

Greater Yellowstone Network

RESOURCE BRIEF

National Park Service
U.S. Department of the Interior
Inventory & Monitoring Program



Whitebark Pine in the Greater Yellowstone Ecosystem *Trend Analysis from 2004 to 2015*

Importance

Whitebark pine (*Pinus albicaulis*) are a keystone species in sub-alpine communities throughout the western United States. They provide high-energy food for birds and mammals, prolong spring snowmelt with their shade, and create favorable habitat to support forest succession. Whitebark pine forests, however, have recently declined in response to a mountain pine beetle (*Dendroctonus ponderosae*) outbreak, infection by white pine blister rust (*Cronartium ribicola*), and the suppression of low severity fires that historically passed through their stands.

The Greater Yellowstone Network identified whitebark pine as one of 12 natural resource vital signs. We have been monitoring its status since 2004 throughout the Greater Yellowstone Ecosystem (Figure 1) as part of the Interagency Whitebark Pine Monitoring Program under the Greater Yellowstone Coordinating Committee Whitebark Pine Subcommittee¹. This Resource Brief summarizes status and trends in whitebark pine in the Greater Yellowstone Ecosystem between 2004 and 2015 based primarily on the second step-trend analysis of long-term monitoring data². The first step-trend report³ analyzed changes between 2004 and 2011. This Brief also includes highlights from research published in *Ecosphere* based on these long-term monitoring data.

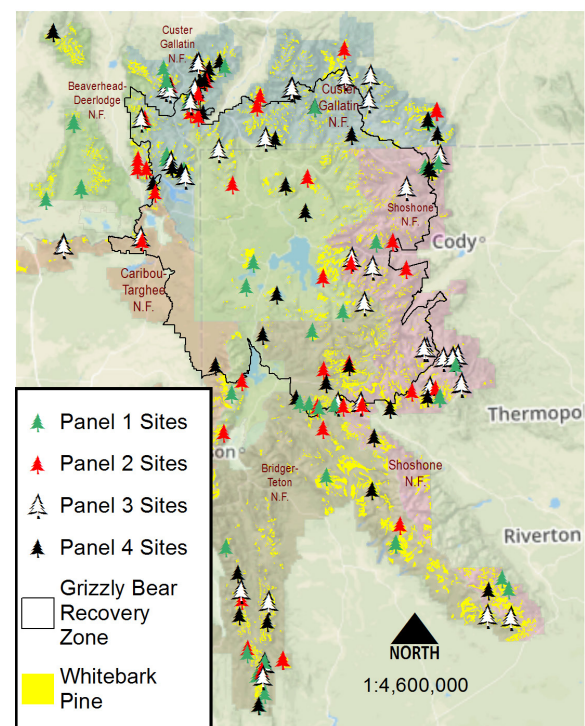


Figure 1. Interagency Whitebark Pine Monitoring Program study area in the Greater Yellowstone Ecosystem (all shaded regions).

Key Findings

Step-Trend Analysis of 2004 to 2015 Data (NPS Natural Resources Report)

- Both white pine blister rust and mountain pine beetle are widespread but variable throughout the Greater Yellowstone Ecosystem.
- The overall proportion of whitebark pine trees infected with blister rust did not significantly change.
- The majority of trees with the least severe type of infection (in tree canopy) eventually developed the more severe type of infection (on the tree bole).
- Mountain pine beetles preferentially attacked and killed larger whitebark pine trees. This has resulted in a demographic shift towards smaller tree size classes.
- Whitebark pine tree mortality decreased towards the end of the 12-year time period.
- Recruitment of new whitebark pine trees was widespread but variable across the study area.

Research Conclusions (Ecosphere publication)

- Warmer than normal temperatures in 2006–2008 likely contributed to the mountain pine beetle outbreak that peaked in 2009. Higher temperatures projected for the Greater Yellowstone Ecosystem will likely cause more local beetle outbreaks where adequate food is available to sustain outbreak level mountain pine beetle populations.
- White pine blister rust caused higher mortality to smaller whitebark pine trees. This suggests that, with the demographic shift towards smaller trees caused by mountain pine beetle attack on large whitebark pine, blister rust may become the most probable cause of mortality for whitebark pine in the future.
- Researchers found no interactive (or added) effect between white pine blister rust infection and mountain pine beetle attack on the mortality of whitebark pine.
- Higher soil water availability improved the survival of whitebark pine trees attacked by mountain pine beetle, offering some guidance on the best conditions for restoration sites.

