

# 2010 Annual Report

Greater Yellowstone Whitebark  
Pine Monitoring Working Group

## Monitoring Whitebark Pine in the Greater Yellowstone Ecosystem

### Introduction

Whitebark pine (*Pinus albicaulis*) occurs in the Pacific Northwest and northern Rocky Mountains where it is a foundation and keystone species in high-elevation forests and alpine communities. Whitebark pine plays a critical role in ecosystem dynamics by regulating a multitude of ecological processes and influencing biodiversity (Tomback and Kendall 2001, Ellison et al. 2005). It is considered a “pioneer” species due to its tolerance of harsh environmental conditions and ability to establish and persist where other species cannot. In doing so, whitebark pine can alter the microclimate and enable species such as subalpine fir (*Abies lasiocarpa*) to establish in these otherwise inhospitable and harsh environments (Tomback et al. 1993). Although whitebark pine has very little commercial value, its seeds provide seasonal forage for a variety of wildlife and its aesthetic qualities and sheer perseverance inspire awe in recreationists.

Whitebark pine, in mixed and dominant stands, occurs in over 2 million acres within the six national forests and two national parks that comprise the Greater Yellowstone Ecosystem (GYE; Greater Yellowstone Coordinating Committee Whitebark Pine Subcommittee [GYCCWPS] 2010). Currently, whitebark pine is being impacted by multiple ecological disturbances. Substantial declines in whitebark pine populations have been documented throughout its range. White pine blister rust (*Cronartium ribicola*), mountain pine beetle (*Dendroctonus ponderosae*), and wildfires all pose significant threats to the persistence of healthy whitebark pine populations on the landscape. The loss of a foundation tree species such as whitebark pine has the potential to cause major secondary losses, changes in biological diversity, and critical and possibly irrevocable community disturbances (Ebenman and Jonsson 2005).

### Interagency Whitebark Pine Monitoring Program

Under the auspices of the Greater Yellowstone Coordinating Committee, the National Park Service Inventory and Monitoring program along with 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), 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 by the GYWPMWG. After rigorous peer review the Interagency Whitebark Pine Monitoring Protocol for the Greater Yellowstone Ecosystem (IWPMP) received final approval in 2007. A complete protocol is available at: <http://www.greateryellowstonescience.org/subproducts/14/72>. This report presents a summary of the data collected by the monitoring program between 2004 and 2010.

### 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 IWPMP 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, fire, and other damaging agents.

Objective 4 - To assess and monitor recruitment of whitebark pine understory individuals (<1.4 m tall) into the cone producing population (In development).

## Study Area

Our study area is within the GYE and includes six national forests and two national parks (the John D. Rockefeller, Jr. Memorial Parkway is included with Grand Teton National Park) (Figure 1). The target population is all whitebark pine trees in the GYE and the sample frame includes stands of whitebark pine approximately 2.5 ha or greater within the grizzly bear Recovery Zone (RZ) and as mapped for the cumulative effects model for grizzly bears (Dixon 1997). Outside the RZ, the sample frame includes whitebark stands mapped by the U.S. Forest Service. Areas that burned since the 1988 fires were excluded from the sample frame.

## 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 2007a) and in past project reports (GYWPMWG 2005, 2006, 2007b, 2008,

2009). 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, individual transects were randomly assigned to one of four panels.

Each panel consists of approximately 44 stands. 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

