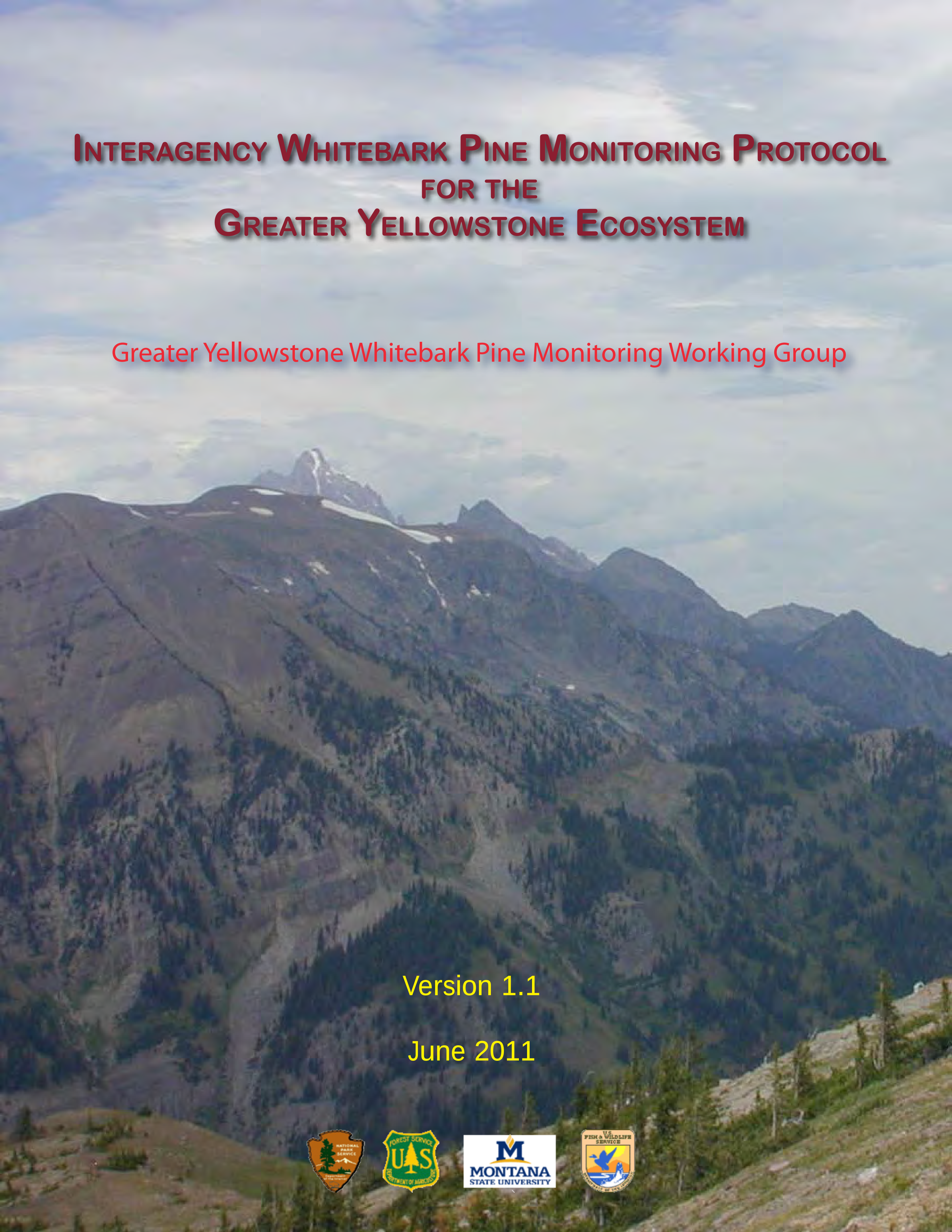
Interagency Whitebark Pine Monitoring Protocol for the Greater Yellowstone Ecosystem

Greater Yellowstone Whitebark Pine Monitoring Working Group



Version 1.1

June 2011

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Interagency Whitebark Pine Monitoring Plan and Protocol for the Greater Yellowstone Ecosystem

Greater Yellowstone Whitebark Pine Monitoring Working Group

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Revising the Protocol

Revision History Log

All changes must be documented, and updated protocol versions must be recorded in the Revision History Log that accompanies the protocol. Version numbers increase by tenths for minor changes that do not involve analytical or procedural methods. Major revisions (changes that affect analytical or procedural methods) receive the next sequential whole number. A project leader must review all modifications for clarity and technical soundness and communicate all changes to affected and prospective users of the protocol. The Whitebark Pine Monitoring Working Group must review and approve major modifications.

The following table lists all edits and amendments to this document since the original publication date. Information entered in the log must be complete and concise. Users of this monitoring protocol will promptly notify the project leader and/or a member of the Whitebark Pine Monitoring Working Group about recommended and required changes. A project leader is responsible for completing the revision history log, changing the date and version number on the title page and in the footer of the document file(s), and managing web-based and other distribution of updated protocol materials.

Interagency Whitebark Pine Monitoring Protocol for the Greater Yellowstone Ecosystem Version 1.1, June 2011				
Date and number of Previous Version	Date of Revision	Author(s) of Revision (with title and affiliation)	Location in Document and Concise Description of Revision	Reason for Change
June 1, 2007 Version 1.0	Various from 2007 through 2011	Erin Shanahan, Cathie Jean, Rob Daley - all with the National Park Service Inventory and Monitoring Program	Front - Changed working group membership to reflect participants by agency and position rather than by name. Chapter 1 – changed date of pilot effort for objective four from 2007 to 2011. Chapter 2 – Updated the Temporal Revisit Design section to explain that monitoring sites established from 2004 through 2007 were assigned by the Working Group to four panels, one of which is surveyed each year for evidence of blister rust infection to build up a complete GYE sample every four years. Also explained that a complete GYE sample of mountain pine beetle data is achieved every two years as a complement to aerial detection surveys. Changed season end date to September. Updated tables 2-1, 2-2, and 2-3 to include 2007 survey summary. Chapter 3 – Reorganized the chapter content to follow field-based workflow. Added numerous procedural details based on field experience. Moved the safety section to the front of the chapter and expanded the content. Added	Changes reflect lessons learned during project operations since 2007, including clarifications, additional explanations, and updates to contact information. Minor additions, edits and corrections throughout document. These updates do not represent substantial changes in where, how, or what type of data are collected to meet project objectives.

Interagency Whitebark Pine Monitoring Protocol for the Greater Yellowstone Ecosystem Version 1.1, June 2011				
Date and number of Previous Version	Date of Revision	Author(s) of Revision (with title and affiliation)	Location in Document and Concise Description of Revision	Reason for Change
			additional explanation and clarification about exact field procedures. Added Table 3.4. Updated description of tree parameters and instructions for recording valid data values. Added images to help identify infection and other tree attributes. Added details to the mountain pine beetle and resurvey aspects of existing methods. Added instructions for recording monument trees for locating plot center. Removed the dwarf mistletoe element from objective 3. Clarified how to monument sites involving non-target habitat. Updated instructions for surveying red squirrel middens. Added instructions for recording cone production. Added instructions for recording new trees during resurvey. Added schedule for recording DBH and height class. Changed in-text occurrences of Primary Conservation Area (PCA) to Recovery Zone (RZ) for consistency. Chapter 4 – Updated all sections to reflect improvements since 2007 in data collection, recording, storage, quality assurance, and distribution. Updated images showing latest data structure and data interface tools for data input and output. Added a section explaining data distribution. Chapter 5 – Updated images and text to reflect latest examples of reporting and change outdated term ‘almanac’ with ‘resource brief’. Chapter 6 – Minor clarifications in the section on differentiating Whitebark and Limber Pines. Chapter 7 – Deleted the heading and first paragraph under “2008 Program Review”. Chapter 8 – No changes. Appendix 1 - Replaced Field Forms with examples of most recent format. Appendix 2 - Replaced Data Dictionary with latest content.	
Add rows each change or set of changes reflected by an updated version of the document.				

Table of Contents

Chapter 1

Introduction and Background

Whitebark pine (*Pinus albicaulis*) occurs in the subalpine zone of the Pacific Northwest and northern Rocky Mountains, where it is adapted to a harsh environment with poor soils, steep slopes, high winds and extreme cold temperatures. Although its inaccessibility and often gnarled growth forms render whitebark pine of low commercial value, it is high in ecological value and has been called a "keystone" species in the subalpine zone (Tomback et al. 2001).

Photo courtesy of Katherine Kendall

Whitebark pine can exist under conditions tolerated by few other trees, which may alter the microclimate and enable other species, such as subalpine fir (*Abies lasiocarpa*), to follow (Tomback et al. 1993). Its occurrence on wind-swept ridges plays an important role in snow accumulation. Perhaps its best-known role in these ecosystems is as a food source for a variety of wildlife species. Whitebark pine seeds are large and high in fat content, making them a valuable food source for numerous wildlife species (Kendall and Arno 1990), especially grizzly bears, which find them in red squirrel middens (Mattson et al. 1992). In fact, in the Greater Yellowstone Ecosystem (GYE), annual whitebark pine cone production in the GYE is one of the major predictors of annual survival and reproduction of the bears (Mattson et al. 1992).

Whitebark pine stands have been decimated in areas of the Cascades and northern Rocky Mountains due to the introduction of the introduced pathogen white pine blister rust (*Cronartium ribicola*). In addition, whitebark pine is impacted by mountain pine beetles (*Dendroctonus ponderosae*) and competition with subalpine fir and Engelmann spruce (*Picea engelmanii*). In order to track the status of the whitebark pine population in the Greater Yellowstone Ecosystem, the National Park Service, US Forest Service and US Geological Survey have developed the following protocol to monitor the level of blister rust infection and other impacts on whitebark pine. This effort represents an expansion of the blister rust monitoring currently performed by the Interagency Grizzly Bear Study Team and will help to understand the status of this important species in the ecosystem.

Introduction and Background

Relevance to Parks

Due to the collaborative nature of whitebark pine monitoring in the Greater Yellowstone Ecosystem, the purpose of monitoring must be relevant to all agencies involved. Following are short descriptions of how whitebark pine monitoring fulfills the guiding principles and goals of the National Park Service (NPS), US Forest Service (USFS) and US Geological Survey (USGS).

National Park Service I&M Program

The mission of the National Park Service is "to conserve, unimpaired, the natural and cultural resources and values of the national park system for the enjoyment of this and future generations" (NPS 1999). To uphold this goal, the Director of NPS approved the Natural Resource Challenge in 2000 to encourage national parks to focus on the preservation of the nation's natural heritage through science, natural resource inventories and expanded resource monitoring (NPS 1999).

Photo courtesy of B. Riley McClelland

The goal of monitoring is to detect change over time and to use this information to understand the state of the parks' ecosystems. Monitoring in the NPS is intended to aid in the development of broadly based, scientifically sound information on the current status and long-term trends in the health, composition, structure and function of park ecosystems. While many Executive Orders and legislative acts direct the purpose of the I&M program, one legislative act of particular relevance is the 1993 Government Performance and Results Act (GPRA). GPRA sets goals to help federal agencies become more accountable to the public for the money they spend and the results that are achieved. GPRA is required as part of the National Park Omnibus Management Act, which calls for the creation of Strategic Plans and Annual Performance Plans. The National Park Service created a Strategic Plan for 2001-2005 (NPS 2001), with the 'Category 1' goal of "preserving park resources," which includes goals that fit the mission of the I&M program, such as choosing vital signs for assessing the health of park ecosystems. In addition, each park also creates five-year strategic plans and annual performance plans that guide progress toward the Service-wide goals.

The National I&M Program has created five major long-term goals that I&M networks must strive to achieve (NPS 2003). These goals include:

1. *Determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more*

effectively with other agencies and individuals for the benefit of park resources.

2. *Provide early warning of "abnormal" conditions and impairment of selected resources to help develop effective mitigation measures and reduce costs of management.*

3. *Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.*

4. *Provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment.*

5. *Provide a means of measuring progress toward performance goals.*

Multi-agency guidance

The Final Conservation Strategy for the Grizzly Bear in the Yellowstone Ecosystem (Interagency Conservation Strategy Team 2003) directs the NPS, USFS and USGS to monitor food sources of the grizzly bear, including ungulate carcasses, cutthroat trout, army cutworm moths and whitebark pine. Specifically mentioned in the conservation strategy is monitoring of select transects throughout the GYE for cone production and white pine blister rust occurrence. Cone transect monitoring has been led by the Interagency Grizzly Bear Study Team and consists of cone counts and some blister rust monitoring (Haroldson et al. 2004). Blister rust is an important factor in the survival and reproduction of whitebark pine stands throughout the Northwest, and it has been determined that current blister rust monitoring within the GYE is not sufficient to understand the impacts of this introduced pathogen on whitebark pine stands and cone production.

Thus, the National Park Service, US Forest Service and US Geological Survey have determined a need to expand blister rust monitoring, as well as monitoring the impacts of succession and mountain pine beetle, on whitebark pine. It is assumed that increased monitoring of whitebark pine will aid in decisions regarding management of the species in the GYE. For instance, monitoring may determine if the status of whitebark pine warrants active restoration of the species (i.e., planting) and the monitoring design can be adjusted to compare alternative restoration practices.

Threats and Concerns

Several of the major threats and concerns regarding whitebark pine within the Greater Yellowstone Inventory and Monitoring Network (GRYN) have also been identified as vital signs chosen by the GRYN as indicators of ecosystem health. These include climate, forest insects and disease and fire. The relationships among whitebark pine and these other vital signs are described in the following paragraphs and in more detail in Appendix IA.

Introduction and Background

Forest insects and disease

White pine blister rust, an exotic fungus first introduced into Vancouver, British Columbia, in 1910, enters the stomata of the whitebark pine needles and then erupts into cankers on the branches, leading to the cessation of cone production and in some cases, the eventual death of the tree (Tomback et al. 2001). Depending on the level of infection, a tree with white pine blister rust can live for decades; however, saplings that are infected generally die within three years (Koteen 2002). Infection by blister rust also weakens the tree and can lead to death by an accumulation of factors, including mountain pine beetle, other pathogens, root diseases and unfavorable climatic conditions (Koteen 2002). While white pine blister rust has devastated populations in areas with maritime climates (namely the Pacific Northwest and Glacier National Park) with infection rates of 82% in the north Cascades (Kendall and Keane 2001) and 90% in Glacier (Koteen 2002), some researchers have suggested that the drier climate of the GYE may be relatively inhospitable to the spread of blister rust (Koteen 2002). Results of recent surveys on blister rust infection rates in the GYE have shown average rates of <5% in Yellowstone and <15% in Grand Teton, and a highest single-site incidence of 40-44% in Grand Teton (Kendall and Keane 2001), an increase from the 1.1% average infection rate found in 1967 (with the highest single-site incidence of 2.3% [Koteen 2002]).

Photo courtesy of Katherine Kendall

Another threat to whitebark pine populations in the GYE is the mountain pine beetle. The mountain pine beetle (Dendroctonus ponderosae) is a native insect that has coevolved with pine forests in the western U.S. (Logan and Powell 2001). Host tree species of mountain pine beetle include ponderosa pine, lodgepole pine, western white pine and whitebark pine (Kipfmueller and Swetnam 2002). Variations in climate are largely responsible for the success of mountain pine beetle outbreaks. Mild summers and winters tend to favor outbreaks, while cold winters and hot summers tend to decrease beetle activity and increase brood mortality (Kipfmueller and Swetnam 2002). Evidence has shown that mountain pine beetles tend to attack—and are more successful when attacking—trees that are already weakened by some other process, such as moisture stress, pathogens or mistletoe (Kipfmueller and Swetnam 2002). Because some evidence suggests that older trees that have been weakened due to other pathogens are more susceptible to mountain pine beetle infestations, it has been suggested that fire suppression can lead to an increase in the spread of infestations because it fosters mature, late-successional stands of trees (Perkins and Roberts 2003, Tomback et al. 2001).

Climate

Climate change is hypothesized to affect whitebark pine communities through three mechanisms: 1) causing a shift in pathogen ranges, which may lead to new regions of hospitable climate for white pine blister rust and, thus, increase the potential for infection; 2) increasing temperatures, which can lead to decreases in range availability for whitebark pine, due to competitive exclusion by more heat-tolerant species, such as lodgepole pine (Mattson et al. 2001); and 3) changes in the frequency of severe fires, which lead to overall decreases in whitebark pine numbers (while whitebark pine is adapted to small fires, large, stand-replacing fires may be detrimental to its overall distribution and abundance [Koteen 2002]). According to Koteen (2002), climate change can also affect the range of blister rust through the following processes: "1) altering the dispersal, reproductive or developmental processes of the pathogen directly; 2) increasing pathogen virulence or growth to host populations; or 3) increas[ing] pathogen predation of host species by mediating pathogen competition with symbiotic organisms, such as mycorrhizae, that protect plants against pathogens."

Photo courtesy of B. Riley McClelland

In general, changes in climate can affect the resiliency of tree populations because seed production, germination and establishment are particularly sensitive to variations in the environment. While recruitment may decrease significantly due to climate change, persistence of adult trees (albeit without reproducing) can lead to a deceptively "healthy" looking forest (Brubaker 1986).

NPS Photo

Fire

Fire is an integral part of the ecology of whitebark pine communities. Whitebark pine has adapted to a fire-prone ecosystem using two strategies: 1) large trees (i.e., trees with a diameter larger than a pole) can survive low- to moderate-severity fires; and 2) Clark's nutcracker facilitates the establishment of whitebark pine in newly burned areas that are created by mixed severity and stand-replacement fires by caching whitebark pine seeds (USFS n/a). Larger, stand-replacing fires can, however, kill mature, seed-producing whitebark pine trees, and may increase in frequency with a warmer and drier climate (Koteen 2002). However, a lack of fire, in conjunction with an increase in temperature and decrease in precipitation, may allow later successional species, such as subalpine fir and Engelmann spruce, to outcompete whitebark pine (Tomback et al. 2001).

Other Monitoring Efforts: Past and Present

Within the Greater Yellowstone Ecosystem

There have been several efforts in recent years to asses the status of whitebark pine and white pine blister rust. In 1995 Kate Kendall (USGS) initiated an effort to determine the status of whitebark pine in national parks of the Rocky Mountains, including the Greater Yellowstone Ecosystem (Kendall et al. 1996a). Dan Tyers (USFS) initiated a similar effort, primarily in the Gallatin National Forest (Kendall et al. 1996b), which is ongoing. More recently, Maria Newcomb completed a Master's thesis aimed at detecting and describing the spatial pattern of white pine blister rust, particularly in relation to its Ribes host species (Newcomb 2003). There have been additional smaller efforts, primarily by the USFS (e.g., Shoshone National Forest) to assess and/or monitor whitebark pine. Since 1980, the Interagency Grizzly Bear Study Team (USGS) has monitored cone production on 19 transects within the grizzly bear recovery zone of the GYE. This effort is used primarily as an indicator of activity and demography of bears, rather than an indicator of whitebark pine health or production.

Although there have been several efforts aimed at assessing whitebark pine in the GYE, contributing agencies share a concern that efforts have generally lacked consistency and cooperation and most efforts have not been explicitly designed to monitor whitebark pine on long time scales. Thus, the aim of our cooperative effort is to design a scientifically defendable and consistent monitoring program for whitebark pine throughout the entire GYE.

Outside the Greater Yellowstone Ecosystem

There have been numerous monitoring efforts outside of the Greater Yellowstone Ecosystem. Probably the most prevalent has been the efforts of the Whitebark Pine Ecosystem Foundation (WPEF), a nonprofit group dedicated to counteracting the decline of whitebark pine and enhancing knowledge of its ecosystems. The WPEF has expended considerable effort in the development of monitoring protocols and training. We have drawn substantially from their effort, although we have also adjusted our protocol to better suit the objectives of our program.

Measurable Long-term Objectives

When reviewing the literature on ecological monitoring, there is universal consensus that setting realistic, clear, specific and measurable monitoring objectives is a critical, but often difficult, first step. Olsen et al. (1999) summarizes well the need for clear and specific monitoring objectives in the following statement:

> *"Although the need for a clear and concise statement of the monitoring objectives may be obvious, we feel that it is worth reemphasizing. Most of the thought that goes into a monitoring program should occur at this preliminary planning*

stage. As illustrated in Knopman and Voss (1989) and Gilbert (1987), different objectives require different monitoring designs. These objectives also guide, if not completely determine, the scope of inference of the study and the data collected, both of which are crucial for attaining the stated objectives. If the monitoring objectives are clearly stated, it will be easier to describe the statistical methods to be used to analyze the data. Although simple in concept, the presence of multiple and perhaps conflicting objectives and the reality that the objectives may change with time complicates monitoring program design. Consequently, an optimal design for any particular monitoring program may not exist, and the choice must be based on compromise (Stehman and Overton, 1994). Nevertheless, a clear and concise statement of monitoring objectives is essential to realize the necessary compromises, select appropriate locations for inclusion in the study, take relevant and meaningful measurements at these locations, and perform analyses that will provide a basis for the conclusions necessary for meeting the stated objectives. ..... In all cases, a general statement of objectives is given that has the elements of 'describe the status and trends of ...' This level of detail is not sufficient to guide the design of major monitoring."

Photo courtesy of Dan Reinhart

Olsen et al. 1999

This step of defining and agreeing upon clear monitoring objectives will be a major thrust of our initial effort toward a long-term monitoring program. Long-term monitoring objectives are presented below.

General Questions Being Asked

Our specific monitoring objectives are intended to answer the following question(s): Is white pine blister rust increasing within the Greater Yellowstone Ecosystem, and is the resulting mortality of whitebark pine sufficient to warrant consideration of management intervention (e.g., active restoration)?

Specific Long-term Monitoring Objectives

OBJECTIVE 1 - To estimate the proportion of whitebark pine trees (>1.4 m high) within the Greater Yellowstone Ecosystem (GRTE, YELL and six national forests) infected with white pine blister rust, and to estimate the rate at which infection of trees is changing over time.

Justification/Rationale for this Objective: White pine blister rust has devastated whitebark pine in other parts of the Northwest (Kendall and Keane 2001, Koteen

2002), and anecdotal evidence suggests that infection rates may be escalating in the GYE (Koteen 2002, D. Tomback, pers. comm.). Whitebark pine is a keystone species of the upper subalpine ecosystem and its large seeds (largest of the conifers in that zone) represent an important food source for Clark's nutcrackers, red squirrels and grizzly bears (Tomback et al. 2001). The loss of seed-producing trees can affect not only grizzly bears and other wildlife, but also the persistence of this community type within the GYE.

OBJECTIVE 2 - Within infected transects, to determine the relative severity of infection (i.e., stage and magnitude of infection and proportion of canopy kill) and to estimate the change in severity over time of white pine blister rust in whitebark pine trees > 1.4 m high within the Greater Yellowstone Ecosystem (GRTE, YELL and six national forests).

Justification/Rationale for this Objective: Determining the proportion of trees infected with white pine blister rust can be misleading without a further understanding of the magnitude of the infection. Given that within-tree spread of blister rust occurs primarily from new infections from the source, rather than spread from existing infections, trees that are infected at low levels may persist for considerable time in the absence of new infections (Koteen 2002). If the tree is infected near the crown, then the infection is most likely to cause cessation of cone production. It has been hypothesized that these types of infections occur more often than other types of infections in the GYE (Koteen 2002). The influence of the infection on tree mortality is highly dependent on the location of the infection, the age of the tree and other factors (such as mountain pine beetle infestations, root diseases, etc.); for instance, young trees that become infected almost always die relatively quickly, as do trees weakened by other causes (Koteen 2002).

OBJECTIVE 3 – To estimate survival of individual whitebark pine trees > 1.4 m high in the Greater Yellowstone Ecosystem (GRTE, YELL and six national forests), explicitly taking into account the effect of the presence and severity of white pine blister rust infection, infestation by mountain pine beetle and fire.

Justification/Rationale for this Objective.-- There has been some debate as to whether whitebark pine in the Greater Yellowstone Ecosystem is as vulnerable to the effects of white pine blister rust as it is in other regions (Carlson 1978, Arno 1986). Basidiospores of white pine blister rust are thought to be transported primarily during high-moisture events (e.g., during periods of rain and fog [Hirt 1942, Van Arsdel 1956]), and the Greater Yellowstone Ecosystem is generally drier than other regions where white pine blister rust has been devastating to whitebark pine. Further, within-tree spread of blister rust occurs primarily from new infections from the source, rather than spread from existing infections (Koteen 2002). Trees that are infected at low levels may persist for considerable time (i.e., decades) in the absence of new infections, depending on the location of the infection (Koteen 2002). Estimating survival will enable us to distinguish the occurrence (and severity) of white pine blister rust from the ecological effect of infestation (i.e., loss of mature whitebark pine), which will allow for determination of the vulnerability of whitebark pine in the Greater Yellowstone Ecosystem directly, rather than relying on potentially controversial extrapolation from other regions.