Methods

Analyses for both the step-trend Natural Resources Report and the *Ecosphere* publication were based on long-term monitoring data collected between 2004 and 2015 throughout the Greater Yellowstone Ecosystem as part of the Interagency Whitebark Pine Monitoring Program. Detailed methods are available from the *Interagency Whitebark Pine Monitoring Protocol for the Greater Yellowstone Ecosystem*⁴. Between 2004 and 2007, 176 transects in whitebark pine stands were randomly selected using a stratified design and grouped into four panels of approximately 44 transects each. The sampling design allows inference to the entire Greater Yellowstone Ecosystem study area. One panel was sampled each year to complete a full survey every four years. These four-year datasets were analyzed as separate time-steps:

Time-Step 1 = 2004–2007

Time-Step 2 = 2008–2011

Time-Step 3 = 2012–2015

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

- clump membership
- DBH
- height
- tree status (live, recently dead, dead)
- cone counts
- blister rust cankers (bole and canopy)
- number of blister rust indicators
- upper tree canopy volume
- mountain pine beetle indicators (pitch tubes, frass, or J-shaped galleries)
- tree health codes
- understory counts

Note that we report two distinct types of values: tree proportions and tree percentages. Proportions are based on a combined ratio estimator appropriate for our sampling design and therefore provide estimates for the entire whitebark pine population in the Greater Yellowstone Ecosystem. Tree percentages are raw counts of tagged trees only (Table 1) and cannot be extrapolated to the larger whitebark pine population.

Table 1. Count of transects, stands, and live and dead tagged, whitebark pine trees sampled, by time period, in the Greater Yellowstone Ecosystem.

Time-Step	No. of transects	No. of stands	No. of live trees	No. of dead trees
2004–2007 [T1]	176	150	4768	0
2008–2011 [T2]	176	150	4078	977
2012–2015 [T3]	176	150	3716	1502



White pine blister rust (*Cronartium ribicola*) on bole (left) and in canopy (right) of a whitebark pine tree.

Results and Discussion

Our results address the four main objectives of the Interagency Whitebark Pine Monitoring Program: document blister rust infection proportions, blister rust infection severity, whitebark pine mortality, and whitebark pine recruitment.

Objective 1 – Infection Proportions

Assess trends in proportion of whitebark pine infected by white pine blister rust

The estimated proportion of live whitebark pine trees infected with white pine blister rust in the Greater Yellowstone Ecosystem did not significantly change among the three time-steps:

- Infected proportion in Time 1 was 0.21 (0.03 SE)
- Infected proportion in Time 2 was 0.21 (0.02 SE)
- Infected proportion in Time 3 was 0.19 (0.03 SE)

We conclude that the overall proportion of whitebark pine trees infected with blister rust at the end of Time 3 (2015) remains in the range of 0.13 to 0.25 (SE 0.03) in the Greater Yellowstone Ecosystem. From Time 2 to Time 3, roughly half of the stands showed a decrease in blister rust infection, a quarter showed an increase, and a quarter remained unchanged.

Objective 2 – Infection Severity

Document status and trends in the severity of blister rust infection in whitebark pine

We chronicled if and when infection location changed in the canopy and bole of infected, tagged trees between time-steps. A bole infection is considered more consequential than a canopy canker. A bole infection compromises not only the overall longevity of the tree, but its functional capacity for reproductive output because blister rust can lead to the loss of all the cone-bearing branches above the infected site. Not surprisingly, we found that over a longer time interval of four to eleven years, as expressed in the Time 1 to Time 3 comparison, 60% (237 trees) of tagged trees with canopy cankers transitioned to trees with bole cankers. In addition, we found that once an infection occurs in the bole, the likelihood of it transitioning back to a canopy canker is low.

Objective 3 – Mortality

Assess trends and describe contributing factors in mortality of whitebark pine

We estimated the proportion of dead whitebark pine trees across all size classes to be 0.26 in the Greater Yellowstone Ecosystem (0.03 SE) by the end of Time 3, using a combined ratio estimator. Peak whitebark pine mortality was 2008–2011, at the height of the mountain pine beetle epidemic. Very few new or active mountain pine beetle attacks were observed on the monitoring transects during Time 3. Overall mortality of trees decreased in Time 3 to a rate of 0.09 (0.02 SE) compared to 0.17 (0.03 SE) during Time 2.

