# 2008 Annual Report

## Greater Yellowstone Whitebark Pine Monitoring Working Group

# Monitoring Whitebark Pine in the Greater Yellowstone Ecosystem

Whitebark pine occurs in the subalpine zone of western North America, including the Pacific Northwest and northern Rocky Mountains, where it is adapted to a harsh environment of poor soils, steep slopes, high winds, and extreme cold temperatures. While its inaccessibility and sometimes crooked growth form lead to low commercial value, it is a highly valuable species ecologically and is often referred to as a "keystone" species (Tomback et al. 2001) and as a foundation species capable of changing forest structure and ecosystem dynamics (Ellison et al. 2005) in the subalpine zone. Whitebark pine contributes to a variety of ecological functions including the retention of snow in upper elevations helping to modulate runoff and streamflow (Farnes 1990). Its best known role in these ecosystems is as a high-energy food source for a variety of wildlife species, including red squirrels, Clark's nutcracker and the grizzly bear.

## Background of the Program

Forest monitoring has shown a rapid and precipitous decline of whitebark pine in varying degrees throughout its range due to non-native white pine blister rust (Kendall and Keane 2001) and native mountain pine beetle (Gibson 2006, Gibson et al. 2008). Given the ecological importance of whitebark pine in the Greater Yellowstone Ecosystem (GYE) and that 98% of whitebark pine occurs on public lands, the conservation of this species depends heavily on the collaboration of all public land management units in the GYE. Established in 1998, the Greater Yellowstone Whitebark Pine Subcommittee, comprised of resource managers from eight federal land management units, has been working together to ensure the viability and function of whitebark pine throughout the region. As a result of this effort, a working group of the subcommittee was formed for the purpose of integrating the common interests, goals and resources into one unified monitoring program for the Greater Yellowstone area. The Greater Yellowstone Whitebark Pine Monitoring Working Group (GYWPMWG) consists of representatives from the U.S. Forest Service (USFS), National Park Service (NPS), U.S. Geological Survey (USGS), and Montana State University (MSU). Since 2004 the working group has collaborated to design and implement a long-term monitoring program. The purpose of the monitoring program is to detect how rates of blister rust infection and the survival and regeneration of whitebark are changing over time. A protocol for monitoring whitebark pine throughout the GYE was completed by the working group (GYWPMWG 2007*a*) and approved in 2007 by the NPS Intermountain Region Inventory and Monitoring Coordinator. Approved monitoring protocols are a key component of quality assurance helping to ensure the methods are repeatable and detected changes are truly occurring in nature and not simply a result of measurement differences. The complete protocol is available at: http://www.greateryellowstonescience.org/topics/biological/vegetation/whitebarkpine/projects/healthmonitoring/protocol.

This monitoring effort provides critical information on the status of whitebark pine on a comprehensive regional scale. The results of monitoring will help to establish the likelihood of this species' ability to persist as a functional part of the ecosystem and can be used to help justify and guide restoration efforts. This report is a summary of the monitoring data collected between 2004 and 2008 from this long-term monitoring project.

*Photo courtesy Rachel Simons*

### *Objectives*

*Our objectives are to monitor the health of whitebark pine relative to levels of white pine blister rust and, to a lesser extent, mountain pine beetle. An additional monitoring objective to assess recruitment of whitebark pine into the cone producing population is in the early planning stages and not presented here.*

*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 effect of blister rust infection rates and severity and mountain pine beetle activity, fire damage, and other agents.*

## Study Area

Our 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 as defined by mapped stands or polygons in a GIS vegetative layer. The sample frame includes stands of whitebark pine approximately 2.5 ha or greater within the grizzly bear Primary Conservation Area (PCA) and was derived from the cumulative effects model for grizzly bears (Dixon 1997). Outside the PCA, the sample frame includes whitebark stands mapped by the US Forest Service. Areas that burned since the 1988 fires were excluded from the sample frame.