OBJECTIVE 4 – Currently in the planning stages, this objective is aimed at assessing recruitment into the cone producing population. We anticipate a pilot effort to begin in 2011.

Photo courtesy of B. Riley McClelland

Future Considerations For Monitoring Whitebark Pine

Moving toward Model-based Inference

The proposed objectives fall primarily under a "design-based" framework (e.g., Hansen et al. 1983), which uses probability sampling to derive inferences about the state variables and/or vital rates of interest. This approach has an advantage of minimizing the number of assumptions required to drawn inference, which makes it well suited for such things as litigation and controversial public policy decisions (Olsen et al. 1999). However, one disadvantage is that it is poorly suited for future predictions (Olsen et al. 1999). Predictions of future system states require a model-based approach, which comes at a cost of requiring a greater number of simplifying assumptions (Olsen et al. 1999). However, as our program advances to the point where it is reasonable to develop alternative hypotheses regarding system changes in response to environmental or management induced factors, a model-based approach will better enable us to move from a descriptive approach to a more scientific (e.g., quasi-experimental) approach that may have considerable advantage for understanding the system and for predicting the outcome of management decisions (see also Yoccoz et al. 2001).

Adaptive Management for Whitebark Pine Restoration

If active restoration of whitebark pine is initiated via planting or other direct management intervention, a second phase of monitoring that would evaluate the relative effectiveness of alternative restoration strategies should be initiated Figure 1-1. This should be designed and implemented to inform decisions regarding the most effective strategy for achieving the management objectives of any restoration effort.

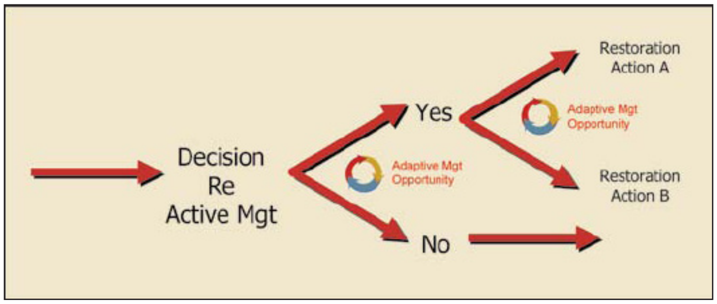


Figure 1-1. Conceptual diagram of potential decisions that could benefit from incorporating an adaptive management approach to the design.

Chapter2

Sample Design

Overall Design

The primary goal of the whitebark pine monitoring effort is to characterize the current status and change over time of blister rust in the GYE. Sampling will generally begin in June and end in September. Our basic approach is a stratified 2-stage cluster survey design with stands (polygons) of whitebark pine being the primary units and 10x50 m transects being the secondary units.

Target Population, Sample Frame And Sampling Units

Our target population is all whitebark pine trees in the GYE. Ideally we would have identified the full target population and sampling frame a priori, especially as regards stratification variables. On one level the target population is easy to identify: all whitebark pine trees in the GYE. It is, however, not possible to identify and map all whitebark pine trees. This target population is also infeasible from a logistical standpoint. Accordingly we decided to define the target population in terms of identified whitebark pine stands or polygons in a GIS vegetative layer. A sample of stands would be chosen using a probability based sampling method followed by selection of transects within stands. Our initial sample frame, from which a sample was drawn in 2004, was from the vegetation layer of the cumulative effects model for grizzly bears derived from photo interpretation (Dixon 1997). From this frame, we identified whitebark pine stands of approximately 2.5 ha or greater within the US Fish and Wildlife Service Grizzly Bear Recovery Zone (RZ). At times the RZ has also been referred to as the Grizzly Bear Primary Conservation Area or PCA (Interagency Conservation Strategy Team 2003). In 2005, we extended our efforts outside the RZ using an expanded sample frame comprised of whitebark stands mapped by the USFS National Forests within the Greater Yellowstone Ecosystem. Areas that had burned since the 1988 fires were excluded from our samples, as they are too young, but these stands will likely be included in a later phase of this project focused on recruitment.

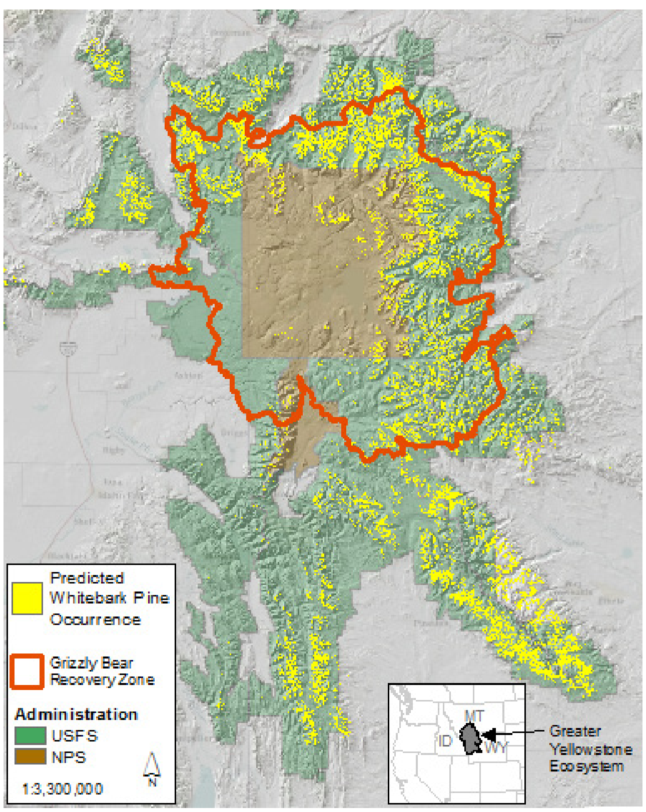


Figure 2-1. The study area showing administrative units (National Park Service and U.S. Forest Service and the boundary of the Grizzly Bear Recovery Area (RZ).

An effort is currently underway for a unified seamless sample frame derived from classified satellite imagery that is augmented with additional predictor variables.

Sample Design

The initial results from this effort look very promising, although it may require some adjustment of our sample when it is completed in order to align our sample with the new sample frame. For example, if the new frame identifies stands of whitebark that were previously overlooked, we may need to augment our sample to include these stands.

Photo courtesy of Karla Sartor

Stratification

In 2004 we had not identified any stratification variables. At that time we were leaning toward stratifying on distance to road or some other variable that would account for the logistical difficulty of visiting some stands. We also knew that we had not accounted for all stands in the GYE due to gaps in our coverages and due to a lack of updates subsequent to fires (especially the 1988 fires). We also had questions about the validity of the data we did have, i.e., size of stand, etc. We attempted to correct for some of these deficiencies in 2005 and 2006. It became apparent, based on discussion with the field crews, that stratification of stands on the basis of the logistical difficulty of visiting them was not necessary. However, a natural stratification variable was identified; whether or not a stand was inside or outside the Grizzly Bear Recovery Zone (RZ). This stratification was instituted the second year of the initial survey (2005).

Sampling Units

Our primary sampling units are whitebark pine dominated stands of approximately 2.5 hectares or larger. Based on our initial sample frame, we had 2428 stands of whitebark within the RZ and 7,924 stands outside the RZ. Our secondary sampling units are 10 by 50 meter transects located within each stand (as recommended by the Whitebark Pine Ecosystem Foundation [WPEF] protocol).

Currently, we have identified 2362 whitebark pine stands inside the RZ and 8408 stands outside the RZ for a total of 10770 stands. These numbers have changed over the past 3 years for a number of reasons. There have been updates in the definition of a stand. There have been changes due to the incidence of fire. One problem we have faced is that the definition of a stand differs from one part of the GYE to another, i.e. the definition of a stand on the Gallatin National Forest was not the same as the definition of a stand on the Bridger-Teton National Forest. Thus a single stand in one administrative jurisdiction might have been denoted as 2 or more stands in another. One consequence of problems such as these is that there was a tendency to under or over sample parts of the GYE. Another implication of inadequate mapping is that some identified stands of whitebark were not whitebark pine, either due to misidentification or fire.

Selection of Sampling Units

We selected a simple random sample from our population of stands. However, the sample frame is subject to inaccuracies due to mapping errors and limitations of spatial extent of mapping. There was consequently the potential for the field crew to spend a great deal of time walking into an area only to find that a mapped polygon does not exist. Accordingly, if the initial polygon was not suitable then the crew choose the next nearest polygon. Our preliminary efforts indicate that this is an extremely rare event, which seems a minor constraint on the randomization procedure that is justified by the limited time during which the crew has to collect data.

In 2005, we discovered an additional source of inaccuracy of our initial sample frame. Different efforts contributing to the mapped distribution of whitebark pine used different criteria to define stands (polygons) of whitebark pine. This resulted in some administrative units having different probabilities of being sampled as an artifact of their delineation criteria. This was most apparent outside of the RZ because similar criteria were used within that area as part of a cumulative effects model (Mattson et al. 2003). Most notably, this problem resulted in over sampling the Gallatin National Forest, and under sampling the Bridger-Teton National Forest. In 2006, we adjusted our sample to correct for this area such that our resulting sample was proportional to the actual area of whitebark pine based on a preliminary effort of consistently mapping whitebark pine using satellite imagery (Figure 2-2). Eventually, we anticipate that a fully consistent sample frame for the entire GYE will be available and we will need to evaluate the tradeoffs at that time of switching to a new sample frame.

Within the selected primary unit, we had pre-selected a simple random sample of five points. The first of these was the targeted mid-point of our secondary unit. A random vector was used to lay out the 10 x 50 m transect. If no whitebark were included within this transect, the next closest alternate was used. In the event that alternative vectors from that location were unlikely to include whitebark, the next "alternative" starting point was used.

Temporal Revisit Design

Infection by white pine blister rust is a slow process, such that detection of annual change would not be effective or practical. Consequently, a "rotating panel" approach is used to build up a complete GYE sample over a four-year revisit frequency (Figure 2-3). Monitoring sites established from 2004 through 2007 were assigned by the Working Group in 2008 to one of four panels, each of which is surveyed every fourth year starting in 2008. Thus a panel that was sampled in 2008 would be sampled again for blister rust evidence in 2012. The simulations below indicate substantial gain in precision for estimating the proportion of trees infected with blister rust using a sample between 50 and 100 transects, but the relative gain after about 150-200 transects may not justify the additional cost and effort.

Sample Design

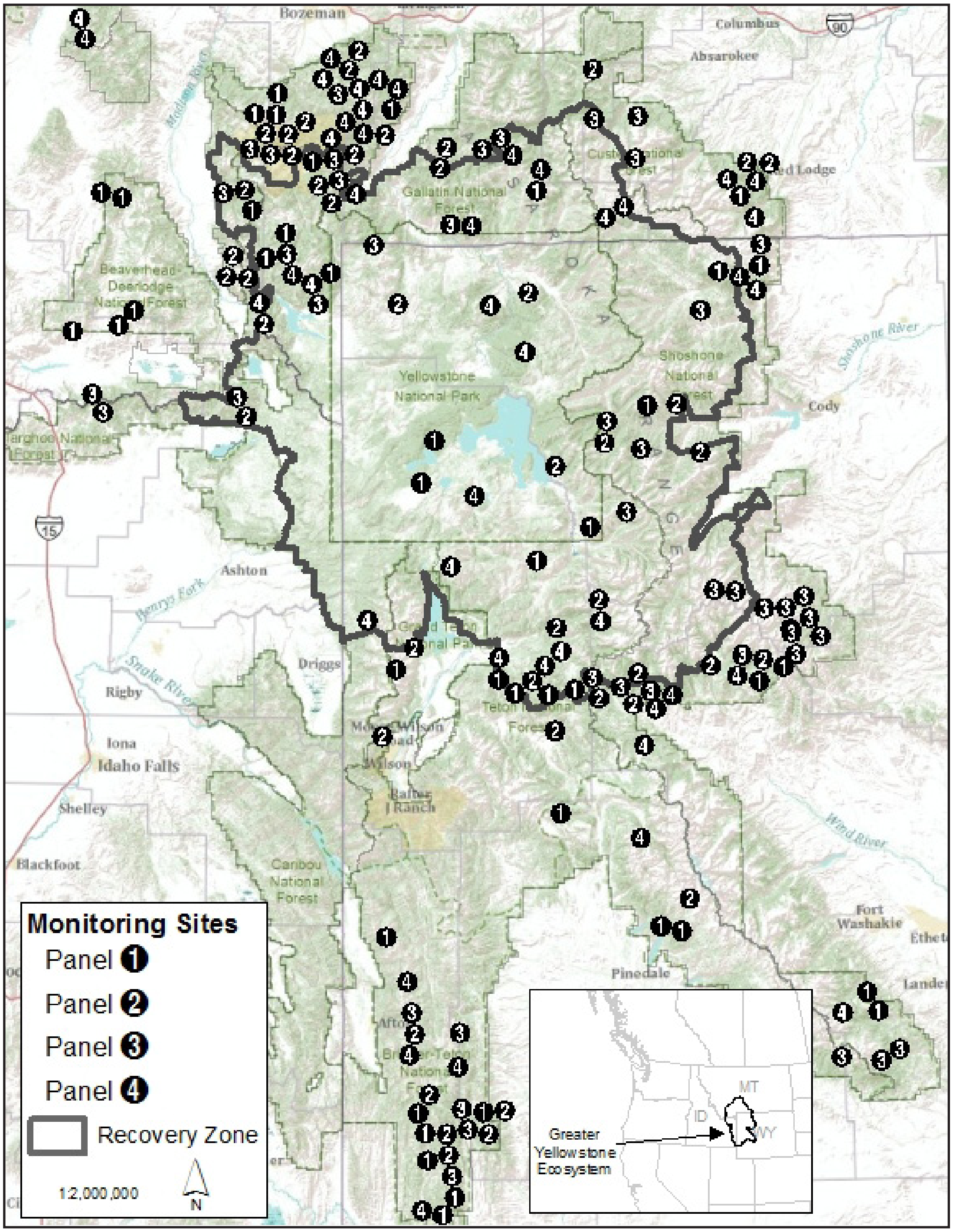


Figure 2-2. Study area showing the location of 176 transects established from 2004-2007 for long term monitoring in six national forests and two national parks.

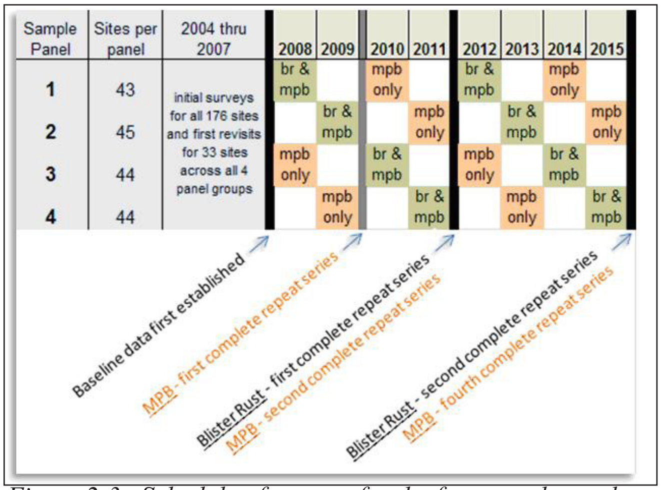


Figure 2-3. Schedule of surveys for the four-panel sample design.

In contrast to blister rust infection, the effects of mountain pine beetle occur much more rapidly. In order to provide a ground-based complement to aerial detection surveys covering large areas, crews visit established monitoring sites in one additional panel each year in order to record evidence of mountain pine beetle. This schedule generates a complete GYE sample of mountain pine beetle data every two years. Continuation of these mountain pine beetle "Only" surveys will depend on the course of the current beetle epidemic and funding availability.Some Preliminary Assessments

The previous protocols have suggested using a variable length transect such that the length is extended from an initial value of 50 m if there are not at least 50 trees within the transect. However, a "variable-length" transect may result in biased estimates of the primary parameter of interest. The basis for this variable length is also a perception that a minimum of 50 trees is needed. However, the sampling unit is the plot, not the individual trees. Using individual trees as the sampling unit would be a form of pseudoreplication (Hurlbert 1984) that results in an inappropriate error term for subsequent statistical analyses. Simulations by Dr. Steve Cherry (Montana State University, Department of Statistics) have indicated the degree of bias from using variable length plots. Given the potential for biased estimates, the tradeoffs between number of transects vs number of trees per transect, and concerns about pseudoreplication, we will use fixed length plots.

Balancing the number of transects and the number of trees within each transect

Recognition of the potential bias resulting from variable length transects still does not resolve our concern about how to balance the number of transects with the number of trees within each transect. Thus a second simulation was used to explore these tradeoffs.

For this simulation, the mean number of trees within transects varied from 10 to 50 in increments of 10. The number of transects varied from 50 to 150 in increments of 50. Thus, there were 15 combinations of transect/tree numbers. The number of trees in each transect was determined by drawing a random sample from a negative binomial distribution with the specified mean. The negative binomial was used because the number of trees was more variable than required for sampling from a Poisson distribution. Once the number of trees on a plot was determined, the number infected was determined by assuming each tree had a probability of 0.10 of being infected (based on infection rates observed during previous studies).

The mean and standard error was computed for each trial and 1000 trials were run for each of the 15 transect/tree size combinations. The results indicated that the standard errors were fairly low in each case (Figure 2-4).

Another view of the tradeoffs between the number of transects and the number of trees within each transect is to examine the resulting confidence intervals (Figure 2-5). Obviously, sampling more transects and more trees within each transect will yield better results. But, realistically, it appears that 100 transects with somewhere around 15 to 20 larger trees per transect on average will be sufficient to produce reasonable estimates of status. It also appears that we gain relatively more efficiency by increasing the number of transects in our sample, as opposed to increasing the number of trees per transect. However, these results are based on an assumed simple random sampling plan with clusters

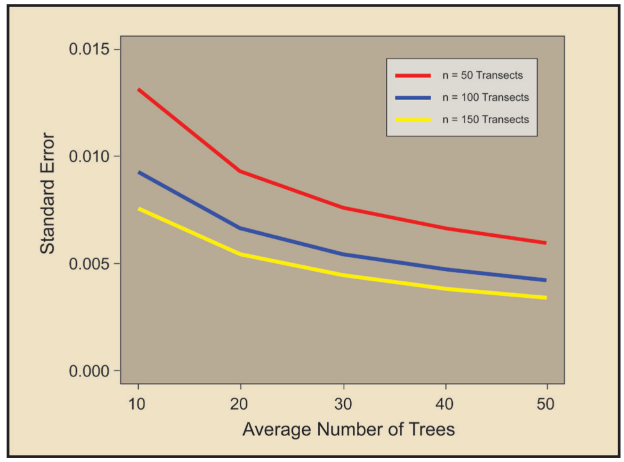


Figure 2-4. Results from simulation showing the mean standard error as a function of the average number of trees (ranging from 10-50), given 50,100, or 150 transects.

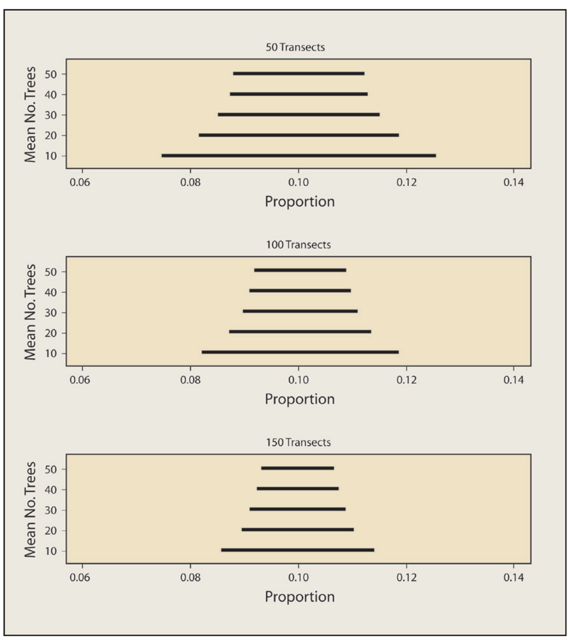


Figure 2-5. Results from simulation showing the empirical 95% confidence interval as a function of the mean number of trees and the number of transects, given a true value of 0.10 proportion of trees.

A Preliminary Evaluation of Precision, Desired Level of Change Detection, and Sample Sizes

We have used previous data collected by Dan Tyers and Kate Kendall to investigate the precision of estimation of the proportion of infected trees assuming that the transects represented a simple random sample of transects across the ecosystem. The updated sampling plan and information of polygon size (in square meters) allows us to update this work. The constraints on randomization have the advantage of helping to insure that the transects are spatially distributed as needed. However, a disadvantage is that such constraints can increase variability in the estimates. This is particularly likely to occur when the units have unequal inclusion probabilities.

We investigated the precision via simulation. The simulations were done in the statistical computing language R. We carried out two types of simulations. The first assumed 100 transects with varying proportions of infection from 0.1 to 0.3 in increments of 0.05. The second assumed an infection rate of 0.1 with 50, 100, 200 and 300 transects. The basic assumption is that a polygon is chosen randomly with a transect randomly chosen within each transect. We further varied the average number of trees in each transect from 5 to 35 in increments of 5. We assumed the number of trees followed a negative binomial distribution with the variance equal to about 10 times the mean. This was based on the results we observed in the transects read by Tyers and Kendall. The proportion of infected trees in the several hundred transects run by Tyers and Kendall was around 0.1 for pole size trees and larger. We assumed the infection rates in the transects followed a binomial distribution with the indicated means. In all cases the proposed method of sampling and analysis produced essentially unbiased estimates of the infection rates. The standard errors are standard deviations of the estimated rates of infection in 1000 simulations.

Simulation 1

As can be seen from Figure 2-6, the standard errors are fairly large. The second is that the average number of trees per polygon is important. The mean number of larger trees observed on the plots run by Tyers and Kendall was around 15 but the overall mean number of trees (including seedlings and saplings) was quite a bit higher. Also, note that the precision decreases dramatically as the proportion of infected trees increases. This obviously has implications for monitoring the change in infection rates over time. As more trees become infected it may be more difficult to detect meaningful changes. In other words, the number of plots needed to detect a meaningful change from 0.10 will be smaller than the number required to detect a meaningful change from 0.30.

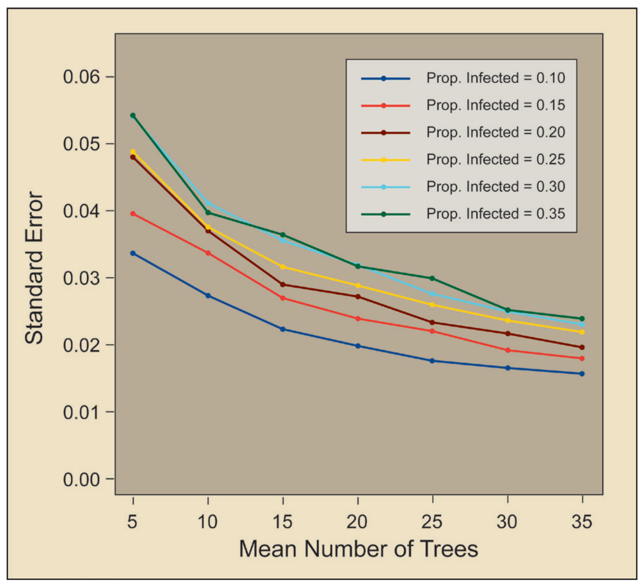


Figure 2-6. The standard error as a function of the mean number of trees per transect and the proportion of trees infected.

Simulation 2

Given a mean infection rate of 0.10 for this comparison, increasing the number of transects improves precision; but the relative advantage of adding more transects decreases as the mean number of trees increases until approximately an average of 20 trees per transect (Figure 2-7). Beyond this, the advantage of adding additional transects is diminished, especially when at least 100 transects have been established. Our sample through 2006 is 166 transects with an average of approximately 27 trees per transect.

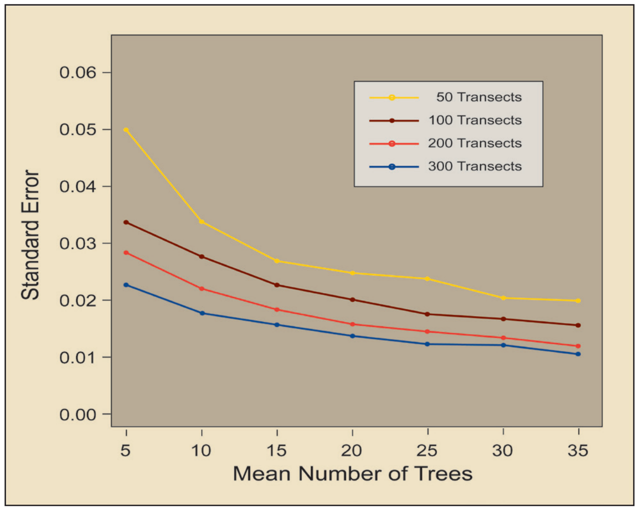


Figure 2-7. The standard error as a function of the mean number of trees per transect and the number of transects.