Potential causes of mortality varied (Figure 2). Of the 1502 tagged trees that had died by 2015 since the start of the monitoring program, roughly one-third of these trees died with mountain pine beetle sign only, mostly in the 10 to 30 cm DBH size class. Of the 203 trees (14%) that died with blister rust sign only, most were >2.5 to 10 cm DBH. Eight percent of trees (121) died with fire sign only. The remaining half of dead trees had signs of multiple stressors.

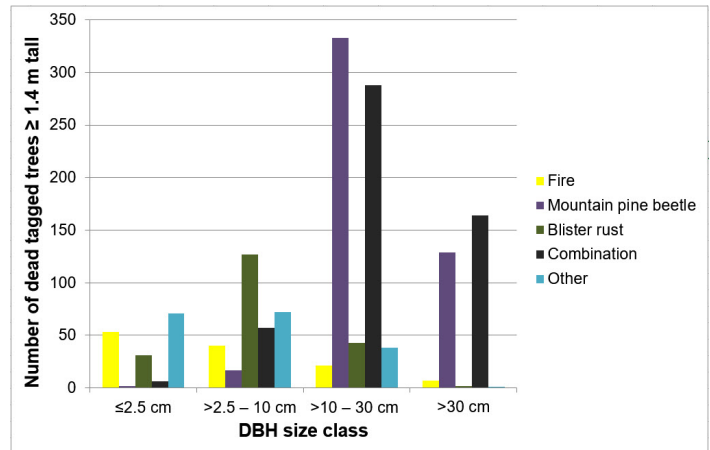


Figure 2. Cumulative mortality of whitebark pine trees in the Greater Yellowstone Ecosystem between 2008 and 2015, with associated factors.

Fire-influenced mortality increased two-fold during Time 3, from a total of 6 burned stands in Time 2 to 14 in Time 3. The majority of these fire events were stand replacing, where all trees within the fire perimeter were killed. Under projected climate change conditions, wildland fire events are predicted to increase in the Greater Yellowstone Ecosystem. Consequently, we expect an increase in the number of stands affected by fire in the future.

With the mortality following the mountain pine beetle outbreak and other factors, we documented a shift in the size class distribution of living whitebark pine to smaller DBH trees (Figure 3). Mean tagged tree DBH decreased from 13.22 cm in Time 1 to 9.09 cm in Time 3.

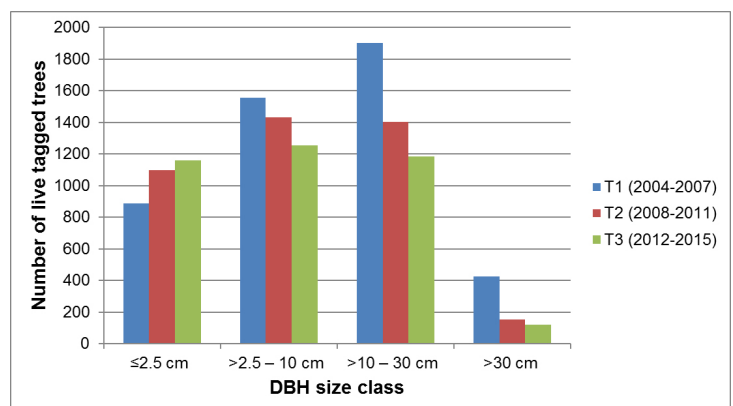


Figure 3. Size class distribution for live, tagged trees over the course of the 12-year whitebark pine monitoring program in the Greater Yellowstone Ecosystem.

Objective 4 – Recruitment

Document recruitment of understory whitebark pine into the reproductive population and the factors influencing recruitment

We assessed recruitment for whitebark pines by the presence of cone-bearing trees (reproduction), seedlings and saplings in the understory (regeneration), and newly tagged trees surpassing 1.4 m in height. We observed all three conditions on the majority of monitoring transects.

By the end of Time 3, 26% (963 trees) of the tagged whitebark pine trees were reproducing, most in the 10 to 30 cm DBH size class. Almost half of the reproducing trees were infected with blister rust (411 trees) and approximately half of those had bole infections (220 trees). Mountain pine beetle sign was documented on 16% (154) of the reproducing trees. Regeneration varied across the 176 transects. Counts of understory trees less than 1.4 m tall ranged from 0 to 521 trees/500 m² (average = 51) (Figure 4). By the end of Time 3, we tagged 447 new trees recruited into the >1.4 m tall population.