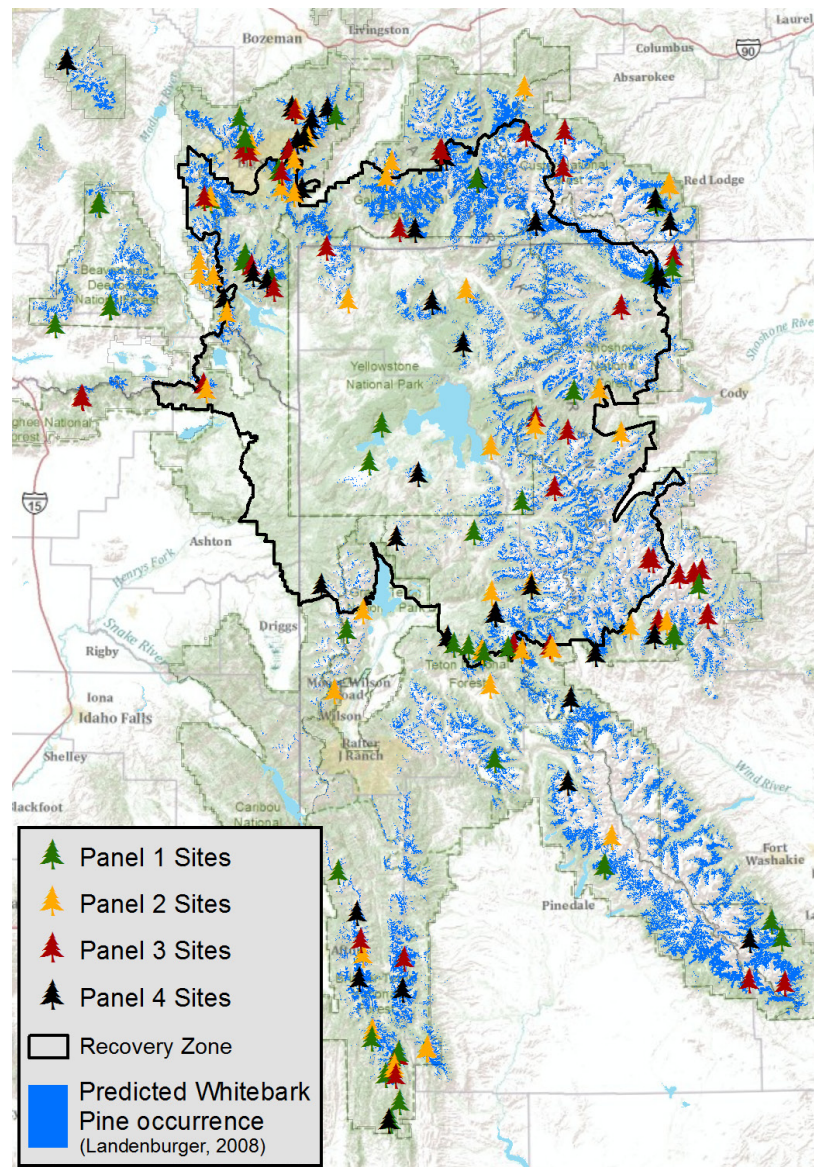


**Figure 1.** Location of whitebark pine survey transects, Greater Yellowstone Ecosystem. Panel 1, 2, and 3 had a full resurvey for white pine blister rust infection in 2008, 2009, and 2010, respectively.

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 white pine blister rust infection and mountain pine beetle indicators while the second panel is subject to a partial survey focused solely on mortality and mountain pine beetle indicators (Figure 2). Both surveys record tree status as live, dead or recently dead.

Eighty-five transects were resurveyed in 2008, 90 in 2009, and 88 in 2010 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.

### White Pine Blister Rust and Mountain Pine Beetle Surveys

From 2008 to 2010, panels 1, 2 and 3 have been revisited for white pine blister rust (BR) and mountain pine beetle (MPB). Panel 4 will be revisited in 2011 both BR and MPB. The presence or absence of white pine blister rust infection was recorded for all live trees in each panel. 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). For each live tree, pitch tubes and frass were recorded as evidence that the tree had been infested with mountain pine beetle. Pitch tubes are small, popcorn-shaped resin masses produced by a tree as a means to stave off a mountain pine beetle attack. Frass or