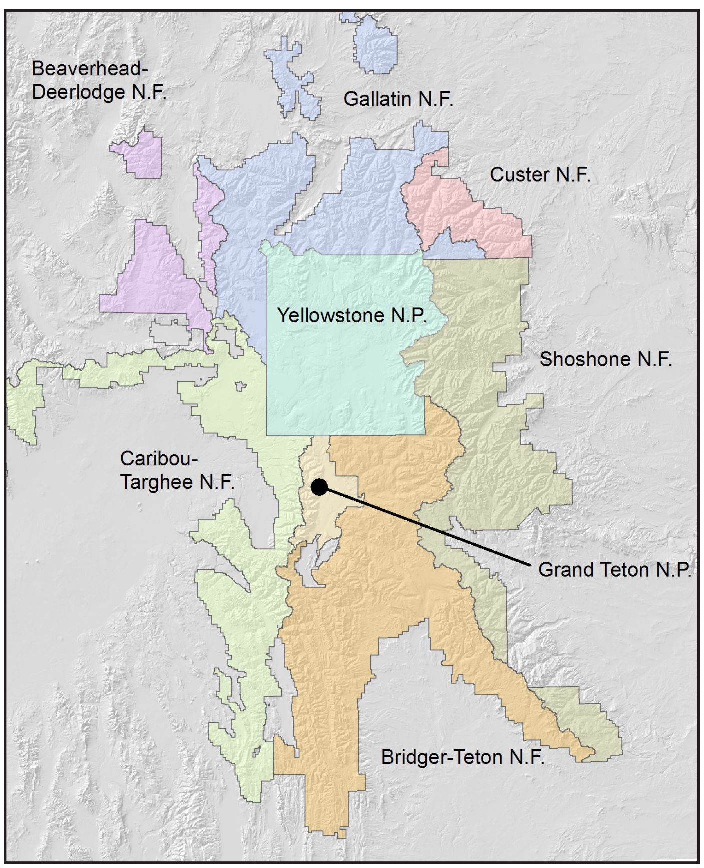


*Figure 1. Study area showing national forest and national park units.*

## Methods

Details of our sampling design and field methodology can be found in the Interagency Whitebark Pine Monitoring Protocol for the Greater Yellowstone Ecosystem (GYWPMWG 2007*a*) and in past project reports (GYWPMWG 2005, 2006, 2007*b*, and 2008). The basic approach is a 2-stage cluster design with stands (polygons) 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 4,774 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. The sample of 176 transects is a probabilistic sample that provides statistical inference to the GYE.

In 2008, we randomly assigned individual transects 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 one, two-person field crew. Sampling every 4 years is sufficient to detect change in blister rust infection. However, with the recent increase in whitebark pine mortality due to mountain pine beetle, the monitoring group became concerned that a 4 year revisit interval might not be sufficient to document overall mortality of whitebark pine trees >1.4 m tall. In response, we temporarily modified our revisit design to incorporate the dynamic nature of the current mountain pine beetle epidemic to a two-year revisit schedule. With this design, two of the four panels are surveyed annually; one panel is subject to the full survey documenting blister rust infection and mountain pine beetle indicators while the second panel is subject to a partial survey focused solely on mountain pine beetle indicators. Both surveys record tree status as live, dead or recently dead.

*NPS Photo, Rosalie LaRue*

Eighty-five transects were resurveyed in 2008 by two, 2-person crews, one led by the NPS Greater Yellowstone Inventory & Monitoring Network and the other led by the USGS Interagency Grizzly Bear Study Team. Of the 85 transects, 42 (panel 1) were subject to the full survey documenting indicators of blister rust infection and mountain pine beetle infestation and 43 (panel 3) were subject to a partial survey focused on indicators of mountain pine beetle. Tree status e.g. a determination of whether the whitebark pine tree is live or dead was recorded on all 85 transects.

