Effects of Collaborative Restoration and Adaptive Management on Forest Structure and Composition in the Colorado Front Range

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Background

- Dry Coniferous forests of the Front Range have undergone a myriad of changes resulting from land use changes including fire suppression, logging, and grazing[1]
- Increases in tree density, species composition shifts to fire-intolerant species such as Douglas-fir, and the homogenization of the forested landscape can contribute to large, uncharacteristic, high severity fires that are increasingly occurring along Colorado's Front Range[2,3,4]
- The Collaborative Forest Landscape Restoration Program (CFLRP) was established in 2010 to address the increasing extent of large, high severity fires and to increase the pace and scale of forest restoration on fire-prone federal lands[5]
- The Front Range Roundtable received CFLRP funding in 2010 and developed a monitoring plan and adaptive management strategy to assess project outcomes based on a set of collaboratively developed desired conditions
- Desired conditions are aimed to increase forest resiliency, and facilitate the reintroduction of fire to the landscape:

1. **Establish a complex mosaic of forest density, size, and age**
   - *A. Forest Density*
   - *B. Quadratic mean diameter (QMD)*
   - *C. Horizontal Complexity**
1. **Establish a more favorable species composition favoring lower montane species over other conifers**
   - *D. Importance Value of ponderosa pine*
2. **Increased removal of Douglas-fir, especially on wetter aspects[2,3]**
   - *E. Importance Value of Douglas-fir*

Objectives

1. Determine if CFLRP restoration treatments are contributing to desired conditions outlined by the Front Range CFLRP
2. Assess the adaptive management process outlined by the Front Range CFLRP by looking at changes in treatment outcomes over time from early to late in the program

Methods

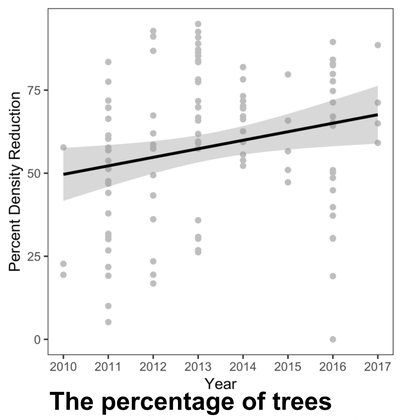
- Compiled 879 paired (pre/post) Common Stand Exam plots from 25 projects spanning 2010-2017
- Summarized plot data into n=107 treatment units
- Paired t-tests for pre- versus post-treatment effects
- Linear regression to test for trends in treatment outcomes over time

Results

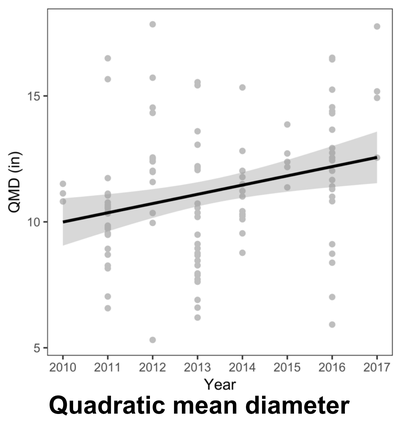
1. Are restoration treatments contributing desired conditions?

Desired Condition	Metric	Pre-treatment Mean	Post-treatment Mean	% Change
Reduce Tree Density	Basal Area (ft^2 ac)	88	49	-44%
	Trees per Acre	246	90	-63%
Increase QMD	QMD (inches)	9.4	11.3	+8%
Favor Ponderosa Pine	Importance Value	175	180	+2%

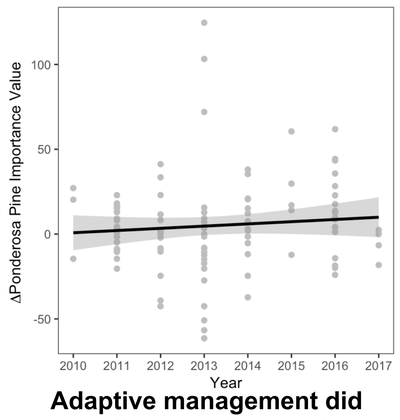
2. Are treatment outcomes changing over time?