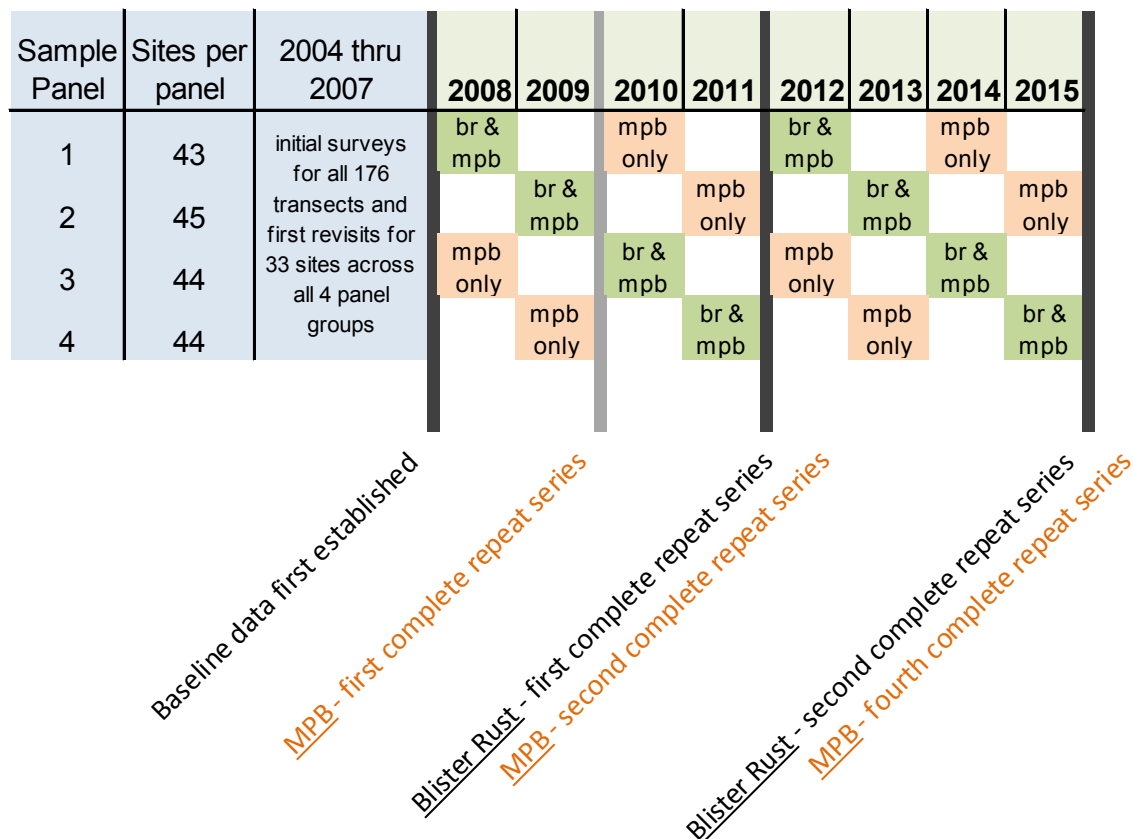


Figure 2. Panel sampling revisit schedule. Although revisits are scheduled for mountain pine beetle through 2015, this is dependent on available funds and length of the outbreak.

boring dust is created during a mountain pine beetle attack and can be found in bark crevices and around the base of an infested tree. Bark is removed from dead trees to expose the J-shaped galleries that are present in an attack and indicate where adult mountain pine beetle and their larvae live and feed.

### ***Mountain Pine Beetle Only Survey***

For mountain pine beetle only surveys, data are collected solely on mountain pine beetle indicators. As described above, each live tree is examined for pitch tubes and frass while all dead trees are investigated for J-shaped galleries. Mortality from any source is also documented.

### ***Recruitment and Understory Individuals***

Within a given transect, all <1.4 m tall whitebark pine trees are counted and observed for white pine blister rust infection. Once a tree has reached a height >1.4 m tall or greater, it is permanently tagged and assessed as with all other live, marked trees in our sample frame.

### ***Analysis Methods***

The proportion of trees infected with white pine blister rust is calculated using a design-based ratio estimator that accounts for the total number of mapped stands within and outside the grizzly bear Recovery Zone (GYWPMWG 2007a).

The GYWPMWG continues to investigate the role of observer variability in white pine blister rust (see Huang 2006) and mountain pine beetle detection. Each field season, 25% (approximately 10) of the full white pine blister rust survey transects are subject to the double observer survey described in the protocol (GYWPMWG 2007a). Information gleaned from these records allows us to correct problems through improved training, hiring, and retention of trained and experienced field crew members. If observer variability is found to be a major contributor to the standard error for our estimated parameters, we will assess this in our data analysis.

## **Results**

### ***Status of White Pine Blister Rust***

The 2007 baseline estimate of the proportion of live whitebark pine trees infected with white pine blister rust in the GYE is 0.20 ( $\pm 0.037$  se) (GYWPMWG 2008). This estimate is based on data from 4,774 individual live trees in 176 transects collected over a 4-year period between 2004 and 2007 after all transects and tree records were established. In Table 1, we report the estimates of the proportion of whitebark pine trees infected with white pine blister rust based on the resurveys of panels 1, 2, and 3 conducted in 2008, 2009, and 2010, respectively. We are presenting the results from each panel separately until 2011 when all panels will have been resurveyed at least once for white pine blister rust infection. Only after that time, can we combine data for a trend analysis.

