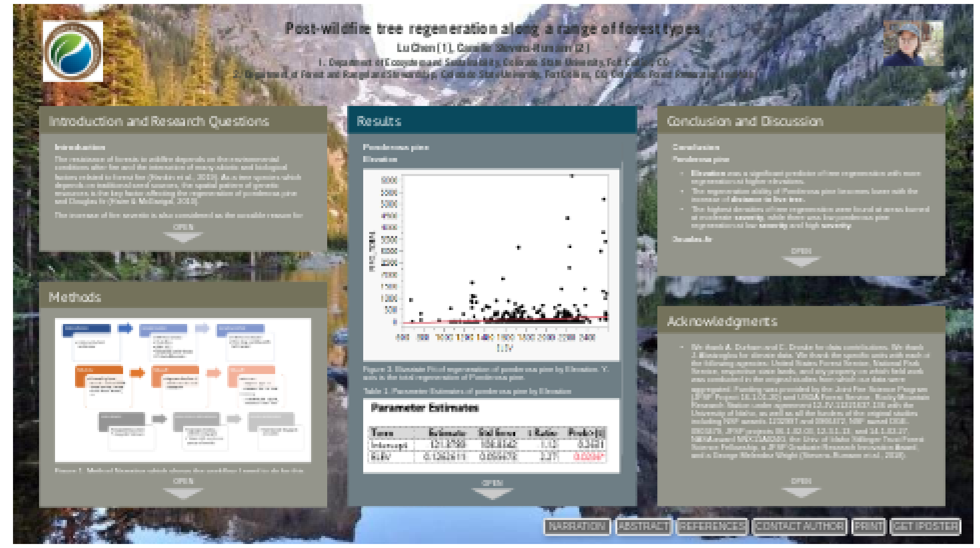
Post-wildfire tree regeneration along a range of forest types



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INTRODUCTION AND RESEARCH QUESTIONS

Introduction

The resistance of forests to wildfire depends on the environmental conditions after fire and the interaction of many abiotic and biological factors related to forest fire (Hankin et al., 2019). As a tree species which depends on traditional seed sources, the spatial pattern of genetic resources is the key factor affecting the regeneration of ponderosa pine and Douglas fir (Haire & McGarigal, 2010).

The increase of fire severity is also considered as the possible reason for the limited regeneration of conifers after fire. It has been suggested that fires have made coniferous forests in the western United States vulnerable.

In this study, our main goal is to find out the relationship between space, severity, and distance from living trees and tree regeneration after fire.

Ponderosa pine

Douglas-fir

Research Question

I will look at this large dataset to answer the following questions: (1) Whether the regeneration of Ponderosa pine and Douglas-fir will be affected by elevation and how; (2): whether the fire severity will affect the regeneration of Ponderosa pine and Douglas-fir, and how; (3): whether the distance to live trees will affect the regeneration of Ponderosa pine and Douglas-fir, and how.

Hypotheses

a.(1) Ponderosa pine may be affected by fire and grow to high elevation areas;

(2) Douglas-fir may be affected by fire and grow to high elevation areas.

b. (1) High fire severity may affect the regeneration of ponderosa pine;

(2) The regeneration of Douglas-fir may be affected by high severity fire;

c. (1) The farther away the fire from the living tree, the lower the density of ponderosa pine regeneration.

(2) The farther away the fire from the living tree, the lower the density of Douglas-fir regeneration.