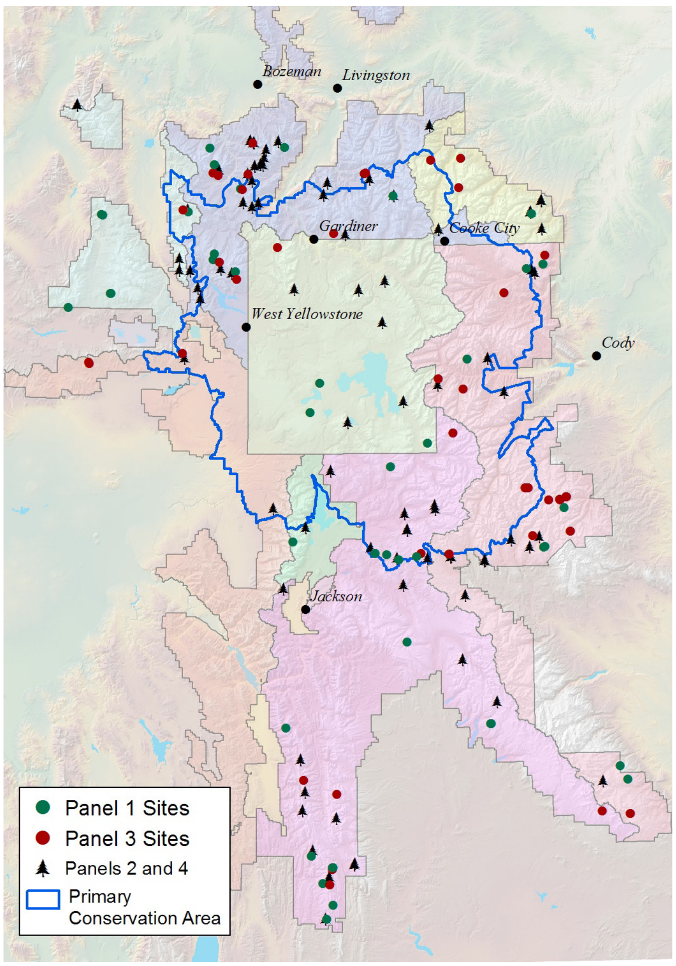


*Figure 2. Location of whitebark pine survey transects, Greater Yellowstone Ecosystem. In 2008 transects in panel 1 had a full resurvey documenting blister rust infection and mountain pine beetle indicators and transects in panel 3 had a partial survey focused solely on mountain pine beetle indicators.*

### *White Pine Blister Rust*

For each live tree in panel 1, the presence or absence of indicators of white pine blister rust infection was recorded. For the purpose of analyses presented here, a tree was considered infected if either aecia or cankers were present. For a canker to be conclusively identified as resulting from white pine blister rust, at least three of five ancillary indicators needed to be present. Ancillary indicators of white pine blister rust included flagging, rodent chewing, oozing sap, roughened bark, and swelling (Hoff 1992).

### *Mountain Pine Beetle*

Prior to 2008, mountain pine beetle evidence was simply recorded as 'present' or not present' based on whether or not pitch tubes, J-shaped galleries, or others signs of infestation were observed on a tree. Beginning in 2008, mountain pine beetle evidence was recorded in all whitebark pine for each of the three indicators: pitch tubes, mountain pine beetle galleries (on dead trees only) and frass. Pitch tubes are small, popcorn-shaped resin masses produced by a tree as a means to stave off a mountain pine beetle attack. Mountain pine beetle galleries are the crooked or J-shaped tubes where adult mountain pine beetle and their larvae live and feed. The galleries are found under the bark of the infested host tree. Frass is the boring dust created during a mountain pine beetle invasion and can be found in bark crevices and around the base of an infested tree.

### *Observer Effects*

We continue to investigate the role of observer variability in blister rust detection (see Huang 2006) and detection of mountain pine beetle indicators. Each field season, 25% (approximately 10) of the full blister rust survey transects are subject to the double observer survey described in the working group protocol (GYWPMWG 2007*a*). By monitoring observer differences, we can examine the consistency between observers and correct problems through improved training and retention of trained and experienced individuals. If the observer variability is found to be a large contributor to the standard error for our estimated parameters, we will need to account for this in our data analysis.

## Results

### *Status of White Pine Blister Rust*

Ecosystem wide estimates of the proportion of whitebark pine trees infected with white pine blister rust were first reported by the working group in 2008 and are reported again here for background information. Our initial baseline estimate of the proportion of live trees with blister rust in

the GYE was 0.20 (± 0.037 se) (GYWPMWG 2008). This estimate was based on data from 4,774 individual live trees in 176 transects collected over a four year period between 2004 and 2007.

Results from our 2008 resurvey of panel 1 provide a preliminary estimate of the rate of change in blister rust infection in whitebark pine over time. Our preliminary estimate is based on data from 984 individual live trees in 42 transects randomly distributed across the GYE. Our results indicate that the proportion of trees across the GYE infected with blister rust increased from 0.20 to 0.25 between time1, when each transect was first established, and time2, when the transects were resurveyed in 2008. We expect that these values will change as panels 2, 3 and 4 are resurveyed in 2009, 2010 and 2011, respectively. An official rate of change in blister rust infection will be available following the 2011 season when all the panels have been resurveyed at least once.

