



Whitebark and Foxtail Pine in the Sierra Nevada

Assessing Stand Structure and Condition



Whitebark pine in Yosemite National Park. Photo by: © Michael Durham.

Importance

Whitebark pine (*Pinus albicaulis*) and foxtail pine (*P. balfouriana*) grow at high elevations in rugged, rocky terrain with harsh weather and short growing seasons. The seeds from these trees provide food for birds and mammals, their canopies provide shade that helps slow snowmelt, and their branches and trunks provide structure important for wildlife habitat.

In most of their range, which extends from the Sierra Nevada to the North Cascades and Rocky Mountains, whitebark pine have declined in response to multiple factors, including infection from the non-native white pine blister rust (*Cronartium ribicola*) and outbreaks of mountain pine beetle (*Dendroctonus ponderosae*). In the southern Sierra Nevada, both whitebark pine and foxtail pine have remained healthy, as these stressors have been rare. However, increasing white pine blister rust and mountain pine beetle occurrence coupled with climate change impacts, may cause future declines.

The Sierra Nevada Network Inventory & Monitoring Program participates in a collaborative monitoring project that tracks change in high-elevation white pines in several Pacific West Region national parks. Sierra Nevada white pines include whitebark, foxtail, limber (*P. flexilis*), western white (*P. monticola*), and sugar (*P. lambertiana*) pine. This Publication Brief highlights whitebark pine and foxtail pine stand structure and condition in Sequoia, Kings Canyon, and Yosemite national parks, based on an initial assessment of monitoring data collected between 2012 and 2017 and published in a special issue of *Forests: Ecology and Restoration of Whitebark Pine*¹.

Key Findings

High elevation white pines are relatively healthy in the Sierran national parks compared to other parts of their range.

White pine blister rust infection rates in whitebark and foxtail pine were low in both parks. For whitebark pine, well below 1% of trees were infected, or about one tree per hectare in Yosemite and Sequoia & Kings Canyon.

- In Yosemite, the infections were all found in one plot, scattered across 12 different whitebark pine trees.
- In Kings Canyon, fewer trees (6) had disease symptoms, but they were more widely scattered across four different plots.

Foxtail pine occurs only in Sequoia & Kings Canyon and showed no symptoms of white pine blister rust.

Mountain pine beetle activity was rare to very rare. Beetle activity was recorded in 1.0% of whitebark pine and 0.1% of foxtail pine in Sequoia and Kings Canyon and <0.1% of whitebark pine in Yosemite.

Although these pine populations are still relatively healthy, our recent observations of white pine blister rust and mountain pine beetle at high elevations may portend future declines.

