Monitoring Whitebark Pine in the Greater Yellowstone Ecosystem: 2005 Annual Report

Whitebark pine (WbP) occurs in the subalpine zone of western North America, including the Pacific Northwest and 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 in the subalpine ecosystem (Tomback et al. 2001). 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 threatened grizzly bear.

NPS Photo by R.G. Johnsson

Whitebark is a high-energy food source for grizzly bears and other wildlife.

NPS Photo by Bryan Harry

Background of the Program

Forest monitoring has shown a rapid and precipitous decline of WbP 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). Given the ecological importance of WbP in the Greater Yellowstone Ecosystem (GYE) and that 98% of WbP 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 Committee, comprised of resource managers from eight federal land management units, has been working together to ensure the viability and function of WbP throughout the region. As a result of this effort, an additional working group 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). This report is a summary of the data collected from the second field season of this long-term monitoring project.

A Unified Effort

Although other efforts within the GYE have contributed greatly to our initial understanding of the status of whitebark pine, differences in study designs and field methods make it difficult to make reliable comparisons across the region and among other monitoring efforts. In order to effectively detect how rates of blister rust infection, survival and regeneration of whitebark are changing over time in the GYE, a repeatable, long-term sampling design provides the most advantageous approach.

The Greater Yellowstone Whitebark Pine Monitoring Working Group has been developing a protocol for monitoring whitebark pine in a consistent manner throughout the entire ecosystem. This program will facilitate a more effective effort to understand the status and trends of whitebark on a comprehensive, regional scale. The GYWPMWG method was designed with the intent of detecting long-term health shifts in the GYE whitebark population, which in turn, will provide critical information on the likelihood of this species' ability to persist as functional part of the ecosystem.

Photo courtesy B.R. McClelland

Whitebark has experienced considerable decline in the Northwest.

Objectives

Our objectives are intended to monitor the health of whitebark pine relative to levels of white pine blister rust and to a lesser extent mountain pine beetle. The approach we are taking is a combination of assessing the status and trends of whitebark pine with respect to these potentially injurious agents as well as to assess the demographic rates that would enable us to determine the probability of whitebark pines persisting in the Greater Yellowstone Ecosystem.

Objective 1 - To estimate the proportion of live whitebark pine trees (>1.4 m high) infected with white pine blister rust, and to estimate the rate at which infection of trees is changing over time.

Objective 2 - Within infected transects, to determine the relative severity of infection of white pine blister rust in whitebark pine trees > 1.4 m high.

Objective 3 - To estimate survival of individual whitebark pine trees > 1.4 m high, explicitly taking into account the effect of infection with, and severity of, white pine blister rust, infestation by mountain pine beetle and fire.

Additional objectives aimed at assessing recruitment and the effect of forest succession are being planned.

Study Area

Our study area is in the Greater Yellowstone Ecosystem and includes 6 National Forests and 2 National Parks (the John D. Rockefeller Memorial Parkway is included with Grand Teton National Park) (Figure 1). The habitat types from which our sample was selected correspond to aggregation of "High Elevation Whitebark Pine Dominated Sites" described by Mattson et al. (2004). However, it should be noted that this name is a bit confusing because "high elevation" in the context of this report, refers to the entire ecosystem, not just to whitebark. Thus, it does not imply that the whitebark sites are limited to higher elevation sites within the whitebark pine cover types. Rather, it includes whitebark pine cover types ranging from relatively pure whitebark pine stands that occur at higher elevations, to mixed-species stands that occur at lower elevations within the range of whitebark.

