



Monitoring Whitebark Pine in the Greater Yellowstone Ecoregion

Introduction

Whitebark pine (*Pinus albicaulis*) occurs at high-elevations and in subalpine communities in the Pacific Northwest and Northern Rocky Mountains. It is a key component in the upper ranges of these ecosystems where it provides a multitude of ecological functions, including regulating runoff by slowing the progress of snowmelt and providing high energy food sources to birds and mammals.

As a stone pine species, it produces indehiscent cones and relies primarily on birds for seed dispersal. High in calories and rich in fat, these seeds provide seasonal forage for a variety of wildlife. In addition to its ecological importance in high elevation ecosystems, whitebark pine is a revered icon for backcountry explorers and mountain recreationists.

In mixed and dominant stands, whitebark pine occurs in over two million acres within the six national forests and two national parks that comprise the Greater Yellowstone Ecosystem (GYE). Currently, whitebark pine is impacted by multiple ecological disturbances. White pine blister rust (*Cronartium ribicola*), mountain pine beetle (*Dendroctonus ponderosae*), wildfires, and climate change all pose significant threats to the persistence of healthy whitebark pine populations on the landscape. Substantial declines in whitebark pine populations have been documented throughout its range.

Interagency Whitebark Pine Monitoring Program

Under the auspices of the Greater Yellowstone Coordinating Committee (GYCC), the National Park Service Inventory and Monitoring Program and several other agencies began a collaborative, long-term monitoring program to track and document the health and status of whitebark pine across the GYE. This alliance resulted in the formation of the Greater Yellowstone Whitebark Pine Monitoring Working Group (GYWPMWG), which consists of representatives from the U.S. Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS), National Park Service (NPS), U.S. Geological Survey (USGS), and Montana State University (MSU).

A protocol for monitoring the health and status of whitebark pine populations in the GYE was developed between 2004 and 2007. After rigorous peer review, the Interagency Whitebark Pine Monitoring Protocol for the Greater Yellowstone Ecosystem received final approval in 2007 and was recently updated in 2011 (GYWPMWG 2011). The complete protocol is available at: <https://irma.nps.gov/App/Reference/Profile/660369> (accessed June 13, 2013). This report summary provides an overview of the 2012 annual report which can be viewed at https://irma.nps.gov/App/Reference/DownloadDigitalFile?code=471383&file=GRYN_GYE_Whitebark_Pine_2012_Annual_Report.pdf. The full annual report provides more data summary results than what is provided here.

Monitoring Objectives

Generally, the objectives of the whitebark pine monitoring program are to detect and monitor changes in the health and status of whitebark pine populations across the GYE due to infection by white pine blister rust, attack by mountain pine beetle, and damage by other environmental and anthropogenic agents. Specifically, the Interagency Whitebark Pine Monitoring Protocol (GYWPMWG 2011) addresses the following four objectives:

- Objective 1** - To estimate the proportion of live whitebark pine trees (>1.4 m tall) infected with white pine blister rust, and to estimate the rate at which infection of trees is changing over time.
- Objective 2** - Within transects having infected trees, to determine the relative severity of infection of white pine blister rust in whitebark pine trees >1.4 m tall.
- Objective 3** - To estimate survival of individual whitebark pine trees >1.4 m tall explicitly taking into account the effects of white pine blister rust infection rates and severity, mountain pine beetle activity, and fire.
- Objective 4** - To assess and monitor recruitment of whitebark pine understory individuals (≤ 1.4 m tall) into the cone producing population.

Study Area

The study area is within the GYE and includes six national forests and two national parks (the John D. Rockefeller Memorial Parkway is included with Grand Teton National Park) (Figure 1). The target population is all whitebark pine trees in the GYE. The sample frame includes stands of whitebark pine approximately 2.5 ha or greater within and outside of the grizzly bear Recovery Zone (RZ). A total of 10,770 mapped whitebark polygons or stands were identified in the mapping process with 2,362 located within the RZ and 8,408 located outside of the RZ. Stands within the RZ were derived from the cumulative effects model for grizzly bears while outside the RZ, the sample frame includes whitebark stands mapped by each of the six separate USFS units and compiled by the NPS for the cumulative effects model effort (Dixon 1997). Areas that burned between 1971 and 2002 were excluded from the sample frame.



Whitebark pine monitoring crew on Table Mountain in the Centennial Range of Idaho.