METHODS

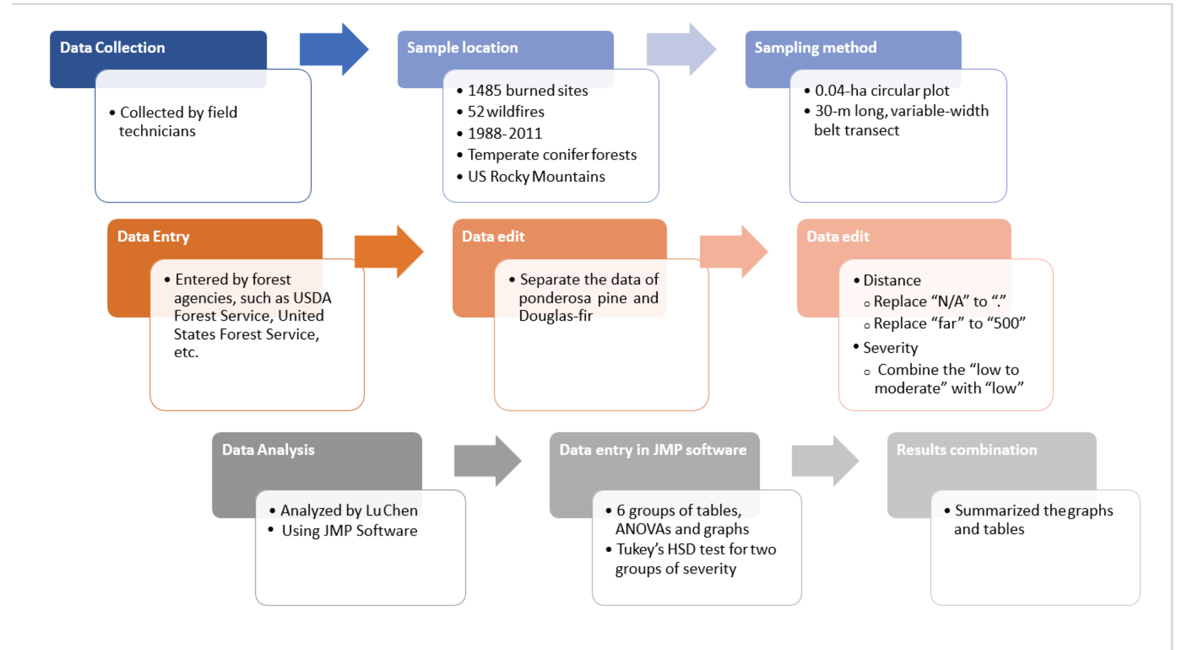

Figure 1. Method Narrative which shows the workflow I need to do for this project.

Data Collection

This data set is the existence and density of tree seedlings collected from 1485 fire sites with different severity from 1988 to 2011 from 2010 to 2014, with an altitude of 692 to 2764m. The forest types are low altitude Ponderosa pine, Douglas-fir and various fir trees.

Data Entry

Data entry and processing by A. Durham, C. Droske, Camille S. Stevens-Rumann, Kerry B. Kemp, Philip E. Higuera, Brian J. Harvey, Monica T. Rother, Daniel C. Donato, Penelope Morgan and Thomas T. Veblen.

Data Analysis

- Data Analysis was completed by Lu Chen using JMP software (a suite of computer programs for statistical analysis).