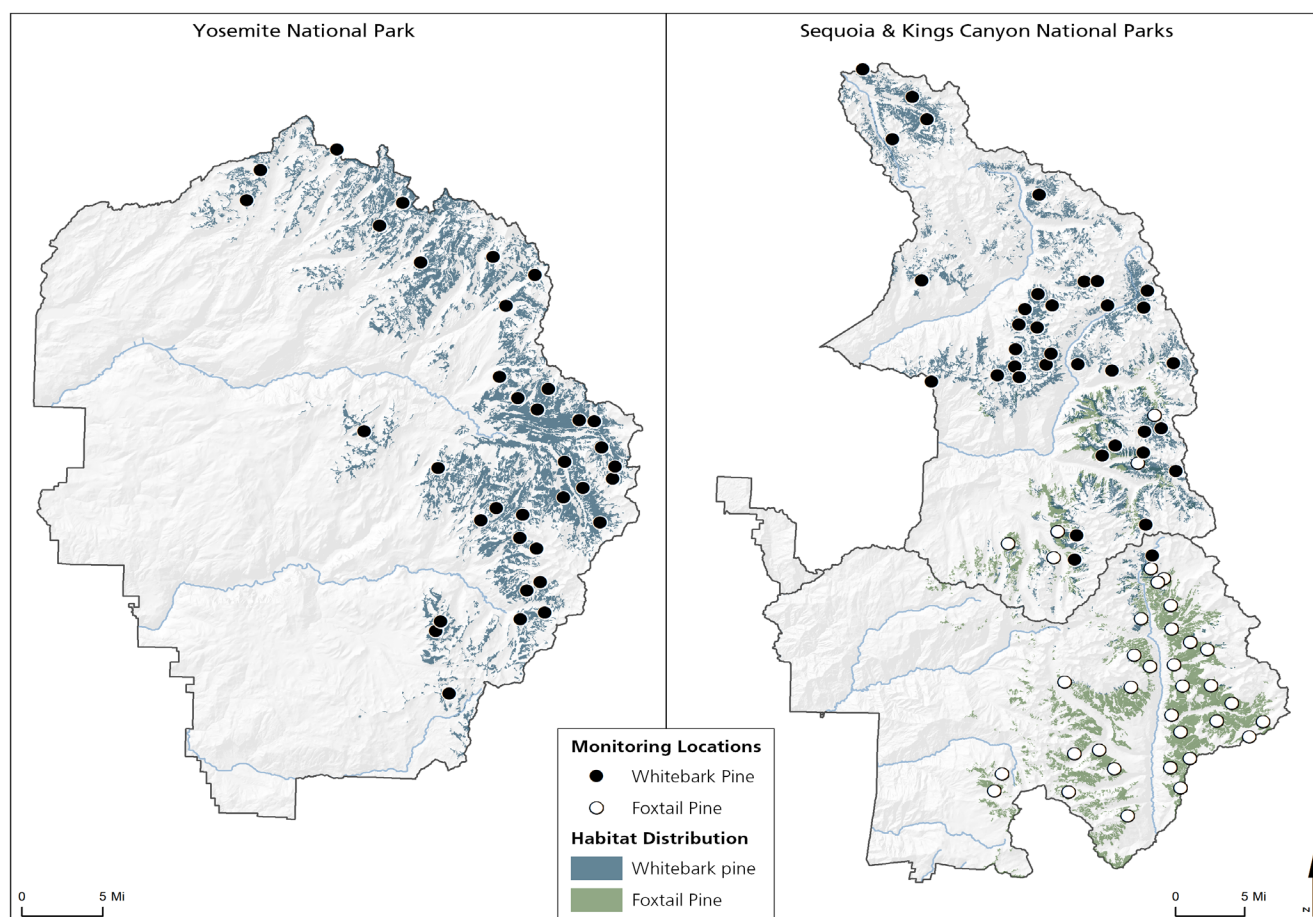


Figure 1. Distribution of whitebark pine and foxtail pine populations and monitoring plots in Sierra Nevada Network parks. Maps by: Alex Eddy.

Methods

We collected long-term monitoring data between 2012 and 2017 in Sequoia & Kings Canyon and Yosemite national parks. Detailed methods are available in the monitoring protocol developed for multiple Pacific West Region national parks². We selected random plot locations using an equal probability, spatially-balanced approach, and based sample frames on the distribution of whitebark pine and foxtail pine identified in park vegetation maps (Figure 1). The sample design allows inference to the entire area of the parks where these species occur.

Field crews documented whitebark pine and foxtail pine tree characteristics and the presence/absence of factors influencing mortality:

- Diameter at Breast Height (DBH)
- height
- cone counts
- level of canopy kill
- live seedling counts and height class assignment
- tree status (live, recently dead, dead)
- assessment of mortality cause
- blister rust cankers (bole and canopy)
- number of blister rust indicators (pitching, rodent chew marks)
- mountain pine beetle indicators (pitch tubes, frass, or J-shaped galleries)
- dwarf mistletoe infection
- growth form (for whitebark pine)

Field crews measured 7899 whitebark pine, 1112 foxtail pine, and 6085 other trees. Table 1 summarizes the number of live and dead trees recorded in plots for each park.

Table 1. Summary of the number of plots, live trees, and dead trees for whitebark pine (PIAL) populations in Yosemite (YOSE) and Sequoia and Kings Canyon (SEKI) and the foxtail pine (PIBA) populations in SEKI. The tree number totals include all tree species in the plots.

