Sierra Nevada Tree Mortality and how it Changed with Management, Precipitation and Forest Density

ECOLOGY PROGRAM *PACIFIC SOUTHWEST REGION * US FOREST SERVICE

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CALIFORNIA DROUGHT: Since 2012, California has experienced extreme drought. Drought conditions in combination with insect outbreaks have fueled extensive tree mortality (especially in pines) across the forests of the Sierra Nevada. Because climate models predict longer and hotter droughts, it is important that we understand how management actions can potentially mitigate drought impacts on forests.

Project Overview

IN SHORT: We are comparing tree mortality patterns in treated (thinned and/or burned) forested stands to untreated stands.

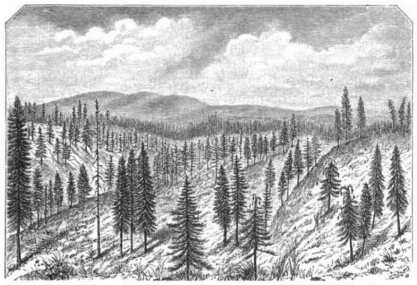
GOAL: To evaluate our common management practices in the context of large disturbance and to inventory our dramatically changed forest conditions.

STATUS: Our published work is showcased here. We are finishing up our next paper where we examine seedlings and saplings and future forests. We are also analyzing tree core data to understand differences between drought survivors and dead trees, related to stand conditions.

Citation: Restaino, C., Young, D., Estes, B., Gross, S., Wuenschel, A., Meyer, M., and Safford, H.. 2019. Forest structure and climate mediate drought-induced tree mortality in forests of the Sierra Nevada, USA. *Ecological Applications* 00(00):e01902. 10.1002/eap.1902

Study Design

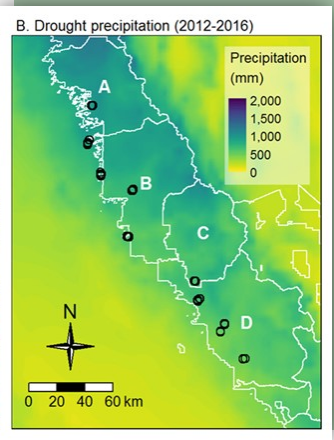
HYPOTHESIS: Treatments designed to reverse forest densification that has occurred due to fire suppression will reduce drought mortality by allowing there to be more water available to each remaining tree.



LOWER MARGIN OF THE MAIN PINE BELT, SHOWING OPEN CHARACTER OF WOODS.

Forest stands in the Sierra Nevada used to be much more open as evidenced in the image to the right from one of John Muir's books. Forests have gotten denser mostly due to fire suppression. Forest treatments like prescribed burning and thinning are designed to restore natural forest structure. We know this allows forests to be more resistant to wildfire, but we are not sure how forest treatment changes how forests respond to drought. In 2016, the US Forest Service (USFS) R5 Ecology Program in partnership with University of California, Davis were granted funds from the USFS R5 State and Private Forestry organization to investigate this question.

Field Measurements



Map showing monitoring sites across the central Sierra Nevada ranging from the Eldorado NF(A) to the Sierra NF (D). In 2017, we collected plot data at 10 paired (treated vs. untreated) sites in pine-dominated stands. At each site there were 16 plots. We measured tree data, fuels and seedlings and saplings at each 12.6 m radius plot.

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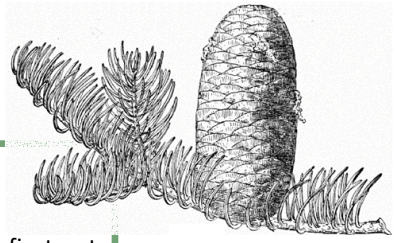
Percentages indicate the proportion of trees of each species that died across the study.



24% White Fir

In both cedar and white fir, treatment reduced mortality in wetter stands but increased it in dry areas. Perhaps these shade-tolerant trees did worse with more sun exposure in more open stands.

Increased Mortality

Reduced Mortality

Mixed Effect Depending on Precipitation

HIGHER DENSITY

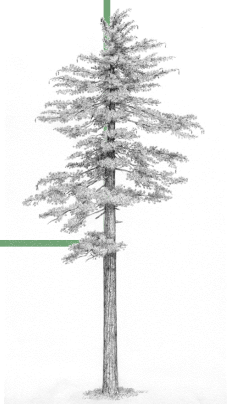
TREATMENT

21% Incense Cedar

While cedar mortality increased with stand density, there was also a higher likelihood of an individual tree dying where there were more cedars present.

35% Sugar Pine

Sugar pine mortality was greatest in areas where there were more, large sugar pines.



40% Ponderosa Pine

More mortality where there were high densities of large pines (more bark beetle hosts), especially in dry areas.

IN SUMMARY

Treatments are effective at mitigating drought impacts, particularly for ponderosa pines. When drought becomes too extreme, treatment may increase mortality for shade-tolerant species, but those species didn't experience the high die-off rates pines did and are more prevalent on the landscape now than they were historically. To effectively mitigate for future drought, treatment pace and scale needs to be amplified.

In our study, incense cedars and oak species proved to be the most drought tolerant. Forest management that maintains a diversity of tree species will buffer forests against future droughts and other large disturbances.

Less precipitation was correlated with higher tree mortality for all species. The graph shows how treatment was related to less ponderosa pine mortality, across the precipitation spectrum.