Monitoring Whitebark Pine in the Greater Yellowstone Ecosystem

2007 Annual Report

Greater Yellowstone Whitebark Pine Monitoring Working Group

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

Photo courtesy Anne Schrag

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). 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 Committee, 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, 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 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 2007a) 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

Photo courtesy Rachel Simons

NPS Photo, Rosalie LaRue

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 2007 from this long-term monitoring project.

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

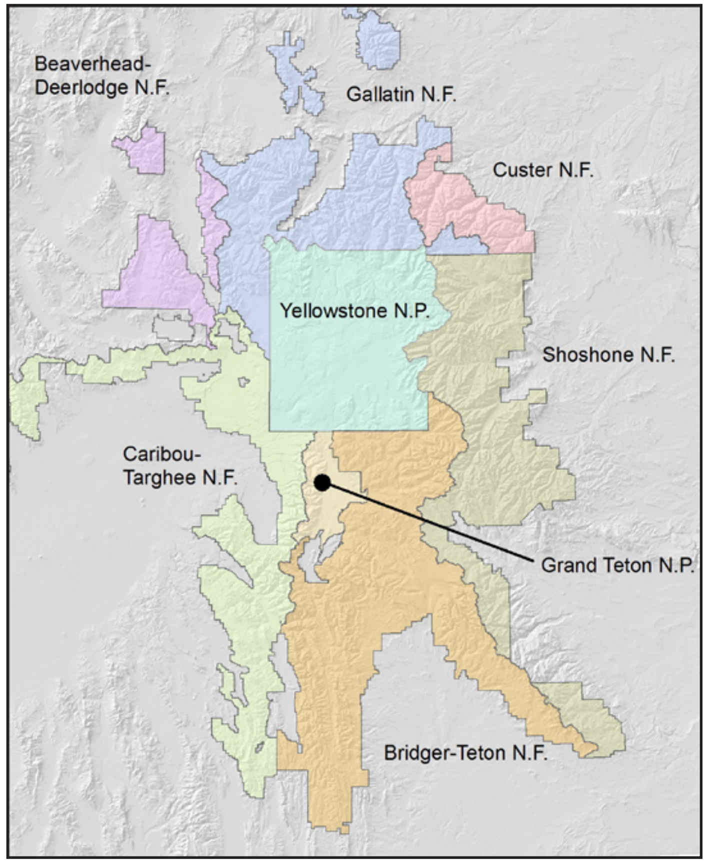

Figure 1. Study area showing national forest and national park units.

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.

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 and 2007b). 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. Monitoring took place between 2004 and 2007; during this period 176 permanent transects in 150 whitebark pine stands were established and 4774 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.

White Pine Blister Rust

For each live tree, the presence or absence of indicators of white pine blister rust infection 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 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

The presence or absence of mountain pine beetle was noted in all whitebark pine based on the presence of small, popcorn-shaped resin masses called pitch tubes. We did not attempt to assign a cause of death for dead whitebark pine trees on transects when first established.

Within vs. Between Stand Variability

To access the potential for between stand variability, two permanent transects were established in 26 of the 150 whitebark pine stands. Both transects will be re-read the same year the stand is scheduled for resurvey.

Results

Table 1. Summary statistics for Greater Yellowstone Ecosystem 2004-2007.			
Location	Within PCA	Outside PCA	Total for GYE
Number Stands	64	86	150
Number of Transects	66	110	176
Number of Unique Trees Sampled	1307	3467	4774
Proportion of Transects Infected	0.79	0.86	0.84
Estimated Proportion of Trees Infected.	0.14 ± (0.044 se)	0.217 ± (0.046 se)	0.20 ± (0.037 se)