White pine blister rust infection remains widespread throughout the ecosystem. Decreases in white pine blister rust infection observed on some transects are most likely an artifact of increased mortality on the transect due to mountain pine beetle infestation or wildfire. Increases in white pine blister rust infection are explained by the actual increase in observable infection on trees within a transect.



Table 1. Design based ratio estimates for the proportion of infected whitebark pine trees >1.4 m tall in panels 1, 2, and 3 and other summary information (Irvine 2010).

| 2008 [Panel 1]                           |                         |                          |                 |
|------------------------------------------|-------------------------|--------------------------|-----------------|
| Location                                 | Within<br>Recovery Zone | Outside<br>Recovery Zone | Total for GYE   |
| Total number of mapped polygons/stands   | 2,362                   | 8,408                    | 10,770          |
| Number of stands                         | 15                      | 22                       | 37              |
| Number of transects                      | 15                      | 27                       | 42              |
| Number of unique trees sampled           | 323                     | 661                      | 984             |
| Number of transects infected             | 15                      | 27                       | 42              |
| Proportion of live trees infected        | 0.137                   | 0.281                    | 0.249           |
| Proportion of live trees infected SE     | 0.055                   | 0.036                    | 0.031           |
| CI for proportion of live trees infected | [0.018, 0.255]          | [0.205, 0.357]           | [0.186, 0.312]  |
| 2009 [Panel 2]                           |                         |                          |                 |
| Location                                 | Within<br>Recovery Zone | Outside<br>Recovery Zone | Total for GYE   |
| Total number of mapped polygons/stands   | 2,362                   | 8,408                    | 10,770          |
| Number of stands                         | 16                      | 21                       | 37              |
| Number of transects                      | 16                      | 28                       | 44              |
| Number of unique trees sampled           | 295                     | 684                      | 979             |
| Number of transects infected             | 16                      | 28                       | 44              |
| Proportion of live trees infected        | 0.16                    | 0.465                    | 0.398           |
| Proportion of live trees infected SE     | 0.066                   | 0.062                    | 0.051           |
| CI for proportion of live trees infected | [0.018, 0.301]          | [0.336, 0.595]           | [0.295, 0.501]  |
| 2010 [Panel 3]                           |                         |                          |                 |
| Location                                 | Within<br>Recovery Zone | Outside<br>Recovery Zone | Total for GYE   |
| Total number of mapped polygons/stands   | 2,362                   | 8,408                    | 10,770          |
| Number of stands                         | 13                      | 22                       | 35              |
| Number of transects                      | 13                      | 29                       | 42              |
| Number of unique trees sampled           | 370                     | 675                      | 1,045           |
| Number of transects infected             | 13                      | 29                       | 42              |
| Proportion of live trees infected        | 0.128                   | 0.102                    | 0.108           |
| Proportion of live trees infected SE     | 0.043                   | 0.07                     | 0.055           |
| CI for proportion of live trees infected | [0.034, 0.221]          | [-0.043, 0.248]          | [-0.005, 0.221] |

*Status of tree survival*

To determine whitebark pine mortality, we resurvey all transects to reassess the status of permanently tagged trees >1.4 m tall. We subtract the total number of resurveyed dead tagged trees from the total number of live tagged trees recorded during our initial establishment period from 2004 to 2007. By the end of 2010, we observed a total of 787 dead tagged whitebark pine trees within the boundaries of the permanent monitoring transects. This equates to a loss of approximately 16% of our original live tagged tree sample. While transects are experiencing varying degrees of mortality, they are also experiencing varying degrees of recruitment. Once a whitebark pine tree within the transect boundary reaches a height of 1.4 m tall or greater, it is permanently tagged and included in our live, tree sample. As of 2010, 3,987 (84%) of our originally marked trees remained alive and we gained an additional 238 new trees (Table 2).

Table 2. Mortality and recruitment status of whitebark pine trees from 2008–2010.

| 2004-2007<br>transect<br>establishment | 2008-2010 resurvey results |                |                    |                          |
|----------------------------------------|----------------------------|----------------|--------------------|--------------------------|
| Live trees<br>tagged                   | Dead<br>counted            | %<br>mortality | %<br>live<br>trees | New<br>recruits<br>added |
| 4,774                                  | 787                        | 16%            | 84%                | 238                      |

Panel 1 and 3 were resurveyed twice (2008 and 2010), since plot establishment. When comparing these two panel revisits, a 10% increase in mortality was observed from 2008 to 2010 (Table 3). Wildfires accounted for mortality on four transects (complete mortality on two and partial mortality on two). The second resurvey of panels 2 and 4 will occur in 2011.