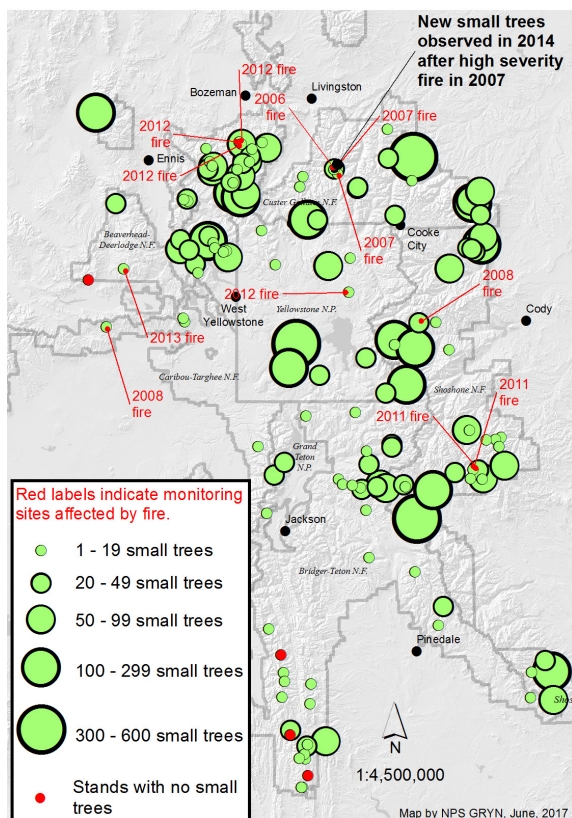


Figure 4. Average count of whitebark pine trees (per 500 m²) less than 1.4 m tall in stands monitored from 2004 through 2015 in the Greater Yellowstone Ecosystem.

Ecosphere Publication

Scientists from the Greater Yellowstone Network and other agencies used long-term monitoring data to study mortality factors for whitebark pine. They examined potential predictors of mortality and their interactions at two levels: (1) Potential tree-level predictors included blister rust infection characteristics, mountain pine beetle present/absence, and tree DBH; (2) Potential stand-level predictors focused on climate variables such as precipitation, temperature, evapotranspiration, and water deficit. Their research is published in the 2016 Special Feature issue of *Ecosphere* (Science for Our National Parks' Second Century) and key findings are on page 2 of this Brief.

Shanahan, E., K. M. Irvine, D. Thoma, S. Wilmoth, A. Ray, K. Legg, and H. Shovic. 2016. Whitebark pine mortality related to white pine blister rust, mountain pine beetle outbreak, and water availability. *Ecosphere* 7(12): [e01610.10.1002/ecs2.1610](https://doi.org/10.1002/ecs2.1610)

More Information

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¹Greater Yellowstone Coordinating Committee,
Whitebark Pine Subcommittee
<http://www.fedgycc.org/subcommittees/whitebark-pine/>

²Shanahan, E., K. Legg, and R. Daley. 2017. Status of whitebark pine in the Greater Yellowstone Ecosystem: A step-trend analysis with comparisons from 2004 to 2015. Natural Resource Report NPS/GRYN/NRR—2017/1445. National Park Service, Fort Collins, Colorado.

³Shanahan E., K. Legg, and R. Daley. 2014. Status of whitebark pine in the Greater Yellowstone Ecosystem: A step-trend analysis comparing 2004-2007 to 2008-2011. Natural Resource Technical Report. NPS/GRYN/NRTR—2014/917. National Park Service, Fort Collins, Colorado

⁴Greater Yellowstone Whitebark Pine Monitoring Working Group. 2011. Interagency Whitebark Pine Monitoring Protocol for the Greater Yellowstone Ecosystem, Version 1.1. Greater Yellowstone Coordinating Committee, Bozeman, MT.

Greater Yellowstone Whitebark Pine Monitoring Working Group

The Greater Yellowstone Whitebark Pine Monitoring Working Group is a collaboration of the National Park Service, U.S. Forest Service, U.S. Fish and Wildlife Service, U.S. Geological Survey, and Montana State University, organized under the auspices of the Greater Yellowstone Coordinating Committee.

