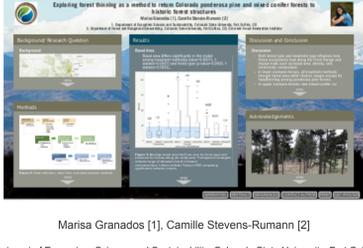
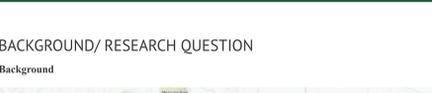


Exploring forest thinning as a method to return Colorado ponderosa pine and mixed conifer forests to historic forest structures



Marisa Granados [1], Camille Stevens-Rumann [2]

1. Department of Ecosystem Science and Sustainability, Colorado State University, Fort Collins, CO
2. Department of Forest and Rangeland Stewardship, Colorado State University, Fort Collins, CO, Colorado Forest Restoration Institute



BACKGROUND/ RESEARCH QUESTION

Background

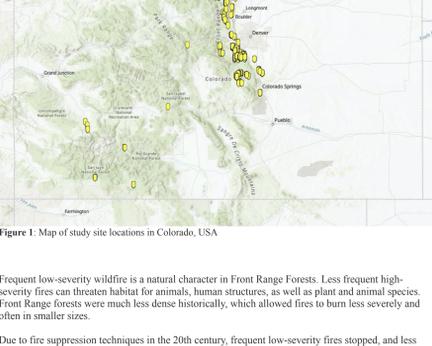


Figure 1: Map of study site locations in Colorado, USA

Frequent low-severity wildfire is a natural character in Front Range Forests. Less frequent high-severity fires can threaten habitat for animals, human structures, as well as plant and animal species. Front Range forests were much less dense historically, which allowed fires to burn less severely and often in smaller sizes.

Due to fire suppression techniques in the 20th century, frequent low-severity fires stopped, and less frequent high-severity fires became the norm (Veblen et al. 2000). Forest thinning is a tool to return forests to the norm of more frequent low-severity burns.

We aim to look at the effectiveness of different types of forest thinning treatments on forest structure throughout the Front Range. Our results will help scientists and forest managers to see weather thinning treatments are aiding in returning forests to the historic structure where fires were less severe and more manageable.

Research Question

Are Ponderosa pine and mixed conifer forests across the study area being restored to a historical forest structure through hand thinning, mastication, and mechanical forest thinning treatments?

Hypothesis

Ponderosa pine and mixed conifer forests are moving toward historical structures through thinning treatments but perhaps these human interventions are not drastic enough to return them to historical structures. These forests may not reach historical structure for some time given the cultural pushback to thinning forests despite historical context.

METHODS

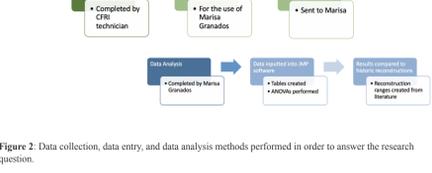


Figure 2: Data collection, data entry, and data analysis methods performed in order to answer the research question.

Data Collection

- Data was collected along the Front Range in Colorado at 600 plots by field technicians between 2016-2019.
- Forest type and treatment method of each plot was determined on site through tree lists and manager communication.
- Species was determined for each tree within a 10-20 Basal Area Factor variable radius plot.
- Each tree was determined live(L), or dead marked from 1-3
- Any necessary notes about individual trees were recorded.
- Basal area and stand density parameters were calculated (Figure 1).
- In order to construct historical reconstruction data, Marisa Granados used Moore et al. 2004 and Brown et al. 2015, basal area and tree density data from the years 1860-1919 to obtain a range of basal areas and densities from that time period.
- Using the community composition data from Battaglia et. al.2018, Marisa Granados created historic reconstructions for percent composition of forests by species in both lower and upper montane forests.



Data Entry

- Data was collected using field tablets by technicians at CFRI and stored in a large database for subsequent research.
- Kevin Barrett, a research associate at CFRI, oversees the database and assisted with all questions and data extraction.

Data Analysis

- Data analysis was completed by Marisa Granados using JMP software.
- Analysis of variants were performed on treatment method and forest type vs basal area and stand density to obtain p-values and f-statistics and to determine significance.
- Data was interpreted by looking at significance, a p-value less than 0.05 indicated significance.
- These results were compared to stand reconstruction ranges from other literature including Moore et al. 2004, Brown et al. 2015, and Battaglia et. al. 2018 (Figure 1).

RESULTS

Basal Area

- Basal area differs significantly in the model among treatment method(p-value=0.00071, f-statistic=0.0007) and forest type (p-value=0.0000, f-statistic=0.0001).

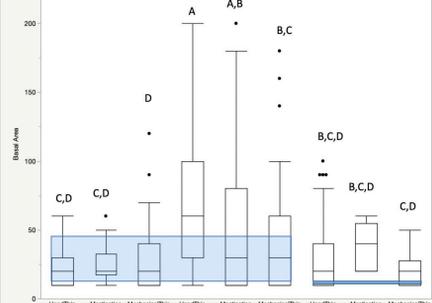


Figure 3: Average basal area ft² per acre by forest type and treatment for forests along the study area. Transparent rectangles indicate range of densities found in historic reconstructions. Letters indicate Tukey's HSD comparing significance between means.

Stand Density

- Live tree density varied significantly in the model among treatment method(p-value=0.00017, f-statistic=0.002) and forest type (p-value=0.0000, f-statistic=0.0001).