Table 3. Percent mortality from resurveys in 2008 and 2010.

|                    | 2008  | 2010  |
|--------------------|-------|-------|
| # of trees sampled | 2,291 | 2,325 |
| Total dead         | 127   | 373   |
| % of trees dead    | 6%    | 16%   |



Greys River, Bridger-Teton National Forest, 7 Aug 2007. Photo courtesy Rachel Simons.

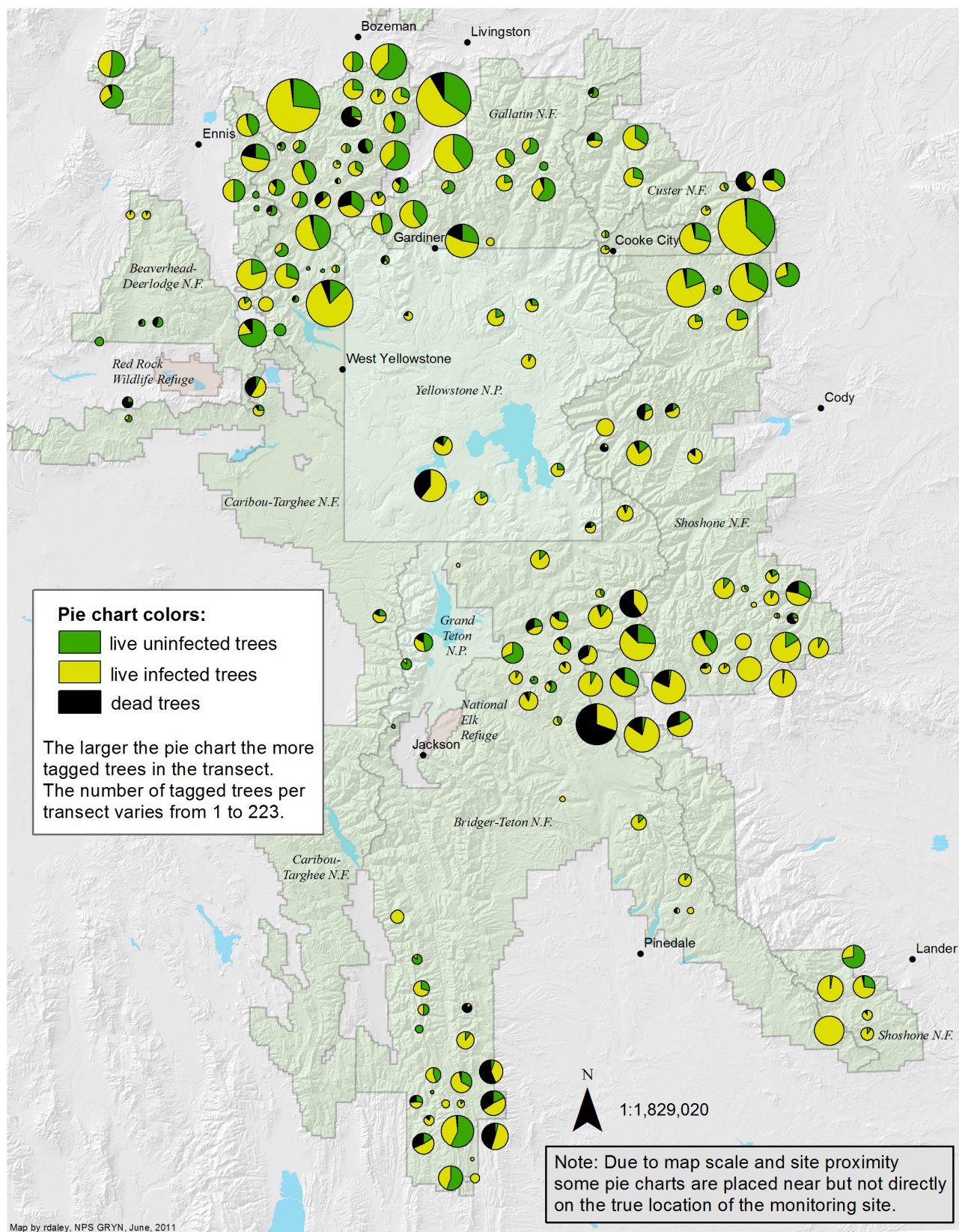


Figure 3 displays the ratio of whitebark pine trees within each transect as live uninfected, dead, or live with the presence of blister rust infection from the 2004–2010 surveys. The infection status portrayed by the pie charts can include blister rust infection evidence on a single terminal branch on a tree which is likely not lethal, compared to a bole canker that over time may kill the tree.