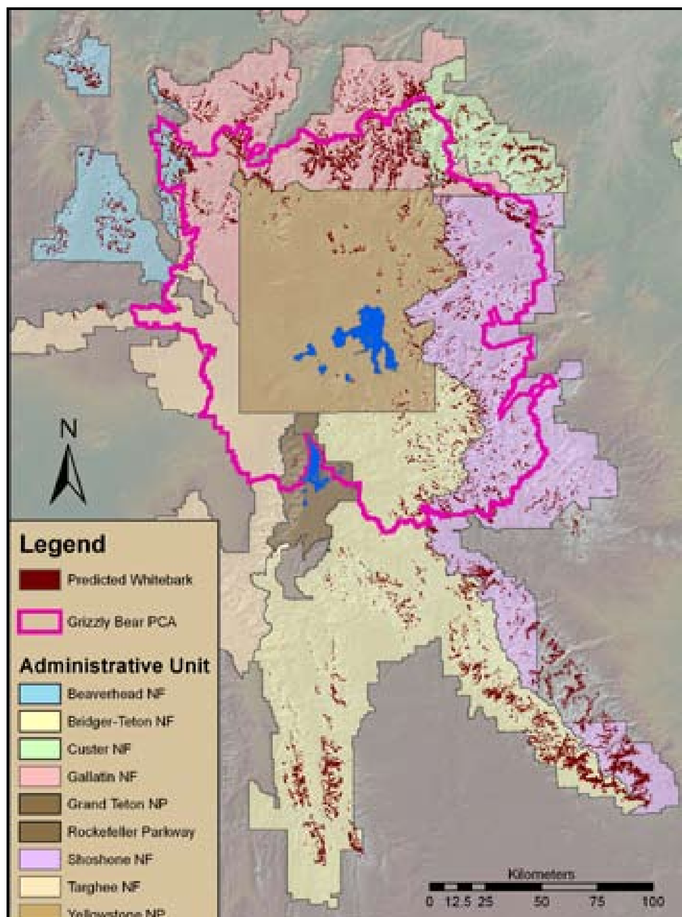


Figure 1. Study area showing administrative units and predicted occurrence of whitebark pine.

Methods

Details of our sampling design and field methodology can be found in GYWPMWG (2005, 2006). However, our 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. During 2004 all WbP stands sampled were within the Grizzly Bear Primary Conservation Area (PCA) due to the limitations in the mapped distribution of WbP across the study area. Our sample during 2005 extended outside of the PCA to the boundaries of what is considered the GYE (Figure 2). Future samples over the next few years will encompass the entire region. Separation of the areas within and outside the PCA enabled us to account for map limitations during 2004 and to analyze survey results separately. Transects and individual trees within each transect were permanently marked in order to estimate changes in infection and survival rates over an extended period. Transects will be revisited approximately every 5 years to determine changes in blister rust or survival since the previous visit.