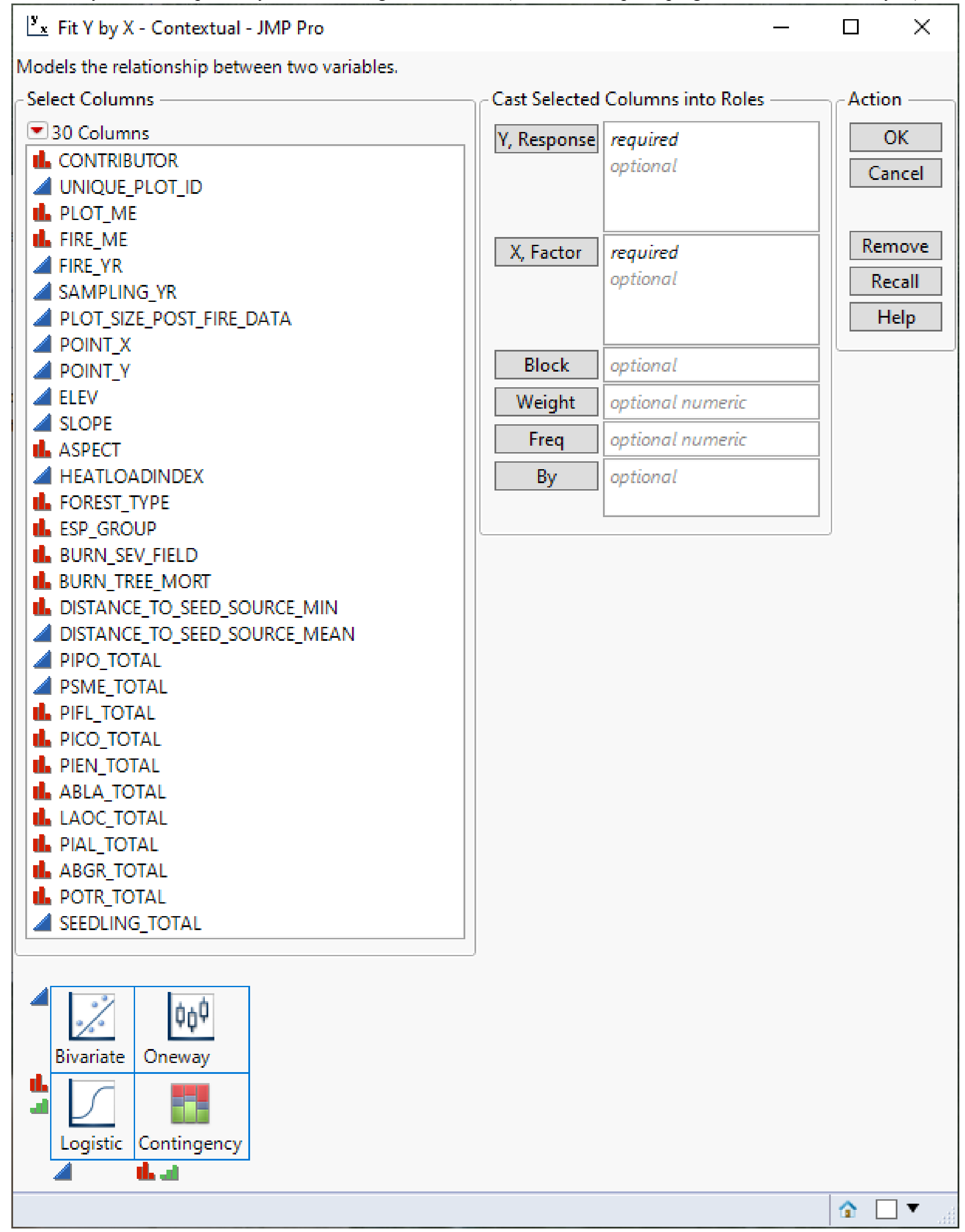

Figure 2. Screenshot of JMP software Chen used to analyze the data

- Set up 6 settings for the different combinations as "X, Factor" and "Y, Response"
- Get 6 different graphs

RESULTS

Ponderosa pine

Elevation

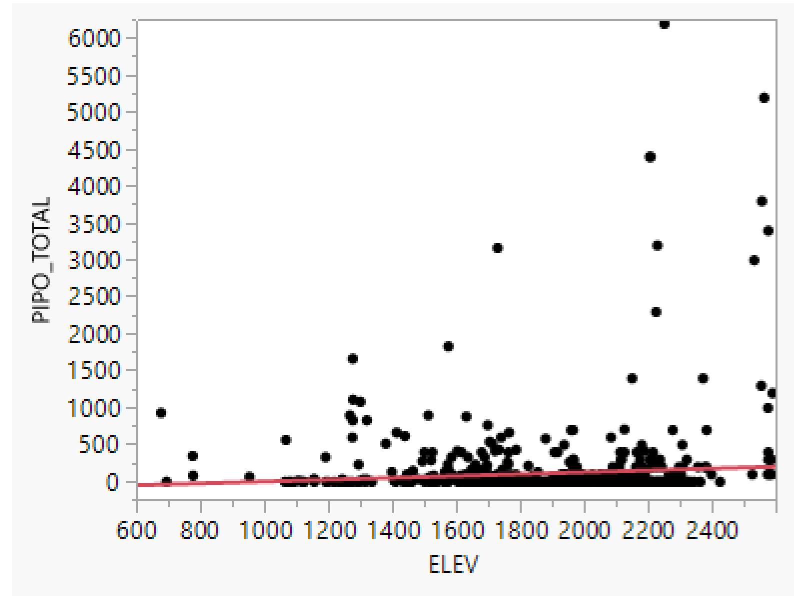

Figure 3. Bivariate Fit of regeneration of ponderosa pine by Elevation. Y-axis is the total regeneration of Ponderosa pine.