## Presence of mountain pine beetle

High elevation forests across the GYE are experiencing elevated mortality as a result of the current mountain pine beetle epidemic. Mountain pine beetle exhibit a propensity for attacking whitebark pine trees that are 10 cm DBH and greater. Trees that are less than 10 cm DBH generally are not large enough to successfully support mountain pine beetle brood. Consistent with this observation, tree mortality in transects was much greater in trees >10 cm DBH. By the end of 2010, we found that 31.8% ( $n = 790$ ) of the trees >10 cm DBH had died whereas only 7.3% ( $n = 194$ ) of the trees  $\leq 10$  cm had died (Figure 4).

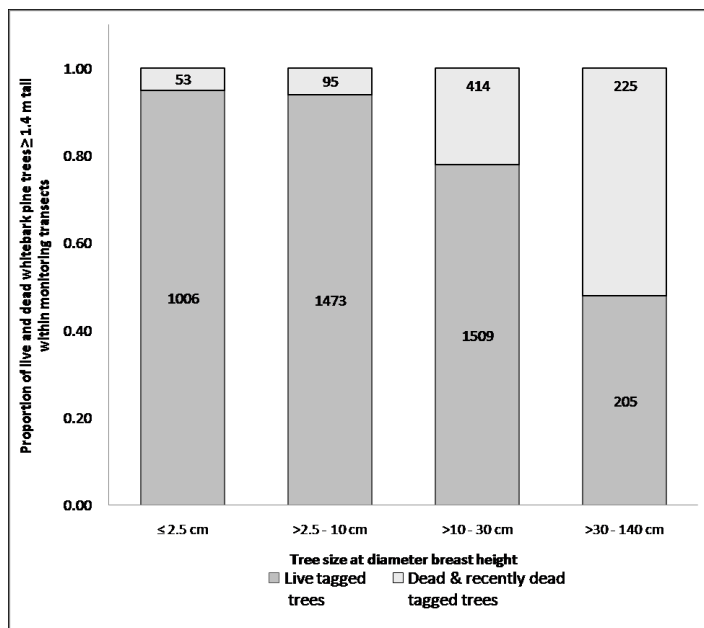


Figure 4. Proportion of live, dead and recently dead tagged whitebark pine >1.4 m tall within the monitoring transects by size class. A recently dead tree has persistent non-green needles where as a dead tree has shed all of its needles. Numeric values on the bars represent the number of trees in each category.

Of the resurveyed trees that were recorded as dead since initial transect establishment, approximately 72% had J-shaped galleries present underneath the bark. Similar to white pine blister rust infection, mountain pine beetle infestation is widespread and varies in severity throughout the GYE. Of the 176 established transects, 102 have recorded evidence of mountain pine beetle infestation while 74 have no observed evidence of mountain pine beetle infestation.

## Future Directions

In 2011 we plan to conduct a full resurvey for each transect in panel 4 and a “mountain pine beetle only” resurvey for panel 2. Successful completion of panel 4 will enable us to report on changes in the proportion of trees with white pine blister rust in the GYE (trend analysis). We also plan to develop and pilot Objective 4 of the IWBMP to assess and monitor the recruitment of whitebark pine understory individuals into the cone producing population.

This long-term monitoring program provides critical information that will help determine the likelihood of whitebark pine persisting as a functional and vital part of the ecosystem. In addition, data from this program are currently being used to inform managers, guide management strategies and restoration planning, and substantiate conservation efforts throughout the GYE. The IWBMP has also been a valuable resource for a variety of agencies embarking on five needle pine monitoring efforts.

## Acknowledgments

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## Cooperating Organizations:

### Greater Yellowstone Coordinating Committee

#### USDA Forest Service

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

#### USDI National Park Service

Greater Yellowstone Inventory and Monitoring Network  
Grand Teton National Park  
John D. Rockefeller, Jr. Memorial Parkway  
Yellowstone National Park

#### USDI Geological Survey

Interagency Grizzly Bear Study Team  
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National Biological Information Infrastructure

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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>.

## Greater Yellowstone Whitebark Pine Monitoring Working Group

### Current Working Group Participants<sup>a</sup>

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<sup>a</sup> 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.