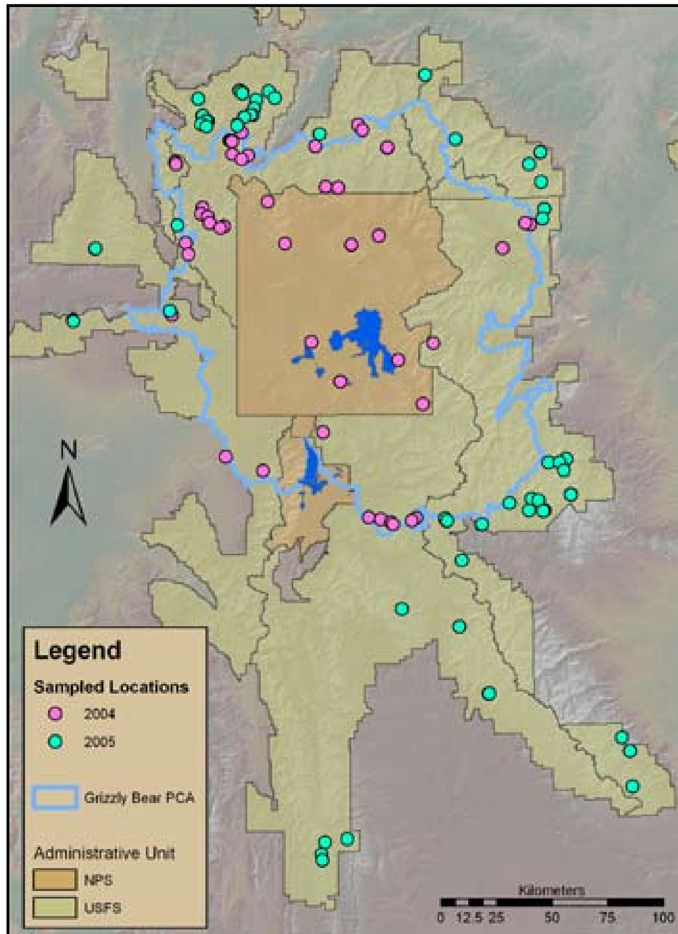


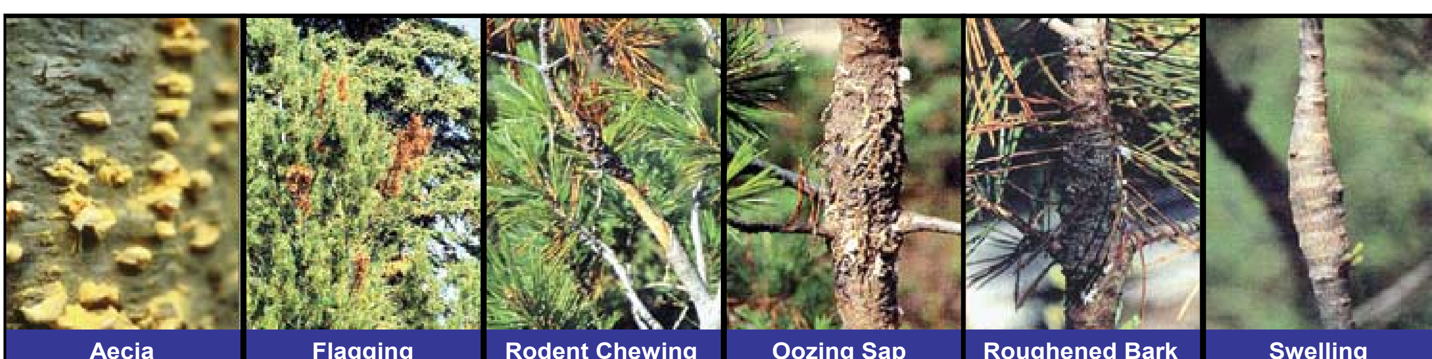
Figure 2. Sites sampled during 2004 from within the grizzly bear PCA and 2005 outside the PCA.

White Pine Blister Rust

For each live tree, the presence or absence of indicators of blister rust were 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 blister rust, at least three of five ancillary indicators needed to be present. Ancillary indicators of blister rust included flagging, rodent chewing, oozing sap, roughened bark, and swelling.

Mountain Pine Beetle

The presence or absence of mountain pine beetle was noted in all WbP; however, we did not attempt to assign a cause of death for dead WbP trees. Mountain pine beetle presence was identified in the following ways: 1) small, popcorn-shaped resin masses called pitch tubes; 2) dust in bark crevices; 3) and presence of live mountain pine beetle and characteristic J-shaped galleries under the bark.



Based on Hoff (1992)

Evaluating Observer Differences

Previous monitoring efforts for WbP have largely ignored observer variability in identifying white pine blister rust infection. To assess this effect, we conducted independent surveys by different observers on 6 transects in 2004 and 18 transects in 2005. The first observer marked the individual trees which were subsequently visited by each of the other observers.

Preliminary Results

White Pine Blister Rust

A total of 51 transects were surveyed within 45 stands of WbP in 2004. In 2005, a total of 76 transects were surveyed within 55 stands. Of the 51 transects surveyed within the PCA in 2004 and the 76 transects outside the PCA in 2005, we observed some level of blister rust on 36 (71%) and 65 (86%), respectively (Figure 3). The proportion of infected trees on a given transect ranged from 0 to 1.0. The number of live trees per transect for each year ranged from 1 to 219 for a total of 1,012 live trees examined during 2004 and 2,732 during 2005. Taking into account both within and between-stand variation, our preliminary estimates of the proportion of live trees infected with blister rust was 0.17 ± (0.062 se) within the PCA, 0.27 ± (0.036 se) outside the PCA, and 0.25 ± (0.031 se) for the overall GYE.