Table 1. Parameter Estimates of ponderosa pine by Elevation

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-121.8789	108.8342	-1.12	0.2631
ELEV	0.1262611	0.055673	2.27	0.0236*

The P-value=0.0236<0.05 indicated significance (Table 1). So, the elevation was a significant predictor of tree regeneration with more regeneration at higher elevations (Figure 3). It supported that my hypothesis a (1), which said ponderosa may be affected by fire and grow to high elevation areas is right.

Distance to seeds

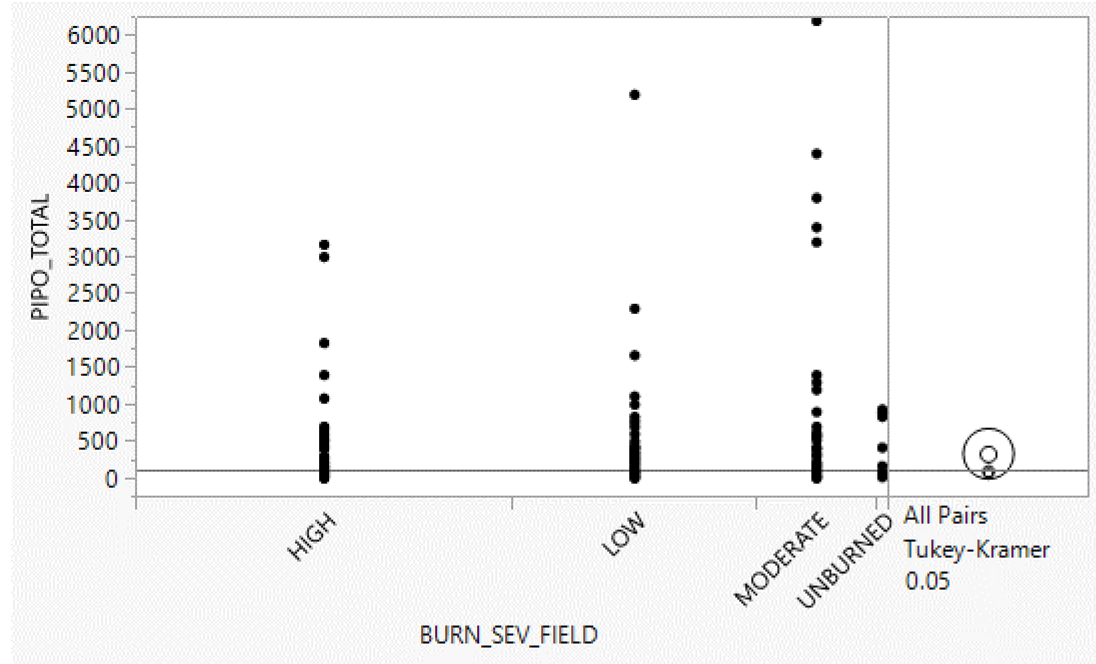

Figure 4. Bivariate Fit of regeneration of ponderosa pine by distance to seeds. Y-axis is the total regeneration of Ponderosa pine.

Table 2. Parameter Estimates of ponderosa pine by distance to seeds

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	106.60475	15.68098	6.80	<.0001*
DISTANCE_TO_SEED_SOURCE_MEAN	-0.229838	0.082168	-2.80	0.0054*

The P-value=0.0054<0.05 indicated significance (Table 2). So, the regeneration ability of ponderosa pine becomes lower with the increase of distance to live tree (Figure 4). It supported that my hypothesis c (1), which the farther away the fire from the living tree, the lower the density of ponderosa pine regeneration is right.