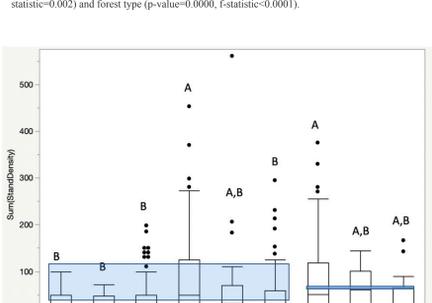


Figure 4: Average density in trees per acre by forest type and treatment for forests along the study area. Transparent rectangles indicate range of densities found in historic reconstructions. Letters indicate Tukey's HSD comparing significance between means.

Community Composition

- Among handthinning treatments, PIPO and PIEN appeared to be preferred
- Mastication treatments preferred PIPO and PIEN
- Mechanical thinning treatments seemed to prefer PIEN, although this type of treatment left much species diversity.

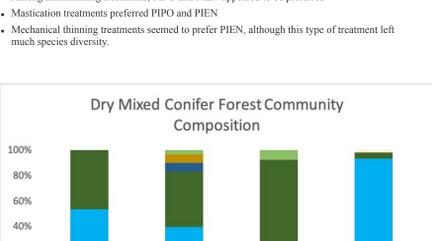


Figure 5: Community composition broken down by species percentage in dry mixed conifer forests.

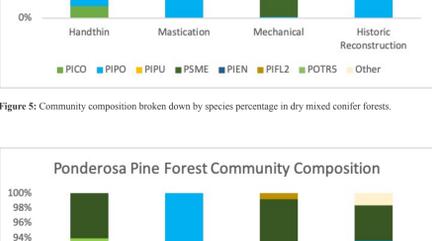


Figure 6: Community composition broken down by species percentage in ponderosa pine forests.

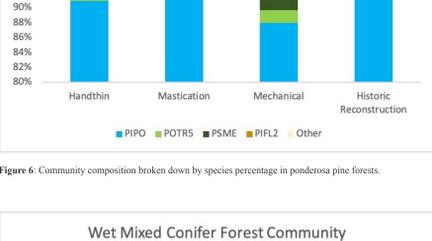


Figure 7: Community composition broken down by species percentage in wet mixed conifer forests.

DISCUSSION AND CONCLUSION

Discussion

- Both forest type and treatment type influence how forest ecosystems look along the Front Range and impact traits such as basal area, density, and community composition.
- In lower montane forests, all treatment methods brought basal area within historic ranges except for handthinning among ponderosa pine forests.
- In upper montane forests: wet mixed conifer, no treatments brought basal area quite to historic ranges, however, handthinning and mechanical thinning were most successful in returning basal area toward historic numbers.
- Mastication and mechanical thinning are hitting the historic basal area and stand density targets more effectively than handthinning treatments.
- A potential explanation for why mechanical thinning and mastication thinned to below historic densities is to stay within historic basal areas as small trees grow larger.
- Overall, when considering community composition, it appears that handthinning is the most effective treatment type. Handthinning is likely most effective in this context because it requires individuals to go through and select individual trees to take.

Limitations

- We did not have access to historical reconstructions for exact study areas
- There was no pre-treatment data available, and as such we are assuming that all of these areas were similar before treatment which may not be the case.
- All treatment methods are limited in the places that they are viable.

Conclusions

On average, lots of treatments are hitting historic forest structure targets. There is large variability between treatments indicating that more emphasis should be put on treatment type being used to fully achieve reference conditions. With all treatment methods there are pros and cons. It is hard to hit every objective with every treatment method. In most cases, the primary objective should determine the treatment method used.

ACKNOWLEDGEMENTS



I would like to thank my SUPER instructor Dr. Stacy Lynn and GTA Anna Clare Monlezun for their guidance through the research process. I would also like to thank Dr. Camille Stevens-Rumann's lab group for welcoming me into their space and helping me grow as a researcher.

ABSTRACT

Current Colorado mixed conifer and ponderosa pine forests have structures much different than historic conditions due to over a century of fire suppression. Climate change has resulted in larger and more severe fire events. Forest management techniques such as thinning are possible tools in returning these forests back to their historic structure including basal area, stand density, and community composition. In this study we examine how mechanical thinning, hand thinning, and mastication are changing forest structure and if these actions are returning forests along the Front Range back to their historic structures. Mechanical thinning is one type of forest thinning treatment that we found to be most effective at returning ponderosa pine and mixed conifer forests to their historic structures. In our study, mastication and hand thinning were not as powerful in returning forests to their historic structures indicating that all thinning treatments are not equally effective. This information will help forest managers to make informed management decisions for returning their forests to historic structures. This could aid in reducing fire severity and damage from fires as climate change causes more frequent fire events.

REFERENCES

Battaglia, M. A., et al. 2018. Changes in forest structure since 1860 in ponderosa pine dominated forests in the Colorado and Wyoming Front Range, USA. Forest Ecology and Management. 422, 147-160.

Brown, P. M. et al. (2015) Historical (1860) forest structure in ponderosa pine forests of the northern Front Range, Colorado. Can. J. For. Res. 45: 1462-1475.

Moore, M., Huffman, D., Fule, P., Covington, W., Croose, J., & Moore, M. (2004). A Comparison of Historical and Contemporary Forest Structure and Composition on Permanent Plots in Southwestern Ponderosa Pine Forests. Forest Science, 50(2), 162-162.

Veblen, T. T., Kitzberger, T., & Donnellan, J. (2000). Climatic and Human Influences on Fire Regimes in Ponderosa Pine Forests in the Colorado Front Range. Ecological Applications, 10(4), 1178-1195.