

# Changes in Forest Structure and Fire Behavior on the Heil Valley Ranch Restoration Project

CFRI-TB-1602

## Background

Ponderosa pine (*Pinus ponderosa*) forests within the Front Range of Colorado, 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 Boulder County Parks & Open Space 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 Project Area 5 of the Heil Valley Ranch 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.

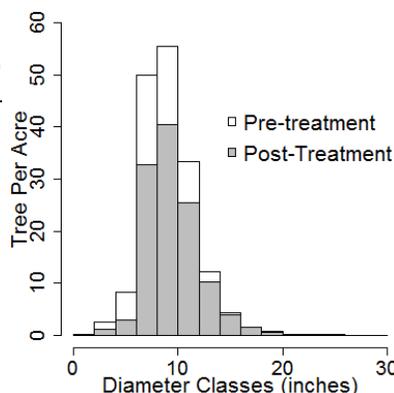
## Forest Structure Changes

This site is typical of many xeric low elevation ponderosa pine stands along the Front Range of the Rocky Mountains in Colorado with a site index of 35 feet (base age 100). Prior to treatment, the stand was dominated by 6-12" DBH trees, with a moderate stocking level of 169 trees per acre (TPA) and 83 ft<sup>2</sup> of basal area (BA) per acre, but areas that approached 300 TPA. Following treatment, the resulting changes occurred:

- Both TPA and BA per acre were reduced by ~27% without impacting the distribution of tree diameters.
- While there was no change in the stands vertical structure, surface fuel loading was reduction 27% and canopy bulk density by 30%.

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

	Pre	Post
TPA	169	119
QMD (in)	9.0	9.8
BA (ft <sup>2</sup> /acre)	83	63
Mean - CBH (ft)	12	12
Mean - HT (ft)	25	26
Canopy Bulk Density (lbs/ft <sup>3</sup> )	0.010	0.007
Surface load (tons/acre)	4.6	3.4
Species	98% PIPO	98% PIPO
	2% JUSC	2% JUSC



## Structure Change Summary

- The Heil Valley Ranch restoration treatment reduced stem density and basal area by approximately 27%, without significantly altering the distribution of tree sizes or species composition.
- Although there was no change in stand vertical structure, there was a 30% reduction in canopy bulk density and a 27% reduction surface fuel loading.
- Only small shifts in the distribution of clump sizes resulted following the thinning.
- The moderate reduction in stand continuity is attributed to balancing treatment objectives to retain and promote wildlife habitat.

## Fire Behavior Implications

- Reductions in canopy and surface fuel loading resulted in predictions of significant reductions in both canopy consumption and fire line intensity.
- Moderate canopy consumption levels were predicted across both wind scenarios, however fire rate of spread remained high.

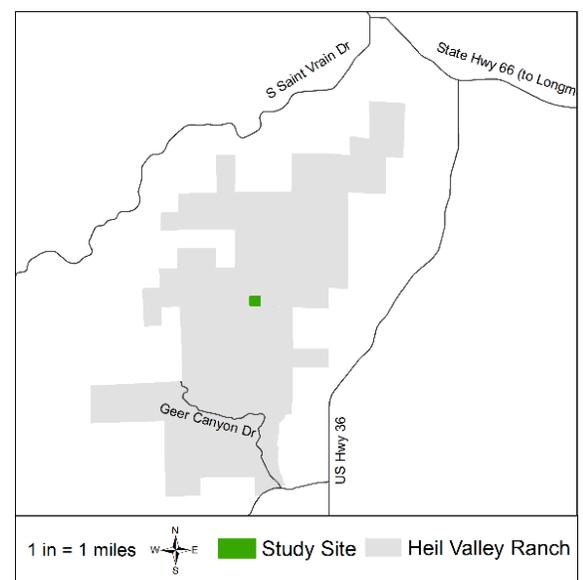


Figure 1. Map of Heil Valley Ranch 10 acre study site.