Simulation 3

In simulation three, we also briefly investigated the improvement in precision attained by increasing the number of transects within the polygons. The mean infection rate was set at 0.10. Figure 2-8 shows the results for selecting 100 polygons with 1 transect per polygon, 200 polygons with 1 transect per polygon, and 100 polygons with 2 transects per polygon. It appears that there is some gain by increasing the number of transects within polygons. This gain in precision is not great but there is an increase and it would be attained with much less effort on the part of field crews. Further, have some level of replicate samples (transects) within polygons gives us a needed within-stand (polygon) variation component for our analysis.

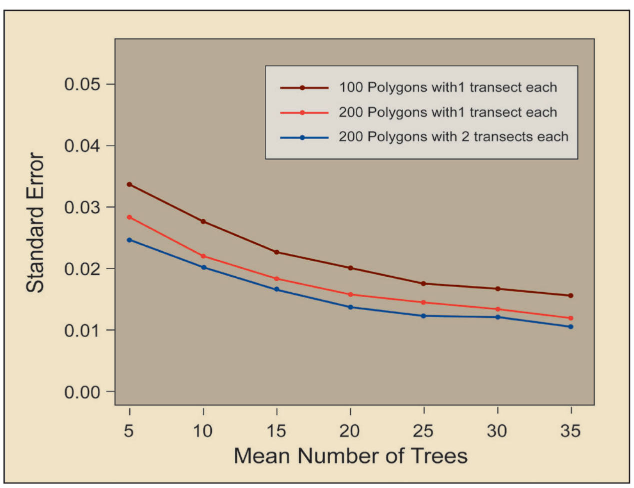


Figure 2-8. The standard error as a function of the mean number of trees per transect, the number of polygons (whitebark pine stands) and the number transects per polygon.

A Revised Evaluation based on Preliminary Data

Within and Between Stand Variation

Denoting transects as secondary sampling units (SSU) and stands as primary sampling units (PSU) we have a two-stage cluster sample. One problem immediately apparent is that with only one 1 SSU per PSU there is no chance to quantify within stand sampling variability of infection rate. In an effort to at least evaluate the importance of within stand variability field crews were instructed to sample an additional transect when possible. Although the second transects were selected randomly from within a stand field crews chose second transects when they had time to complete them, i.e. either the first transect was quickly run due to there being few trees or it was close to a road. Thus, the use of second transects assumes that within stand variability is not related to either of those 2 variables.

The tables below summarize stand visitation by year and stratification variable.

Table 2-1. Number of whitebark pine stands visited and transects run by year in the Greater Yellowstone Ecosystem. There are a total of 10770 such stands currently mapped in the ecosystem.

Year	Number Stands	Number Transects
2004	45	51
2005	55	76
2006	36	40
2007	15	15

Table 2-2. Number of whitebark pine stands visited and transects run by year inside the Grizzly Bear RZ. There are a total of 2362 such stands currently mapped in the ecosystem.

Year	Number Stands	Number Transects
2004	43	49
2005	0	0
2006	16	18
2007	5	5

Table 2-3. Number of whitebark pine stands visited and transects run by year outside the Grizzly Bear RZ. There are a total of 8408 such stands currently mapped in the ecosystem.

Year	Number Stands	Number Transects
2004	43	49
2005	0	0
2006	16	18
2007	10	10

Estimation

We assume we have the following sampling design. We have 2 strata. Within each strata we have a 2 stage cluster sample. It is apparent from above that an analysis based on this design requires assumptions that are going to be violated to some extent. These assumptions are based on modifications to our original sampling plan imposed by logistics, different definitions of a stand in 2 different administrative units, changes to the sampling frame of stands due to changes in definitions and mapping, and other reasons. Ideally we would use the first 3 years of data as a pilot study to aid in the design and implementation of a sampling plan whose validity would not depend on so many assumptions. Unfortunately, this is both logistically and politically undesirable. We present an initial analysis of the results based on both the above suggested sampling plans.

Cluster Sampling

We randomly sampled 59 stands from the 2362 stands inside the RZ and 77 stands from the 8408 outside the RZ. Due to logistical constraints we were able to sample only one transect from most stands but, we did get 2 transects run on 8 stands inside the RZ and 23 stands outside the RZ. The area of each stand was determined (in meters squared) and this was used to determine the potential number of 500 square meter transects that could have been run. This is not strictly true because we did not grid each stand into separate transects but determined a transect location and orientation randomly. The total number of trees was recorded on each transect as well as the number that were believed to be infected with white pine blister rust. We estimated the proportion of trees infected with rust in each of the strata and in the ecosystem as a whole. We accomplished this as follows.

Let y_{ij} denote the number of trees recorded on the *j*th transect in stand *i*. Let y_i be the mean number of trees per transect in stand *i*. Let M_i be the number of transects in stand *i*. The estimate of the total number of trees is given by equation 5.28 on page 148 in Lohr (1999):

Let x_{ij} be the number of infected trees recorded on the *j*th transect. Let x_i be the mean

$$\hat{\hat{y}} = \frac{\sum M_i \overline{y}_i}{\sum M_i}.$$

number of infected trees per transect in stand *i*. The estimate of the total number of infected trees is :

$$\hat{\hat{x}} = \frac{\sum M_i \overline{x}_i}{\sum M_i}.$$

The proportion of infected trees is then

$$\widehat{p} = \frac{\widehat{\overline{x}}}{\widehat{\overline{y}}} = \frac{\sum M_i \overline{x}_i}{\sum M_i \overline{y}_i}.$$

Ignoring the within stand variability the variance is

$$\widehat{V}(\widehat{p}) = (1 - n/N) \left[\frac{1}{n(n-1)\left(\overline{M_i \overline{y}_i}\right)^2} \sum (M_i \overline{x}_i - \widehat{p} M_i \overline{y}_i)^2 \right].$$

These calculations are carried out for each stratum separately then combined to produce an estimate for the ecosystem. The results are given below.

Stratum Population	Stratum Sample Size	$\hat{p}$	$\hat{V}(\hat{p})$	SE
2362	59	0.1383	0.0020219	0.04497
8408	77	0.2957	0.0020247	0.04500

Let $\hat{p}_0$ be the estimated proportion outside the RZ and $\hat{p}_1$ be the estimated proportion inside the RZ. Similarly we use N_0 and N_1 to denote the number of stands outside and inside the RZ, respectively. The total number of stands is $N = N_0 + N_1$. We can combine the stratum level estimates above into an ecosystem wide estimate as

$$\widehat{p}_{str} = \frac{N_O}{N}\widehat{p}_O + \frac{N_I}{N}\widehat{p}_I$$

with estimated variance

$$\widehat{V}(\widehat{p}_{str}) = \left(\frac{N_O}{N_I}\right)^2 \widehat{V}(\widehat{p}_O) + \left(\frac{N_I}{N}\right)^2 \widehat{V}(\widehat{p}_I).$$

The estimate for the entire ecosystem is then

$$\widehat{p}_{str} = \frac{2362}{10770}(0.1383) + \frac{8408}{10770}(0.2957) = 0.2612.$$

The estimated variance is

$$\widehat{V}(\widehat{p}_s) = \left(\frac{2362}{10770}\right)^2 (0.0020219) + \left(\frac{8408}{10770}\right)^2 (0.0020247) = 0.00133$$

yielding a standard error of 0.0365.

The above calculations of variances and standard errors ignore the finite population correction factors (which are very close to 1). They also ignore the within stand variability. We feel this is justified based on analysis of mutlitransect stands. We evaluated this, for example, by analyzing the stands outside the RZ for which we had $m_i = 2$ transects. We had $i = 1; 2, \cdots, 23$ such stands. We estimate the proportion of infected trees outside the RZ to be $\hat{p} = 0.282$. This is close to the estimate using all 77 stands. Define $d_{ij} = y_{ij} - \hat{p}x_{ij}$ and

Ignoring the finite population correction factor, the estimate of the within stand variance is given by

$$s_i^2 = \frac{\sum_{j=1}^{m_i} \left(d_{ij} - \widehat{p\overline{d}}\right)^2}{m_i - 1} = \sum_{j=1}^{2} \left(d_{ij} - \widehat{p\overline{d}}\right)^2 .$$

$$\frac{1}{n^2 N} \left(\frac{n}{\sum_{i=1}^{n} M_i \overline{x}_i}\right)^2 \frac{\sum_{i=1}^{n} \left(M_i^2 s_i^2\right)}{m_i}$$

which is added to the between stand variance formula above. Ignoring the within stand variance we estimate the variance of the estimated proportion to be 0.007481 (se = 0.08649) and taking the within stand variability into account yields an estimated variance of 0.007494 (se = 0.08657). Thus, the within stand variability adds little for these 23 stands. If these stands are typical then we would appear to be justified in sampling only a single transect within each stand. However, we believe that it is worthwhile to continue to sample multiple transects per stand when feasible so that we may continue to evaluate this.

Change Over Time

White pine blister rust has been in the GYE for decades. Aside from anecdotal accounts little has been done on quantifying its spread. USGS Research Biologist Kate Kendall led a study in the mid 1990's to examine the extent of rust in the GYE. The data have never been published, however Kendall has made the data available.

We were able to identify 113 transects in the GYE that contained enough information to carry out an initial analysis. These 113 plots all fell within the RZ. Plot layout and field crew training differed from our protocol. Plot locations were not randomly selected, or at least were not selected using a probability based sampling method. Trees were classified into age categories based on diameter at breast height (DBH). We did not consider seedlings (DBH < 1 inch) in the following analysis. Kendall also recognized that diagnosis of rust infection was often subjective. Her field crews used 3 different codes for rust infection, definitely infected, probably infected, and uninflected. Data were recorded at the tree level. For our analysis we pooled definitely infected and probably infected into a single category (infected).

We treated the 113 plots as a simple random sample of plots and estimated the proportion of infected trees using ratio estimation. This approach is equivalent to considering the sample to be a single stage cluster sample with plots as primary sample units and trees as secondary sample units. We estimated the proportion of infected trees to be 0.086 with a standard error of 0.0162. Our estimate of infection inside the RZ was 0.138, an increase of 0.052 over an approximately 8 to 10 year period. We bootstrapped the standard error of the difference in infection rates (0.052). The 95% confidence interval, based on identification of the 2.5th and 97.5th percentiles of the bootstrap distribution of the difference in infection rates ranged from -0.023 to 0.175, i.e. the data are consistent with changes in infection rate ranging from a decrease of approximately 2:3% to an increase of 17.5%. We caution that formal statistical inference is valid only under an assumption that Kendall's data resulted from a simple random sample of plots selected from a larger population of plots. Our primary use of these data is to provide us with ball park estimates of the infection rate in the mid to late 90's and of changes since that time. We believe it is adequate for that. We have no previous data from outside the RZ where our estimated infection rates are considerably higher. One question of interest is how to estimate a change in the rate of infection. The comparison discussed above is not relevant as it was based on a comparison of 2 estimates from data collected using 2 different methods. The obvious estimator for our data is the difference between the estimated rates of infection in time period 2 and time period 1. However, this would not be a difference in proportions determined from 2 independent samples because the data are paired by transect. Let $\hat{p}_j$ be the estimated rate of infection at time period j. Let

$$y_{\cdot j} = \sum_{i=1}^{n} M_i y_{ij}.$$

Then

$$\widehat{p}_j = \frac{\sum_{i=1}^{n} M_i x_{ij}}{y_{\cdot j}}$$

and

$$\widehat{p}_2 - \widehat{p}_1 = \sum_{i=1}^{n} M_i \left[\frac{x_{i2}}{y_{\cdot 2}} - \frac{x_{i1}}{y_{\cdot 1}} \right] = \sum_{i=1}^{n} d_i$$

The standard error of the estimated difference is just the standard deviation of the di's. This standard error should be less than a standard error computed ignoring the paired nature of the data. Standard errors could also be estimated using bootstrapping, which might be advisable as it obviates the requirement of normality.

We do not have data currently available to assess how well such an approach might work. A simple example of the approach using fake data follows. The sample size is 67 stands with sizes equal to the sizes of the 67 stands we currently have inside the RZ. We created a new data set with counts adjusted to create an increase in infection rate of 0.071. The data are paired but manipulated so that total number of trees and number of infected trees varied. The mean of the bootstrap distribution (based on 1000 bootstrap iterations) was 0:076 implying a slight bias in the estimate. The bootstrapped standard error was 0:020, large enough to justify ignoring the bias but small enough to provide some confidence in the ability to detect changes of interest to managers.

Multiple observer plots

One source of error which has not been adequately addressed by existing protocols, but anecdotal evidence indicates may be extremely important, is observer differences. To better assess the extent of this potential source of error, we will use a double observer approach for a subset of the sample. For this effort a second (or third) observer should work one tree behind the initial observer, but remain sufficiently close so as not to impose a safety hazard. All observers will record the same information for each tree without any knowledge of what the other recorded. We emphasize that this is not a test of the accuracy of the individual observing. Observers should not compare notes, communicate about what they recorded or in any way alter their data in response to the other observer. Our intent is only to determine the extent of consistency among observers so that, if necessary, we might better take this into account in our final design.

3 Field Methods

3.1 Preparation for the field season

3.1.1 Panel membership

Transects are assigned to a membership panel. One panel (at a minimum) will be surveyed by field crews during each field season. If a transect is not surveyed in its assigned panel year (weather, fire closure, etc.), that transect will be surveyed as soon as possible the following year.

3.1.2 Seasonal timing of surveys

The survey season is scheduled during the summer months when all or most of the winter snow pack has melted. Surveying will start in June, depending on the hiring date of the field crews and on accessibility to whitebark pine (WbP) stands selected for monitoring. Surveying should continue into late August or through September, depending on funding and accessibility to stands.

3.1.3 Equipment

The following materials should be taken in the field each day that surveys are conducted. Make certain that you have sufficient amounts of the various articles on the list to get you through the survey and the rest of the day.

1. Timepiece
2. Binoculars
3. One (1) metric forestry tape
4. Metric DBH (diameter at breast height) tape
5. Two (2) compasses
6. GPS unit
7. Extra batteries
8. Maps—topographic, aerial, and photo quad
9. Data sheets, clipboard, pens, and pencils
10. Digital camera
11. Tree tags (both numbered and blank), nails, and wire—bring plenty
12. Hammer/hatchet
13. Monumenting nails and washers
14. Flagging/survey flags
15. Habitat and cover type forms keys and plant identification information
16. Bear spray
17. First aid kit
18. Radio and batteries or cell phone
19. PLB (personal locator beacon)

3.2 Safety in the field

Safety of field personnel should always be the first concern in implementing a long-term monitoring program. Fieldwork requires an awareness of potential hazards and knowledge of basic safety procedures. The basic elements of safety involve using common sense and being aware of your surroundings at all times. Advanced planning can eliminate many safety hazards or at least reduce them. Fieldwork requires planning that anticipates the risks and dangers that field personnel may be exposed to so that precautions may be taken to limit threats to human safety as much as possible. Above all, employees should stop work if they feel that it is unsafe and remove themselves to a position of safety.

Field crews will consist of two employees and all transects will be visited by both members of the crew together—do not "divide and conquer." A basic itinerary will be discussed between the crew leader and the crew prior to deployment into the field. Should any changes occur while in the field, contact the crew leader as soon as possible with any variations to the original itinerary. Field crews will check in at the end of every work day or in cases where reception is not possible, as soon as contact can be made. The crew leader will carry a cell phone at all times while employees are in the field and will be available 24 hours/day during the entire working trip "hitch" for any assistance that the field crew may need. Field crew members will be trained in basic first aid and adult cardiovascular pulmonary resuscitation (CPR). Field crew personnel will carry basic safety equipment including but not limited to the following:

- First aid kit
- Flashlight
- Matches
- Radio and/or satellite phone
- All-weather personal gear
- Bear spray
- Personal locator beacon (SPOT or FastFind)

All new employees will attend a bear safety training course. Employees will be instructed on radio procedures and satellite phone operation. Prior to each hitch, the crew leader will hold a "tailgate" safety meeting specific to the area in which the crew will be working. If weather (lightening, extreme cold, rain, snow, etc.), animal (bear, moose, etc.), and/or road conditions are placing you at risk, STOP—take cover, get warm, pull over, or do whatever it takes to get to safety. Under all circumstances, safety comes first.

3.3 Locating and establishing permanent transects

3.3.1 Establishing transects within stands

Within each stand five random points will be selected to serve as potential center points for each transect and a corresponding random number between 0 and 359 will be selected to define the vector for the transect. The random points will be listed in rank order of selection, such that the first point in the list is the intended starting location. If that location is unsuitable (i.e., misclassified as having whitebark pine when it does not), the next closest point on the list becomes the starting point, and so on.

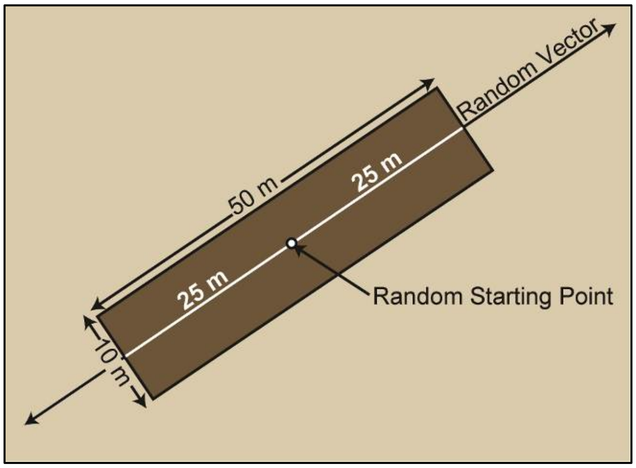


Figure 3-1. The layout of 10 x 50 m transects.

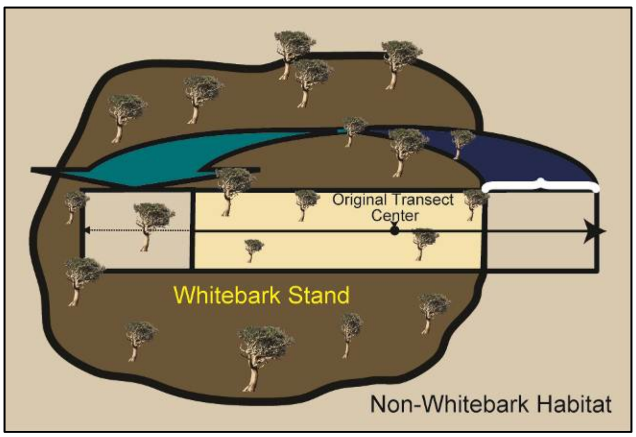


Figure 3-2. When a transect extends beyond whitebark habitat (e.g., into alpine tundra), then a distance equal to that which is outside of whitebark habitat is added to the opposite end of the transect to compensate.

A handheld GPS will be used to locate the coordinates. If a site is suitable for sampling (i.e., has at least one live WbP tree >1.4 m tall) a 10 x 50 meter transect will be permanently established (fig. 3.1).

If a transect has the minimum requirements for WbP but lies partly in non-target habitat type (e.g., open meadow, rock outcropping, cliff), establish the transect as usual but include a detailed description of where the end points were monumented (e.g., "end point was monumented at the 65 meter point beside the base of a large boulder"). Should a site not meet the minimum requirements except by adding the amount of the transect in the non-target habitat, monument as usual and note the reason for the shift.

3.3.1.1. Monumenting the transect

To assist in relocation of the transect in subsequent years, the beginning, center, and end points will be monumented with a 12 inch steel nail and large washer driven in at ground level and "X" and “Y” trees will be marked to facilitate relocating the monumented points. When the “X” and “Y” trees are found for each monumented point (beginning, center, end) upon future resurvey visits to the transect, the recorded azimuth taken from both trees should intersect at the respective point.

Begin with the center monument. To mark the “X” and “Y” trees, from the center monument, select the nearest, live tree to the transect line. This tree will be the “X” tree. Measure the distance from the center monument to the base of the “X” tree and drive a 2 1/8 inch aluminum “tree tag” nail into the base of the tree where the measurement was taken. At DBH or in a visible zone on the trunk, mark the tree with an aluminum tree tag, inscribed with a large “X” facing the transect line. Record the species, DBH and azimuth from the tree to the center monument. To monument the “Y” tree, select a tree that is as close to 90° from the monument as possible. Mark and record the same information for the “Y” trees as was marked and recorded for the “X” tree. Also record anything unusual or of note that would facilitate locating the “X” and “Y” trees. From the center point (UTM coordinates provided), a random vector (0 to 359°) will be determined for the transect (a list will be provided). With a compass, walk the random vector out 25 meters using a metric forestry tape. Monument the 25 meter mark with a 12 inch steel nail and a large washer driven in at ground level. This will be considered the “end” point of the plot. Back at the center point, walk the “back” vector (azimuth) 25 meters. At this monument, attach a numbered tag to the nail and washer and again drive in to ground level. This is the “beginning” of the transect. Next mark “X” and “Y” trees for both the beginning and end points in the same manner that the “X” and “Y” trees were marked for the center monument. Leave the tape stretched between the monuments until completion of the survey. At the center point and at both monuments record a UTM. Take a photo of the transect that captures the general nature of the stand.

3.3.1.2. Layout of the transect

After completion of monumenting, begin to delineate the boundaries of the 10 x 50 meter rectangle. With a second metric tape, measure out 10 meters using the centerline tape as a reference (5 m on both sides). At approximately 5 meter intervals, place a removable surveyor’s flag. These flags will provide a visual reference for the plot.

3.4 Measuring and recording site, survey, and tree attributes

When establishing or revisiting a transect, certain attributes will be collected at the site, survey and tree levels (fig. 3.2a), and recorded on paper forms while in the field.

3.4.1 Field units

All measurements will be taken or converted to metric units. The International System of Units is a modernized version of the metric system established by international agreement that provides a logical and interconnected framework for all measurements in science, industry, and commerce. As such, metric is the only acceptable standard for all scientific endeavors and will be the only acceptable units for this monitoring program.

3.4.2 Site attributes

Site attributes describe the transect location and environment (see table 3-1). These attributes are relatively constant and stable values that are only collected at initial plot establishment although these values can be updated if necessary. Some examples of site attributes include location UTM coordinates of beginning, center, and end points of transect, transect elevation, habitat type from Steele et al. (1983), and administrative unit.

3.4.3 Survey attributes
Survey attributes describe the actual survey, including characteristics of the survey site, and are collected and recorded during each survey occasion (see table 3-2). Example survey attributes include the survey date, crew members, survey type, cover type from Mattson and Despain (1985), and a count (or tally) of all trees ≤ 1.4 meters tall with and without white pine blister rust.

3.4.3.1. Counting trees ≤ 1.4 meters tall with and without blister rust

Individual WbP trees within the transect ≤ 1.4 meters tall will not be marked, but they will be counted and assessed for presence or absence of white pine blister rust at each full survey occasion. When a tree ≤ 1.4 meters tall is found in direct association with a tree > 1.4 meters tall (e.g., appear to be growing from the base of the tree and thus are possibly branches), it is not considered for this survey as individual seedling/saplings (fig. 3-3).

Snowpack can linger into the early summer and may obscure the detection of tree seedlings and small saplings. On occasion, crews may find the transect fully or partially buried by snow. If snow interferes with the ability to detect and count trees ≤ 1.4 meters tall on the entire 10m X 50m transect, the count of small trees cannot take place and a note in the survey comment field should explain the rationale for not conducting the survey.

Figure 3-3. Basal sprouts associated with a given tree are not considered as individual seedlings or saplings.

Table 3-1: Fields describing identity and location of a transect

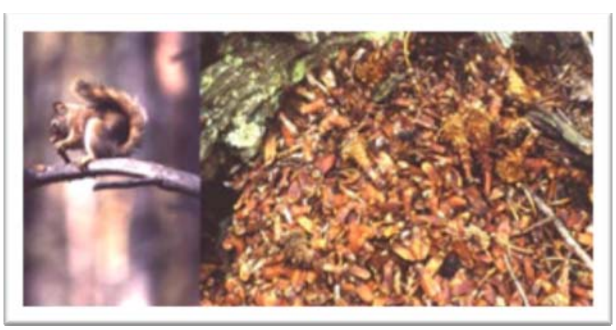
Field Name	Description	Potential Values
Polygon ID	Unique identification for each WbP stand in CEM Model Vegetation Layer that will be provided.	1-xxxxx
Transect ID	Number between 1-5 that will be provided by the mapping department denoting which of the 5 random sites was used for the transect.	1-5
Date	Date of transect survey	MM/DD/YY
Field Crew	Full Name of any person involved in surveying on a particular day.	Full Name- First Middle I. Last
State	Two-letter state abbreviation for state in which transect survey occurred.	MT, WY, ID
County	County name in which transect survey occurred.	All counties in study area
Ownership	Name/abbreviation of administering agency or owner	USFS, NPS, Other (specify)
Forest/Park	Name of administering national forest or national park on which survey occurred.	YELL = Yellowstone National Park GRTE = Grand Teton National Park GNF = Gallatin National Forest BTNF = Bridger Teton National Forest SNF = Shoshone National Forest CTNF = Caribou-Targhee National Forest BDNF = Beaverhead-Deerlodge National Forest CNF = Custer National Forest
District	Name of district within park or forest	All districts in study area
Contact name	Name of best person to contact for assistance on forest/park where the transect survey occurred.	Contact name
Location description	Short, detailed description of where the polygon is located using landmark names	Text description
Topo Map ID [USGS 7.5' quad map name]	Name of USGS 7.5 minute quadrangle	Quad name

Table 3-2: Fields describing layout attributes of a given transect.