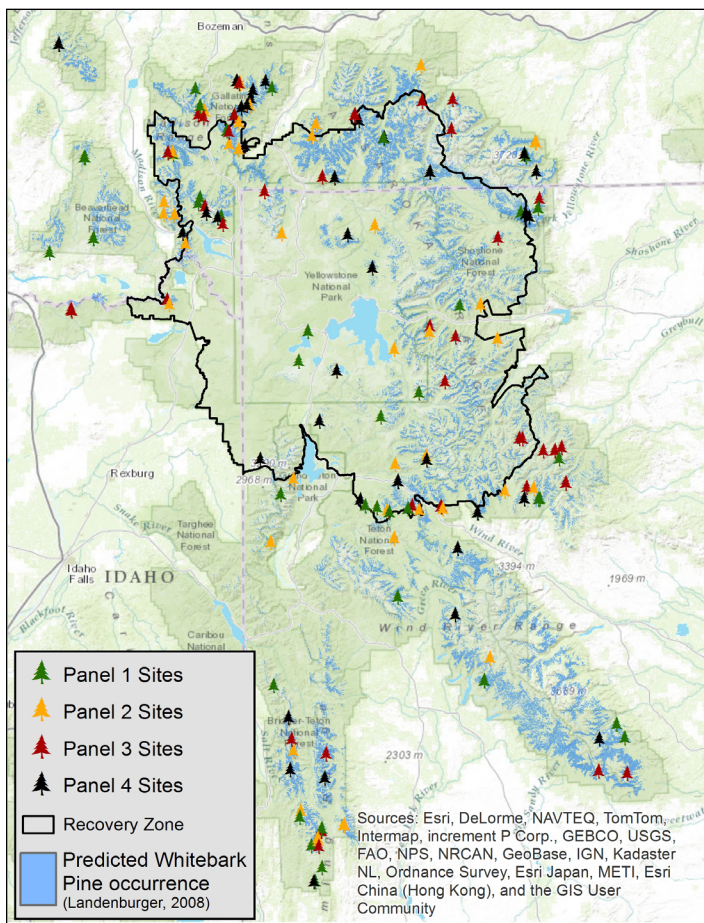


Figure 1. Location of whitebark pine survey transects, Greater Yellowstone Ecosystem.

Methods

Details of the sampling design and field methodology can be found in the Interagency Whitebark Pine Monitoring Protocol for the GYE. The basic approach is a two-stage cluster design with stands of whitebark pine being the primary units and 10x50 m transects being the secondary units. Initial establishment of permanent transects took place

between 2004 and 2007; during this period, 176 permanent transects in 150 whitebark pine stands were established and all individual trees >1.4 m tall were permanently marked in order to estimate changes in white pine blister rust infection and survival rates over an extended period. During revisits, new trees that grow to 1.4 m tall are tagged and monitored into the future. The sample of 176 transects is a probabilistic sample that provides statistical inference to the GYE.

In 2008, individual transects were randomly assigned to one of four panels; each panel consists of approximately 44 transects. This is the number of transects that can be realistically visited in a given field season by a two-person field crew. Sampling every four years is sufficient to detect change in blister rust infection; however, sites in each panel were surveyed every other year from 2008 through 2012 to incorporate the dynamic nature of the current mountain pine beetle epidemic. These extra surveys focused solely on mountain pine beetle indicators. Both surveys record tree status as live, dead, or recently dead.

Time-Step Assignment

In order to evaluate step-trends in white pine blister rust infection, infection transition, and overall mortality, every four-year revisit period has been classified as a time-step (T#) interval. Time-step 0 (T0) consists of the 176 transects established in the period from 2004 to 2007 and is considered the baseline. Time-step 1 (T1) is comprised of Panels 1 through 4 that were revisited between 2008 and 2011. Time-step 2 (T2) was initiated in 2012 and will be completed in 2015 once all four panels are revisited a second time (Figure 2).

Full Survey: White Pine Blister Rust and Mountain Pine Beetle Surveys (BR&MPB)

During a full survey visit, the presence or absence of white pine blister rust infection is recorded for all live trees in each panel. A tree is considered infected if either aecia or cankers were present. For a canker to be conclusively identified as resulting

Survey Schedule		Time0	Time1				Time2				Continued Monitoring 2016 Forward
Sample Panel	Sites per panel	2004 thru 2007	2008	2009	2010	2011	2012	2013	2014	2015	
1	43	initial surveys for all 176 transects	BR & MPB		MPB only		BR & MPB				
2	45			BR & MPB		MPB only		BR & MPB			
3	44		MPB only		BR & MPB		MPB only		BR & MPB		
4	44			MPB only		BR & MPB		MPB only		BR & MPB	

Figure 2. Panel sampling revisit schedule that includes full surveys for blister rust (BR) and mountain pine beetle (MPB) and mountain pine beetle/mortality only surveys (MPB only). This table denotes the designated time series for each Time-Step assignment (Time0 [T0]: 2004-2007, Time1 [T1]: 2008-2011, Time2 [T2]: 2012-2015).

from white pine blister rust, at least three of five ancillary indicators needed to be present (GYWPMWG 2011). Ancillary indicators of white pine blister rust included flagging, rodent chewing, oozing sap, roughened bark, and swelling (Hoff 1992). For each live tree, pitch tubes and frass are recorded as evidence that the tree had been infested with mountain pine beetle.