Burn Severity

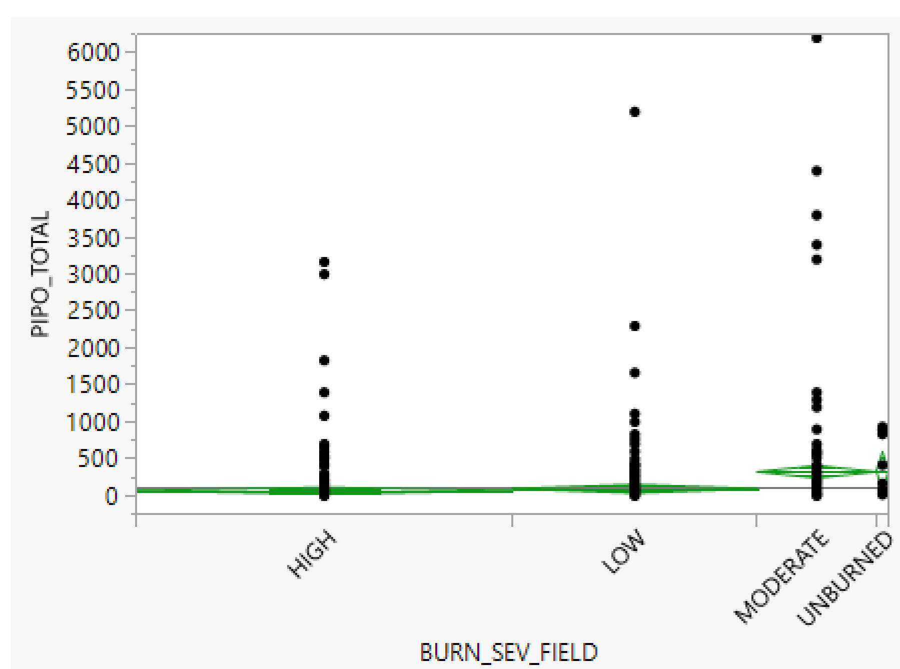

Figure 5. Oneway Analysis of regeneration of ponderosa pine by burn severity. Y-axis is the total regeneration of Ponderosa pine.

Table 3. Connecting letters report of ponderosa pine by burn severity

Connecting Letters Report

Level			Mean
UNBURNED	A	B	333.97538
MODERATE	A		324.75444
LOW		B	95.27966
HIGH		B	67.95190

The P-value<0.0001 (Table 3). The highest densities of tree regeneration were found at areas burned at moderate severity, while there was low ponderosa pine regeneration at low severity and high severity (Figure 5). It supported that my hypothesis b (1), which said high fire severity may affect the regeneration of ponderosa pine is wrong.

Douglas-fir

Elevation

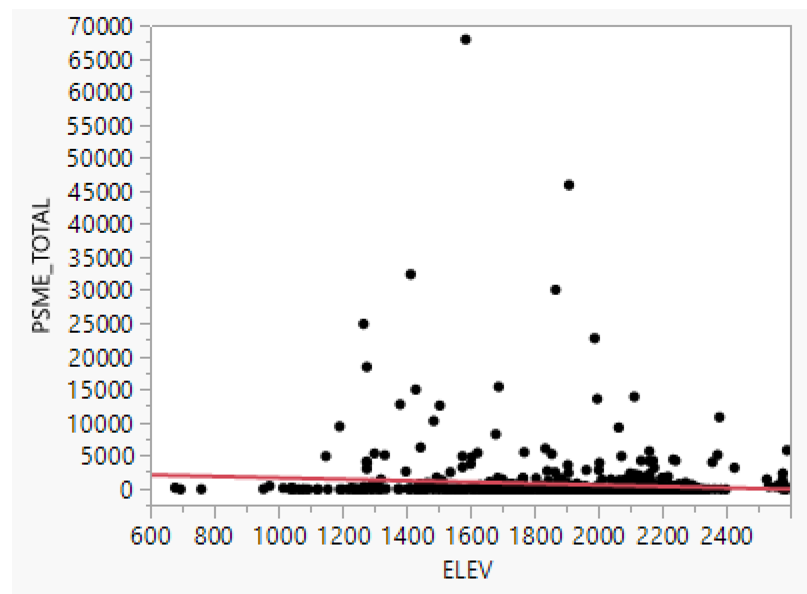

Figure 6. Bivariate Fit of regeneration of Douglas-fir by Elevation. Y-axis is the total regeneration of Douglas-fir.

