Patterns of post-fire diversity and regeneration in subalpine forests of the Sierra Nevada

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Introduction

Climate-fueled changes in snow pack and growing season are increasing sapling density and changing stand dynamics in subalpine forests of the Sierra Nevada[1]. These changes will likely continue in coming years, and, combined with a trend in increasing size and upper elevation of fire in the Sierra Nevada[2,3], may contribute to larger and more severe fire events in subalpine forests. Despite potential changes in high elevation fire behavior, there is no published literature documenting how subalpine understory communities and regenerating tree seedlings respond to fire severity in a Mediterranean climate. The goal of this study is to determine how fire severity affects understory diversity and tree regeneration in subalpine forests of the Sierra Nevada, California.

Research Questions

1. **What is the relationship between understory plant species diversity and fire severity in high elevation forests?**
2. **How does fire severity affect tree regeneration in high elevation forests?**

Methodology

We sampled 7 fires in subalpine forest ranging from 2 to 16 years post-fire (Figure 1). We defined subalpine forest first by elevation (above 2750m[4]) and second by forest type. We used CALVEG spatial data to determine the extent of subalpine forest types [5] in burned areas and made the preliminary fire severity classification using a remotely sensed fire severity index (RdNBR)[6]. We stratified sampling plots initially by fire severity (Figure 2) and subsequently by aspect.

In each plot we took a complete census of plant richness, cover, and modal height, as well as structural measurements such as DBH and basal area. We counted and aged seedlings in a "regeneration plot" (Figure 3).

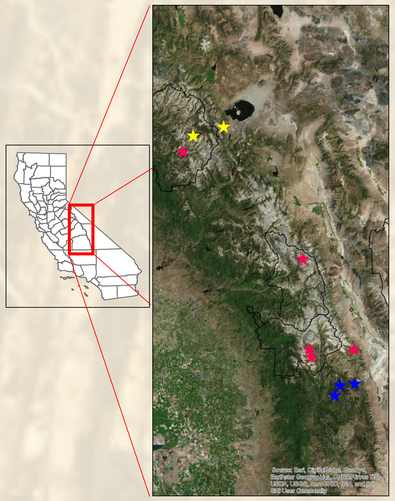


Figure 1: Locations of fires sampled in the California Sierra Nevada in 2017 (yellow), 2018 (red), and proposed for sampling in 2019 (blue).

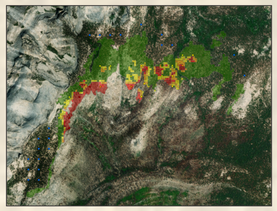


Figure 2: RdNBR fire severity layer shown clipped by CALVEG subalpine forest layers and with sampling grid of plots above.

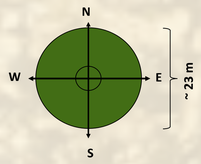
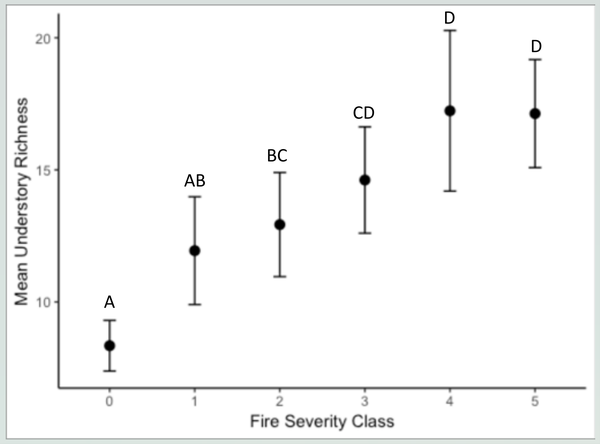


Figure 3: Schematic of plot design. A 60m² regeneration plot is nested inside the total plot area (~405m²).