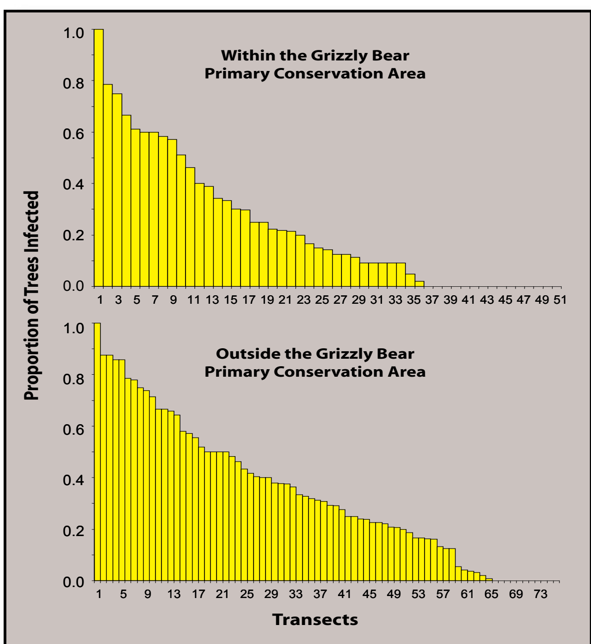


Figure 3. The 127 individual transects sampled in 2004 (n=51) and 2005 (n=76) showing the proportion of infected trees on each transect. The transects are shown in rank order from those with the highest percentage of infected trees per transect to those that were least infected.

Although a formal spatial analysis has not yet been conducted, our preliminary data indicate that infection rates are highly variable across the region (Figure 4).

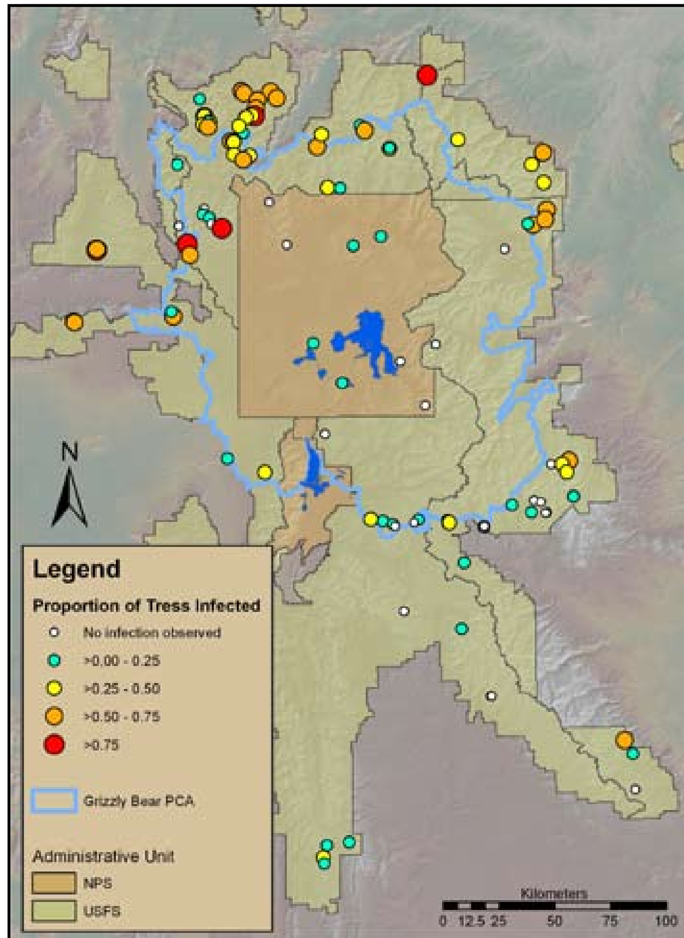


Figure 4. The proportion of trees infected on transects sampled during 2004 and 2005.

Severity of White Pine Blister Rust on Infected Trees

The total number of cankers observed on infected live trees in 2004 and 2005 combined was 2,425, of which 1,942 (80%) were located on branches and 483 (20%) were located on a main bole (Figure 5). The total number of cankers per infected tree ranged from 1 to 35. Bole cankers that are located on the lower portion of the bole (middle to bottom third) are generally considered lethal to trees. Cankers that are found in the upper third of the bole are not necessarily lethal but can have a negative impact on cone production. Such cankers were less numerous than branch cankers and ranged from 0 to 7 per infected tree; whereas branch cankers ranged from 0 – 32 per infected tree.

