CALIFORNIA FIRE SCIENCE CONSORTIUM

Research Brief for Resource Managers

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Tree recruitment over centuries: influences of climate and wildfire

Stephens, Scott L., Zachary L. Steel, Brandon M. Collins, Danny L. Fry, Samantha J. Gill, Hiram Rivera-Huerta, and Carl N. Skinner. 2023. "Climate and Fire Impacts on Tree Recruitment in Mixed Conifer Forests in Northwestern Mexico and California." Ecological Applications: e2844. https://doi.org/10.1002/eap.2844.

This study uses tree cores gathered at three 4-hectare plots to make inferences about temporal aspects of tree recruitment in pine-dominated ecosystems of the California Sierra Nevada (SN) and the Sierra San Petro Martir (SSPM) in northwestern Mexico.

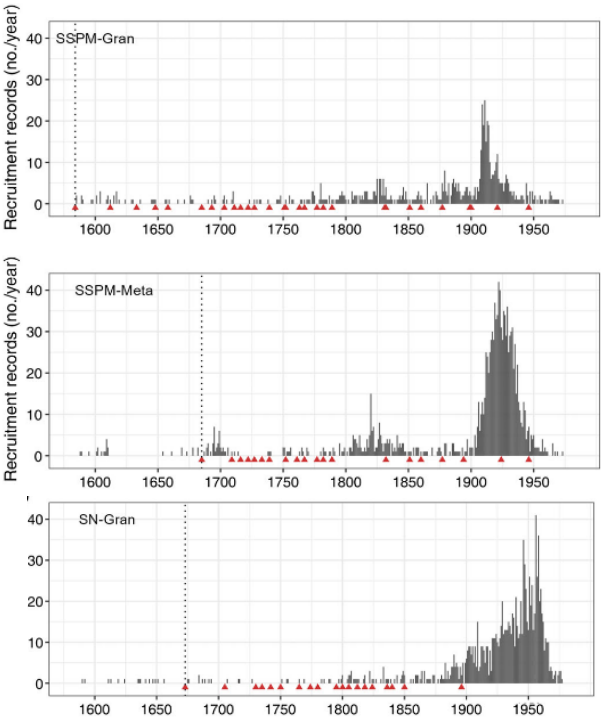
This study evaluates a much longer time horizon than is typically found in tree regeneration studies. To achieve this, the researchers used tree cores to calculate the age of each tree within the study plots, characterized all same-aged trees as being part of the same cohort, and assessed the ecological drivers of cohort density. With this approach, they inferred recruitment densities across centuries and investigated the potential influences of fire history and soil moisture (a climate indicator) in driving these patterns.

Fire history (fire free intervals) were assessed for each site using local fire scar data. The researchers used an existing database of soil moisture, which was derived from a different tree core dataset (Williams 2022). This dataset also includes an estimate of soil moisture in the absence of anthropogenic climate change, allowing the authors to specifically estimate the influence of climate change on recruitment patterns.

Management Implications

- Tree recruitment is episodic, with many years not having any tree recruitment.
- In fire-restored landscapes, soil moisture has a stronger influence on recruitment.
- Fire-suppressed landscapes tend to be associated with higher tree recruitment, possibly due to a lack of a mortality agent.

This paper finds that recruitment is largely episodic and influenced both by climate patterns and fire histories. At the two SSPM sites – which supported frequent fire until recently – tree recruitment was associated with higher soil moistures as well as a longer length of time between fires. At the SN site, tree recruitment was not associated with soil moisture, but it was strongly associated with the length of time between fires. Specifically, the SN site experienced a dramatic increase in recruitment in the 20th century, corresponding to a long period of fire suppression. These patterns can be seen in the following figure (corresponding with sections of Figure 3 in the published article), where the "SN-Gran" site has a fairly long-lasting pulse of recruitment in the 20th century. SSPM sites have a similar pulse that is accompanied by several other small pulses in prior centuries. Importantly, many years (42%) had no recruitment at all. This figure also shows how these patterns correspond with fire (represented with red arrows), with SSPM sites experiencing continued (albeit reduced) fire activity in the 20th century.



With the relationship between soil moisture and tree recruitment at SSPM, the researchers evaluated the effect of climate change by modeling outcomes under the counterfactual "no climate change" soil moisture scenario. They found that climate change led to 16% and 11% declines in annual recruitment at each of the two SSPM sites. The SN site did not have climate-associated declines, as there was no estimated effect of soil moisture on recruitment.

The age structure of trees at the three sites in the Sierra Nevada and Sierra San Pedro Martir highlights that the drivers of episodic recruitment vary based on the fire history of the site. The absence of fire at the Sierra Nevada site led to recruitment dynamics being dominated by the fire history, whereas at the relatively frequent-fire sites in SSPM, climatic variation also influenced recruitment. This study highlights the importance of site history and how it interacts with other ecological drivers to affect forest structure.

Also referenced:
Williams, A. P. 2022. "Climate Observation Data, Modeled Soil Moisture and Reconstructed Soil Moisture Model Outputs from June 800 through 2021 (NCEI Accession 0241207)." NOAA National Centers for Environmental Information. Dataset. https://doi.org/10.25921/8pt9-hz08.