Table 4. Parameter Estimates of Douglas-fir by Elevation

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2815.4715	772.1323	3.65	0.0003*
ELEV	-1.080812	0.399709	-2.70	0.0070*

The P-value=0.0070<0.05 indicated significance (Table 4). Tree regeneration was highest in mid-elevations, and we saw low densities at the lowest and highest elevations (Figure 5). It supported that my hypothesis a (2), which said Douglas-fir may be affected by fire and grow to high elevation areas is wrong.

Distance to seeds

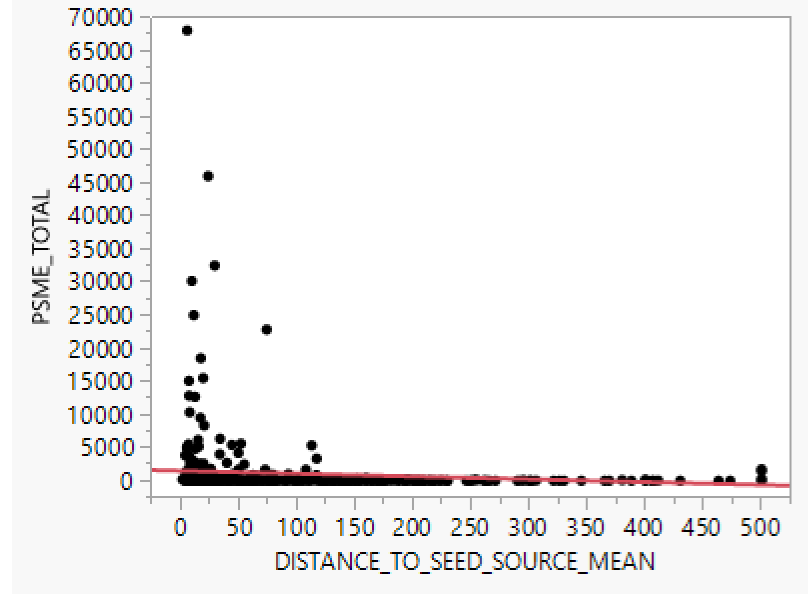

Figure 7. Bivariate Fit of regeneration of Douglas-fir by distance to seeds. Y-axis is the total regeneration of Douglas-fir.

Table 5. Parameter Estimates of Douglas-fir by distance to seeds

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1487.1446	269.6009	5.52	<.0001*
DISTANCE_TO_SEED_SOURCE_MEAN	-4.225877	1.433428	-2.95	0.0033*

The P-value=0.0033<0.05 indicated significance (Table 5). The regeneration ability of Douglas-fir become lower with the increase of Distance to live tree (Figure 6). It supported that my hypothesis c (2), which said the farther away the fire from the living tree, the lower the density of Douglas-fir regeneration is right.