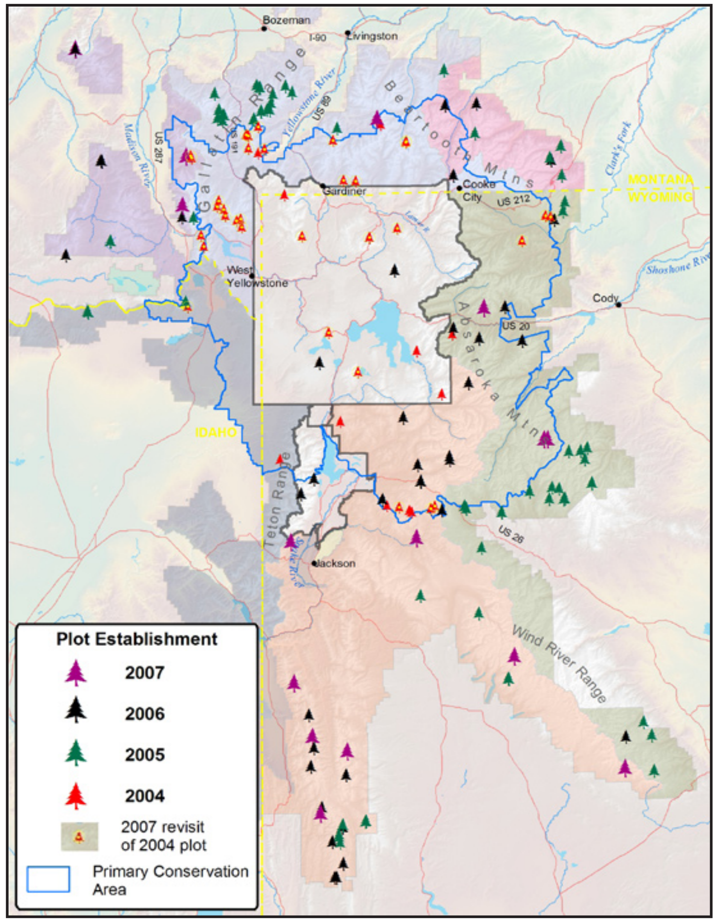

Figure 2. Distribution of samples (transects) established between 2004 and 2007. The grizzly bear PCA is shown in blue.

A total of 176 transects were surveyed within 150 stands of whitebark pine in the GYE between 2004 and 2007 (Figure 2). Of these, 66 transects in 64 stands were surveyed within the grizzly bear PCA and 110 transects within 86 stands were sampled outside the PCA. Summary statistics are presented in Table 1. Preliminary analysis of data from 33 transects established in 2004 and resurveyed in 2007 (see Figure 2) found that 29 of the 744 permanently marked trees (3.9%) had died over the three-year period.

Status of White Pine Blister Rust

Preliminary estimates suggest the proportion of live trees infected with white pine blister rust is 0.20 (± 0.037 se) in the GYE. The proportion of infected trees on a given transect ranged from 0 to 1.0. The number of live trees per transect (n = 176) ranged from 1 to 220 for a total of 4774 live trees examined. Although a formal spatial analysis has not yet been conducted, our preliminary data indicate that white pine blister rust infection is widespread and highly

variable across the region (Figure 3).

Severity of White Pine Blister Rust on Infected Trees

The total number of cankers observed on infected live trees for the four years (2004-2007) combined was 3498, of which 3009 (86%) were located on branches and 489 (14%) were located on a main bole. The total number of cankers per infected tree ranged from 1 to 39. Bole cankers that are located on the lower portion of the bole (middle to bottom third) are generally considered lethal to trees whereas branch cankers are generally considered to be less lethal (Koteen 2002). Cankers that are found in the upper third of the bole are not necessarily lethal but can have a negative impact on cone production.