Field Name	Description	Potential Values
Transect Begin Point	UTM Easting(NAD83) - coordinate at the beginning monument.	UTM Easting(NAD83)
	UTM Northing(NAD83) - coordinate at the beginning monument.	UTM Northing(NAD83)
	GPS unit error for UTM Easting at beginning monument.	310,000-690,000
	GPS unit error for UTM Northing at beginning monument.	4,660,000-5,128,000
Transect Center Point	UTM Easting(NAD83) - coordinate for the random center point of the transect.	UTM Easting(NAD83)
	UTM Northing(NAD83) - coordinate for the random center point of the transect.	UTM Northing(NAD83)
Transect End Point	UTM Easting(NAD83) - coordinate at the beginning monument.	UTM Easting(NAD83)
	UTM Easting(NAD83) - coordinate at the beginning monument.	UTM Northing(NAD83)
	GPS unit error for UTM Easting at beginning monument.	310,000-690,000
	GPS unit error for UTM Northing at beginning monument.	4,660,000-5,128,000
Habitat Type	Climax community habitat type from Steele et al. guide.	Climax community habitat types from Steele et al. guide.
Cover Type	Cover type from Despain descriptive guide, arboreal community type.	Cover types from Despain descriptive guide, arboreal community type.
Transect Orientation	Randomly selected vector	Degree 0^{o} - 360^{o}

3.4.3.2. Survey of red squirrel middens

For the purpose of determining if grizzly bears are in the area, a survey is also conducted for red squirrel middens within the transect or from the transect. Tally all undisturbed and excavated red squirrel middens during each survey and record on the survey form. An undisturbed midden has no evidence of having been excavated by bears and, conversely, an excavated midden has evidence of having been excavated by bears.



The excavation of red squirrel middens can be an indicator of grizzly bear use of the area.

3.4.4 Tree attributes

Tree attributes describe the characteristic of individual trees and whether the tree has white pine blister rust and/or has been attacked by mountain pine beetle (see table 3-3). Tree attributes are collected on every tree > 1.4 meters tall on each survey occasion. Example tree attributes include tree status, cone production, blister rust cankers, blister rust indicators (non-aecia), upper tree canopy volume, mountain pine beetle indicators, and tree health codes.

A given tree or cluster of trees are included within a transect if, and only if, the center of the trunk (or cluster of trunks) at ground level is within 5 meters of the center of the transect line.

Some tree attributes such as DBH and height class are slow to change and are initially measured and recorded during transect establishment and then measured again and recorded every 12 years (or fourth visit). ALWAYS remember to record DBH and height class for newly tagged trees.

Table 3-3: Fields describing counts of trees < 1.4 m DBH.

Field Name	Sub-Field	Description
Blister Rust Present	Tally	A running tally of whitebark pine trees < 1.4 m DBH that are infected with white pine blister rust (e.g.,). The tally is only used to derive the total count.
	Total	The total count of whitebark pine trees < 1.4 m DBH that are infected with white pine blister rust.
Blister Rust Absent	Same as above	Same as above for tress that are not infected with white pine blister rust.
Blister Rust Uncertain	Same as above	Same as above for trees in which the presence of white pine blister rust is uncertain.

3.4.4.1. Identify and record dead whitebark pine trees > 1.4 meters tall within transects

Dead or recently dead whitebark pine trees >1.4 meters tall within the transect will not be permanently marked, but will be recorded as being present. Clump assignment (number and letter), DBH, and the presence or absence of mountain pine beetle indicators will be collected. Evidence of other insect or disease agents should be noted in the tree health codes (see also section for handling tagged trees found dead during resurvey).

3.4.4.2. Identify and tag live whitebark pine trees > 1.4 meters tall within transects

During initial transect establishment, all live whitebark pine trees within the transect and > 1.4 meters tall are marked with a permanent aluminum tree tag at 1.4 meters breast height(BH) on the side of the tree facing, and perpendicular to, the transect centerline (note that DBH should be measured from the uphill side of the tree). Tags will be fixed to the tree by an aluminum nail (2 1/8″ long). Hammer the nail into the trunk such that the point of the nail is at an angle above the head of the nail. This will ensure that the tag will hang off the end of the nail and not imbed in the tree. In federally designated and proposed Wilderness Areas, tags will be placed on the same side of the tree, but at the base of the tree, rather than breast height.

Table 3.4. Fields describing individual tree measurements of whitebark pine trees > 1.4 m DBH

Field Name	Description	Potential Values
Tree ID (tag no.)	Numeric value from metal tag fastened to tree	Within a range of zero to all positive integers
Observer	Initials of observer who performed the actual visual identification of cankers for that particular tree.	Initials
Clump Number	For each transect, start with # 1 and with each consecutive clump of WbP along the transect, increase the number by one.	Integer from 1 to x.
Clump Letter	Sequential letter assigned to each individual stem (tree) within a given clump.	Each member of a clump is assigned a letter- a,b,c,d,e,f, etc. Start back at “a” with a new clump (i.e. clump 1a,1b,1c, 2a,2b,2c).
DBH(cm)	Tree diameter at breast height (1.4 m, measured and recorded in centimeters	Within a range of positive numeric values to include one decimal place [specify a reasonable lower and upper limit?]
Height Class	Tree height class code	1: <= 5m 2: > 5m <= 10m 3: >= 10m
Tree Status	Tree status code	L: Live (green needles present) RD: Recently Dead (non-green needles present) D: Dead (needles absent)
Cone Producing	Presence or absence of mature, full or partial same-year cones, empty hulls, cone scars, first year cones, or germinant buds	Y (yes), N (no, ‘-‘, 0)
Branch Cankers - Upper Third	A = The number of blister rust cankers observed on branches in the top one third of the tree that have aecia present. I = The number of blister rust cankers observed on branches in the top one third of the tree that do not have aecia present, but were determined via secondary indicators.	Counts of cankers in each category (A & I). If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable
Branch Cankers - Middle Third	Same as above, except on the middle one third of the tree	Counts of cankers in each category (A & I).). If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable
Branch Cankers - Bottom Third	Same as above, except on the bottom one third of the tree	Counts of cankers in each category (A & I). If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable
Bole Cankers – Upper Third	A = The number of blister rust cankers observed on the bole of the tree in the top one third of the tree that have aecia present. I = The number of blister rust cankers observed on the bole of the tree in the top one third of the tree that do not have aecia present, but were determined via secondary indicators..	Counts of cankers in each category (A & I).). If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable

Table 3.4. Cont'd.

Field Name	Description	Potential Values
Bole Cankers – Middle Third	Same as above, except on the middle one third of the tree	Counts of cankers in each category (A & I).). If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable
Bole Cankers – Bottom Third	Same as above, except on the bottom one third of the tree	Counts of cankers in each category (A & I).). If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable
Rodent Chewing	Total number of cankers with rodent chewing	Counts of cankers with this indicator.). If no indicators are observed, a N (no), dash (-), or zero (0) is acceptable
Flagging	Total number of cankers with dead branch flagging	Counts of cankers with this indicator). If no indicators are observed, a N (no), dash (-), or zero (0) is acceptable
Swelling	Total number of cankers with swelling observed	Counts of cankers with this indicator.). If no indicators are observed, a N (no), dash (-), or zero (0) is acceptable
Oozing Sap	Total number of cankers with oozing sap observed	Counts of cankers with this indicator.). If no indicators are observed, a N (no), dash (-), or zero (0) is acceptable
Live Canopy Volume (%) – Upper Third	The percent of canopy in the upper one third of the foliage that is alive	0-100. A dash (-) is acceptable to indicate no canopy observed.
Mountain Pine Beetle Pitch Tube Category	Number of mountain pine beetle pitch tubes observed 0 = zero pitch tubes, 1 = 1-5 pitch tubes, 2 = >5 pitch tubes	0-2. A dash (-) or N (no) is acceptable to indicate no pitch tubes observed.
Mountain Pine Beetle Galleries Present (dead trees only)	Presence or absence of J-shaped mountain pine beetle galleries under the bark of ONLY dead trees	Y (yes), N(a dash (-) or zero (0) is acceptable to indicate that no J-shaped galleries are observed or that this field was not active due to tree status
Mountain Pine Beetle Frass Category	Absence or percentage of mountain pine beetle frass observed around the trunk of the tree 0 = frass absent, 1 = frass less than 30%, 2 = frass more than 30%	0-2. A dash (-) or N (no) is acceptable to indicate no frass observed.
General Health Comments		'yes' or 'no' Bt = broken top Db = dead branch (sometimes associated with positioning on the tree denoted as T = top, M = middle, B = bottom, and a number as to how many are present in that particular location i.e., Db2- 1 M, 1 B means two dead branches, one found in the middle 1/3rd one found in the bottom 1/3rd) Ad = animal damage Md = mechanical damage Ns = needle shed Us = understory (found in the understory, shaded by another tree or trees) Dt = dead top Tg = trunk girdling Bg = branch girdling F = flagging H = healthy Uh = unhealthy (for some unknown reason) NFP = needle/foliage problems

* All required fields on the data sheet should be filled out with an appropriate and permissible value. If a required field is missed (skipped), crew members should leave the field blank. When a blank field is encountered by data entry personnel, the blank field will be populated with a -999 value.

If a tree tag is lost from its assigned tree, make sure that the original tree can be positively identified as the tree that was initially tagged with that specific number. If a tree is conclusively identified as the previously tagged member of the survey, on a blank tree tag inscribe the ORIGINAL assigned number and reaffix the tag to the tree. Note that the tag was replaced. If the tree is not found, record the lost tree number in the "tree tag numbers not located" section under Survey Comments of the field form and include an explanation as to why the tree was not located. If a given tagged tree, upon subsequent visits, is determined to be a limber pine, leave the tag in place, make note of the correct species ID, and record all data as would be recorded for a tagged whitebark. Should the species be something other than whitebark or limber pine, remove the tag and note the reason in the comment field.

3.4.4.3. <u>Distinguishing individual trees from clusters of trees</u>

Tree clusters (clumps) may form when multiple seeds are cached at the same location by Clark's nutcrackers or squirrels. Although multiple trunks of an individual tree are possible, it is more often the case that multiple trees sprout from the same location. Thus, to ignore that these are individual trees can be problematic and under sample the density of trees at a given location. Further, a given tree within a cluster may suffer damage and/or mortality from white pine blister rust, while an adjacent trunk with less or no infection may remain undamaged and survive.

Tree tags.

3.4.4.4. <u>Clump number and letter</u>

For our purposes, we have defined several criteria to determine if a particular growth form should be considered a lone tree, an individual bole that is part of a clump or simply a branch emerging from a bole. Any tree separated at ground level by > 1 foot is considered a lone tree and is marked accordingly. Trees in proximity to each other with < 1 foot of separation below DBH (1.4 m) are considered members of a clump. Each tree clump (i.e., tree with > 1 main stem) will be assigned a consecutive number as they are encountered, such that the first clump encountered is clump # 1, the second is clump #2 and so on (figs. 3–4). Within each clump, the individual main stems (boles) are each assigned a consecutive letter, identifying them as a bole within a clump. If a > 1.4 meters high tree is in a clump with other whitebark that are ≤ 1.4 meters high, the above DBH should receive a clump number and letter assignment. If a > 1.4 meters high tree is in a clump with a dead tree, the live, tagged tree will get a clump number and letter assignment(as does the dead tree). Finally, if a tagged tree is in a clump with a tree that is not a part of the transect (the bole of the tree is not bisected by at least ½ of the transect line) it will also receive a clump number and letter. In the database, a tree that appears to be the only member of a clump or "orphaned", is most likely paired with either a dead tree(s), a tree(s) < 1.4 meters tall, or a tree(s) outside of the transect boundary.

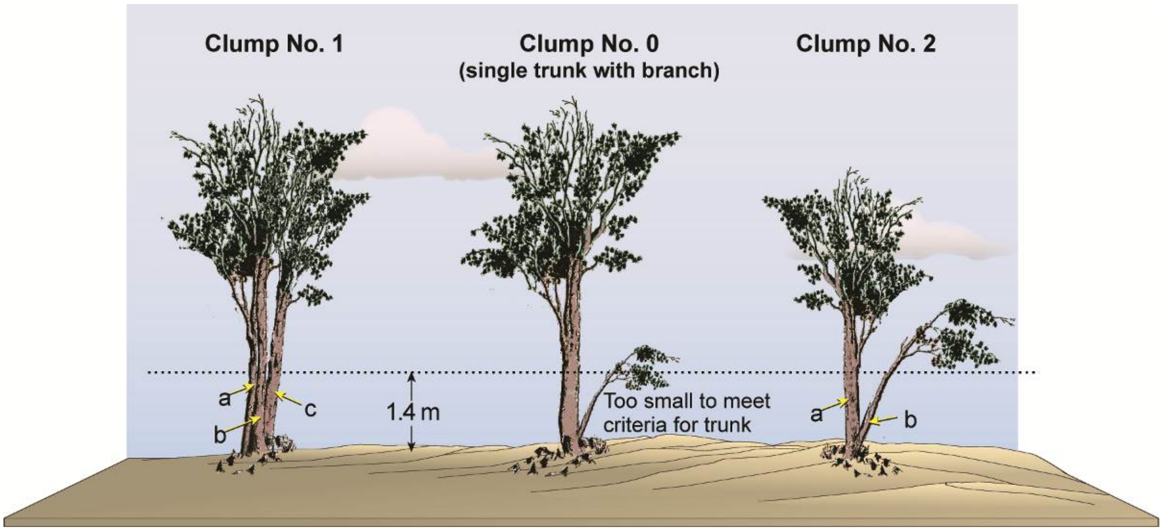


Figure 3-4. Tree clusters are assigned when individual stems cannot be distinguished as individual trees. This often happens as a result of seeds being cached by Clark's nutcrackers.

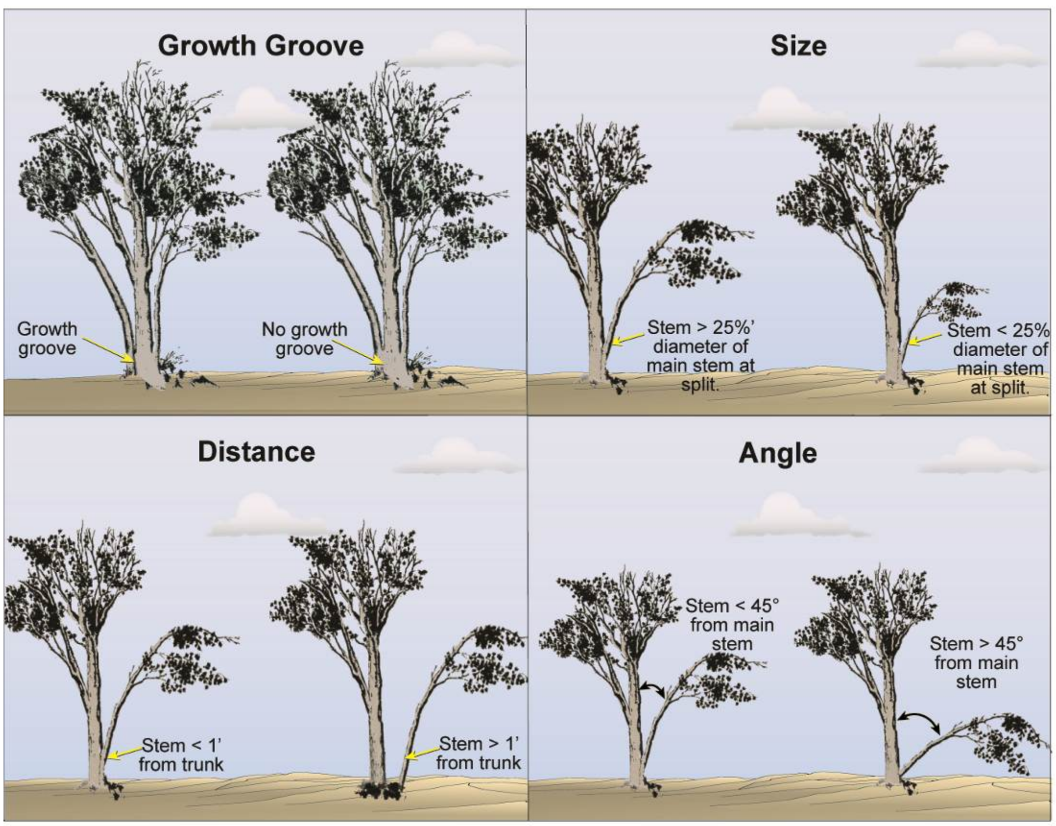


Figure 3-5. The criteria by which a branch is distinguished from a bole within a given tree.

3.4.4.5. Criteria for recording the presence of white pine blister rust

Once individual trees within the transect are identified and permanently tagged, observers can begin measuring tree attributes and evaluating trees for blister rust infection and mountain pine beetle infestation. The criteria for inclusion of cankers in the count is based on Hoff (1992).

We use two criteria for determining the presence of a white pine blister rust canker: (1) the presence of aecia; or (2) the presence of three of five secondary indicators. The number of cankers meeting each of those criteria is recorded. Those that have aecia present should be noted in the "A" column under the corresponding location (upper third, middle third, etc.). The presence of aecia (left) is considered definitive and sufficient evidence, such that other indicators need not be present to assign it as a canker. It should be noted that "A" denotes the visible presence of aecia, and should not be confused with designation of "active" cankers used on efforts monitoring blister rust.

3.4.4.5.1. Location of cankers

Both the severity of the blister rust infection and the detectability of blister rust cankers are influenced by position on the tree. In addition to whether the infection is located on a branch(es) or the bole(s), severity and detectability are also influenced by how high they are in the tree. For example, a girdling canker near the top of a tree may result in top kill, whereas a girdling canker near the bottom could kill the tree. Similarly, cankers near the bottom of a tree are more likely to be detected than those obscured by branches near the top. To account for differences in severity and detectability, we have adopted the concept proposed by Six and Newcomb (2005) of dividing each tree and foliage into thirds for the purpose of recording blister rust infection.

3.4.4.5.2. Distinguishing a branch from a bole

In order to discern between a branch and a bole, three of the four following criteria must be met for a given stem to be considered as a separate bole of a given tree:

1. There must be a discernible growth groove that separates that stem from other stems of the tree.
2. The diameter of a given stem must be > 25% of the diameter of the largest stem.
3. The stem must be < 1 foot from the "mother" tree to which it is associated. Otherwise it is to be considered as a separate seedling, sapling, or tree.
4. The angle of the stem in question must be less than a < 45° angle from the main stem.

3.4.4.5.3. Dividing the tree for recording cankers

The bole of the tree is divided into thirds for bole cankers. The bole is defined as the most vertically oriented portion of the tree that extends from the ground to a division point or split at which the observer can no longer discern by diameter any size difference in regards to a given stem (fig. 3-6). Cankers observed above this point are considered branch cankers. Should a bole canker in a given third of the bole extend beyond that third to the next, it is assigned to the lowest third (fig. 3-7).

The extent of live foliage is also divided into thirds for the purpose of counting branch cankers. In contrast to Six and Newcomb (2005), who propose a rating system based on percent of the area infected within each third, we are counting cankers. The reason for the approach taken by

Six and Newcomb is to expedite the assessment, as well as the recognition that counts of cankers may be highly influenced by the circumstances under which they are counted. We recognize the weaknesses of counting cankers, but have adopted this as an initial approach to better enable us to refine an alternative. Additionally, Six and Newcomb (2005) found that the mean number of cankers from counts was highly correlated with their rating system. Branch cankers are assigned to the third in which the canker occurs, rather than by the origin of the branch on which they occur (fig. 3-8).

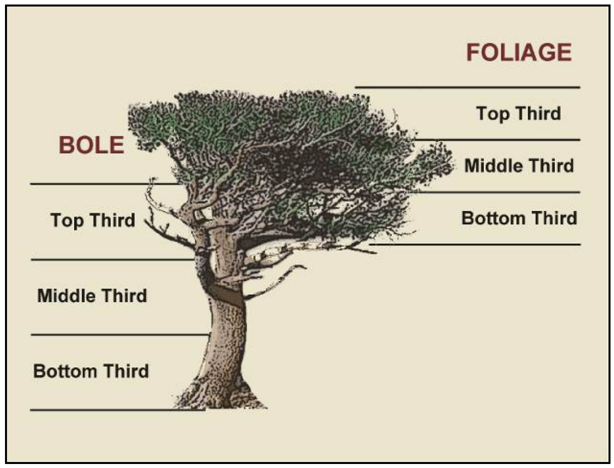


Figure 3-6. Bole and branch cankers are each assigned to their relative position (thirds) in the bole or foliage.

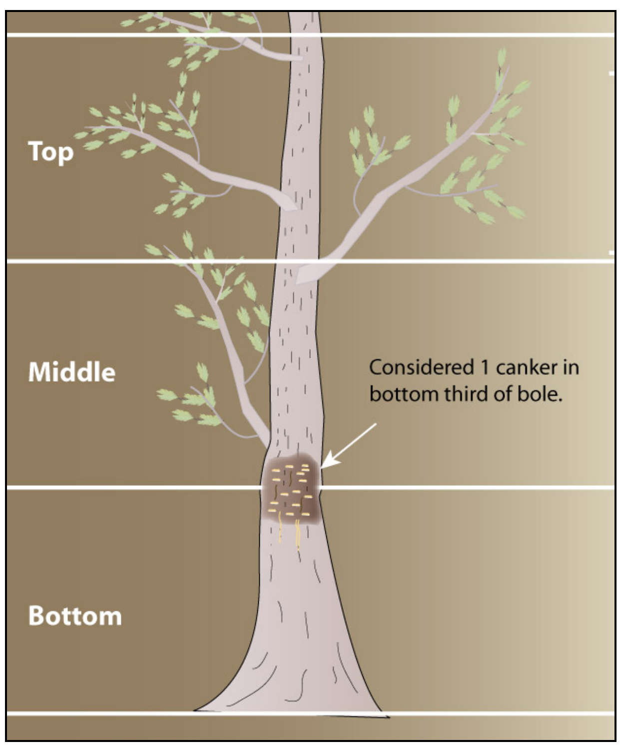


Figure 3-7. Bole cankers that cover more than one third are assigned to the lowest third in which they occur.

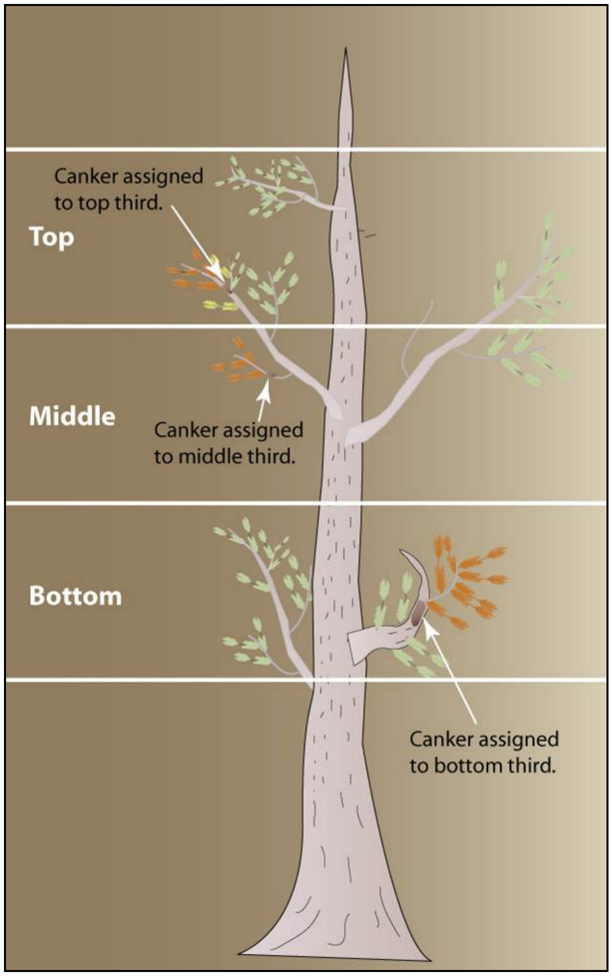


Figure 3-8. Branch cankers are to the third in which they occur.

