Effects of restoration treatments and adaptive management on forest structure in ponderosa pine forests of the Colorado Front Range

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Introduction

- Large, severe wildfires are impacting many dry conifer forests across the western U.S.
- Federal initiatives have been enacted to treat landscapes in need of fuels reduction and restoration, including the Collaborative Forest Landscape Restoration Program (CFLRP).
- The Front Range CFLRP (FR-CFLRP) initiated restoration treatments in the Pike-San Isabel and Arapaho-Roosevelt National Forests in 2010.
- FR-CFLRP objectives:
  - Reduce tree density and potential for crown fire,
  - Maintain or improve forest structural variability and vertical complexity,
  - Favor Douglas fir (*Pseudotsuga menziesii*) for removal over ponderosa pine (*Pinus ponderosa*),
  - And use adaptive management (AM) to continually improve treatments over the program's lifespan.

FR-CFLRP treatment project in the Pike-San Isabel National Forest. Photo credit: P.M. Brown

Research Questions

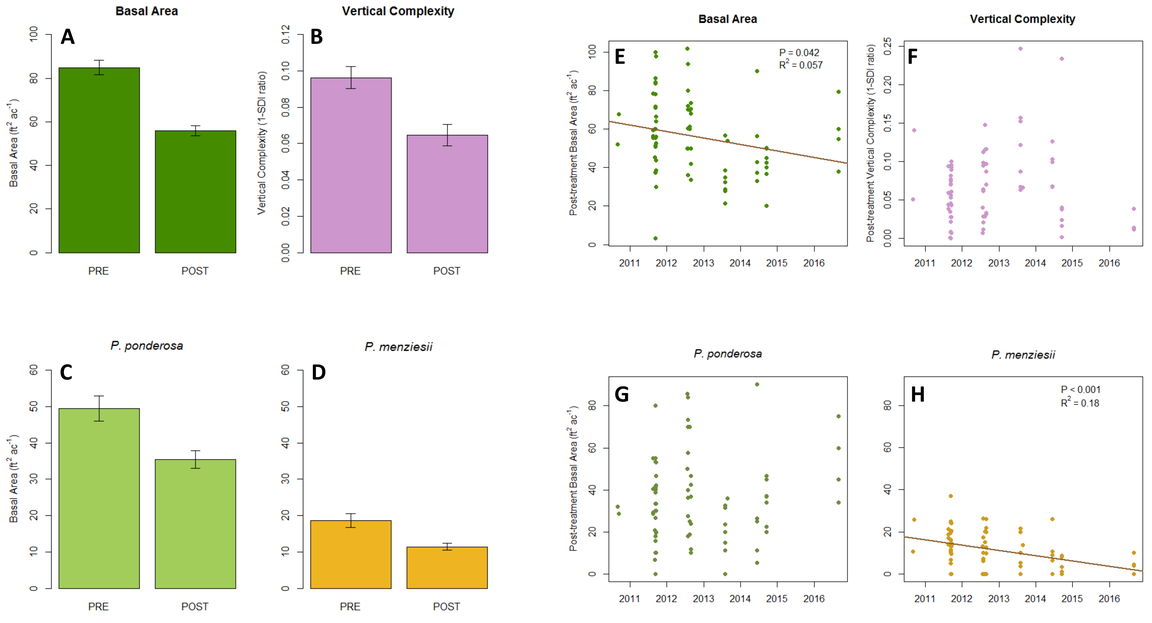
1. **How did forest density and composition change following FR-CFLRP treatments?**
2. **How have treatments changed over time with adaptive management?**

Methods and Results

- Data on tree density and composition were obtained before and after restoration treatments using Common Stand Exam protocols.
- Summarized forest structural data for 1,212 plots in 71 treatment subunits over 6 years (2010 – 2016).
- Compared pre- and post-treatment forest density and composition with paired *t*-tests.
- Evaluated changes in treatment outcomes over time with linear regression.

	Species	Pre	Post	% Change*
Basal Area (ft² ac⁻¹)	all	84.9	56.0	-34%
	P. ponderosa	49.5	35.5	-28%
	P. menziesii	18.7	11.5	-39%
Tree Density (ac⁻¹)	all	408.5	194.1	-52%
	P. ponderosa	133.2	62.9	-53%
	P. menziesii	115.6	43.8	-62%
Vertical Complexity	all	0.096	0.064	-33%
Quadratic Mean Diameter (in)	all	8.4	10.4	+24%

Treatments significantly reduced basal area, vertical complexity, and tree density, and significantly increased quadratic mean diameter. Vertical complexity is calculated as the complement of the ratio of stand density indices (SDI) of Reineke and Shaw (Shaw, 2000).
***all p-values < 0.001**



Fuels reduction and restoration treatments:

- **A. Reduced basal area by 34%**
- **B. Reduced vertical complexity by 33%**
- **C. Reduced *P. ponderosa* basal area by 28%**
- **D. Reduced *P. menziesii* basal area by 39%**

Compared to early treatments, in more recent treatments:

- **E. Residual basal areas were lower**
- F. Post-treatment vertical complexity was the same
- G. Post-treatment *P. ponderosa* basal area was the same
- **H. Post-treatment *P. menziesii* basal area was lower**

Discussion

- Evaluations of early treatments showed that *P. ponderosa* and *P. menziesii* were both reduced by 28% (Cannon et al., 2018).
- **Later treatments in this study indicated *P. menziesii* were favored for removal, suggesting change in treatment outcomes over time (Fig. H).**
- Residual basal area of plots was lower in more recent treatments (Fig. E), potentially due to the AM process.
- Post-treatment outcomes are denser relative to historical reconstructions (36 ft² ac⁻¹ BA, 64 trees ac⁻¹; Battaglia et al., 2018; Cannon et al., 2018).
- Early restoration treatments had various scientific, social, and logistical constraints. **However, later outcomes displayed greater congruence with desired conditions, indicating that AM may improve restoration treatments in collaborative settings.**
- More formal means of AM may bring restoration outcomes in closer alignment with desired conditions.

Future Research Questions

- How do post-treatment outcomes compare on wet and dry slopes?
- How will future post-treatment outcomes look with collaboration on NEPA drafting?
- How are treatments affecting non-structural forest objectives, such as crown fire potential and understory richness?

References & Acknowledgements

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