Park-Species	No. of plots	No. of live trees	No. of dead trees
YOSE - PIAL	35	7866 (48% PIAL)	181 (15% PIAL)
SEKI - PIAL	31	5038 (71% PIAL)	125 (66% PIAL)
SEKI - PIBA	33	2192 (49% PIBA)	191 (50% PIBA)



White pine blister rust spores on tree bole (left) and typical symptoms of white pine blister rust infection (right) on whitebark pine in Yosemite National Park in 2017.

What Did We Learn?

This study provides a baseline for quantifying status and trend in: tree species composition and structure; incidence of white pine blister rust and level of crown mortality; incidence of bark beetles; tree species birth, death, and growth rates; and cone production.



Figure 2. Low, shrubby krummholz growth form of whitebark pine, Yosemite National Park. Whitebark pine growing as krummholz was much more common in Yosemite than in Sequoia & Kings Canyon. NPS photo by: 2017 forest crew.

Species Composition and Structure

Stand structure for whitebark pine was variable and reflects the multiple habitats and growth forms of this species. Figure 2 illustrates the krummholz form that can occur in harsh growing conditions near treeline. Whitebark pine can occur in pure stands as a single species as well as in mixed forests with other species, such as lodgepole pine (*P. contorta*) and mountain hemlock (*Tsuga mertensiana*). Foxtail pine stand structure was less variable and it tended to occur at lower stem densities but higher basal area than whitebark pine (Figure 3). Foxtail pine co-occurred most often with whitebark pine and lodgepole pine.



Figure 3. Foxtail pine stand in Sequoia National Park. NPS photo by: Roxanne Kessler.

Whitebark pine average stem densities were: 431 trees/ha in Yosemite and 442 trees/ha in Sequoia & Kings Canyon, with greater variability in Yosemite. Foxtail pine average stem density was 130 trees/ha.

White Pine Blister Rust and Crown Mortality

White pine blister rust was rare in whitebark pine for both Yosemite and Sequoia & Kings Canyon, with an average infection rate of 0.1%. Only one plot was infected in Yosemite - 12 out of 251 live trees within that plot showed signs of infection. This plot had the highest overall whitebark pine basal area in Yosemite, with relatively low basal area for other species. Fewer whitebark pine (6) were infected in Sequoia & Kings Canyon, but they were more spatially dispersed, occurring over four plots in Kings Canyon National Park. We found no symptoms of white pine blister rust on foxtail pine within the monitoring plots, though we observed one infected whitebark pine within a foxtail plot in Kings Canyon National Park.

Whitebark pine generally appeared to be in good health and had low levels (8.2%) of crown mortality in Yosemite as well as Sequoia & Kings Canyon. The average proportion of crown mortality in live whitebark pine increased with DBH and was significantly higher in 2017 for Yosemite compared to other years (Figure 4a), and in 2016 and 2017 for Sequoia and Kings Canyon (Figure 4b). Much of this crown damage was due to environmental factors including wind and ice damage, as well as limited damage from biological agents like brown felt blight and insects. For foxtail pine, average crown mortality was low, averaging 6%. Crown mortality increased with DBH, and was higher in 2017 compared with 2013-2016. (Figure 4c).

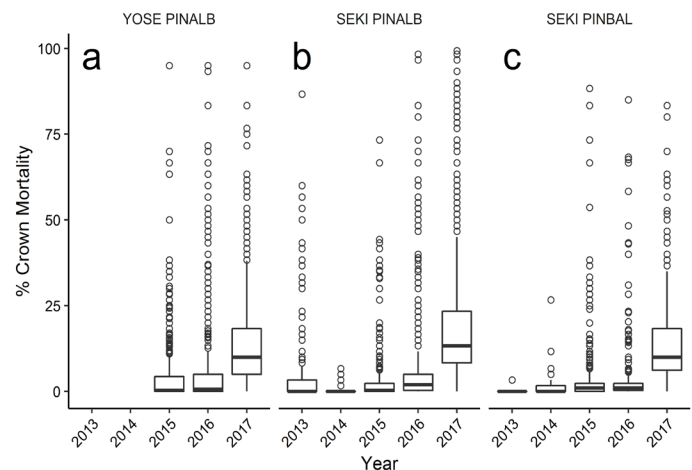


Figure 4. Individual tree percent crown mortality by year in (a) Yosemite whitebark pine sample frame (YOSE PINALB), (b) Sequoia & Kings Canyon whitebark pine sample frame (SEKI PINALB), and (c) Sequoia and Kings Canyon foxtail pine sample frame (SEKI PINBAL).