Burn Severity

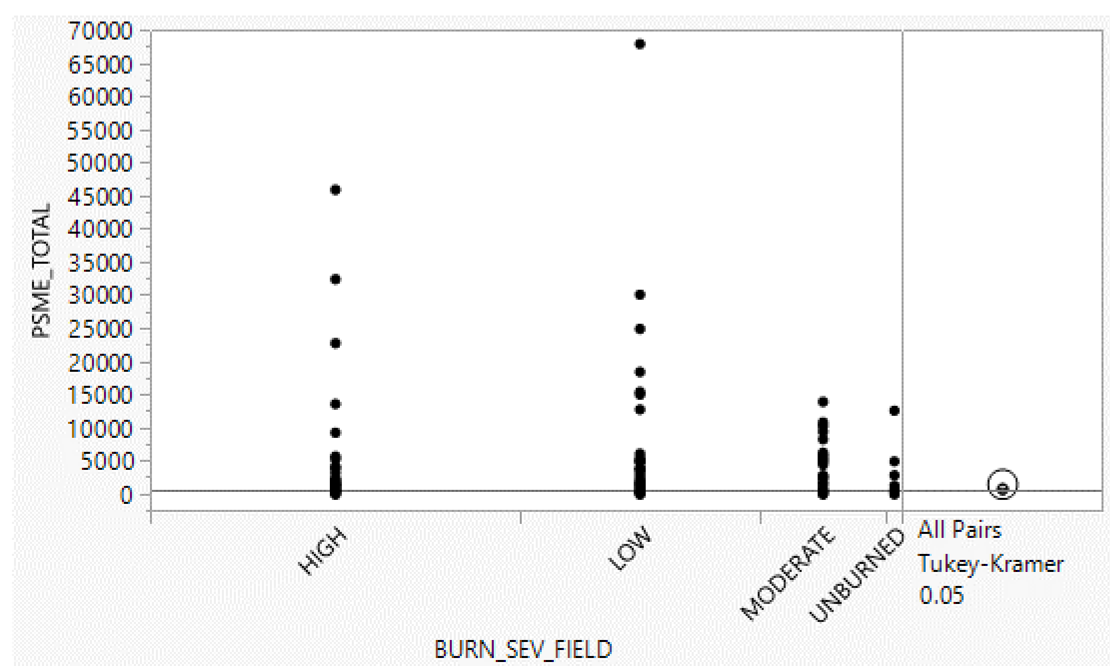

Figure 8. Oneway Analysis of regeneration of Douglas-fir by burn severity. Y-axis is the total regeneration of Douglas-fir.

Table 6. Connecting letters report of Douglas-fir by burn severity

Connecting Letters Report

Level		Mean
UNBURNED	A	1529.8247
LOW	A	1002.4339
MODERATE	A	796.5734
HIGH	A	547.4607

The P-value=0.3456>0.05 indicated no significance (Table 6). There are no significant differences in Douglas-fir regeneration by burn severity (Figure 7). It supported that my hypothesis b (2), which said Douglas-fir may be affected by fire and grow to low fire severity is wrong.

CONCLUSION AND DISCUSSION

Conclusion

Ponderosa pine

- **Elevation** was a significant predictor of tree regeneration with more regeneration at higher elevations.
- The regeneration ability of Ponderosa pine becomes lower with the increase of **distance to live tree.**
- The highest densities of tree regeneration were found at areas burned at moderate **severity**, while there was low ponderosa pine regeneration at low **severity** and high **severity.**

Douglas-fir

- Tree regeneration was highest in mid-**elevations**, and we saw low densities at the lowest and highest elevations.
- The regeneration ability of Douglas-fir become lower with the increase of Distance to live tree.
- There are no significant differences in Douglas-fir regeneration by **burn severity**.

Ponderosa pine and Douglas-fir cover a wide area across the western US. According to the analysis results, the fire has a great influence on these two trees, especially for ponderosa pine. Therefore, according to their different regeneration reactions to different fire factors, relevant forestry management can be managed accordingly.

And for mixed forests, I think we should also take some corresponding analysis to take effective measures to protect them.

Discussion

The results demonstrated that both altitude and distance from living trees were related to the regeneration of ponderosa pine and Douglas-fir. Therefore, altitude and distance from living trees can be used as important predictors for predicting these two tree species. The results also show that the severity of fire is related to regeneration of ponderosa pine. Therefore, the severity of fire can also be another factor to predict the regeneration of ponderosa pine.

This study focuses on the regeneration of two separate tree species. However, the regeneration of mixed forest was not discussed. It is possible that under mixed conditions, these trees will be affected by fire differently from single tree species. So I think this research is limited here. We can do some research and analysis on the mixed forest in the future to learn more about these two kinds of trees.

ACKNOWLEDGMENTS

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ABSTRACT

Post-fire tree regeneration is often impacted by altitude, the severity of burning, and distance from living trees. We collected data from fires that burned between 1988 to 2007 in the Rocky Mountains. All sites were measured between 2011 to 2014. This data can tell us how different factors of fire affect the regeneration of different tree species. In order to determine this effect, we plotted the regeneration across different predictor factors and Ponderosa pine and Douglas Fir and used regression and analysis of variance to understand the relationship between them. We can get by analyzing images and variance tables that the altitude of the fire, the severity of the burning, and the distance from the living tree are all directly related. In the fire management of Ponderosa pine and Douglas Fir, relevant measures can be taken to reduce the impact of these aspects.

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