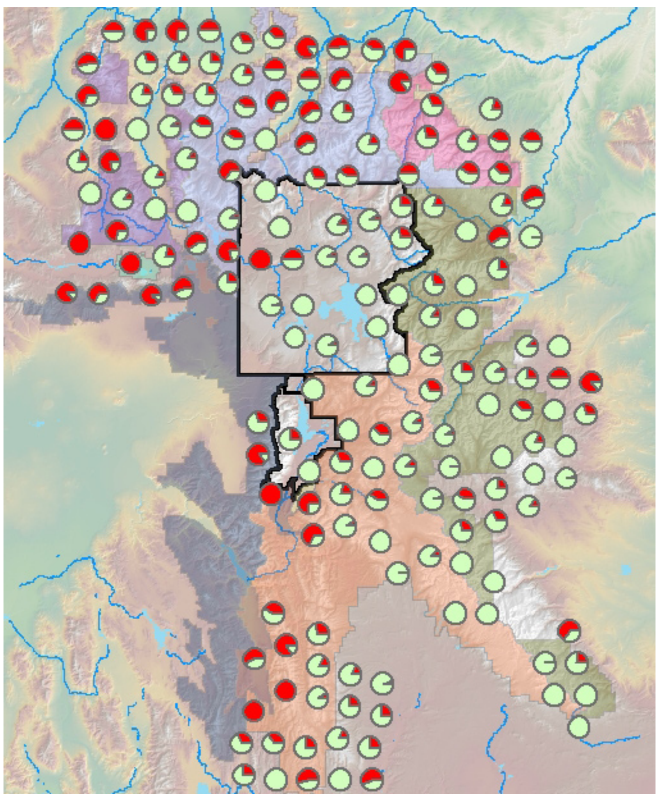

Figure 3. Chart showing the ratio (in red) of trees at each monitoring site in which white pine blister rust was recorded during ground-based surveys from 2004 through 2007. Due to map scale the pie charts are distributed for readability and may not be placed on the actual survey location.

Discussion

In this report, we consider the proportion of transects that show the presence of white pine blister rust as an indication of how widespread the disease is within the GYE. Our preliminary results indicate that 80% of all transects had some level of infection and white pine blister rust is widespread throughout the GYE. We consider the proportion of trees infected and the number and location (branch or bole) of cankers as indicators of the severity of white pine blister rust infections. We know that the proportion of trees infected with white pine blister rust in the GYE is 0.20 (± 0.037 se). This is the first GYE estimate of white pine blister rust based on a probabilistic sample design; comparison with results from efforts using different field methods or sampling design is not possible. Changes in white pine blister rust and rates of tree mortality will be derived from repeated sampling of permanent transects over time.

In addition to the white pine blister rust infection described above, a significant outbreak of mountain pine beetle is currently taking place in the GYE. Mountain pine beetle is a native North American insect persisting at low levels in lodgepole and whitebark pine throughout most of the last century. When favorable conditions exist, beetle populations can quickly increase to epidemic proportions and outbreaks occasionally result in high levels of mortality of mature trees. Research has shown that mountain pine beetle activity increases significantly in whitebark pine with heavy white pine blister rust infection. Furthermore, warming in the northern hemisphere has favored bark beetle reproductive success in whitebark pine ecosystems and interactions between the beetle and white pine blister rust are placing whitebark pine in a precarious state (Bockino 2008). Forest insects and disease can directly and indirectly affect many ecological processes in whitebark pine ecosystems. Episodes of tree mortality change the amount of coarse woody debris accumulation and net primary productivity in the subalpine ecosystems. The loss of cone producing trees has a direct affect on the amount of whitebark pine seeds available for wildlife.

Future Directions

Following the establishment of permanent transects, the working group decided how transects would be assigned to panels and determined the revisit design for implementation beginning in 2008. Infection by white pine blister rust is a slow process, such that detection of annual change would not be effective or practical. Consequently, we have based our design on a "rotating panel" with a 4-year rotation schedule. Panel membership is based on a random selection of stands that include the permanently monumented transects from both inside and outside the PCA. This approach ensures that each panel is representative of the population and not merely an artifact of the year the transect was first established.

In contrast to white pine blister rust infection, the effects

of mountain pine beetle occur much more rapidly and a 1-2 year revisit schedule may be more appropriate during periods of rapid change such as the current mountain pine beetle outbreak. Although our approach of sampling every four years will be sufficient to establish mortality due to white pine blister rust, we believe an increase effort to document the amount of mortality due to mountain pine beetle is warranted during the current outbreak. Thus we have created a split panel design where alternating panels are revisited on a 2-year schedule to specifically record mortality of whitebark pine during the current outbreak. Also beginning in 2008 field crews will consistently strip a portion of the bark from recently dead trees to look for the characteristic J-shaped galleries under the bark. The presence of the J-shaped gallery is a positive and more reliable form of mountain pine beetle evidence than pitch tubes alone.