Aecia, shown as sporolating (left) and empty (right) are considered as definitive evidence for the presence of a canker. Photo: USFS, Dorena GRC (left), Erin Shanahan (right).



Left to right: Flagging (USFS/Roy Hoff); Swelling (USFS/Roy Hoff); Roughened bark (USFS/Roy Hoff).


Left to right: Rodent chewing; Oozing sap (USFS/Roy Hoff).

3.4.4.5.4. Number of cankers

The number of cankers is recorded for each tree based on: (1) whether or not it occurs on a branch or a bole; (2) which third of the tree (bole) or foliage (branch) it occurs; and (3) whether or not it was determined to be a canker based on aecia being present or by at least three of five other indicators (see section titled Criteria for Inclusion of Cankers in the count).

3.4.4.6. Aecia – the primary indicator of blister rust infection

Cankers having visible aecia (the sporulating or fruiting body of blister rust) and other secondary indicators are not counted twice for each form of evidence. Thus if aecia are visible, secondary indicators need not be recorded.

Active cankers may, or may not, have visible aecia; thus, we do not attempt to distinguish active vs. inactive cankers.

3.4.4.7. Secondary indicators of blister rust infection

An alternate criteria for determining the occurrence of a blister rust canker is the presence of three of five secondary indicators. If three of five secondary indicators are present in the same spot on the tree, a canker will be counted. These cankers should be recorded under the "I" column. As above, "I" denotes the presence of secondary indicators and should not be confused with "inactive" cankers recorded on other studies.

Secondary indicators consist of:

- Flagging: When cankers girdle a branch, the branch dies and becomes a "flag."
- Swelling: The occurrence of a canker often causes swelling on the branch or trunk (which may be yellow-orange in color). This is amplified when rubbed with water.
- Roughened Bark: The occurrence of a canker often causes roughened bark.
- Rodent chewing (stripped bark): The high sugar content associated with cankers makes them attractive to rodents and insects. Thus chewing of these sweet tissues is often an indicator of blister rust.
- Oozing Pitch: Pitch is often associated with the margin of a canker and may run down the branch or trunk.

In addition to the indicators being used to verify the occurrence of a canker, the number of occurrences of each indicator itself is also recorded. This is intended as an aid to help determine which indicators are best suited to identify the occurrence of white pine blister rust.

3.4.4.8. Identification and recording mountain pine beetle

Evidence of mountain pine beetle infestation should be recorded in all live, recently dead and dead whitebark pine trees.

Mountain pine beetle infestation can be identified by popcorn-shaped resin masses called pitch tubes, crooked or "J" shaped galleries under the bark, boring dust commonly called frass found in bark crevices and around the base of an infected tree and/or the presence of live mountain pine beetle (fig. 3-9). Crew members should become familiar with these signs of infestation and be able to positively identify mountain pine beetle presence/absence on both live and dead trees within the plots. For pitch tube categories (field #32), if there are no pitch tubes observed enter a 0 (a dash or N is also acceptable to indicate 0 pitch tubes); for one to five pitch tubes observed, enter a 1; for more than five pitch tubes observed, enter a 2. Mountain pine beetle gallery detection is only considered for dead or recently dead WbP trees. If mountain pine beetle galleries (field #33) are present enter "Y" for yes and if they are absent enter "N" for no (a dash is also acceptable to indicate no galleries). Look for frass (boring dust) on the ground around the base of the tree. If there is no frass (field #34) observed enter a 0 (a dash or N is also acceptable if there is 0 frass), if there is frass present but surrounds the base of the tree by a circumference of less than 30%, enter a 1 and for frass that is present and surrounds the base of the tree by a circumference of more than 30%, enter a 2. See the following website for helpful images: http://www.ext.colostate.edu/pubs/insect/05528.html (Leatherman 2002).

Figure 3-9. Mountain pine beetle galleries.

Figure 3-10. Mountain pine beetle pitch tubes.

Figure 3-11. Mountain pine beetle frass.

Mature cones.

Close-up of a cone scar.

Many mature cones on whitebark pine.

3.4.4.9. Cone production

Indicate with a Y or N (a dash is also acceptable to indicate no cones observed) whether a given tree (≤ 1.4 m tall) exhibits evidence of having produced cones at some point in time. This may include mature, full or partial same-year cones, empty hulls, cone scars, first year cones or germinant buds.

3.4.4.10. Tree health comments

This section is included to comment on any additional visual health observations for each tree. It is intended to augment the white pine blister rust infection data by providing information on other types of damage or influences that may be affecting the health of the tree. For example, if the tree was burned in a fire a tree health code on fire damage should be noted.

3.5 Resurvey of monitoring transects

After initial establishment, transects will be resurveyed according to the assigned panel membership. The resurvey goal is one panel of 35–40 transects per year. If a transect is not surveyed in its assigned year (weather, fire closure, etc.), it will be surveyed as soon as possible the following year.

An exception to this revisit design is when an extra effort is expended to record rapid changes in whitebark pine tree mortality during a mountain pine beetle outbreak. This type of resurvey is called a mountain pine beetle only survey and is distinguished from the regular survey in that blister rust surveys (e.g., counts of branch and bole cankers or indicators) do not occur and no small trees ≤ 1.4 meters tall are counted. Also, if there are no longer any living trees > 1.4 meters tall, the mountain pine beetle only survey for such a transect will not be conducted.

During resurvey, many of the data fields will be provided on the field sheets (i.e., tree number, clump number and letter) for a given transect prior to the field visit. If the actual UTMs for the beginning, center, and end points of the transect are more than 6 meters different from that recorded on the form, the corrected UTM should be added to the field sheet.

A resurvey will include the same survey and tree attributes as those during initial transect establishment with this exception:

- Diameter Breast Height and Height Class will be measured every third panel visit (12-year interval for each panel starting with the 2008 season).

3.5.1 Determining status (dead, recently dead or live) of trees > 1.4 meters tall

If a tree that was previously alive during an earlier survey dies at anytime during the monitoring process, record the status of that tree as dead or recently dead if it still has not shed all its needles. When all the needles are shed, record the tree as dead.

On dead or recently dead trees, look for and record presence of mountain pine beetle J-shaped galleries beneath the bark and any other evidence of mountain pine beetle infestation.

Do not remove the tree tag or alter the tree in any manner.

3.5.2 Transects that have burned or have no live trees > 1.4 meters tall

Transects that no longer have any live trees > 1.4 meters tall, will remain in the four-year blister rust panel rotation. Crews should make every effort to be on plot during the scheduled revisit year, but should they view the plot from afar due to logistical issues, a detailed explanation should be include on the plot form as to why the site was not physically visited, what mechanism was used to view the plot, and from what distance the plot was observed. If viewed from a distance, crews need to be 100% confident that they can correctly observe tree status from their position.

3.6 Adding new trees during resurvey

During resurvey, any whitebark pine tree on a given transect that has grown and reached a height of 1.4 meters or more will be added to the data set. These new trees will be tagged and individual tree data will be collected following the section titled "Live Whitebark Pine Trees > 1.4 meters high. New trees should be assigned and tagged with a unique tree number. Be sure to record any new tree tag #s in the "New Tree" section provided on the data sheet.

3.7 Quality assurance

3.7.1 Multi-observer transects

A multiple-observer transect is a transect in which more than one observer is recording individual tree measurements independently. Multiple observer transects are used to evaluate observer variation in individual tree attributes. THIS IS NOT A TEST OF OBSERVER COMPETENCE! A multitude of factors may influence an observer's ability to detect blister rust and other attributes of individual trees, including observer experience, position on the ground, entanglement of branches, lighting, optics used, etc. Consequently, it is important to be able to account for observer variation in our analysis so that we can try to better understand what part of the variation is due to observer differences compared to actual changes in infection levels of blister rust. Thus, it is extremely important for multiple observers to not view this as a competition among observers or as any test of their abilities.

A minimum of 10 multiple observer plots (approximately 10%) should be conducted each season in order to track and monitor observer variation. Tree attributes for multi-observer surveys include tree status, blister rust cankers, blister rust indicators, mountain pine beetle indicators, and upper live canopy volume.

For established trees, each observer should record tree ID and their own initials on the form and survey individual trees on the transect for the following fields:

- 12. Tree Status
- 13. Cone Production (if needed for that particular tree)
- 14–30. All Canker and Indicator fields
- 31. Live Canopy Vol.
- 32–34. Mountain Pine Beetle fields
- 35. Tree Health

Observers should always record the data exactly as they would if they were alone. Although consultation is a normal part of training and gaining experience, a given data field from a multiple observer plot should never be changed as a result of consultation with other observers.

This defeats the purpose of the multiple observer plots, and reduces our ability to account for observer variation.

For any new trees added to the transect, one observer should tag the new tree and then survey the new tree for all tree attribute fields. All additional observers should observe new trees for just those attributes listed for multiple observer transects (e.g., tree status, cone production, cankers, and indicators).

3.7.2 Prepare data sheets for data entry

Prior to leaving the transect, field crews should inspect all data sheets to ensure that all data fields are complete. For every data field, enter a value following the list of potential values from Tables 3.1–3.4. For certain fields, a N (no) or dash (-) is acceptable to indicate that a value is not observed for that field. Again, if a field is missed (skipped), the field should be left blank. Any blank fields will be populated with a -999 by data entry personnel.

Should questions arise regarding data collection while crews are in the field, contact the crew leader as soon as possible.

All data sheets and corresponding maps will be handed in to the crew leader at the end of each hitch.

The crew leader is responsible for all data entry upon completion of the field season.

4 Data Management

4.1 Data model and database system

The relational data model in Microsoft Access 2007/2010 format (figure 4.1) includes separate tables to store records for sampling locations (sites), unique tagged trees, sampling events (surveys), tree parameter data with only one observed value per survey, and tree parameter data with values recorded by each observer during 'multi-observer' surveys. Supporting tables hold lists of site and survey images, personnel information, and look-up values to aid in data validation and streamline data entry. Key elements of the data dictionary are presented in Chapter 3 – Table 4, and a comprehensive data dictionary for use by database developers and users is available in Appendix 2.

The Microsoft Access Database comprises a user interface file (front end) and master data file (back end) developed and administered by the NPS GRYN data manager. The user interface presents a collection of easily navigable tabs and forms (figure 4.2) to accommodate essential data entry and output requirements. Numerous queries, reports, forms, and VBA code support these custom functions.

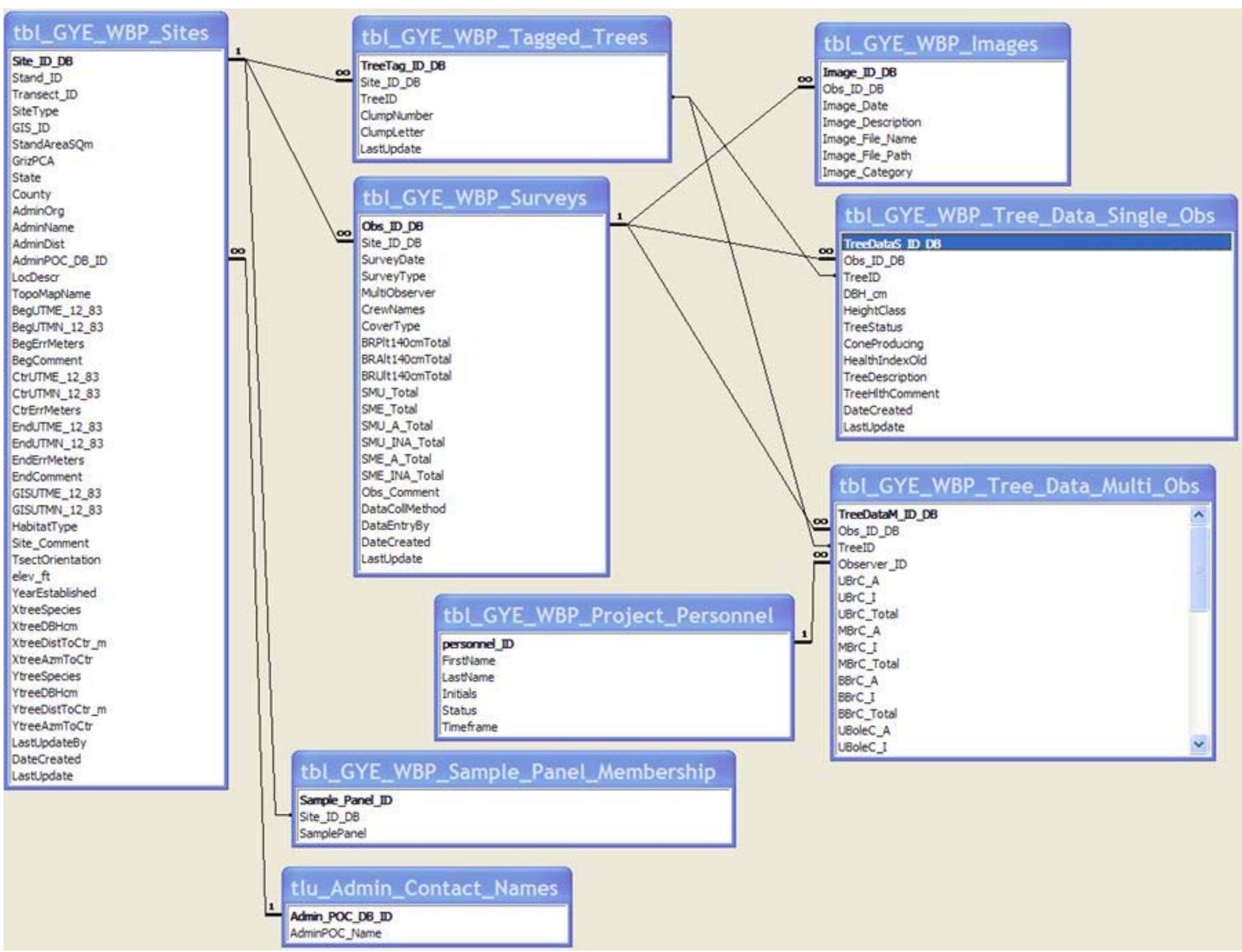


Figure 4-1. Microsoft Access data model for GYE Whitebark Pine Monitoring Project.

Archive copies of the master data file are stored securely at regular intervals on the NPS GRYN server and separate backup media. New data are entered directly in the master data file containing all prior data because some data entry and retrieval functions rely on values from the entire period of record. Prior data are protected from intentional or accidental modification by user interface controls.

4.2 Data stewardship roles and responsibilities

The stewardship of data and materials for the project is shared among staff of the USGS Interagency Grizzly Bear Study Team and the NPS Greater Yellowstone Inventory and Monitoring Network, as listed in Table 4-1. To successfully catalog, organize, structure, archive and make available relevant whitebark pine monitoring data and results, project staff should expect to spend approximately one third of their time, overall, on activities related to the stewardship, analysis, and reporting of project data.

Table 4-1. Data Stewardship Roles and Responsibilities

Data Stewardship Responsibility:	Name	Organization	Contact Information
Master copy of protocol	Ecologist/Project Leader	NPS-GRYN	(406) 994-7734
Master copy of database	Data Manager	NPS-GRYN	(406) 994-4124
Master copy of database and protocol (backup person)	Data Manager	USGS-IGBST	(406) 994-5041
USFS database Coordination	Data Manager	NPS-GRYN	(406) 994-4124
Security and backup plan for primary database	Data Manager	NPS-GRYN	(406) 994-4124
Verification of data in primary database	Project Leader	NPS-GRYN	(406) 994-7734
Validation of data in primary database	Project Leader	NPS-GRYN	(406) 994-7734
Original data sheets/field forms	Project Leader	NPS-GRYN	(406) 994-7734
Documentation for data structure and database application	Data Manager	NPS-GRYN	(406) 994-4124
Maintenance of documentation for data structure and database application	Data Manager	NPS-GRYN	(406) 994-4124
Annual storage and long-term archiving of physical project materials	Data Manager	NPS-GRYN	(406) 994-4124

4.3 Data entry and quality assurance

Observed and measured field data are recorded on paper forms generated by the project data manager prior to each field collection period from specialized reporting functions in the master database application. The data recording forms list every tagged tree for each site and certain established values from prior surveys that provide context and guidance to the person responsible for completing the current survey. Field observers are trained to carry and use a detailed data recording guide that helps ensure legible, valid entries and maximize the quality of recorded values. Data recording instructions emphasize the importance of field personnel as one of the first links in a chain of data quality, and how double checking recorded values during and immediately following each survey is integral to the overall quality assurance process.

Project personnel enter data from field data sheets into the Microsoft Access database on a regular basis throughout the field season (usually every two weeks) using a customized data entry form that includes a cascading system of data validation controls. In most cases the field crew leader personally reviews and enters the data in order to immediately identify and resolve data quality issues and prevent entry of invalid or questionable data. If necessary a qualified person appointed by the field crew leader and approved by the project leader enters the data.

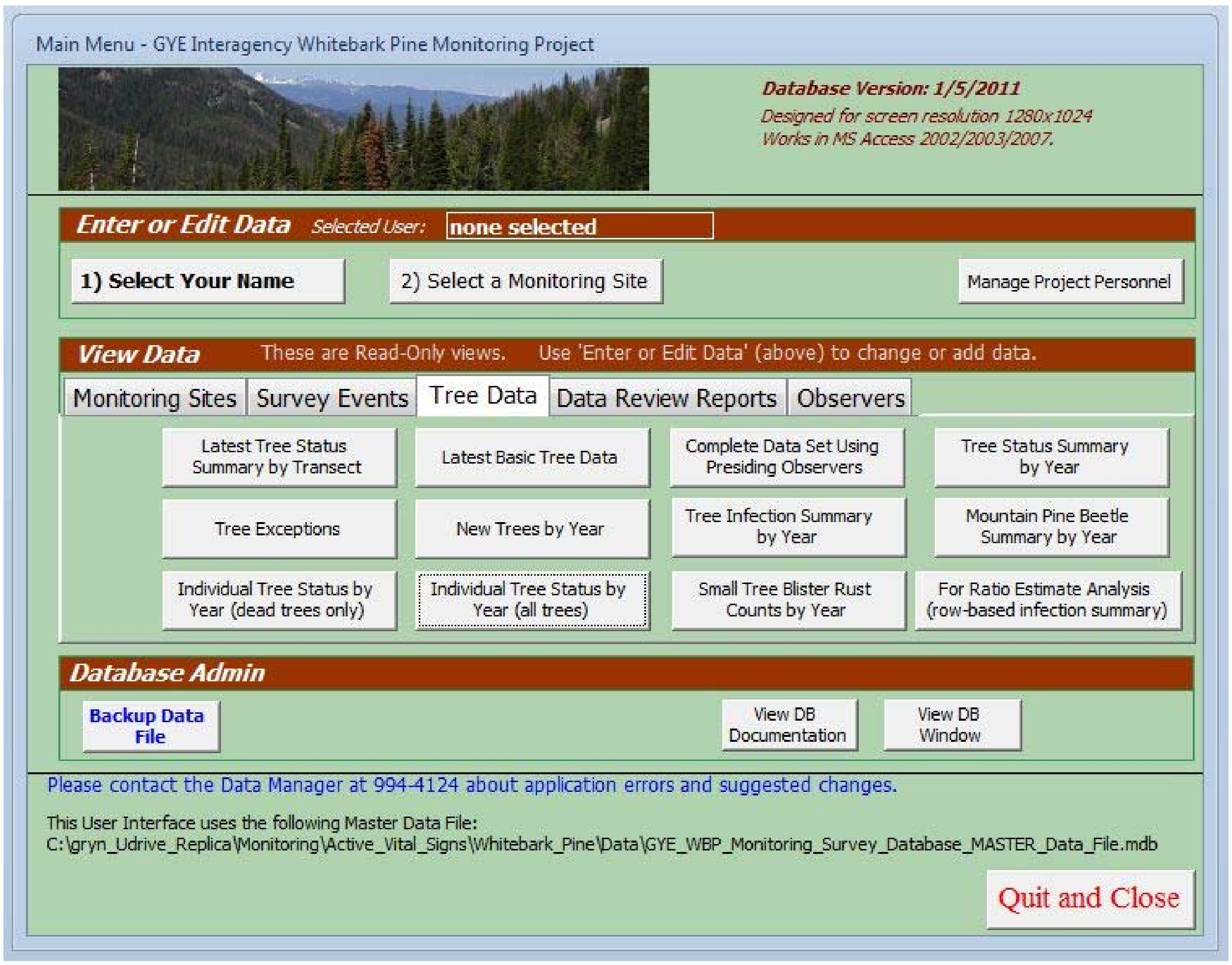


Figure 4-2. View of database interface for whitebark pine monitoring project.

Direct recording of observed and measured values to electronic devices was field tested in 2006 using Dell Axim handheld computers and Pendragon Forms for the Microsoft Windows Mobile operating system. While the electronic data collection system showed promise, a variety of technical, logistical, and human factors led project leaders to postpone full implementation of electronic data collection. As prices decline and capabilities improve for portable electronic recorders, more robust and effective solutions will be tested with this project in future years.

4.4 Digital images

Project staff select at least one image per visit (where available), and not more than five images per transect per visit that represent the general nature of established transects. During or immediately following the survey period, project staff name image files to include a project identifier, stand ID, transect ID, and the date the image was acquired. Images of subjects other than surveyed transects are not stored in the project's file structure. Digital images are stored in a folder that indicates project and year. For example:
\Whitebark_Pine\Resources\Images\Unrestricted\Images_2009\GYE_WBP_4095_1_2009.jpg

File size for digital images stored with the project data should normally be between 300KB and 1MB. Project staff will resize original image files larger than 1MB.

4.5 Data verification

Crew members are responsible for legible, accurate written entries on field forms and in log books. As a first step to verify data, crew members visually check and double check the recorded values on the day of data collection. On a daily or weekly basis, as allowed by the schedule and duration of field visits, the project leader gathers the data collection forms, verifies the completeness, accuracy, and legibility of each form, and resolves related issues prior to entering data in the master data file.

As soon as all data are entered in the master database for the entire survey period the project leader or someone they designate prints a Data Review report from the database's user interface to generate a complete or partial list of data to compare with the original field data sheets. Data from a minimum ten percent of surveyed sites are used for comparison. The project crew leader decides whether to compare additional data based on results from the initial comparison and based on other circumstances such as the experience level of those who observed, recorded, and entered the data. Where data reported from the database do not match data recorded in the field, the project leader investigates and resolves discrepancies, ensures that all similar issues are identified and corrected or addressed, and incorporates solutions in training and operations for the following survey period.

The printed Data Review Report documents the data verification process with corrections, notes, name of person(s) performing verification, and other relevant details. Data review reports are filed in the printed project record.

4.6 Data validation

After verifying that data in the master database from the latest survey period are correctly transcribed from field data sheets, the project leader or other qualified person reviews the data for validity and accuracy before the data are used for analysis or reporting. Output from summary queries in the database's user interface are viewed, sorted, filtered and otherwise analyzed by the subject matter expert to assess data distribution and ranges, inconsistencies with expected values for the field circumstances, integrity of data structure (e.g., expected and valid data types and relationships). Errors found during data validation procedures are corrected with explanation on the original field data sheets, which are filed in the printed project record.

4.7 Meta data

Correct interpretation and use of project data relies on a complete understanding of the project's objectives, methods, and the data fields and values in the project database. The person responsible for database documentation (Table 4.1) annually reviews and updates the content and structure of project metadata, including the comprehensive description of data fields and values. Documentation for the Whitebark Pine Monitoring Project includes descriptions of site, survey, and tree parameters/variables in this monitoring protocol document, database object descriptions in the project database, and complete descriptions of database tables, fields, and values in the project's Data Dictionary (Appendix 2). A current version of the project Data Dictionary is available in Microsoft Excel format by contacting the NPS Greater Yellowstone Network.

4.8 Archiving

The NPS GRYN data manager maintains electronic archives for the GYE Whitebark Pine Database on the GRYN server. All data on the server receive daily differential and weekly full backups stored on-site and quarterly backups stored off-site. At the end of each field season all physical project materials, including field data collection forms, site sketches, and log books, are submitted by the project leader for filing with the project record in the NPS GRYN office.

4.9 Data distribution

The GYE Interagency Whitebark Pine Monitoring Working Group (Working Group) accepts requests for project data to support other scientific efforts working on whitebark pine. Each request is tracked in order to maintain the long term integrity of the project and associated data. The data request process ensures that project staff has the opportunity to discuss, explain, and qualify the project data in relation to intended applications. Prior to submitting a request for project data, users should become familiar with the monitoring objectives and the related data by reading the project methods (monitoring protocol) and referring to the most current data dictionary available at this link or by contacting the NPS Greater Yellowstone Network or the Interagency Grizzly Bear Study Team:
http://www.greateryellowstonescience.org/topics/biological/vegetation/whitebarkpine/projects/healthmonitoring

As with any data set, issues related to the integrity, accuracy, precision, and applicability of the data values may become apparent as the data are used for various purposes. The Working Group requests and appreciates feedback about any such issues. Requests for project data can be made by contacting the NPS Greater Yellowstone Network or the Interagency Grizzly Bear Study Team.