Mountain Pine Beetle Only (MPB only)

For mountain pine beetle only/mortality surveys, data are collected solely on mountain pine beetle indicators. Each live tree is examined for pitch tubes and frass, while all dead trees are investigated for J-shaped galleries under the bark.

Recruitment and Understory Individuals

During a full survey visit, all whitebark pine trees ≤ 1.4 m tall on a given transect are counted and observed for white pine blister rust infection. Once a tree has reached a height greater than 1.4 m, it is permanently tagged and assessed in a manner consistent with all other live, marked trees in the sample frame.

In 2012, Objective 4 of the Interagency Whitebark Pine Monitoring Protocol was initiated to assess and monitor recruitment of whitebark pine understory individuals (≤ 1.4 m tall) at an enhanced level. This objective was designed and integrated into the established transect surveys as an effort to detect trends in the understory population of whitebark pine. We provide a general description of the methods for measuring recruitment in this report. These methods will be further expanded to include analysis methodology and peer review for inclusion in the protocol.

Results

In 2012, 85 transects were resurveyed between June and September from Panels 1 and 3 by a two-person crew led by the GRYN and another two-person crew led by the USGS Interagency Grizzly Bear Study Team (IGBST). This marks

the second revisit to Panel 1 in our time-step series (first panel resurveyed in T2) for full survey data collection (BR and mortality), and the third revisit to Panel 3 for MPB only/mortality.

Status of White Pine Blister Rust

Approximately 885 live tagged trees (including new trees added in 2012) in 43 transects from Panel 1 were examined for BR infection. Results from a paired Student t-test comparing the proportion of trees infected with BR on a transect level for Panel 1 between 2008 and 2012 revealed no significant evidence of a change in the percent of live trees ≥ 1.4 m tall infected with BR.

Of the 807 trees that were surveyed both in 2008 (T1) and 2012 (T2), approximately 66% (531) had no evidence of blister rust infection, 19% (155) were infected in both years, 7% (59) transitioned from no evidence of infection to infected, and 8% (62) went from infected to uninfected. A transition from infected to uninfected could be the result of factors such as observer error, an earlier-documented infection that upon resurvey no longer meets the established standards of three indicators in the same location rule set, or infected branches that broke and fell off.

Status of Mountain Pine Beetle

Trees in high-elevation forests across the GYE are experiencing elevated mortality as a result of the current mountain pine beetle epidemic. Mountain pine beetle primarily attack whitebark pine trees that are ≥ 10 cm DBH. Trees that are ≤ 10 cm DBH are typically not large enough to successfully support mountain pine beetle brood (Amman et al. 1977); consistent with this observation, tree mortality observed in transects was much greater in trees > 10 cm DBH. Of the 156 dead trees recorded in 2012, 108 trees (69%) occurred in the > 10 -30 cm DBH size class, with approximately 56% of those having evidence only of mountain pine beetle infestation.

Similar to white pine blister rust infection, the mountain pine beetle infestation is widespread and varies in severity throughout the GYE. Of the 176 established transects, 123 have recorded evidence of mountain pine beetle infestation while 53 have no observed evidence of mountain pine beetle infestation by the end of 2012 (Figure 3).