The next phase of planning for this project will focus on the recruitment of immature trees into the cone-producing population. The decline of whitebark pine can result either from increased mortality (e.g., as a result of white pine blister rust and/or mountain pine beetle), or it can result from a lack of recruitment into the reproductive population. A lack of recruitment can result from changes in a variety of life history stages from decreased cone production to recruitment of immature trees into the cone-producing population.

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Literature Cited

Bockino, N.K. 2008. Interactions of White Pine Blister Rust, Host Species, and Mountain Pine Beetle in Whitebark Pine Ecosystems in the Greater Yellowstone. M.S., Department of Botany, University of Wyoming, Laramie, Wyoming, USA.

Dixon, B.G. 1997. Cumulative Effects Modeling for Grizzly Bears In The Greater Yellowstone Ecosystem. Thesis Montana State University. 143 pages plus appendices. Bozeman, Montana, USA.

Ellison, A.E., M.S. Banks, B.D. Clinton, E.A. Colburn, K. Elliott, C.R. Ford, D.R. Foster, B.D. Kloeppel, J.D. Knoepp, G.M. Lovett, J. Mohan, D.A. Orwig, N.L. Rodenhouse, W.V. Sobczak, K.A. Stinson, J.K. Stone, C.M. Swan, J. Thompson, B. Von Holle, and J.R. Webster. 2005. Loss of foundation species: consequences for the structure and dynamics of forested ecosystems. Frontiers in Ecology and the Environment. 3 (9): 479-486.

Farnes, P.E. 1990. SNOTEL and snow course data describing the hydrology of whitebark pine ecosystems. In: W.C. Schmidt and K.J McDonald (Eds). Proceedings of a symposium on whitebark pine ecosystems: ecology and management of a high mountain resource. Ogden, UT: USDA Forest Service Intermountain Research Station.

Gibson, K. 2006. Mountain pine beetle conditions in whitebark pine stands in the Greater Yellowstone Ecosystem, 2006. U.S.F.S. Forest Health Protection, Numbered Report 06-03, Missoula, Montana, USA.

Greater Yellowstone Whitebark Pine Monitoring Working Group. 2005. Interagency Whitebark Pine Health Monitoring Program for the Greater Yellowstone Ecosystem, 2004 Annual Report. Pages 92-125 in C.C. Schwartz, M.A. Haroldson, and K. West, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2004. U.S. Geological Survey, Bozeman, Montana, USA.

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.

Greater Yellowstone Whitebark Pine Monitoring Working Group. 2007a. Interagency Whitebark Pine Monitoring Protocol for the Greater Yellowstone Ecosystem, Version 1.00. Greater Yellowstone Coordinating Committee, Bozeman, Montana, USA.

Greater Yellowstone Whitebark Pine Monitoring Working Group. 2007b. Monitoring Whitebark Pine in the Greater Yellowstone Ecosystem: 2006 Annual Report. Pages 46-54 in C.C. Schwartz, M.A. Haroldson, and K. West, editors. Yellowstone grizzly bear investigations: annual report of the Interagency Grizzly Bear Study Team, 2006. U.S. Geological Survey, Bozeman, Montana, USA.

Hoff, R.J. 1992. How to recognize blister rust infection on whitebark pine. USDA Forest Service, Intermountain Research Station, Research Note INT-406, Ogden, Utah., USA.

Kendall, K.C., and R.E. Keane. 2001. Whitebark pine decline: infection, mortality, and population trends. Pages 221–242 in D.F. Tomback, S.F. Arno, and R.E. Keane, editors. Whitebark pine communities. Island Press, Washington, D.C., USA.

Koteen L. 2002. Climate change, whitebark pine, and grizzly bears in the Greater Yellowstone Ecosystem. Pages 343-414 in S.H. Schneider and T.L. Root, editors. Wildlife responses to climate change: North American case studies. Island Press, Washington, D.C., USA.

Tomback D.F., S.F. Arno, and R.E. Keane. 2001. The compelling case for management intervention. Pages 3-25 in D.F. Tomback, S.F. Arno, and R.E. Keane, editors. Whitebark pine communities: ecology and restoration. Island Press, Washington, D.C. USA.

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

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

USDI Geological Survey

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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.