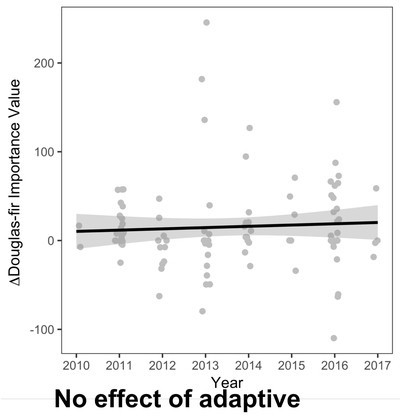
The percentage of trees removed increased over time



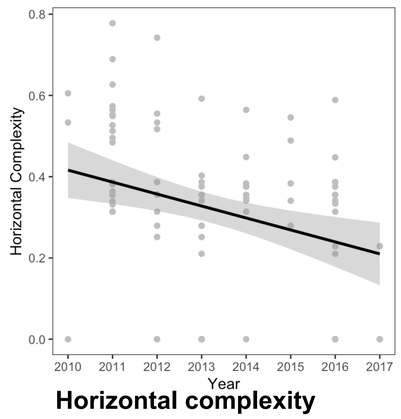
Quadratic mean diameter increased over time



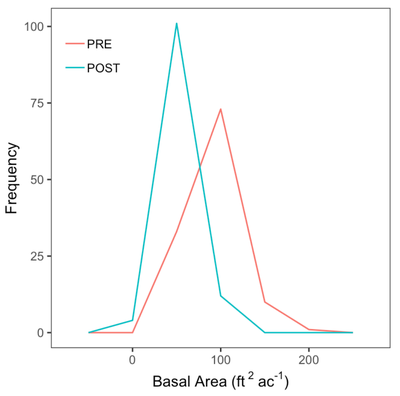
Adaptive management did not effect ponderosa pine importance value

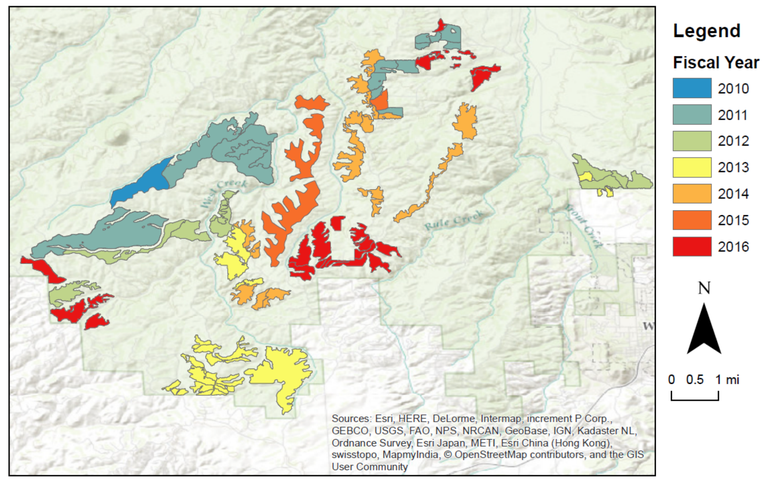


No effect of adaptive management on Douglas-fir on wet aspects



Horizontal complexity decreased over time





Discussion

- The Front Range CFLRP is making progress towards some of its goals, particularly structural metrics
  - Forest density
  - Quadratic mean diameter
- However, treatments are struggling to meet compositional goals
  - Ponderosa pine relative abundance
  - Douglas-fir removal on wet aspects
- Additionally, the Front Range CFLRP may not be meeting spatial goals
  - Decreases in within-treatment unit variability in forest density (Horizontal Complexity)
- The adaptive management process may be improved by incorporating solid, tangible targets
  - Beyond directional targets based on historical conditions
- It can be difficult to operationalize horizontal complexity at the stand scale
  - Harvesting trees inherently truncates the basal area distribution within the stand
  - Larger scale monitoring and forest planning may help

* We binned treatment unit basal area into 6 classes (0-50, 50-100, 100-150, 150-200, 200-250, and 250+ ft^2ac^{-1}), and used Shannon's evenness index (Eh) to assess changes in horizontal complexity. This results in an estimate of horizontal complexity ranging from 0 to 1, with 1 representing even representation of density classes in the treatment unit, thus more horizontally complex[5,7,8].

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