CALIFORNIA FIRE SCIENCE CONSORTIUM

JOINT FIRE SCIENCE PROGRAM

Research Brief for Resource Managers

Release:	Contact:	Phone:	Email:
May 2021	Sara Winsemius	-	swinsemius@ucdavis.edu
	Joan Dudney	415-400-9733	jdudney@berkeley.edu

Sierra Nevada Fire Science Delivery Consortium | One Shields Avenue, Davis, CA 95616

Blister rust, beetles, and fire threaten white pines

Dudney, J. C., J. C. B. Nesmith, M. C. Cahill, J. E. Cribbs, D. M. Duriscoe, A. J. Das, N. L. Stephenson, and J. J. Battles. 2020. Compounding effects of white pine blister rust, mountain pine beetle, and fire threaten four white pine species. Ecosphere 11.
https://doi.org/10.1002/ecs2.3263

In recent decades white pine blister rust, mountain pine beetle, and fire have increased in extent and caused tree mortality across the western USA. This study used long-term monitoring plots to determine mortality of four white pine species in Sequoia and Kings Canyon National Parks.

Management Implications

- The extent of white pine blister rust increased from 20% of plots to 33% of plots when resampled ~20 years later
- The blister rust infection rate declined in sugar pine due to high mortality rates of infected trees but increased in western white pine and whitebark pine
- Fire and mountain pine beetle impacts were the greatest in sugar pine, which has declined more rapidly than previously documented. Sugar pine may need active restoration to sustain the southern Sierra population
- Within each species, lower elevations were associated with increased mortality; climate warming may lead to increased mortality
- More frequent sampling of long-term monitoring plots is needed to track subalpine white pine mortality in the southern Sierra Nevada

Background

White pine blister rust (*Cronartium ribicola*) is an invasive, lethal disease that infects white pines. The impact has been severe in the USA and Canada, and control efforts have led to some of the most expensive and widespread tree pathogen eradication campaigns. White pines in North America have high susceptibility to white pine blister rust, and spores can travel hundreds of kilometers via wind currents.

Other white pine mortality agents interact with blister rust to dampen or increase infection. Native mountain pine beetle (*Dendroctonus ponderosae*) may preferentially attack trees weakened by infection, resulting in more rapid mortality than one agent alone. Fire can increase or decrease mortality, though little research has investigated these potential interactions. Forest restoration techniques could improve forest health and resilience, however managers often lack information to prioritize areas for treatment.

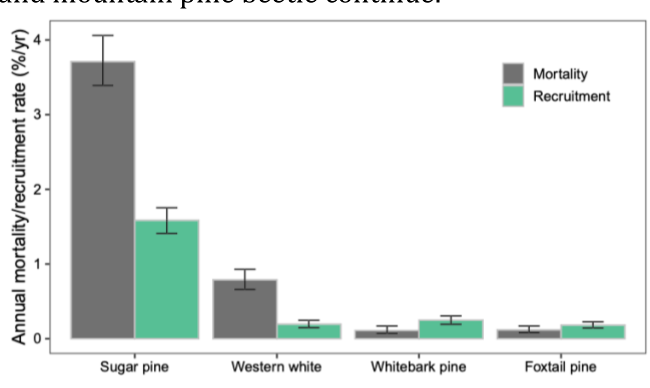
In this study, the authors sampled permanent plots with four white pine species across an elevational gradient from mixed conifer to high subalpine: sugar pine (*Pinus lambertiana*) in mixed-conifer forests; western white pine (*P. monticola*), which spans from upper mixed conifer to lower subalpine forests; whitebark pine (*P. albicaulis*), an IUCN listed endangered species that was recently recommended for listing as threatened under the Endangered Species Act; and foxtail pine (*P. balfouriana*), which along with whitebark pine occurs in the subalpine elevations (Fig. 2). Plots were originally sampled from 1995-

1999 and were resampled about 20 years later, from 2013-2017. Surveys assessed the extent of blister rust (number of plots with at least 1 infection), mortality (annual tree mortality of stems between the first and second survey), and recruitment (based on final density and the number of stems that survived from the first survey).

Results and Discussion

Sugar pine populations experienced high mortality rates between surveys: 52% of originally surveyed trees died. In surviving sugar pines, infections of blister rust declined since infected trees were more likely to have died. The annual mortality rate was more than double the annual recruitment rate (Fig. 1), which resulted in a population reduction of over half over the 20 years. Mortality was best explained by fire, mountain pine beetle, blister rust, and smaller size. Many plots were sampled before the full effect of the 2012-2016 drought, which likely means mortality is underestimated here.

Western white pines experienced an increase in blister rust infection rate, from 3.0% to 8.7% of trees infected, and a spread of extent from 17.5% of plots to 55.0% of plots. Mountain pine beetle and fire were both strongly associated with mortality as well: beetle attack was visible in 49% of dead trees but only 10% of live trees, and 50% of trees in burned plots died compared to 6% in unburned plots. The annual mortality rate was four times greater than the recruitment rate (Fig. 1), leading to a 13% decline in population over the 20-year study period. Low resistance to blister rust indicates western white pine populations are highly susceptible to infection. Mortality rates may follow the rapid declines seen in sugar pines if current trends in blister rust, fire and mountain pine beetle continue.