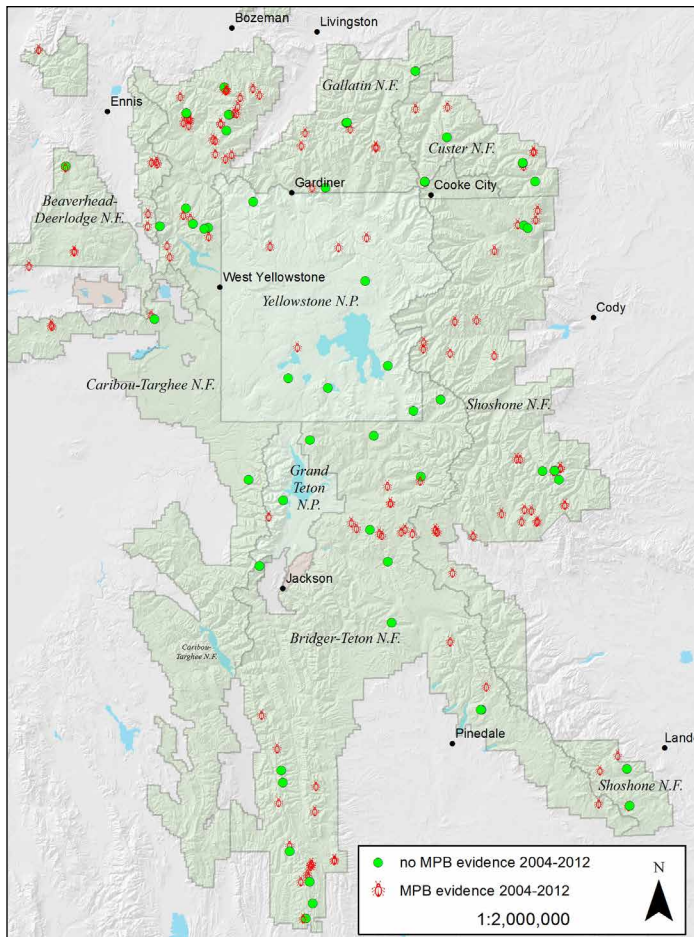


Figure 3. Location of transects throughout the Greater Yellowstone Ecosystem with and without evidence of mountain pine beetle infestation.

Mortality and Recruitment Status

In 2012, we observed a total of 1,801 live tagged trees and 156 newly dead tagged trees from Panels 1 and 3. Trees died with evidence of fire; BR; a combination of fire, MPB, and/or BR; or with other factors, such as wind damage, animal damage, or unknown. Figure 4 presents health indicators that were recorded for each dead tagged tree by DBH size class (<2.5 cm, >2.5-10 cm, >10-30 cm, and >30 cm).

While transects are experiencing varying degrees of mortality, they are also experiencing varying degrees of recruitment. In 2012, we tagged a total of 85 new trees (42 on Panel 1 and 43 on Panel 3) that grew to >1.4 m tall since the last survey visit.

The majority of trees that have been added to the sample frame fall within the ≤ 2.5 cm DBH size class; this cohort



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Following a successful attack, the canopy of an infested whitebark pine rapidly starts to fade from green to red (upper photo). Mountain pine beetle enter host trees through the bark; and as a defense mechanism, the infested tree will attempt to pitch out the beetle resulting in a pitch tube (lower left). Beetles feed in galleries under the bark of the host tree (below right).

has experienced a net increase of roughly 25%. Based on monitoring observations, trees ≤ 2.5 cm DBH can reproduce; it will be informative to track how this metric changes as more data are collected in future years, particularly as the mountain pine beetle outbreak wanes.

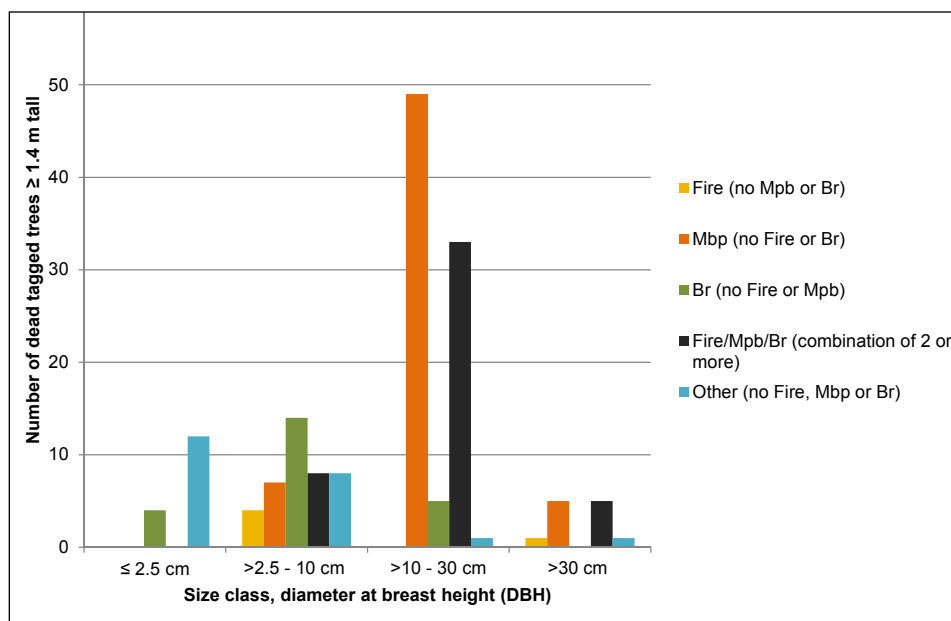


Figure 4. Mortality of tagged trees from 2012 surveys with associated health status indicators. Indicators (fire, mountain pine beetle, white pine blister rust, a combination of the three, or other) were recorded for each dead tagged tree by DBH size class (≤ 2.5 cm, >2.5 -10 cm, >10 -30 cm, and >30 cm).

