CALIFORNIA FIRE SCIENCE CONSORTIUM

Research Brief for Resource Managers

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Analysis of burn patterns in Sierra Nevada reveals unprecedented levels of high-severity fire: a research summary of comparisons by forest type to pre-Euro-American Settlement

Williams, JN, Safford HD, Enstice, N, Steel, ZL, Paulson, AK. 2023. High-severity burned area and proportion exceed historic conditions in Sierra Nevada, California, and adjacent ranges. Ecosphere 14(1):e4397. DOI: 10.1002/ecs2.4397.

This study presents a new analysis of area burned by wildfire and fire severity trends for the Sierra Nevada and Southern Cascades (SNSC) region from 1984 to 2020. It analyzes wildfire burn areas from the California Fire Perimeter database using Vegetation Burn Severity data from the US Forest Service and new analyses using Google Earth Engine. The results show the average annual area burned (AAB) by wildfire has trended upward, both for the region as a whole and for most of the major forest types (Fig. 1). At the same time, with the exception of the record-setting 2020 fire year, AAB has continued to lag behind historical levels (AAB_{Pre}) estimated to have existed prior to 1850, when major Euro-American settlement started and when wildfire suppression and prohibition of Native American cultural burning began to be implemented in earnest.

The study also looks at wildfire severity patterns in the SNSC and how the fraction of burned area characterized by high severity fire has increased over pre-1850 levels and recently. This is true both for the study region as a whole and for most of the major forest types examined. This research builds on a study looking at trends from 1984 to 2009 (Mallek et al. 2013). As such, the emphasis is on changes since 2009. While AAB from 2010 to 2020 was still far below AAB_{Pre}, it rose significantly from the previous period and the average annual area burned at high severity ($\geq$ 95% tree mortality) exceeded historical levels for the first time on record.

This jump in high severity burned area is of concern because most of the forest types affected are adapted to fire regimes characterized mainly by low-to-moderate

Management Implications

- High severity wildfire is increasing in absolute and relative terms across the Sierra Nevada. This is especially true for low-to-mid elevation forest types adapted to more low-to-moderate severity fire.
- From 2010-2020, annual area burned at high severity exceeded historical (pre-1850) levels for the first time on record. Meanwhile, the percentage of low-to-moderate severity fire decreased.
- These trends are opposite what most forest types in the region need to restore natural ecological processes and stability.
- Changes in fire severity patterns were less notable in high elevation forest types adapted to infrequent, high severity fire.

severity fire. Excessive high severity fire can have negative impacts on numerous ecological processes, including post-fire regeneration, species composition, wildlife habitat and carbon storage.

Historically in percentage terms, roughly 7% of the forest area affected by wildfire burned at high severity. That figure had risen to 29% for 1984-2009, and has since climbed to 36%

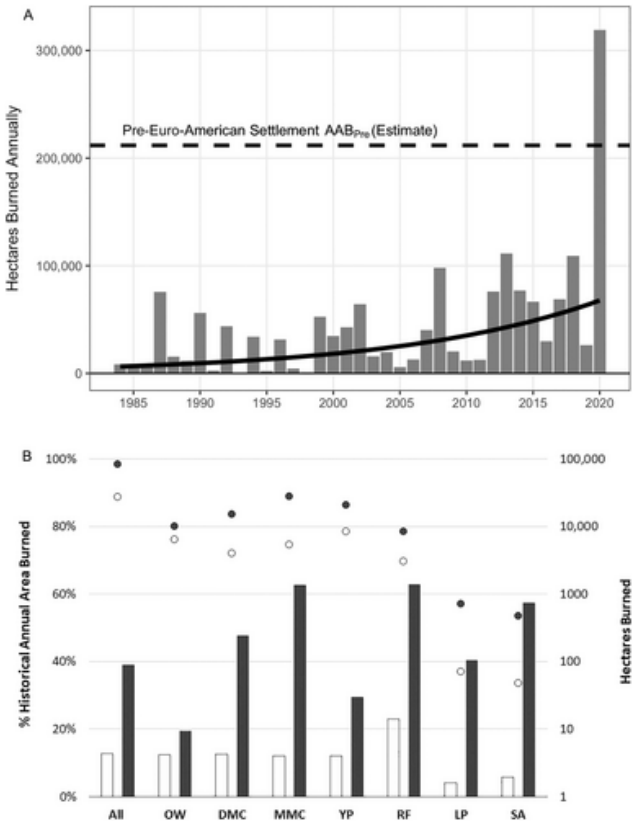
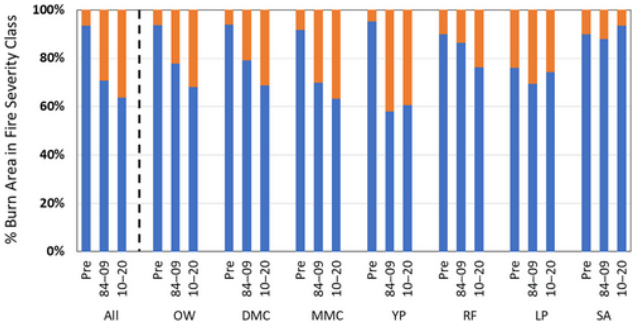


Figure 1. (A) Annual area burned (AAB) by wildfire in the Sierra Nevada-Southern Cascades region for the period 1984-2020. The dashed line shows the estimated AAB_{Pre} prior to Euro-American settlement (~1850). The solid upsloping trend line shows the fitted linear model with log area as the response variable and time as the predictor. (B) AAB by forest type for 1984-2000 (white bars) and 2010-2020 (black bars) as a percentage of AAB_{Pre} (left axis). White and black circles show AAB for the same two periods, respectively (right axis). OW: oak woodland; DMC: dry mixed conifer; MMC: moist mixed conifer; YP: yellow pine; RF: red fir; LP: lodgepole pine; SA: sub-alpine.

for 2010-2020. For each of the seven major forest types evaluated, one can see how the mix of low-to-moderate and high fire severity has changed relative to historical levels and during the study period (Fig. 2).



The changes are most pronounced in low-to-mid elevation forests, from oak woodlands to mixed conifer-yellow pine forests, where the negative impacts of high severity fire are expected to be the most consequential.

By contrast, upper elevation forest types, such as lodgepole pine and sub-alpine forests, experienced a mix of fire severities during the study period that were roughly in keeping with historical patterns. This is likely due to two factors. First, climatically, these forests experience colder temperatures and shorter growing seasons and thus accumulate fuels more slowly and have longer natural fire return intervals. As such, fire exclusion will have less of an effect on fuels. Second, while wildfire is infrequent at higher elevations, it occurs more often as higher severity fire to which the flora and fauna may be better adapted. Together, these factors mean that fire exclusion and climate change may be less disruptive to natural fire regimes than would be the case in forests adapted to more frequent, low-to-moderate severity fire.

Cited: *Mallek, C, Safford, H, Viers, J & J Miller. 2013. "Modern departures in fire severity and area vary by forest type, Sierra Nevada and Southern Cascades, California, USA." Ecosphere 4: 1–2*