Summary data from the project are shared with the US Forest Service Forest Health Protection's Whitebark and Limber Pine Information System, which compiles an online summary of survey plots and selected data from numerous projects.

Monitoring data from the project are uploaded for public access to the NPS Natural Resource Information Portal (NRInfo) once the GYE Interagency Whitebark Pine Monitoring Working Group validates and reports on a complete data series following repeat surveys of all sample transects (figure 2.3).

Chapter 5

Analysis & Reporting

Analysis

Our data analysis is intended to provide estimates for the target population, rather than merely reporting the observed values from our sample.

Parameter Estimation

Let y_i be the observation for the ith transect, i=1,...,n . Let Ψ_i be the probability that the ith transect is sampled. As indicated above this is the area of the transect (500 square meters) divided by the area of the polygon times 1/N. Define a new variable $v_i = y_i / \psi_i$. This is actually an unbiased estimator of the population quantity of interest y but we have n observations to work with so a better estimator is

$$\hat{y} = (1/n)\sum_{i=1}^{n} v_i = (1/n)\sum_{i=1}^{n} (y_i / \psi_i) .$$

The estimated variance is the sample variance divided by n,

$$s_{\hat{y}}^2 = \frac{\sum_{i=1}^{n} \left(v_i - \hat{y}\right)^2}{n(n-1)} .$$

One of the key parameters we want to estimate is the proportion of trees infected. There are at least two approaches one can take for this but we will use the technique known as ratio estimation. Let y_i be the total number of infected trees on the ith transect and let m_i be the total number of trees on the ith transect. The estimate of the population proportion is

$$\hat{p} = \frac{\sum_{i=1}^{n} \frac{y_i}{\psi_i}}{\sum_{i=1}^{n} \frac{m_i}{\psi_i}} = \frac{\sum_{i=1}^{n} v_i}{\sum_{i=1}^{n} u_i} .$$

The estimated variance of $\hat{p}$ is (ignoring the finite population correction factor)

$$s_{\hat{p}}^2 = \frac{\sum_{i=1}^{n}\left(v_i - \hat{p}u_i\right)^2}{n(n-1)\bar{u}^2}.$$

The ratio estimator is biased, but negligibly so, and will tend to be more precise than the other intuitively reasonable estimator: the mean of the sample proportions from each transect. We would use the same approach to estimate the mean severity index.

Reporting

Our approach to reporting is hierarchical and intended for multiple audiences and media. The primary delivery system will be the internet via the Greater Yellowstone Science Learning Center (GYSLC), currently located at: http://www.greateryellowstonescience.org/. However, the individual products available on the web site are also in a format (pdf) that will facilitate easy printing or enable us to deliver a printed version to appropriate audiences.

The GYSLC is a partnership between Grand Teton, Yellowstone, and Bighorn Canyon national parks, the Greater Yellowstone I&M Network, and the Rocky Mountains Cooperative Ecosystem Studies Unit. Its purpose is to build stronger relationships with scientists and better communicate science results to interested park audiences.

The hub of the Learning Center is a web page that gathers information about a number of resource topics in one place. The web-enabled Learning Center concept is founded in the belief that all internet-using members of the public, from university researchers to primary school students, should be able to access the vast amounts of scientific information that exist about YELL, GRTE, and BICA's natural and cultural resources, appropriate to their level of technical sophistication. As technology advances and our ideas evolve, we fully expect changes in our reporting system, but currently the GYSLC is designed to be resource centric rather than institutionally driven. It is our belief that most users scientific information will find it easier to navigate when all of the information about a given resource are located together, rather than having to find each source of information within the institutional unit where it originated. The latter is still easily accessed via the project level of the web site.

Our information is organized hierarchically within two major levels, the resource level and the project level. The resource level reports on the condition of the resource, regardless of the source of information. This is the level that best synthesizes the available information regarding the status and trends of the resource. In contrast the project level reports the available information from a given project, whether it be monitoring, research, etc. Thus, I & M monitoring data will contribute to, and sometimes be the only source of information for the resource level. In addition, the results from the monitoring itself will be reported at the project level. Thus, someone looking for the most comprehensive information about status and trend of a resource would find it at the resource level, and someone looking for the specific results from a given project would find it at the project level.

Resource Level

The home page for a given resource (Figure 5-1) will provide background information for that resource, as well as a series of products at the resource level. At this level a projects page will provide additional links to all of the projects related to that resource. The resource-level products for whitebark pine will include an: (1) overview, (2) almanac, (3) references and links, and (4) scientists, each of which are explained below:

Analysis & Reporting

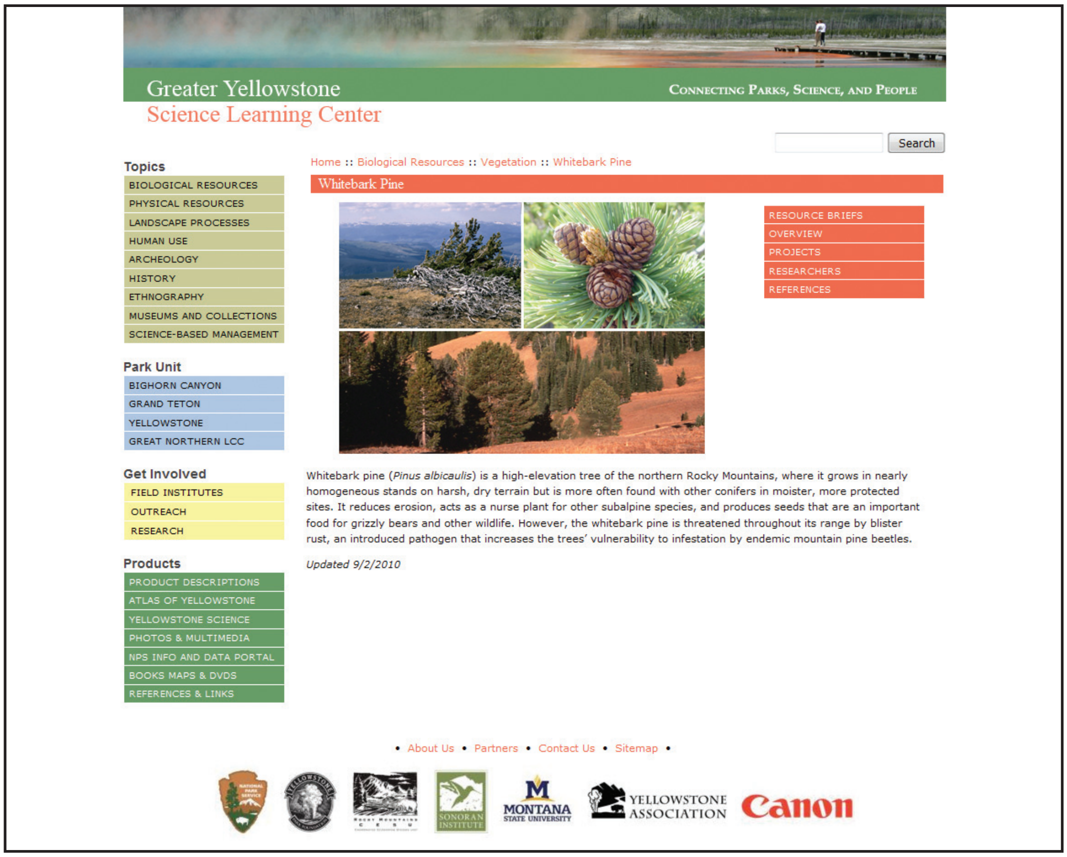


Figure 5-1. The home page for a given resource will provide access to a several products, including a link to the individual projects related to that resource.

Overview

The Overview provides the background on a given resource. It is a description of the natural history and ecological function of the resource, as well as how it is managed and monitored, including relevant citations. The overview includes the following sections:

- *Overview. This covers basic taxonomic information and the species' scientific name, and explains how the species in Greater Yellowstone is similar to or different from species that are known by similar names elsewhere in the world.*
- *Distribution. This describes where the species is currently present in its entire native range and in Greater Yellowstone in particular. This section may also include information about the historic and prehistoric range of the species. This section should also include information about the population size or relative abundance of the species across its range and in Greater Yellowstone in particular.*

- *Physical description. This describes how the individual species are visually identified and what physical characteristics distinguish them from other species.*

- *Ecology. This includes topics such as habitat (a description of what the species needs in its environment to survive and how it affects its environment; what it eats and what eats it) and life cycle (how the species reproduces, life stages, life span, what causes or contributes to its death). Other topics may be more specific to a particular species.*

- *Status in the Greater Yellowstone Area. If applicable, this includes an explanation of the species' legal status, i.e., whether the species has ever been or is now listed or being considered for listing as a threatened or endangered species, and what, if any, special protections apply. Regardless of the species' legal status, describe what, if any, threats exist to its presence as a viable population in Greater Yellowstone.*

- *Management activities in YELL, GRTE or BICA). This may include information on historical or past management policies and practices if they are significantly different from those currently in effect. In any case, some indication should be given as to how long the current management policies and practices have been in place.*

Resource Brief

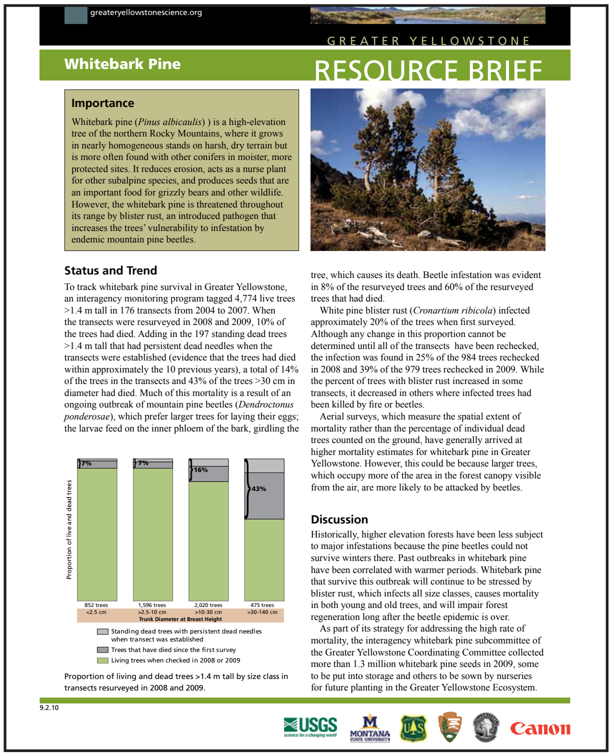
The Resource Brief (the name is still being considered) is a one-page synopsis that explains the importance of the resource, its status and trends, and a discussion of the drivers and stressors (at least for species) contributing to the status and trends (Figure 5-2). Thus, the text consists of three parts:

- *Importance. This is a one-paragraph explanation of why the resource matters. This could refer to its ecological role or historical significance specifically as it pertains to Greater Yellowstone.*

- *Status and Trend. This is a one-paragraph summary of the current population and how the resource has changed over a specified period of time.*

- *Discussion. This is a one-paragraph discussion of the key reason(s) for any changes that have occurred (e.g., the key drivers and stressors). If this is unknown or not applicable, describe the issues faced in managing this resource and recent progress or accomplishments.*

The text should be accompanied by minimal relevant graphics: photos, maps, and/or graphs. For natural resource topics for which data are available, include graphs to show the most important trends over a relevant period of time. Such graphs may not be possible or the best use of space for all cultural resource topics.



greateryellowstonescience.org

GREATER YELLOWSTONE

Whitebark Pine RESOURCE BRIEF

Importance

Whitebark pine (*Pinus albicaulis*)) is a high-elevation tree of the northern Rocky Mountains, where it grows in nearly homogeneous stands on harsh, dry terrain but is more often found with other conifers in moister, more protected sites. It reduces erosion, acts as a nurse plant for other subalpine species, and produces seeds that are an important food for grizzly bears and other wildlife. However, the whitebark pine is threatened throughout its range by blister rust, an introduced pathogen that increases the trees' vulnerability to infestation by endemic mountain pine beetles.

Status and Trend

To track whitebark pine survival in Greater Yellowstone, an interagency monitoring program tagged 4,774 live trees >1.4 m tall in 176 transects from 2004 to 2007. When the transects were resurveyed in 2008 and 2009, 10% of the trees had died. Adding in the 197 standing dead trees >1.4 m tall that had persistent dead needles when the transects were established (evidence that the trees had died within approximately the 10 previous years), a total of 14% of the trees in the transects and 43% of the trees >30 cm in diameter had died. Much of this mortality is a result of an ongoing outbreak of mountain pine beetles (*Dendroctonus ponderosae*), which prefer larger trees for laying their eggs; the larvae feed on the inner phloem of the bark, girdling the tree, which causes its death. Beetle infestation was evident in 8% of the resurveyed trees and 60% of the resurveyed trees that had died.

White pine blister rust (*Cronartium ribicola*) infected approximately 20% of the trees when first surveyed. Although any change in this proportion cannot be determined until all of the transects have been rechecked, the infection was found in 25% of the 984 trees rechecked in 2008 and 39% of the 979 trees rechecked in 2009. While the percent of trees with blister rust increased in some transects, it decreased in others where infected trees had been killed by fire or beetles.

Aerial surveys, which measure the spatial extent of mortality rather than the percentage of individual dead trees counted on the ground, have generally arrived at higher mortality estimates for whitebark pine in Greater Yellowstone. However, this could be because larger trees, which occupy more of the area in the forest canopy visible from the air, are more likely to be attacked by beetles.

Proportion of living and dead trees >1.4 m tall by size class in transects resurveyed in 2008 and 2009.

Discussion

Historically, higher elevation forests have been less subject to major infestations because the pine beetles could not survive winters there. Past outbreaks in whitebark pine have been correlated with warmer periods. Whitebark pine that survive this outbreak will continue to be stressed by blister rust, which infects all size classes, causes mortality in both young and old trees, and will impair forest regeneration long after the beetle epidemic is over.

As part of its strategy for addressing the high rate of mortality, the interagency whitebark pine subcommittee of the Greater Yellowstone Coordinating Committee collected more than 1.3 million whitebark pine seeds in 2009, some to be put into storage and others to be sown by nurseries for future planting in the Greater Yellowstone Ecosystem.

9.2.10

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Figure 5-2. The Resource Brief is a one-page resource brief that explains the importance of the resource, its status and trends, and a discussion of the drivers and stressors contributing to the status and trends.

References and Links

This section would include PDFs or links to agency or other documents like the relevant Management EISs, monitoring plans, MOUs, briefing statements—any document that influences how we manage or partner on a resource. We would also include key references for that topic. Internet links to the agencies or groups most commonly associated with that topic would also be provided.

Scientists

Here we envision linking to web pages and other information from the most important scientists working in the Greater Yellowstone Network on this topic.

Projects

One navigation pathway from the resource home page is to the individual projects related to that resource, of which our monitoring programs are such projects. This would lead to an additional set of products and resources which are described within the project-level discussion below.

Annual Report to the Superintendent

The annual report to the superintendent is a printable document that extracts the most relevant information for each resource from the individual almanacs into a single collection (Figure 5-3). This is preceded by an executive summary that further extracts the information highlights for that year. The resources are group into five classes that are relevant to their management implications: (1) Ecosystem Drivers, (2) Stressors, (3) Landscape-scale Indicators, (4) Rare and Sensitive Species, and (5) Species of Management Concern.


National Park Service
U.S. Department of the Interior
Yellowstone National Park

Yellowstone National Park

Superintendent's 2008 Report
on Natural Resource Vital Signs

Whitebark Pine (GRYN/GYCC)

Reference Condition TBD

Based on 4,774 live whitebark pine trees that were examined in 176 transects from 2004 to 2007, preliminary estimates suggest that 20% of the whitebark pine in the GYE are infected with white pine blister rust; 2% of the trees showed evidence of mountain beetle activity. Approximately 86% of the blister rust cankers detected were on branches rather than on the main bole of the tree, where cankers are generally more detrimental to the tree's survival. Of the 744 trees that were examined in 2004, 29 (4%) had died by 2007; evidence of mountain beetle activity was found on only 9 of the dead trees.

Aerial surveys by the U.S. Forest Service since 2008 show increasing levels of whitebark pine mortality in the GYE as a result of mountain pine beetle activity, although the infested area within the park declined from 36,837 acres in 2007 to 29,805 in 2008. The currently affected area is comparable to the peak seen during the last outbreak, in 1983. Aerial surveys conducted through 2005 indicated that approximately 16% of whitebark pine dominated forest stands in the GYE had some level of mountain pine beetle mortality.

Whitebark pine seeds are dispersed almost exclusively by Clark's nutcrackers; the decline in tree density could make an area less attractive to the birds, resulting in a downward spiral for both the whitebark pine and the nutcracker.

Ratio (in red) of infected trees at each monitoring site where white pine blister rust was recorded during ground surveys, 2004–07 (provisional data). Due to map scale, symbols may not be placed at the actual survey location. The number of trees sampled per site ranged from 1 to 220. Blister rust infection does not necessarily result in tree mortality.

Figure 5-3. The annual report to the superintendent extracts the most relevant information from the individual resource almanacs into a single collection.

Periodic Synthesis Report

From the outset, the I & M program, in partnership with the parks were expected to synthesize the vital signs (reportable resources) in some form that would help us to better understand the state of the parks. Although the Annual Report to the Superintendents provides an excellent means of reporting the status and trend of individual resources, it does not address the sum of the parts. Thus, there remains a need for some mechanism to merge the results of all efforts into a meaningful synthesis (Figure 5-4).

Analysis & Reporting

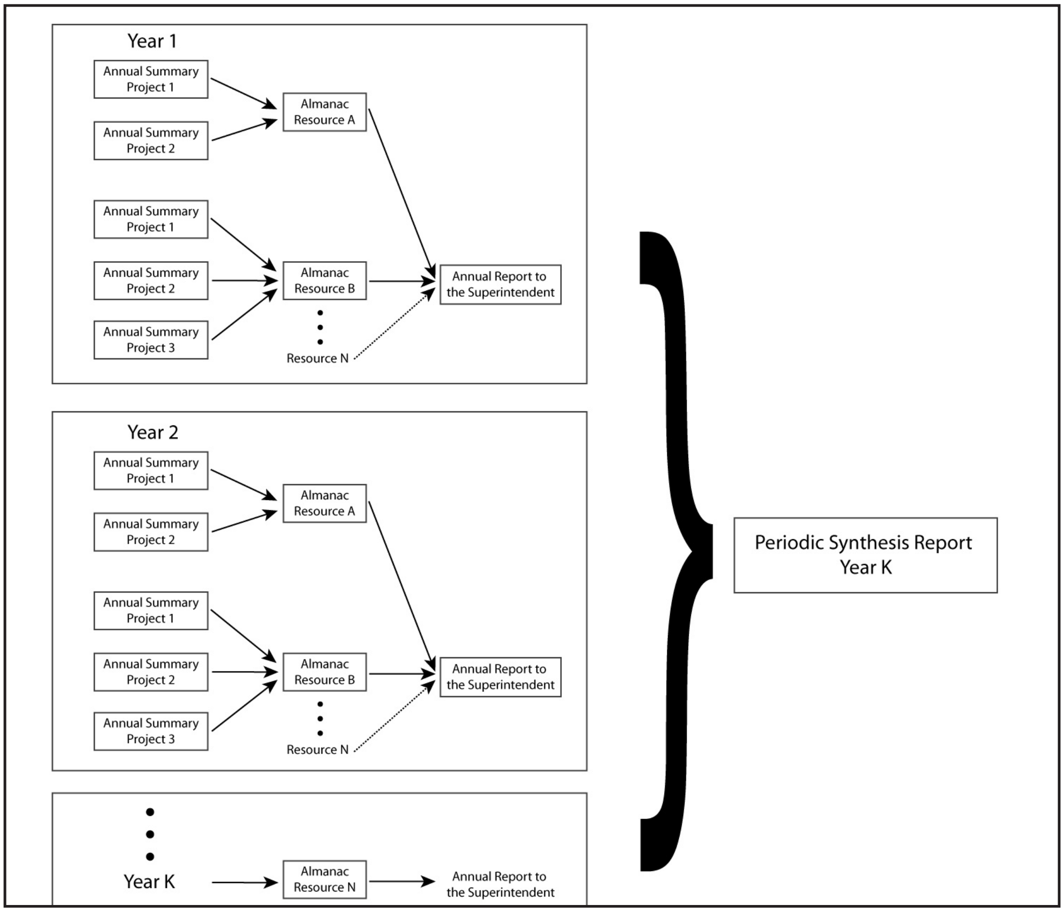


Figure 5-4. A periodic report will synthesize all of the data collected for the period, and will include estimates of any trends, estimates and effects of any covariates measured, include a regional context. The report will also include an assessment of any threats that have been hypothesized or observed, and how the vital sign influences or is influenced by other vitals signs being monitored.

For this synthesis, we use the same grouping structure as the Report to the Superintendents. This would be a familiar structure , and would lend itself well to a synthesis. For each category, the synthesis would consider the following elements:

- *The synthesis would be conducted every 5-10 years (the exact interval needs to be determined).*
- *The synthesis of each element should directly address the major concerns or considerations that contributed to why this vital sign was selected in the first place (i.e., its importance).*
- *The synthesis for each element is not restricted to the vital sign (reportable resource) itself; rather it includes additional relationships, associations, and interactions that are related to that vital sign (e.g., as an indicator, or as a*

stressor/driver or recipient of a stressor/driver).

- *Although it is probably unrealistic to think that this synthesis would be a sufficient means of parameterizing complex ecosystem models, the synthesis report should draw upon and feed back to the conceptual models to the extent practical.*
- *The models presented in this synthesis should concentrate on a few of the most important components. More detailed models can be presented on other forms better suited to their appropriate audience.*
- *The syntheses should include important issues and concerns even if we have no data. This will facilitate understanding our information needs and should help direct future monitoring and research.*
- *Similarly, the syntheses report should constitute a time to take a step back and see what we have learned. This can simultaneously serve to facilitate a program review, and to allow us to look at where we want to go with a better understanding of where we have been.*
- *Like the Resource Brief, the syntheses report is not limited to I&M or park projects. Rather, it is a comprehensive assessment of what we have learned about the system. As such, it draws upon all of the resources that contribute to our understanding. This does not imply that all outside scientists need to write parts (although in some cases that may be warranted); rather, it implies that we synthesize all of the evidence.*

Analysis & Reporting

Project Level

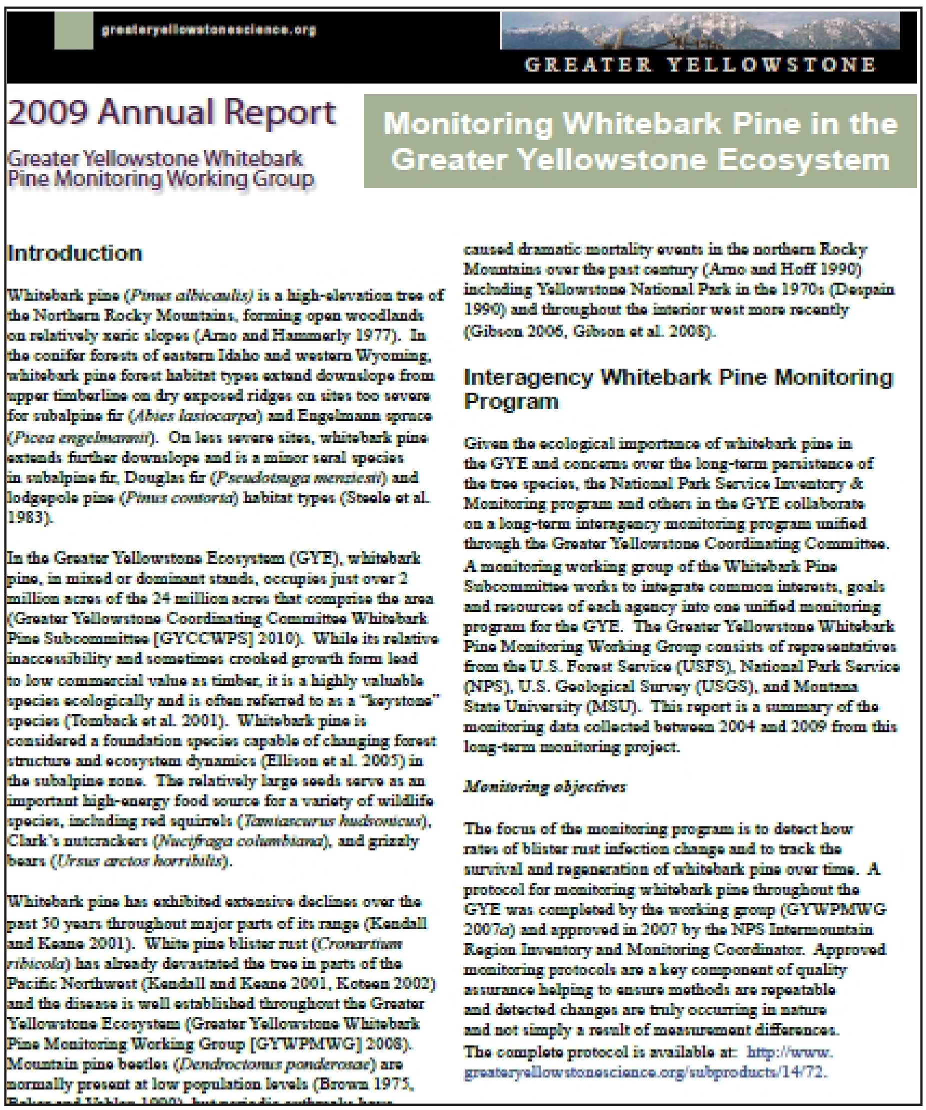
The projects level entry page provides an initial portal to the individual projects related to the resource, in this case whitebark pine (Figure 5-5). From this page, one can navigate to any project associated with that resource.

