CALIFORNIA FIRE SCIENCE CONSORTIUM

Research Brief for Resource Managers

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Maximum Fire Elevation in the Sierra Nevada Has Increased Over the Past Century

Schwartz, M., N. Butt, C. Dolanc, A. Holguin, M.Moritz, M. North, H. Safford, N. Stephenson, J. Thorne, and P. van Mantgem. 2015. Increasing elevation of fire in the Sierra Nevada and implications for forest change. Ecosphere ***6****(7): 121. DOI: 10.1890/ES15-00003.1.*

Management Implications

- The maximum elevation extent of wildfires and the probability of wildfire occurrence above 3000 m have increased over the last century in the Sierra Nevada.
- This trend may accelerate vegetation shifts towards upper montane forest types in current subalpine systems.
- Refugia for disease resistant white pines may be lost, and the incidence of high elevation bark beetle induced conifer mortality may increase.
- Research and monitoring of the effects of increasing fire elevation on ecosystem composition, structure, and function are needed.

In high elevation forests of the Sierra Nevada, fire occurrence was historically rare due to sparse fuels and relatively high fuel moisture levels. Empirical studies have documented increasing tree density in Sierra Nevada sub-alpine forests. This potential increase in fuels coupled with warming temperatures that may be reducing fuel moistures led Schwartz *et al.* to investigate whether there has been an upward shift in maximum elevation of fire in the Sierra Nevada.

Using the California Fire Perimeter Geodatabase (version 12.1, April 2014: http://frap.fire.ca.gov/projects/fire_data/fire_perimeters_index.php), the authors collected fire perimeters for all fires recorded in the Sierra Nevada between 1908 and 2012 and spanning elevations from 10 to 4421 m. Their analysis controlled for a potential increase in detail and thoroughness of the dataset through time.

Both the maximum elevation within each fire boundary and the highest elevation along the fire boundary were calculated. Because both metrics demonstrated substantively the same patterns and were highly correlated with each other, the authors only reported results of the analysis of maximum elevation along the fire boundary.

This metric was determined for the seven fires with the highest maximum elevation for each year and the correlation between elevation and year was tested. They also used a contingency test to evaluate changes in fire frequency at different elevation bands through time.

The results indicated an increase in maximum fire elevation of over 700 m. The probability

of fires occurring above 3000 m elevation also increased through time.

The authors note that this observed trend of increasing frequency of wildfire at higher elevations in the Sierra Nevada suggests a fundamental change in the disturbance regime that may affect the structure, composition, and function of subalpine forests.

These data are observational, but the authors suggest five potential mechanisms:

- *Fire management strategies* – cessation of fire suppression at higher elevations;
- *Changing climate* – warming temperatures and earlier snowpack melt;
- *Increasing forest fuels* – previous fire suppression and warming temperatures could be drivers of the increase in subalpine forest density;
- *Increasing ignitions* – due to increasing human presence at higher elevations;
- *Sampling bias* – the authors consider this effect negligible.

Two important management implications are highlighted by the authors: 1) this trend could cause increased mortality rates of existing subalpine vegetation and accelerate a climate-driven transition towards upper montane forest types and proportional shifts in tree density from larger to smaller trees; and 2) an acceleration of the upward shift of montane vegetation could decrease the ability of high elevation Sierran forests to provide refuge for disease resistant white pine populations and accelerate increases in high elevation bark beetle induced conifer mortality.

Further reading:

*Dolanc, C., J. Thorne, and H. Safford. 2013. Widespread shifts in the demographic structure of subalpine forests in the Sierra Nevada, California, 1934 to 2007. Global Ecology and Biogeography **22**:264-276.*

*Millar, C., R. Westfall, D. Delany, J. King, and L. Graumlich. 2004. Response of subalpine conifers in the Sierra Nevada, California, USA, to 20th-century warming and decadal climate variability. Arctic Antarctic and Alpine Research **36**:181-200.*

*Stephens, S., J. Agee, P. Fulé, M. North, W. Romme, T. Swetnam, and M. Turner. 2013. Managing forests and fire in changing climates. Science **342**:41-42.*

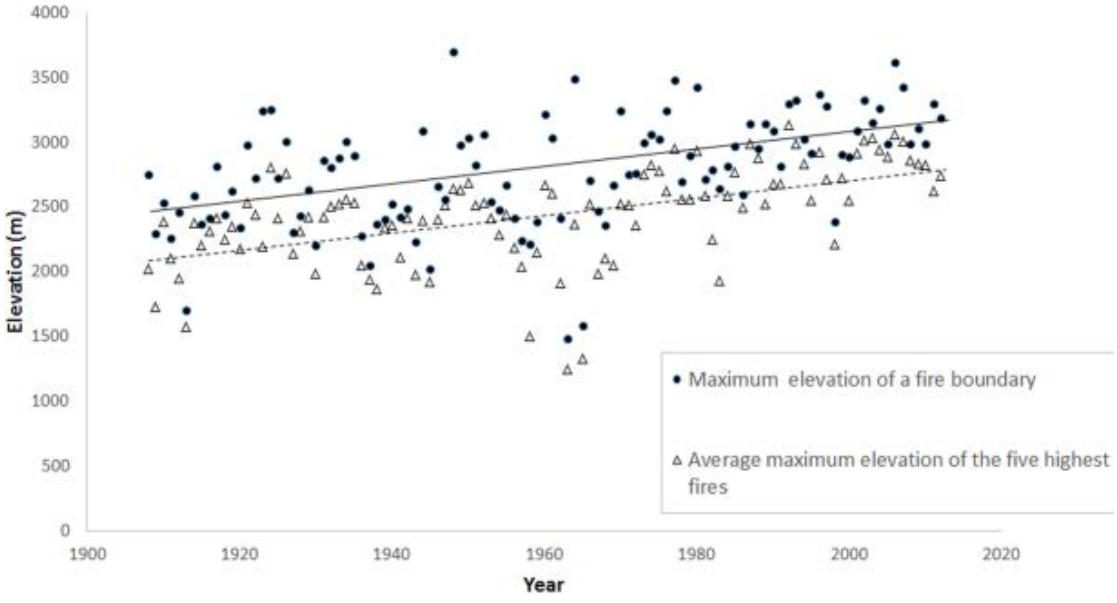

Figure 1. Two metrics of the increasing elevation of fire in the Sierra Nevada: The upper elevation of the highest (solid circles, $r^2 = 0.24$, $p < 0.0001$); and fifth highest (triangles; $r^2 = 0.23$, $p < 0.0001$) fires by year. Each set of points shows an increasing trend.