Bark Beetles

Mountain pine beetle activity was rare, averaging less than five attacked trees per hectare and representing less than one percent of all white pines. In contrast, lower elevation forests in the Sierra Nevada have experienced dramatic mortality driven by the recent severe drought and associated mountain pine beetle outbreak. We observed successful attacks primarily on whitebark pine and lodgepole pine, often limited to single trees or very small clumps. In addition, whitebark pine has experienced significant mortality from bark beetles in other parts of its range, including other areas of the Sierra Nevada.

Demography - Tree Birth, Death, Growth Rates



Field biologist Tressa Gibbard measures a foxtail pine's diameter.
Photo by: © Michael Durham.

As this is the first complete cycle of monitoring high-elevation pine plots, we cannot yet report birth, mortality, or growth rates, but have recorded existing dead trees and seedling recruitment at plot establishment. Environmental factors appear to be the driving factor of tree mortality, however, as most of the snags where we were able to assign a cause of death were attributed to environmental or physical causes. Standing dead basal area was low in general, indicating extensive mortality has not occurred in these areas in recent history. Seedling recruitment was low but variable for whitebark pine and was consistently low for foxtail pine. Low seedling densities for foxtail pine in the southern Sierra Nevada do not appear uncommon, and other research indicates populations have been stable for the last 1,000 years.

Cone Production

The proportion of cone-bearing trees was quite different across species: roughly 25% of whitebark pine trees had female cones (23% and 28% in Yosemite and Sequoia & Kings Canyon, respectively), compared to 69% for foxtail pines. The proportion of cone-bearing trees increased with tree size and decreased with crown mortality across all sample frames. While these results generally agree with previous research in other areas, one study reported a much larger percentage of cone-bearing whitebark pine in Lake Tahoe area further north (80%). This may be a reflection of asynchronous mast years, as whitebark cone production is believed to be somewhat periodic with large cone crops generally occurring every three to five years, depending on specific location.



Whitebark pine with cones. NPS photo by: Jonny Nesmith.

Conclusion

Managers face multiple challenges related to conservation of white pines, including a rapidly changing climate, existing widespread degradation of white pine ecosystems, and potential conflicts between restoration activities and wilderness policy. These data provide a solid baseline for assessing current status and evaluating future change in subalpine forests of the southern Sierra Nevada. As this long-term monitoring plot network is re-sampled its value and utility will continue to grow and help both current and future land managers ensure the persistence of these iconic species.

More Information

Jonathan Nesmith, Ecologist, National Park Service
[Sierra Nevada Network I&M Program](#)
Email: jonathan_nesmith@nps.gov
Phone: 559-565-3765

¹Nesmith, C. B., M. Wright, E. S. Jules, and S. T. McKinney. 2019. Whitebark and foxtail pine in Yosemite, Sequoia, and Kings Canyon National Parks: Initial assessment of stand structure and condition. *Forests* 10, 35; doi:10.3390/f10010035.

²McKinney, S. T., T. Rodhouse, L. Chow, A. Chung-MacCoubrey, G. Dicus, L. Garrett, K. Irvine, S. Mohren, D. Odion, D. Sarr, and L. A. Starceovich. 2012. Monitoring white pine (*Pinus albicaulis*, *P. balfouriana*, *P. flexilis*) community dynamics in the Pacific West Region - Klamath, Sierra Nevada, and Upper Columbia Basin Networks: Narrative version 1.0. Natural Resource Report NPS/PWR/NRR—2012/532. National Park Service, Fort Collins, Colorado.

To access the entire special issue of *Forests*, visit this link:
http://www.mdpi.com/journal/forests/special_issues/whitebark_pine

Download an overview brief for the [Sierra Nevada Network high elevation forest monitoring project](#).