High elevations: Blister rust continued to spread upward in elevation between the two surveys, and the first whitebark pine infections were detected in the 2013-2017 resamples (Fig. 2). While blister rust infection was not observed in foxtail pine plots, the authors found evidence of blister rust infections in foxtail pine outside of the plots. The recruitment rates of both whitebark and foxtail pines were about 0.2%/year, exceeding the mortality rate in both species (Fig. 1). Current trends indicate blister rust will increasingly threaten subalpine white pines, as already observed in western white pine. Mountain pine beetle incidence was lower for higher elevation pines than for sugar pine or western white pine, but this trend will likely change as increased warming creates a more suitable climate for the beetles.

Fire was an important factor leading to mortality for sugar pine and western white pine: 61% of sugar pines and 50% of western white pines died in burned plots, up from 29% and 6%, respectively, in unburned plots. Fire was not associated with blister rust infection, however because the majority of fires in the study occurred ~8 years before resampling, sampling may have missed the immediate effects of fire such as the reduced numbers of infected hosts or preferential removal of small trees and alternate hosts by fire.

With climate warming, these pathogens and pests are likely to spread further up in elevation within and across species. Increasing the frequency of sampling in long-term monitoring plots is important to disentangle drivers of blister rust spread from fire, mountain pine beetle, and climate warming. The southern Sierra Nevada has historically had lower levels of blister rust and mountain pine beetle outbreaks compared to other western forests, however this paper shows those trends are changing.

Figure 1. Annual mortality (grey bars) and recruitment rates (green bars) by white pine species. Error bars represent 95% confidence intervals.

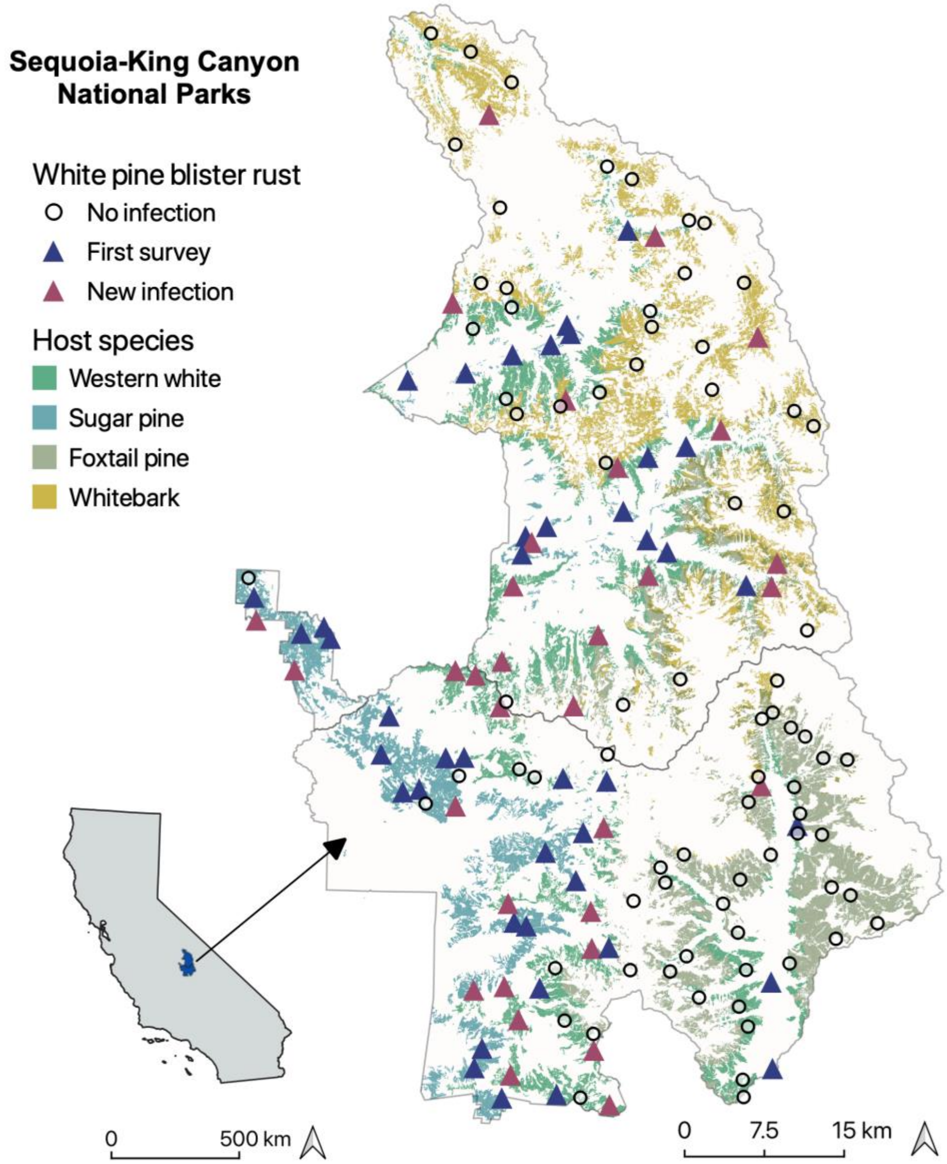


Figure 2. First survey infections (blue triangles; infections identified in the original sampling) and second survey infections (red triangle; new infections at the time of the second survey) across long-term monitoring plots. Color shades indicate the four white pine species ranges.