Figure 5-5. The project level entry page of the Greater Yellowstone Science Learning Center provides a list of the projects on a given topic, and serves as a portal to one or more project level pages.

Annual Project Reports

Annual project reports (Figure 5-7) will synthesize the accomplishments and results of a given year's effort for that project. The provide additional detail not included within the project summary, and contribute to the information that will be complied in a periodic synthesis report. These annual reports will include at a minimum the following sections:

- *Introduction - Explaining the purpose and background of the project.*
- *Methods - A brief synopsis of the methods with reference to the full monitoring protocol.*



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GREATER YELLOWSTONE

2009 Annual Report

Greater Yellowstone Whitebark Pine Monitoring Working Group

Monitoring Whitebark Pine in the Greater Yellowstone Ecosystem

Introduction

Whitebark pine (*Pinus albicaulis*) is a high-elevation tree of the Northern Rocky Mountains, forming open woodlands on relatively xeric slopes (Arno and Hammerly 1977). In the conifer forests of eastern Idaho and western Wyoming, whitebark pine forest habitat types extend downslope from upper timberline on dry exposed ridges on sites too severe for subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*). On less severe sites, whitebark pine extends further downslope and is a minor seral species in subalpine fir, Douglas fir (*Pseudotsuga menziesii*) and lodgepole pine (*Pinus contorta*) habitat types (Steele et al. 1983).

In the Greater Yellowstone Ecosystem (GYE), whitebark pine, in mixed or dominant stands, occupies just over 2 million acres of the 24 million acres that comprise the area (Greater Yellowstone Coordinating Committee Whitebark Pine Subcommittee [GYCCWPS] 2010). While its relative inaccessibility and sometimes crooked growth form lead to low commercial value as timber, it is a highly valuable species ecologically and is often referred to as a "keystone" species (Tomback et al. 2001). Whitebark pine is considered a foundation species capable of changing forest structure and ecosystem dynamics (Ellison et al. 2005) in the subalpine zone. The relatively large seeds serve as an important high-energy food source for a variety of wildlife species, including red squirrels (*Tamiascurus hudsonicus*), Clark's nutcrackers (*Nucifraga columbiana*), and grizzly bears (*Ursus arctos horribilis*).

Whitebark pine has exhibited extensive declines over the past 50 years throughout major parts of its range (Kendall and Keane 2001). White pine blister rust (*Cronartium ribicola*) has already devastated the tree in parts of the Pacific Northwest (Kendall and Keane 2001, Koteen 2002) and the disease is well established throughout the Greater Yellowstone Ecosystem (Greater Yellowstone Whitebark Pine Monitoring Working Group [GYWPMWG] 2008). Mountain pine beetles (*Dendroctonus ponderosae*) are normally present at low population levels (Brown 1975,

caused dramatic mortality events in the northern Rocky Mountains over the past century (Arno and Hoff 1990) including Yellowstone National Park in the 1970s (Despain 1990) and throughout the interior west more recently (Gibson 2006, Gibson et al. 2008).

Interagency Whitebark Pine Monitoring Program

Given the ecological importance of whitebark pine in the GYE and concerns over the long-term persistence of the tree species, the National Park Service Inventory & Monitoring program and others in the GYE collaborate on a long-term interagency monitoring program unified through the Greater Yellowstone Coordinating Committee. A monitoring working group of the Whitebark Pine Subcommittee works to integrate common interests, goals and resources of each agency into one unified monitoring program for the GYE. 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). This report is a summary of the monitoring data collected between 2004 and 2009 from this long-term monitoring project.

Monitoring objectives

The focus of the monitoring program is to detect how rates of blister rust infection change and to track the survival and regeneration of whitebark pine 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 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/subproducts/14/72.

Figure 5-6. Annual project reports will synthesize the accomplishments and results of a given year's effort for that project.

- *Results – The results of the current year's efforts, including estimates of blister rust infection.*
- *Discussion – A short narrative describing the current years results in the context of previous years, observed trends or patterns, and implications to management.*

Chapter6

Personnel Requirements & Training

Personnel Requirements

To complete the monitoring of whitebark pine, the following positions will be required: 1) project manager; 2) project coordinator/crew leader; 3) crew members. The roles, responsibilities and minimum qualifications for the positions are described in Table 6-1.

Training

This section explains training required to: 1) positively identify white pine blister rust infection and/or signs of possible infection; 2) positively identify mountain pine beetle infestation; 3) take standard forest measurements helpful in monitoring whitebark pine and mark trees; and 4) identify plant species, including tree species of interest and those plants that will help to determine cover and habitat types.

Identification of white pine blister rust infection

White pine blister rust infection can be identified in one of two ways: the observer may see sporulating cankers, which constitutes a positive identification, or the observer may identify other signs of possible infection. Signs of possible infection include: rodent chewing (including bark stripping); flagging (branches with dead needles); swelled cankers (cankers present, but no aecia); roughened bark (which may be identified with rubbed water); and/or oozing sap. Crew members should be able to identify these signs of infection on both short saplings and tall, large, adult trees through the use of binoculars. Because detection of infection is quite difficult on large trees, it is essential that the crews become extremely competent with canker identification and expert with the use of binoculars, moving around a tree to get clear views of potential infections. The following papers should be of great use to field crews:

Hoff RJ. 1992. How to recognize blister rust infection on whitebark pine. USDA Forest Service, Intermountain Research Station, INT-406.

Hunt RS and Meagher MD. 1992. How to recognize white pine blister rust cankers. Forestry Canada, Pacific Forestry Centre.

Personnel Requirements & Training

Table 6: Roles, responsibilities and minimum qualifications for each position.			
Position	**Roles**	**Responsibilities**	**Minimum Qualifications**
Project Manager	-Serves as a liaison among project cooperators (cooperating agencies), other related projects (i.e., monitoring by other groups or in neighboring locales), and between other staff (crew leader and members) and the GRYN (and its cooperators)	-To hire other staff members (crew leader and members) -To coordinate field schedules and availability of supplies with the crew leader -To participate in the creation of (and possibly lead) training for crew leader and members -To inform GRYN staff and cooperators of the progress of monitoring and any areas where adjustments may be needed -To act as a direct channel of communication between this project and others of this nature, thus building relationships and cooperation among this project and other similar projects -To be the party responsible for providing data from fieldwork to GRYN staff for analysis in a quality checked format, along with copies of all original data, and to be available for any questions pertaining to the data	-Excellence in identifying (and explaining the identification of) whitebark pine, white pine blister rust, mountain pine beetle, dwarf mistletoe parasitism, other tree and herbaceous species of interest to the project -Experience hiring personnel -Experience managing projects and communicating results in a clear and concise manner to all interested parties through a variety of media -Experience collecting and quality checking reliable data -Experience training crews and performing field work
Project Coordinator	-Serves as the leader of the field crew members and is the primarily liaison between the project manager and the crew members	-To participate in field training -To act as the primary coordinator with respect to field schedules and supplies -To serve as the party who is primarily responsible for the safety of crew members -To accompany crew members in the field until they demonstrate the ability to be self-sufficient -To act as a direct liaison between the project manager and the crew members -To enter and quality check all data before submitting for analysis	-Experience performing field work -Experience training, leading and coordinating crews -Experience with data collection, entry and quality assurance -Experience communicating with a variety of audiences -Experience with teaching outdoor safety and route finding - Excellence in identifying (and explaining the identification of) whitebark pine, white pine blister rust, mountain pine beetle, dwarf mistletoe parasitism, other tree and herbaceous species of interest to the project -Experience using a GPS unit -Must be able to hike long distances to high elevation sites in difficult weather and carry a heavy backpack

Table 6-1. Cont.

Position	Roles	Responsibilities	Minimum Qualifications
Crew Members	-Serve as the work horse of the field operation by performing all field work related to the monitoring project	-To participate in field training -To alert crew leader of any scheduling conflicts or needed supplies -To account for safety of yourself and others at all times -To be responsible for all loaned equipment and use it properly -To collect reliable, accurate data and submit it to the crew leader in a timely manner	-Capability to learn to identify tree and herbaceous species, white pine blister rust infection, mountain pine beetle infestations and dwarf mistletoe parasitism -Capability to learn backcountry safety and route finding -Capability to learn the use of a GPS unit and undergo training if necessary -Experience communicating and working with a variety of personalities in close settings under arduous conditions -Must be able to hike long distances to high elevation sites in difficult weather and carry a heavy backpack -Preferably have experience performing field work in forest measurements, have experience working with dichotomous keys and identifying species, and have extensive hiking/backpacking experience

Taking Standard Forest Measurements and Marking Trees

Monitoring whitebark pine requires understanding how to measure the diameter at breast height (DBH) of trees. DBH should be practiced by all field crew members prior to starting the field season. It is important to attempt to measure all trees at approximately the same height from the ground. This can be accomplished by measuring out 1.4 m (4.5 ft) on each person to give them an idea of where DBH measurements should be taken, as this measurement will vary depending on each crew member's height. In addition, it is important to try to measure around the tree as straight as possible, as altering the diameter line will cause the measurement to be inaccurate. Diagram A explains how to measure trees under various circumstances (taken from Jenkins M. Great Smoky Mountains National Park: vegetation monitoring protocols. National Park Service—Great Smoky Mountains National Park. 40 pp.).

Marking trees is also an important aspect of establishing long-term plots for monitoring whitebark pine. Crew members should use small, round, numbered metal tags in sequential order from the beginning of the transect to the end. It is essential to use aluminum nails that are of the correct diameter (2 1/8 " long wood siding type) to allow the metal tags to hang to the end of the nail instead of being pressed against the bark of the tree. Hammering tags into the bark of the tree can result in the loss of tags due to the bark growing over the tag between site visits.

Chapter 6

Personnel Requirements & Training

Identifying Plant Species, Cover Types and Habitat Types

Crew members should become familiar with using dichotomous keys during training. Additionally, identifying characteristics of the species should be clarified in the field and with pictures. Cover typing requires the ability to estimate relative abundance of different tree species and age classes, while habitat typing also requires identification of herbaceous vegetation within the plot. Crew members should be familiar with all possible habitat types—either by picture or through field visits—prior to the field season. Crew members should also be familiar with the scientific names for all commonly encountered plants and be confident of the tree species they will be identifying. Field crews should be comfortable with the identification of cover (according to Despain's cover types) and habitat types (according to Steele's cover types) using the (dichotomous-key based) identification sheets provided to them.

Identifying Whitebark versus Limber Pine

The easiest, most obvious and accurate way to tell the difference between whitebark and limber pine is by their cones. If a tree is producing cones, they can be seen in the top canopy. Typically, old and occasionally cut, fresh cones can be found scattered on the forest floor close to the trunk. Whitebark cones are deep purple in color, squat, thick and sappy. They are extremely tight and more difficult to open when they are fresh. Due to the fact that they are highly sought after by wildlife, intact, fresh whitebark cones rarely remain in the canopy once they have matured. Often, the remains or skeleton of the outer shell of a cone can be seen in the canopy after birds have eaten the fleshy seeds from the inside. In contrast, limber pine cones are green in color and are significantly longer and thinner than whitebark. Because they are less sought after by wildlife, they tend to remain in the canopy, gradually turn brown, open their bracts and eventually fall to the ground. It is more typical to find limber pine cones on the forest floor at the base of the tree than whitebark cones.

Photo courtesy of Lisa Landenburger

Whitebark Pine Cones

If cones are not visible, there is a period of time (early spring through late July-mid August) that the young male "catkin-like" cones can be found on the terminal ends of the branches of both species. The young whitebark cones are all bright red to deep purple, whereas the limber pine young cones are generally green-yellow (note: the exception to this is that for a very short time in early spring, the male immature cones of limber pine can also appear red). Later in the season (mid August-September), the whitebark "catkin-like" bodies will begin to turn dark brown as they age. The limber pine "catkin-like" bodies begin to turn a more tan color as they age.

Photo courtesy of Lisa Landenburger

Limber Pine Cones

Elevation and substrate provide clues to aid in the identification process, but neither should be used soley to differentiate whitebark and limber pine.

Photo courtesy of Karla Sartor

Early season "catkin-like" cones of whitebark pine.

In a situation where a mixed stand is encountered, use cone identification as the main tool to identify between the two species. Next, look at the immature female/male cones on the end of the branches. (Keep in mind the "note" mentioned above: If you encounter a tree that has just a few red "catkins" and green-yellow "catkins", it is most likely limber pine. Make sure you survey the tree entirely before you draw any conclusions as to which species the tree belongs). If it is still unclear as to which species of conifers you are encountering on a transect and you cannot, with 100% confidence, verify which trees on the plot are whitebark, select an alternate plot from the list provided to sample. (It is fine to monument a mixed plot as long as you can clearly eliminate any limber pine from the sample and are completely confident that you have done so).

Chapter 7

Continual Improvement

Quality assurance extends beyond data management and must be an integral component of all aspects of the GRYN program. The USFS Forest Inventory and Analysis Program (FIA) identified three aspects of quality assurance (prevention, assessment and correction), which are referred to as the QA triangle (Figure 7-1). In the context of the overall GRYN program, prevention is addressed through sound development of sampling design, data management and analysis. Although prevention is extremely important, it is not sufficient by itself, due to changing programs, funding, environments, technologies, etc. Thus, this protocol includes the following section for assessment (i.e., the review process) and correction.

Review Process

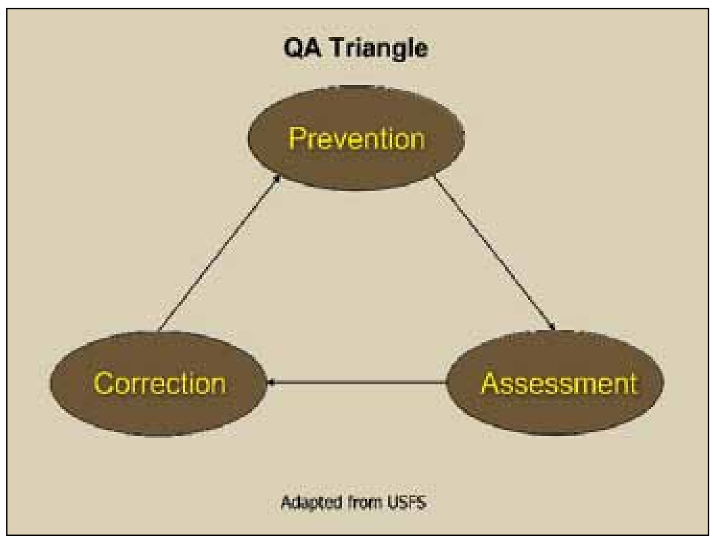

Figure 7-1. The quality assurance triangle. Adapted from the USFS.

Reviews may be periodic (planned at a predefined interval) or episodic (resulting from changing mandates, funding, priorities, etc). The review process should permeate through all phases of our monitoring. It also should permeate through all of our thematic elements (i.e., applicability, reliability and feasibility), although it may not be the same review process for each element. Rather, the details of a given review should reflect which element(s) is being targeted. For example, a review intended to assess the scientific reliability is likely to be conducted by qualified scientists. In contrast, a scientific review panel may have little insight if a review is intended to assess whether or not the monitoring meets the needs of managers. Consequently, the review strategy should also clearly specify the purpose of the review and, at least in general terms, who should conduct the review.

Chapter 7

Continual Improvement

Process for Change

Determining the status and trends of selected indicators of the condition of park ecosystems is an essential and critical goal of the I&M Program. Understanding the spatial and temporal scales over which change occurs is paramount to achieving this goal. We have considered the spatial and temporal scale in several elements of this report, including sampling design and implementation. However, many ecosystem attributes of interest operate at such long time scales that implementing a temporal sampling design requires a long-term commitment that enables teasing apart true change from environmental noise (i.e., variation). Thus, one of the key values of the I&M program is its long-term prospect. Frequent changes in monitoring protocols in the attributes being monitored and how they are being monitored would likely lead to an ever-weakening ability to meet the program goals, leading to erosion of support, further weakening the program, etc. Thus, at the outset the GRYN needs to be vigilant about disruptive change in our monitoring, while at the same time recognizing that changing resources and management regimes may require some degree of flexibility. The difficulty lies in finding the right balance between maintaining the necessary consistency to meet our program goals with enough flexibility to meet the challenges of changing natural and political environments. Thus, when making changes in protocols, the following questions should be addressed:

1. *What are the criteria for determining whether or not a change is warranted? These should reflect the general themes identified above:*
    - *Reliability - The data are not reliable in their present form*
    - *Applicability- The data are not applicable to managers, the public, etc. in their present form*
    - *Feasibility- The data are not feasible to obtain in their present form (e.g., funding, logistics, priorities, etc).*
2. *If it is determined that a change is required, what programmatic element needs to be changed?*
    - *Objectives?*
    - *Design?*
    - *Field Methods?*
    - *Data Management?*
    - *Analysis?*
    - *Reporting?*

Note: Changing a vital sign or an objective is far more drastic than changing a reporting method. Thus the criteria for making changes to different elements may reflect their relative degree of severity.

3. *What is the procedure for making the change?*
4. *What precautions will be taken to ensure that the revised protocol will be acceptable?*
   - *Pre-change reviews (based on planned changes)?*
   - *Post-change reviews (based on results from implemented changes)?*
   - *Testing concurrent with existing protocol?*
   - *Post-change analyses*
5. *How will the transition to the revised protocol be accomplished?*
   - *Will there be a period of overlap; if so, how?*

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Appendix 1: Field Forms

Site 1792-1	Panel 3 Full Survey	2010	GYE Interagency WBP Monitoring Project FIELD SURVEY DATA SHEET version: 6.17.2010

White cells are required. | Shaded cells are optional or as needed. | Don't leave cells blank. Enter 0 if a count is zero.

Survey Date: (mo/dy/year)		Full names of all crew members and guests on site during survey:	

Topo Map: Sphinx Mountain
Sample Panel: 3 | Most Recent Survey: 7/25/2008
Total Tagged Trees: 2 | Transect elevation (ft): 9045
Tree Tag location: base

transect center point reference	Species	DBH (cm)	Distance To Ctr (m)	Azimuth To Ctr
Xtree	ABLA	13.7	13	109
Ytree	ABLA	25	7	165

	Easting	Updates?*	Northing	Updates?*	GPS Error*
Begin Point	462390		5000007		
Center Point	462402		5000001		
End Point	462423		4999990		

* Only update a point location if the listed location is more than 6 meters from the monumented point on the ground. Use only averaged position values for updates. Coordinates are UTM zone 12, NAD83.

Multi-observer Survey? circle one: Yes No

Transect Orientation: 113

Habitat Type: ABLA/SYAL

Habitat Type Update (only if needed): (only from Steele et. al. 1983)

Last Recorded Cover Type: WB3/SF

Cover Type for current survey:

Always enter current cover type even if it matches the last recorded cover type. Only use cover type values from Mattson and Despain, 1985.

Site Photo Number(s): (As named on camera)

Small Tree Totals by Blister Rust Category (for all Whitebark pine trees less than 1.4 meters in height within the sample transect)

Small Trees Blister Rust Present:	Tally area for Present	Small Trees Blister Rust Absent:	Tally area for Absent	Small Trees Blister Rust Unknown:	Tally area for Unknown

Squirrel Midden Totals observed in or from the survey site. (Do not include middens observed on the hike to and from the site)

Total Undisturbed Active Middens:		Total Undisturbed Inactive Middens:		Total Excavated Active Middens:		Total Excavated Inactive Middens:	

General Location:
S.side Sphinx Mtn

Driving and Hiking Directions:
Driving: From Ennis, MT drive south along 287 and at Cameron, turn east (left) and follow signs to Bear Crk campground (not the state area) approx 5 miles in. Hiking: Take trail up Bear Crk., turn south at first junction to Manley Camp, then east approx 5 miles. Camp at Manley and combine with plot 1830. Plot and hike from camp = 4 hours.

Land Access and Overnight Accommodations:
Manley Camp

Survey Comments - Concisely describe any relevant conditions during the survey that may affect or help interpret recorded data:

Site Comments - Concisely describe any relevant info about physical site characteristics that aren't expected to change over time:

This Field Survey Data Sheet was generated by NPS GRYN from GYE_WBP_Monitoring_Survey_Database_MASTER_User_Interface.mdb on Thursday, June 17, 2010

Site 1792-1	Panel 3 Full Survey	2010	GYE Interagency WBP Monitoring Project FIELD SURVEY DATA SHEET	version: 6.17.2010

transect begin point reference:

	Species	DBH (cm)	Distance To Ctr (m)	Azimuth To Ctr
Xtree				
Ytree				

transect end point reference:

	Species	DBH (cm)	Distance To Ctr (m)	Azimuth To Ctr
Xtree				
Ytree				

Site 2673-4	Panel 3 Full Surveys	2010	GYE Interagency WBP Monitoring Project TREE DATA SHEET	version: 6/17/2010

Please write carefully, neatly, and legibly for all data sheet entries. **Review and double-check all entries for quality.**

For Multi-observer Surveys, EACH independent observer enters values for columns **6**, 7 and **14** - 35.
Refer to the Data Recording Instructions to determine when and whether to enter values in columns 8-13.
Always enter DBH and Height Class for new trees.

MPB Pitch Tubes [32]	MPB Frass [34]
0 = 0 pitch tubes	0 = frass absent
1 = 1-5 pitch tubes	1 = frass less than 30%
2 = > 5 pitch tubes	2 = frass more than 30%

6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
								Branch Cankers						Bole Cankers						Indicators						Mountain Pine Beetle			
								Upper Third		Middle Third		Bottom Third		Upper Third		Middle Third		Bottom Third											
Tree ID (tag no.)	Observer's Initials	Clump Number	Clump Letter	DBH (cm)	Height Class (1-3)	Tree Status (L, RD, D)	Cone Producing (Y,N)	A	I	A	I	A	I	A	I	A	I	A	I	Rodent Chewing	Flagging	Swelling	Roughened Bark	Oozing Sap	Live Canopy Volume (%) (Upper Third)	Pitch Tube Category(0-2)	MPB-Galleries Present (Y/N)	MPB-Frass Category(0-2)	Tree Health Code(s) **(Use only valid codes from Potocol)**
1		3	a	19	3																								
2		3	b	5	2																								
3		-	-	8	2																								
4		-	-	2	1																								
5		-	-	3	1																								
6		-	-	2	1																								
7		-	-	9	2																								
8		-	-	6	2																								
9		-	-	4	1																								
10		-	-	3	1																								
11		-	-	16	3																								
12		-	-	8	2																								
13		-	-	17	3	RD																							
14		-	-	2	1																								
15		-	-	4	1	RD																							
17		-	-	3	1																								
18		-	-	26	3		Y																						
19		-	-	12	2																								
20		-	-	5	1																								
21		-	-	2	1																								
22		-	-	47	3		Y																						
23		-	-	1	1																								
24		-	-	5	2																								
25		-	-	2	1																								
26		-	-	0.4	1																								
27		-	-	18	2		Y																						
28		-	-	11	2																								

Comments on individual trees (Objective and concise comments only please.)

Tree ID	Comment

Site 2673-4	Panel 3 Full Surveys	**2010**	**GYE Interagency WBP Monitoring Project** TREE DATA SHEET	version: 6/17/2010

Please write carefully, neatly, and legibly for all data sheet entries. **Review and double-check all entries for quality.**

For Multi-observer Surveys, EACH independent observer enters values for columns **6**, 7 and **14** - 35. Refer to the Data Recording Instructions to determine when and whether to enter values in columns 8-13 **Always enter DBH and Height Class for new trees.**	MPB Pitch Tubes [32]	MPB Frass [34]
	0 = 0 pitch tubes	**0** = frass absent
	1 = 1-5 pitch tubes	**1** = frass less than 30%
	2 = > 5 pitch tubes	2 = frass more than 30%

6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
								Branch Cankers						**Bole Cankers**						**Indicators**						**Mountain Pine Beetle**			
Tree ID (tag no.)	**Observer's Initials**	**Clump Number**	**Clump Letter**	**DBH (cm)**	**Height Class (1-3)**	**Tree Status (L, RD, D)**	**Cone Producing (Y,N)**	Upper Third		Middle Third		Bottom Third		Upper Third		Middle Third		Bottom Third		Rodent Chewing	Flagging	Swelling	Roughened Bark	Oozing Sap	Live Canopy Volume (%) (Upper Third)	Pitch Tube Category(0-2)	MPB-Galleries Present (Y/N)	MPB-Frass Category(0-2)	Tree Health Code(s) **(Use only valid codes from Potocol)**
								A	I	A	I	A	I	A	I	A	I	A	I										

Enter newly tagged trees here:

Comments on individual trees (Objective and concise comments only please.)