Preliminary Results Question 1

Effect of fire severity on understory diversity

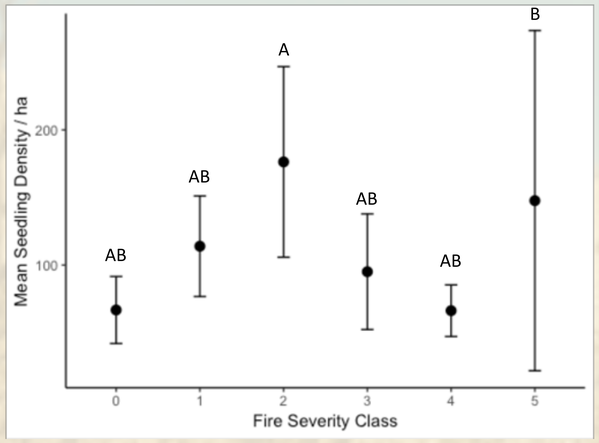
Figure 4: Mean understory species richness plotted as a function of fire severity class. Error bars show standard error of the mean. Letters show if means are significantly different from one another based on pairwise general linear hypothesis tests of a Generalized Linear Mixed Model. Means that share a letter are not significantly different.



Preliminary Results Question 2

Effect of fire severity on tree regeneration

Figure 5: Mean seedling density per hectare plotted as a function of fire severity class. Error bars show standard error. Letters show if means are significantly different from one another based on pairwise general linear hypothesis tests of a Linear Mixed Model. Means that share a letter are not significantly different.



Fire Severity

Fire severity is a measure of the impact of fire on an ecosystem (eg. basal area mortality).

Fire severity classes used in study

Fire severity class	Fire severity label	Percentage basal area mortality
0	Unburned	0
1	Low	0-25
2	Low	25-50
3	Low-moderate	50-75
4	High-moderate	75-90
5	High	>90

Figure 6 (above): A table outlining the six fire severity classes used in the study.

Figure 7 (right): Pictures of unburned (above), moderately burned (middle), and severely burned (below) subalpine forest.

Conclusions

Research Question 1

- **Broadly speaking, high severity fire (>50% basal area mortality) increases understory diversity in subalpine forests of the Sierra Nevada, while**

Research Question 2

- **low severity fire (25-50% basal area mortality) stimulates tree regeneration. In general, higher fire severity classes do not produce the same stimulating effects on tree regeneration when compared to unburned areas, though results are variable.**

Why is this important?

- **Baseline knowledge**: this study generates a baseline understanding of how subalpine forests respond to fire.
- **Fire management**: while fires have generally been allowed to burn in wilderness areas and my research is unlikely to change management actions in the study area, it provides empirical data for understanding the repercussions of management actions.
- **Future predictions**: with median fire size and upper elevation increasing in the Sierra Nevada[3], this study will aid those trying to predict the effects on subalpine forest persistence, structure, diversity, and carbon balance.

Next Steps

Field work is not yet complete for this study and I hope that patterns become clearer with additional data. After the coming field season, I would like to ask questions such as:

- How does the diversity-severity relationship at high elevations change over time and at relevant spatial scales?
- Does understory plant life-form composition differ with fire and/or fire severity?
- How does the regeneration-severity relationship change over time at high elevations?

And even further afield:

- How does the fire severity-diversity relationship change across a major elevation and productivity gradient in the Sierra: from yellow pine mixed conifer to subalpine?

References

1. Dolanc, C. R., Thorne, J. H. & Safford, H. D. Widespread shifts in the demographic structure of subalpine forests in the Sierra Nevada, California, 1934 to 2007. Glob. Ecol. Biogeogr. **22,** 264–276 (2013).
2. Mallek, C. M., Safford, H., Viers, J. & Miller, J. Modern departures in fire severity and area vary by forest type , Sierra Nevada and southern Cascades , California , USA. Ecosphere **4,** 1–28 (2013).
3. Schwartz, M. W. et al. Increasing elevation of fire in the Sierra Nevada and implications for forest change. Ecosphere **6,** art121 (2015).
4. Millar, C. I. & Rundel, P. W. Subalpine Forests. in 579–612 (2016).
5. USDA. CALVEG zones and alliances – vegetation descriptions. (2013).
6. Miller, J. D. & Thode, A. E. Quantifying burn severity in a heterogeneous landscape with a relative version of the delta Normalized Burn Ratio (dNBR). Remote Sens. Environ. **109,** 66–80 (2007).