## 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, 90% of trees and basal area in the plot were contained in clumps of >15 trees. Following treatment, the resulting changes occurred:

- The area occupied by clumps was reduced by 9% and redistributed mostly to openings, reducing stand continuity and increasing the size of openings.
- The variation in stand-level forest structures increased, but remained dominated by clumps of >15 trees indicating that a more aggressive thinning may be appropriate.

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

	Pre-treatment		Post-treatment	
<b>Aerial cover (%)</b>				
Single tree		8.4		8.3
Clumps		30.7		21.9
Openings		60.1		69.2
<b>Clump Size Composition</b>	<b>% TPA</b>	<b>% BA acre<sup>-1</sup></b>	<b>% TPA</b>	<b>% BA acre<sup>-1</sup></b>
Single Tree	1.7	2.6	6.1	4.1
Small (2-4 trees)	4.3	4.7	7.5	7.0
Medium (5-9 trees)	1.9	2.2	5.6	4.7
Large (10-15 trees)	2.2	1.7	6.8	7.5
Very large (15+ trees)	89.9	88.8	74.1	76.7

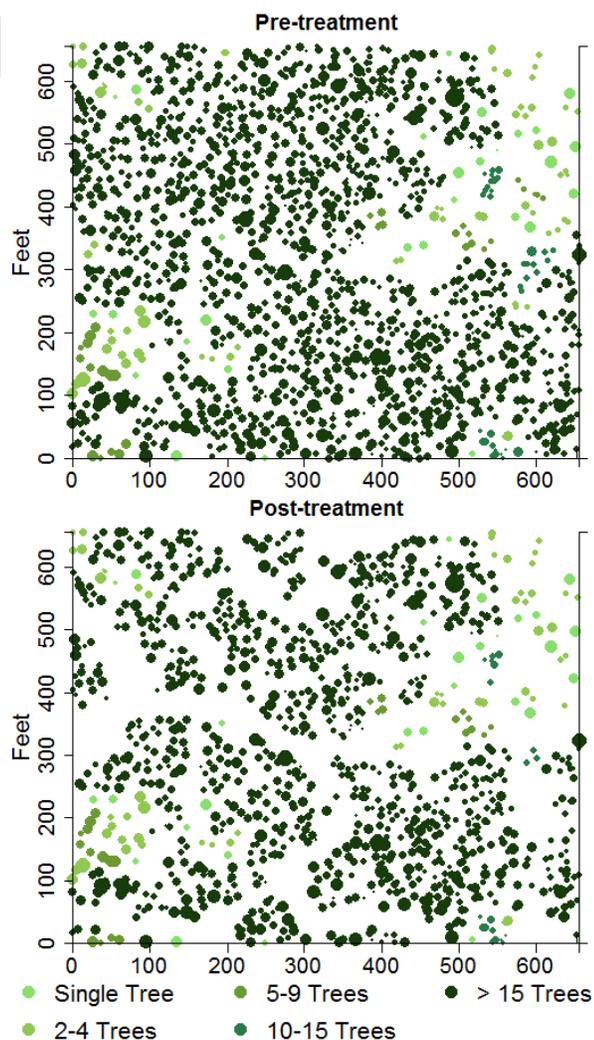


Figure 2. Stem-map of sampled area. Trees sized to represent crown area.

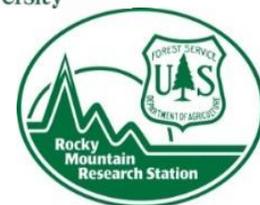
## Fire Behavior Changes

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 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 in canopy consumption (28%), fire rate of spread (7%), and fireline intensity (50%). The moderate wind scenario found no effect of treatment on the rate of fire spread, but reduced canopy consumption (31%) and fireline intensity (39%). 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 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	125	131	13,810	8,476	70.2	48.8
30	195	181	28,011	14,005	79.2	57.3

Colorado State University



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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](http://cfri.colostate.edu)). Project conducted by:

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