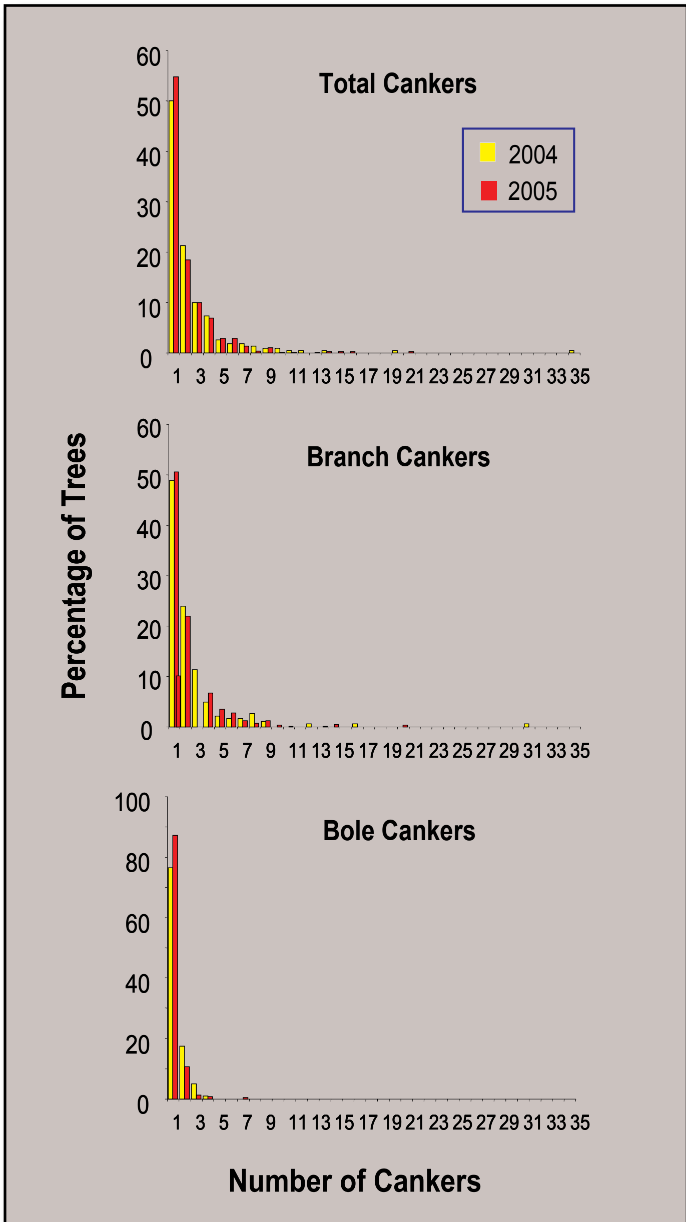


Figure 5. The percentage of whitebark pine trees from the sample in each year infected with one, two, three, etc number of cankers per tree for (1) the total number of cankers, (2) branch cankers, and (3) bole cankers.

Mountain Pine Beetle

Of the 45 stands visited in 2004, 10 (22%) had evidence of mountain pine beetle attacks in live or recently dead (i.e., with intact needles) trees. Of the 1,062 live or recently dead trees we sampled in these stands, 30 (3%) had evidence of mountain pine beetle attacks. In 2005, 12 out of 55 (22%) stands had evidence of mountain pine beetle attacks and of the 2,827 live or recently dead trees, 26 (1%) had evidence of mountain pine beetle attacks.

Observer Differences

Some of the factors that may influence observer variability are observer positioning, observation effort, stand density and physical structure, observer experience, lighting, and equipment (e.g., binoculars). Twenty four transects in 2004 and 2005 were surveyed by multiple observers. Each observer recorded blister rust infections independently for each tree on the same transect. The results of this effort are still being analyzed and will be reported in detail in a separate manuscript intended for publication.

Discussion

As previously stated, this study concentrates on the health and status of whitebark pine in the Greater Yellowstone area. Although WbP is important to an array of wildlife including the grizzly bear, it is important to reiterate that the focus of this project is on WbP as opposed to any of the species with which it may be associated.

