.0	5.8	17.1	10.3
Large (10-15 trees)	4.5	10.0	8.4	6.0
Very large (15+ trees)	76.3	62.0	0.0	0.0

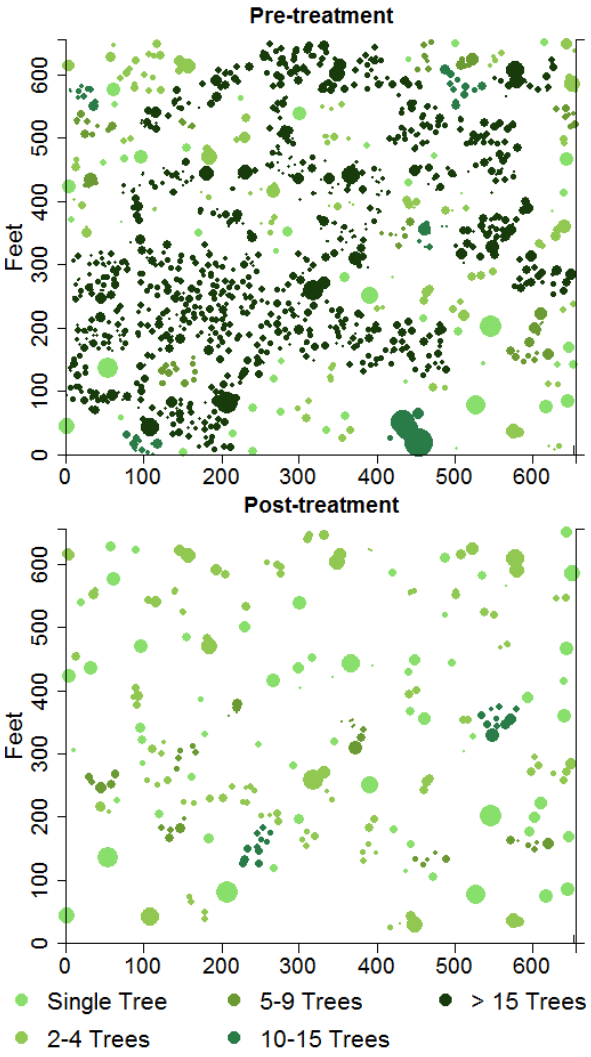


Figure 2. Stem-map of sampled area. Trees sized to represent crown area.

Fire Behavior Changes

Beyond increasing stand-level forest structural variability, often forest restoration treatments seek to reduce fire behavior and effects. Prior to treatment this stand exhibited minimal fire behavior and resulting effects due to the low surface and canopy fuel loadings under both wind speeds. Sites like this that are selected for treatment were the primary objective is to restore historic forest structure and function may show less response in fire metrics. Following treatment, all metrics of fire behavior and effects showed minimal change as there was not much room for improvement. However, the extreme wind scenario did increase in rate of spread as a result of reduced stand density which increased surface wind speeds. Overall, the treatment did not exhibit any undesirable fire effects in response to the treatment, which sometimes can be seen following poorly executed silvicultural prescriptions.

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	36	36	333	361	0.2	0.7
30	49	61	556	629	0.8	0.1

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:

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