Table 1. 2008 white pine blister rust summary statistics for Panel 1.

| Location | Within PCA | Outside PCA | Total for GYE |
|---|---|---|---|
| Number Stands | 15 | 22 | 37 |
| Number of Transects | 15 | 27 | 42 |
| Number of Unique Trees Sampled | 323 | 661 | 984 live trees |
| Proportion of Transects Infected | 13 of 15 | 19 of 27 | 32 of 42 |
| Estimated Proportion of Trees Infected in 2008 | 0.137 ± (0.055 se) | 0.281 ± (0.0366 se) | 0.250 ± (0.0314 se) |

### *Survival and mortality of whitebark pine*

A total of 2,290 permanently monumented whitebark pine trees were examined in Panels 1 and 2 to determine if the tree was alive or dead and to record indicators of mountain pine beetle. Our survey data recorded 130 dead whitebark pine trees >1.4 m tall. This equates to 5.7% of the whitebark pine sample population. Our definition of dead is strict in that it requires that no green needles are present on the tree. This definition has little ambiguity, however it should be noted that field crews recorded fading crowns on additional whitebark pine trees determined to be alive because of the continued presence of green needles.

Mountain pine beetle indicators were observed in 11% of the 2,290 trees examined. Of the 130 dead whitebark pine in our transects, 41% had indicators of mountain pine beetle activity. We cannot determine cause of death with confidence, however fire, mountain pine beetle, and blister rust were recorded as causal factors by the field crews. Fire alone accounted for 31% of the dead.

## Discussion

Our preliminary estimate shows an increase in the number of trees with blister rust infection, however since this estimate is based on a single panel, this estimate is provisional only and must be interpreted with caution. Each year as we resurvey transects we will recalculate the proportion of trees infected and revise our provisional estimate. We expect to have an official rate of change in blister rust infection following 2011 when all the transects have been resurveyed once.

There is currently widespread mortality of whitebark pine in the Greater Yellowstone Ecosystem associated with the current mountain pine beetle epidemic. Several lines of evidence including aerial detection surveys by the USDA Forest Service (Gibson 2006, Gibson et al. 2008), mid-level forest canopy mortality maps created by the Forest Service Remote Sensing Application Center (Goetz et al. 2009) and a citizen monitoring effort (Logan et al. 2009) all report high levels of mortality in the overstory canopy of whitebark forest stands.

In contrast to aerial detection surveys which look mainly at the overstory canopy, our monitoring looks at the survival of whitebark pine across all tree height classes above 1.4 m tall. In addition we are adding new whitebark pine trees into our sample population as they reach 1.4 m in height. We do not view the differences in our results as contradictory but rather as support for a combination of aerial and ground based methods to adequately describe the condition of whitebark pine in the GYE.

*Photo courtesy Anne Schrag*

### *Future Directions*

For the 2009 field season, we plan to conduct a full resurvey for each transect in panel 2 and a partial resurvey focused on mountain pine beetle indicators in panel 4. As before, both surveys will record tree status as live, dead or recently dead. At the end of 2009 we will have revisited 100% of our transects looking specifically at mountain pine beetle indicators and mortality/survival of whitebark pine. Depending on funding, we may continue with the split panel revisit design for another 2 years.

The USGS Status and Trend program has funded the Interagency Grizzly Bear Study Team to conduct an integrated synthesis and analysis of our whitebark pine data. This project will explore the rate of blister rust infection and mountain pine beetle mortality in the GYE using spatial regression models and a suite of spatially explicit covariates. The NPS Greater Yellowstone Inventory & Monitoring Network and statisticians from Department of Mathematics Sciences at Montana State University are collaborating with the study team on this project.

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**Greater Yellowstone Coordinating Committee (GYCC)**

**USDA Forest Service**

Forest Health Protection
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Bridger-Teton National Forest
Caribou-Targhee National Forest
Custer National Forest
Gallatin National Forest
Shoshone National Forest

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[a] This project represented a collaboration in the truest sense of the word, such that distinguishing order of participants with respect to relative contribution was virtually impossible. Consequently, order of participants is alphabetical.


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Copies of this, and other products from this project can be found at the Greater Yellowstone Science Learning Center at: http://www.greateryellowstonescience.org/topics/biological/vegetation/whitebarkpine.