It is also important to be very clear about what we are reporting. When examining reports of blister rust infection, it often is not clear whether the rates of infection being reported are the proportion of plots (e.g., transects) that have some indication of infection, or the proportion of trees that have some level of infection. In this report, we consider the proportion of transects that show the presence of blister rust as an indication of how widespread blister rust is within the GYE. Our preliminary results indicate that the occurrence of white pine blister rust is widespread throughout the GYE (i.e, 80% of all transects had some level of infection).

We consider the proportion of trees infected and the number and location (branch or bole) of cankers as indicators of the severity of blister rust infections. By these measures, the severity of infections was less alarming than the spatial extent, with an estimated 25% of the trees in the GYE estimated as having some level of infection.

In most cases, the number of cankers per tree was low with approximately 73% of the infected trees having ≤ 2 cankers observed, 80% of which were branch cankers. Branch cankers are generally considered to be less lethal (Koteen 2002).

It should be noted that the results presented here are preliminary and some caution in interpretation is warranted. First, we have not yet completed a full sample of the ecosystem. Our sampling design is such that a full sample is achieved over several years, after which the samples are

The location of blister rust on the tree can greatly influence its effect.

USFS Photo: Dorena Genetic Resource Center

revisited. Thus, our estimates to date comprise only a subset of what will be a complete sample of the ecosystem.

An additional caution to take into consideration is that the results presented here are estimates from a specific protocol of sampling design and field methods. Few, if any other efforts within the GYE have selected sites using a probabilistic sampling design specifically intended for deriving inference to the GYE population as a whole. Thus, comparison with results from efforts using different field methods or sampling designs is likely to produce questionable conclusions. It is largely for this reason, that we have attempted a consistent approach for the entire GYE.

The detection of blister rust cankers can be difficult under some circumstances, and can vary among observers.

It should also be noted that our estimates from 2004 and 2005 do not represent an annual change in blister rust infection. Rather, these samples were taken from different parts of the ecosystem (within and outside of the PCA) and are more likely to reflect spatial variation rather than an annual change. Our estimates of change in infection within the GYE will be derived from repeated sampling of our selected sites over time.

Finally, our overall estimate of blister rust infections is likely conservative. Our criteria of having aecia or at least three of the other indicators (rodent chewing, flagging, oozing sap, roughened bark or swelling) present to confirm infection, may result in the rejection of questionable cankers. We are continuing to evaluate the efficacy of these criteria for future sampling. Our data also suggests that observer variability may be quite important. This result has broad implications for all monitoring efforts of whitebark pine where observer differences are not considered. For monitoring efforts to be reliable, differences in infection rates observed over time should not be confounded with observer differences.

Acknowledgments

We thank our field technicians Justin Hof, Karla Sartor, and Amy Jesswein. We also thank Maria Newcomb, Veronika Klukas, Dale Dawson, Rachel Feigley, Andy Pils, Bill Oliver, Rob Daley, Jim Robertson, Steve Schadt, Jodie Canfield, Dennis Barron, Allen Kyles, David Meyers, Marcus Engler, Jeff Dibenedetto, Ellen Jungck, Bev Dixon, and Anne Schrag for their advice and/or field and logistic support. Funding for the field work portion of this project was provided by USFS FHM. Additional funding and support for preliminary analysis of data, mapping, additional field gear, and vehicle support was provided by NPS (Greater Yellowstone Network and Yellowstone National Park), USGS (Interagency Grizzly Bear Study Team) and the Greater Yellowstone Coordinating Committee (GYCC).

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Our sampling is intended to encompass a wide range of whitebark pine stand types, from higher elevation stands of pure whitebark pine to relatively lower elevation mixed-species stands.

Photo credits clockwise from upper left: NPS, R.G. Johnsson; Lisa Landenburger; Karla Sartor; Dan Reinhart

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Cooperating Organizations:

Greater Yellowstone Coordinating Committee (GYCC)

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

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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.

Photo courtesy Anne Schrag

The Realm of Whitebark

Recommended citation for GYWPMWG (2006):

Greater Yellowstone Whitebark Pine Monitoring Working Group. 2006. Monitoring Whitebark Pine in the Greater Yellowstone Ecosystem: 2005 Annual Report. Pages 73-80 in C.C. Schwartz, M.A. Haroldson, and K. West, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2005. U.S. Geological Survey, Bozeman, Montana, USA.