Discussion

Status and trend assessments are more meaningful after many years of monitoring as comparable data accumulate over time. Comparisons of whitebark pine monitoring data from year to year is misleading due to different transects being monitored each year. The reader is cautioned not to draw conclusion about the health and status of whitebark pine in the GYE based solely on this summary report.

Based on 2012 data, white pine blister rust infection remains widespread and variable across the ecosystem. Our proportional estimate of a 20% to 30% infection rate for the GYE reflects the geographical differences that exist throughout the sample frame (Figure 5). Preliminary analysis showed that blister rust infection in Panel 1 transects remained relatively stable with no indication of significant increases or decreases between the 2008 and 2012 surveys. Our data suggest that the rate of mortality of tagged trees has decreased in the transects compared to mortality levels from previous years. These findings lend support to a waning MPB outbreak as articulated by other federal agencies and private entities (Hayes 2013, Olliff et al. 2013).

Following the panel revisit schedule, both Panels 2 and 4 are scheduled for resurvey in 2013. In a deviation from the monitoring schedule, crews will conduct full survey visits on both panels during the 2013 season in order to help determine if the established four-year revisit interval sufficiently captures blister rust infection spread and transition. A step-trend analysis of data collected between 2004 and 2011 will be completed (Irvine et al. in prep, Shanahan et al. in prep). In addition, we will establish whitebark pine monitoring transects on BLM lands in Wyoming following the Interagency Whitebark Pine Monitoring Protocol. And finally, we will continue to collaborate with other research endeavors that are taking place in the ecosystem as well as participate on the Greater Yellowstone Coordinating Committee Whitebark Pine Subcommittee.

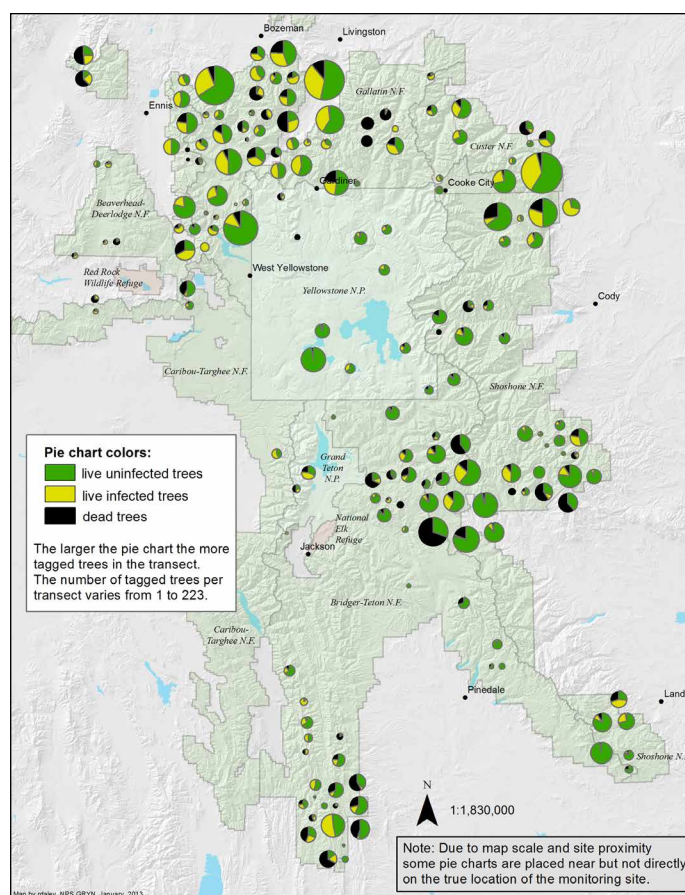


Figure 5. Preliminary map of the ratio of whitebark pine trees within each transect as alive, dead, or with the presence of blister rust infection from surveys 2009-2012. The infection status ranges from a tree with a single canker on a branch to a tree that may have a bole canker.

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Greater Yellowstone Whitebark Pine Monitoring

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