Tree ID	Comment

Appendix 2: Data Dictionary

This description of the core data tables is followed by tables that provide details and descriptions for each field in the master data tables and some other important and useful database objects.

The Greater Yellowstone Interagency Whitebark Pine Monitoring Survey Database is composed of two Microsoft Access (version 2003) files. One is a master data file (backend database) and the other is the user interface file (frontend file).

The Master Data File contains the six master data tables described below. Several additional tables support database functionality and data quality - primarily lookup lists containing enumerated data domain elements. These six principal tables follow a relational data model based on location (sample sites), survey events (observation and measurement events that are normally repeated over time at established sample sites), and natural resource item(s) of interest (Whitebark pine trees in this case, which have multiple attributes for which data values are recorded repeatedly over time, and based on specific criteria, to establish the basis for determining status and trend over time, i.e. monitoring).

Database table 'tbl_GYE_WBP_Sites' contains master data for established and monumented survey locations on Forest Service and Park Service administered lands throughout the Greater Yellowstone Ecosystem (GYE).

Database table 'tbl_GYE_WBP_Surveys' contains master data for survey events occurring at sites listed in the Sites table.

Database table 'tbl_GYE_WBP_Tagged_Trees' contains the master list of unique trees for each sample site.

Database table 'tbl_GYE_WBP_Tree_Data_Single_Obs' contains master tree data for attributes (data fields) recorded only once per tree for each survey (including surveys for which multiple independent observers record tree health observations), resulting in one data record per tree per survey. Separating these records and fields from the multi-observer records and fields maintains a more normalized database, reduces blanks (and confusion) in each data table, and makes coding easier for database functions and procedures. However, to view a complete record of all tree characteristics and tree health data, the values from the 'Multi_Obs' table must also be associated with the tagged trees.

Database table 'tbl_GYE_WBP_Tree_Data_Multi_Obs' contains master tree data for those attributes recorded by each independent observer during surveys designated as 'multi-observer' surveys, resulting in more than one data record per tree per survey. Data in this table may be misleading unless the distinction is made between full surveys and pine beetle only surveys, for which the blister rust infection and indicator values are recorded as zero because these attributes aren't recorded for pine beetle only surveys. Until the data structure is changed to separate the pine beetle and blister rust fields into separate tables, users must recognize and address this issue during output data processing.

Database table ‘tbl_GYE_WBP_TreeExceptions’ contains a list of tagged trees that do not have field observation data for some surveys, for example if the tree could not be located.

The User Interface file contains the queries, forms, and Visual Basic functions and procedures that support database functionality, quality controls, and user interaction such as getting data in and out of the database in meaningful and useful ways. The user interface emphasizes data entry and validation to ensure high quality data. Data output functionality is developed as time permits and the demand for output functionality is determined.

The database includes records starting in 2004. Initial site establishment and surveys conducted in 2004 yielded information about the utility and feasibility of some site, survey, and tree attributes. Consequently, the 2004 data structure differs in some ways from the data structure used in 2005 and thereafter. The field description and database design notes in the data dictionary tables below help to explain these differences and how the database structure is affected.

The field descriptions provided below also appear in the design view of the database tables directly in the Microsoft Access database file. Additional description and explanation in the context of monitoring objectives is found in the published methods (monitoring protocol) for this project.

Table A2-1. Greater Yellowstone Ecosystem whitebark pine sites

Database Field Name	Database Field Caption (when used)	Field Name (label) on hardcopy data collection form	Field Description	Data Type	Field Size	Format	Valid Field Values or lookup source
Site_ID_DB (PK)	<not used>	*<not on data collection form>*	Primary key for this table. Uses Microsoft Acces Autonumber data type. Each new record is automatically assigned a unique integer value.	AutoNumber	Long Integer	numeric	<positive integer value>
Stand_ID	Stand	Stand ID	user-generated identifier originally from timber stand selection process but with a different value than the 'GIS_ID' value for some stands due to evolution of the project.	text	<= 50		<positive integer value>
Transect_ID	Trans	Transect ID	User-generated identifier from transect selection and identification process	text	<= 50		1, 2, 3, 4, or 5
SiteType	SiteType	*<not on data collection form>*	Distinguishes permanently monumented sample sites from unmonumented sites tested in 2004 (project year one) as 'double stand transects' that will not be resurveyed for monitoring.	text	50	lower case	monumented and monitored' or 'not monumented and not monitored'
GIS_ID	GIS_ID	*<not on data collection form>*	user-generated identifier from timber stand selection process in GIS. Use this value to relate survey data to GIS data representing Whitebark pine polygons. Individual polygons can contain multiple monitoring transects. Sometimes referred to as 'plot ID' or 'Poly ID'.	text	<= 50		<positive integer value>
StandAreaSQm	AreaSQm	*<not on data collection form>*	planimetric area in square meters of the timber stand in which the sample plot occurs. Source: Lisa Landenburger (USGS or IGBST)	number	Long Integer	numeric	<positive integer value>

Database Field Name	Database Field Caption (when used)	Field Name (label) on hardcopy data collection form	Field Description	Data Type	Field Size	Format	Valid Field Values or lookup source
GrizPCA	GrizPCA	*<not on data collection form>*	a 'yes' value means the site is within the Primary Conservation Area/Recovery Zone for grizzly bears.	text	3	Normal Case	Yes or No
State	State	State	2 character abbreviation of the state in which the survey occurred	text	2	UPPER CASE	MT, WY, ID
County	Co	County	Name of county in which the survey occurred	text	<= 50	Normal Case	From lookup table: 'tlu_GYE_WBP_County_Names'
AdminOrg	Own	Ownership	Abbreviated name of administering organization (i.e. 'USFS', 'NPS', etc)	text	<= 50	Normal Case	USFS, NPS, Other (specify)
AdminName	Admin	Forest/Park	Name of administering unit (e.g. <National Forest name> or <National Park name>)	text	<= 50	Normal Case	From lookup table: 'tlu_GYE_WBP_Administrative_Unit_Names'
AdminDist	Dist	District	Name of USFS District or NPS Subdistrict	text	<= 50	Normal Case	From lookup table: 'tlu_GYE_WBP_Administrative_District_Names'
AdminPOC_DB_ID	Contct	*<not on data collection form>*	Foreign key to lookup table containing names of administrative point of contact (POC) for the project activities occurring on the admin unit.	number	Long Integer	numeric	From lookup table: 'tlu_Admin_Contact_Names'
LocDescr	Loc	Location Description	Narrative description of transect location	Memo	<= 200	Normal Case	From a range of alphanumeric characters
TopoMapName	Topo	Topo Map ID	Name of 7.5 minute topographic quadrangle map. Name source: USGS.	text	<= 50	Normal Case	From lookup table: ''tlu_Topo_Map_Names'

Database Field Name	Database Field Caption (when used)	Field Name (label) on hardcopy data collection form	Field Description	Data Type	Field Size	Format	Valid Field Values or lookup source
BegUTME_12_83	B_UTMe	Transect Begin UTM Easting (NAD83)	Easting Coordinate at beginning point of transect, UTM zone 12, NAD83	number	double, auto decimal	numeric	Between 310000 – 690000
BegUTMN_12_83	B_UTMn	Transect Begin UTM Northing (NAD83)	Northing Coordinate at beginning point of transect, UTM zone 12, NAD83	number	double, auto decimal	numeric	Between 4660000 - 5128000
BegErrMeters	B_err	Transect Begin Location Error	Estimated transect beginning point position error in meters - normally recorded from recreation-grade GPS. If possible less than <??> meters.	number	double, auto decimal	numeric	<positive integer value> less than <??> when possible
BegComment	B_comm	<white space below Transect Begin>	Narrative of pertinent information about the position of the point at the beginning of the transect	Memo			From a range of alphanumeric characters
CtrUTME_12_83	C_UTMe	Transect Random Point UTM Easting (NAD83)	Easting Coordinate at center point of transect, UTM zone 12, NAD83. For 2005 this value was recorded in the field using recreation-grade GPS. Transect center coordinates were not recorded in 2004 (field value = 0)	number	double, auto decimal	numeric	Between 310000 – 690000

Database Field Name	Database Field Caption (when used)	Field Name (label) on hardcopy data collection form	Field Description	Data Type	Field Size	Format	Valid Field Values or lookup source
CtrUTMN_12_83	C_UTMn	Transect Random Point UTM Northing (NAD83)	Northing Coordinate at center point of transect, UTM zone 12, NAD83. For 2005 this value was recorded in the field using recreation-grade GPS. Transect center coordinates were not recorded in 2004 (field value = 0)	number	double, auto decimal	numeric	Between 4660000 - 5128000
CtrErrMeters	C_err	Transect Random Point Location Error	Estimated transect center point position error in meters - normally recorded from recreation-grade GPS. If possible less than <??> meters.	number	double, auto decimal	numeric	<positive integer value> less than <??> when possible
EndUTME_12_83	E_UTMe	Transect End UTM Easting (NAD83)	Easting Coordinate at end point of transect, UTM zone 12, NAD83	number	double, auto decimal	numeric	Between 310000 – 690000
EndUTMN_12_83	E_UTMn	Transect End UTM Northing (NAD83)	Northing Coordinate at end point of transect, UTM zone 12, NAD83	number	double, auto decimal	numeric	Between 4660000 - 5128000
EndErrMeters	E_err	Transect End Location Error	Estimated transect end point position error in meters - normally recorded from recreation-grade GPS. If possible less than <??> meters.	number	double, auto decimal	numeric	<positive integer value> less than <??> when possible
EndComment	E_comm	<white space below Transect End>	Narrative of pertinent information about the position of the point at the end of the transect	Memo			From a range of alphanumeric characters

Database Field Name	Database Field Caption (when used)	Field Name (label) on hardcopy data collection form	Field Description	Data Type	Field Size	Format	Valid Field Values or lookup source
GISUTME_12_83	R_UTMe	Transect Random Point UTM Easting (NAD83)	target coordinate value generated in the office using GIS, UTM zone 12, NAD83, as the initial easting coordinate of the target point location for crews to establish the transect. In November 2007 this field was renamed for clarity from 'rdmUTME_12_83' to 'GISUTME_12_83'.	number	double, auto decimal	numeric	Between 310000 – 690000
GISUTMN_12_83	R_UTMn	Transect Random Point UTM Northing (NAD83)	target coordinate value generated in the office using GIS, UTM zone 12, NAD83, as the initial northing coordinate of the target point location for crews to establish the transect. In November 2007 this field was renamed for clarity from 'rdmUTMN_12_83' to 'GISUTMN_12_83'.	number	double, auto decimal	numeric	Between 4660000 - 5128000
HabitatType	Hab	Habitat Type	Climax community habitat type for the monitoring site from Steele et al. guide.	text	25	UPPER CASE	4-character codes representing climax community habitat type from Steele et al. guide.
Tree_Tag_Location	<not used>	*<not on data collection form>*	indication of whether trees are tagged at the base (for sites in designated wilderness areas) or at breast height. Project leader Erin Shanahan provided this data for 66 transects in March 2010	text	40	lower case	'base' = tag affixed at/near base of tree. ''dbh' = tag affixed at/near diameter breast height.

Database Field Name	**Database Field Caption (when used)**	**Field Name (label) on hardcopy data collection form**	**Field Description**	**Data Type**	**Field Size**	**Format**	**Valid Field Values or lookup source**
HabTypeConf	<not used>	*<not on data collection form>*	Relative categorical rating of the accuracy of the assigned habitat type - initially assessed and assigned by Erin Shanahan in August 2009.	text	10		high medium low unknown
Site_Comment	Comm	Site Comments	Narrative about the general nature of the transect or related pertinent information	Memo	memo	Normal Case	From a range of alphanumeric characters
TsectOrientation	Orient	Transect Orientation (azimuth)	Transect orientation referenced to magnetic North degrees, measured on site using a compass with declination set at zero degrees	number	Long Integer	numeric	integer values between 1 - 360
elev_ft	<not used>		Representative site elevation in feet	number	Double	numeric	positive integer values
YearEstablished	YrEstbl	*<not on data collection form>*	The year in which the monitoring plot was initially established	number	Double	yyyy	<valid year>
BegXtreeSpecies	<not used>	X Tree Species (transect begin)	Species of 'X' tree used to help locate plot beginning. Tree tag number can be listed following species if the reference tree is tagged.	text	20	UPPER CASE	4-character species code from <?>
BegXtreeDBHcm	<not used>	X Tree DBH (transect begin)	Diameter(in centimeters) meastured at breast height of 'X' tree used to help locate plot beginning	number	single, 1 decimal	single	positive integer values
BegXtreeDistToCtr_m	<not used>	X Tree DistanceToPlotCenter (transect begin)	Distance in meters of 'X' tree to beginning point of plot	number	single, 1 decimal	single	positive integer values

Database Field Name	Database Field Caption (when used)	Field Name (label) on hardcopy data collection form	Field Description	Data Type	Field Size	Format	Valid Field Values or lookup source
BegXtreeAzmToCtr	<not used>	X Tree AzimuthToPlotCenter (transect begin)	Azimuth referenced to magnetic north of 'X' tree in relation to plot beginning	number	integer	numeric	integer values between 1 - 360
BegYtreeSpecies	<not used>	Y Tree Species (transect begin)	Species of 'Y' tree used to help locate plot beginning. Tree tag number can be listed following species if the reference tree is tagged.	text	20	UPPER CASE	4-character species code from <?>
BegYtreeDBHcm	<not used>	Y Tree DBH (transect begin)	Diameter(in centimeters) measured at breast height of 'Y' tree used to help locate plot beginning	number	single, 1 decimal	single	positive integer values
BegYtreeDistToCtr_m	<not used>	Y Tree DistanceToPlotCenter (transect begin)	Distance in meters of 'Y' tree to beginning point of plot	number	single, 1 decimal	single	positive integer values
BegYtreeAzmToCtr	<not used>	Y Tree AzimuthToPlotCenter (transect begin)	Azimuth referenced to magnetic north of 'Y' tree in relation to plot beginning	number	integer	numeric	integer values between 1 - 360
CtrXtreeSpecies	<not used>	X Tree Species (transect center)	Species of 'X' tree used to help locate plot center. Tree tag number can be listed following species if the reference tree is tagged.	text	20	UPPER CASE	4-character species code from <?>
CtrXtreeDBHcm	<not used>	X Tree DBH (transect center)	Diameter(in centimeters) meastured at breast height of 'X' tree used to help locate plot center	number	single, 1 decimal	single	positive integer values

Database Field Name	Database Field Caption (when used)	Field Name (label) on hardcopy data collection form	Field Description	Data Type	Field Size	Format	Valid Field Values or lookup source
CtrXtreeDistToCtr_m	<not used>	X Tree DistanceToPlotCenter (transect center)	Distance in meters of 'X' tree to center point of plot	number	single, 1 decimal	single	positive integer values
CtrXtreeAzmToCtr	<not used>	X Tree AzimuthToPlotCenter (transect center)	Azimuth referenced to magnetic north of 'X' tree in relation to plot center	number	integer	numeric	integer values between 1 - 360
CtrYtreeSpecies	<not used>	Y Tree Species (transect center)	Species of 'Y' tree used to help locate plot center. Tree tag number can be listed following species if the reference tree is tagged.	text	20	UPPER CASE	4-character species code from <?>
CtrYtreeDBHcm	<not used>	Y Tree DBH (transect center)	Diameter(in centimeters) measured at breast height of 'Y' tree used to help locate plot center	number	single, 1 decimal	single	positive integer values
CtrYtreeDistToCtr_m	<not used>	Y Tree DistanceToPlotCenter (transect center)	Distance in meters of 'Y' tree to center point of plot	number	single, 1 decimal	single	positive integer values
CtrYtreeAzmToCtr	<not used>	Y Tree AzimuthToPlotCenter (transect center)	Azimuth referenced to magnetic north of 'Y' tree in relation to plot center	number	integer	numeric	integer values between 1 - 360
EndXtreeSpecies	<not used>	X Tree Species (transect end)	Species of 'X' tree used to help locate plot end. Tree tag number can be listed following species if the reference tree is tagged.	text	20	UPPER CASE	4-character species code from <?>

Database Field Name	Database Field Caption (when used)	Field Name (label) on hardcopy data collection form	Field Description	Data Type	Field Size	Format	Valid Field Values or lookup source
EndXtreeDBHcm	<not used>	X Tree DBH (transect end)	Diameter(in centimeters) meastured at breast height of 'X' tree used to help locate plot ending	number	single, 1 decimal	single	positive integer values
EndXtreeDistToCtr_m	<not used>	X Tree DistanceToPlotCenter (transect end)	Distance in meters of 'X' tree to ending point of plot	number	single, 1 decimal	single	positive integer values
EndXtreeAzmToCtr	<not used>	X Tree AzimuthToPlotCenter (transect end)	Azimuth referenced to magnetic north of 'X' tree in relation to plot ending	number	integer	numeric	integer values between 1 - 360
EndYtreeSpecies	<not used>	Y Tree Species (transect end)	Species of 'Y' tree used to help locate plot end. Tree tag number can be listed following species if the reference tree is tagged.	text	20	UPPER CASE	4-character species code from <?>
EndYtreeDBHcm	<not used>	Y Tree DBH (transect end)	Diameter(in centimeters) measured at breast height of 'Y' tree used to help locate plot ending	number	single, 1 decimal	single	positive integer values
EndYtreeDistToCtr_m	<not used>	Y Tree DistanceToPlotCenter (transect end)	Distance in meters of 'Y' tree to ending point of plot	number	single, 1 decimal	single	positive integer values
EndYtreeAzmToCtr	<not used>	Y Tree AzimuthToPlotCenter (transect end)	Azimuth referenced to magnetic north of 'Y' tree in relation to plot ending	number	integer	numeric	integer values between 1 - 360
LastUpdateBy	UpdateBy	*<not on data collection form>*	Full Name of person entering or updating data from field sheets into database.	text	50	Normal Case	From tbl_GYE_WBP_Project_Personnel

Database Field Name	Database Field Caption (when used)	Field Name (label) on hardcopy data collection form	Field Description	Data Type	Field Size	Format	Valid Field Values or lookup source
DateCreated	<not used>	*<not on data collection form>*	Application-generated date (when using appropriately-configured form for data entry) when site record was created	date/time	not applicable	MS Access default, like: '9/27/2004'	<system date and time>
LastUpdate	<not used>	*<not on data collection form>*	Application-generated date (when using appropriately-configured form for data entry) when site record was changed	date/time	not applicable	MS Access default, like: '9/27/2004'	<system date and time>

Table A2-2. Greater Yellowstone Ecosystem whitebark pine surveys

Database Field Name	Database Field Caption (when used)	Field Name (label) on hardcopy data collection form	Field Description	Data Type	Field Size	Format	Valid Field Values or lookup source
Obs_ID_DB (PK)	Obs_ID_DB	*<not on data collection form>*	Primary key for this table. Uses Microsoft Acces Autonumber data type. Each new record is automatically assigned a unique integer value.	Auto Number	Long Integer	numeric	<positive integer value>
Site_ID_DB	Site_ID_DB	*<not on data collection form>*	foreign key for link to tbl_GYE_WBP_Sites	number	Long Integer	Long Integer	values existing in tbl_GYE_WBP_Sites.Site_ID_DB
SurveyDate	SrvyDate	Date	Date of transect survey event	date/time	not applicable	MS Access default, like: '9/27/2004'	any accurate and correct date: month/day/year
SurveyType	SrvyTyp	Checkbox for Full Survey or Pine Beetle Only Survey or No Survey (in case of hazards or conditions including wildfire)	This field was added in 2008 when crews started surveying blister rust and pine beetle attributes during some surveys, while surveing only pine beetle attributes during other surveys. This field specifies the type of survey conducted. Note that for 'pine beetle only' surveys, Whitebark pine trees less than 1.4m tall are not surveyed for blister rust presence/absence. This affects fields 'BRPlt140cmTotal', 'BRAlt140cmTotal', 'BRUlt140cmTotal' in this table. For 'special' an explanation is required in the survey comment field (Obs_Comment)	text	20 lo	wer case	Surveys must be one of the following: 'pine beetle only' OR 'full' OR 'special'
MultiObserver	MultObs	CHECKBOX : 'Multi-observer Blister Rust Survey'	A 'yes' value means that more than one person independently observed and recorded tree infection, indicator, and pine beetle attribute values during the same survey, resulting in one record for each independent observer in tbl_GYE_WBP_Tree_Data_Multi_Obs for for a given survey. Two records for each tree are	text	3	lower case	'yes' or 'no'

usually present for multi-observer surveys, but some include three or more records per tree.

A 'no' value means that only one record with attribute values exists for each tree surveyed. Attribute values for each surveyed tree can be from any one of the trained and qualified crew members. A single record per tree exists in tbl_GYE_WBP_Tree_Data_Multi_Obs for trees related to a survey.

The Working Group recommends using the following order of precedence when selecting a single record for each tree in multi-observer surveys. In order to generate a complete and correct data set for each year, the complete order of precedence must be applied by year, because not all the same people were present for all multi-observer surveys, and the same name can appear in a different order between years. Caution is required here to prevent incorrect analytical and summary results.
2004: Erin Shanahan, Justin Hof, Amy Jesswein
2005: Erin Shanahan, Justin Hof, Karla Sartor
2006: Erin Shanahan, Polly Buotte, Jenny Birdsall
2007: John Fothergill, Erin Shanahan, Justin Hof, Rachel Simons
2008: John Fothergill, Rachel Simons, Shannon Podruzny, Jonathan Ball, Nancy Bockino
2009: John Fothergill, Rachel Simons, Shannon Podruzny, CarsonLindbeck, Nancy Bockino
2010: Fothergill, Shanahan, Podruzny, Lindbeck, Brodhead, Bockino, Sims, Johnson, Thompson

(See Marcia Huang's 2006 report on analysis of observer differences for this project).

4/15/2008 WBP Working Group Decision: Mulitple-observer surveys are done opportunistically, a minimum of 10 annually which is approximately a quarter of the transects. The crew leader will plan these in advance using a combination of logistics and judgment.

CrewNames	Crew	Crew Members	Full name(s) of field personnel on-site during the survey event. This is different from and less critical than the independent observer name recorded in tbl_GYE_WBP_Tree_Data_Multi_Obs.	text	150	Normal Case	Oneor more values existing in lookup table 'tbl_GYE_WBP_Project_Personnel' and visitors not listed in the table of project personnel.
CoverType	CovT	Cover Type	Cover type at the time of survey from Mattson and Despain descriptive guide, arboreal community type. Following fire impacts to monitoring sites (2007), began using value 'not applicable' when surveys following burns resulted in no observable boreal ground cover.	text	20	UPPER CASE	From: Mattson and Despain, 1985, Grizzly Bear Habitat Component Mapping Handbook for the Yellowstone Ecosystem
BRPlt140cmTotal	BRP14	Blister Rust Present Total	The total plot-wide count of whitebark pine trees less than 1.4 meters in height in which white pine blister rust infection is observed. The value is -999 for records corresponding to 'Mountain Pine Beetle Only' surveys, during which this attribute is not observed or recorded. For records with -999 from survey type = 'Full Survey' it means that the ground was covered with snow, preventing the small tree tally.	number	integer, zero decimal	fixed	Within a range of zero to all positive integers -999 for 'Mountain Pine Beetle Only' surveys during which this attribute is not observed or recorded.
BRAlt140cmTotal	BRA14	Blister Rust Absent Total	The total plot-wide count of whitebark pine trees less than 1.4 meters in height in which white pine blister rust infection is not observed The value is -999 for records corresponding to 'Mountain Pine Beetle Only' surveys, during which this attribute is not observed or recorded. For records with -999 from survey type = 'Full Survey' it means that the ground was covered with snow, preventing the small tree tally.	number	integer, zero decimal	fixed	Within a range of zero to all positive integers -999 for 'Mountain Pine Beetle Only' surveys during which this attribute is not observed or recorded.

BRUlt140cmTotal	BRU14	Blister Rust Uncertain Total	The total plot-wide count of whitebark pine trees less than 1.4 meters in height in which the observer is uncertain about the presence of white pine blister rust infection The value is -999 for records corresponding to 'Mountain Pine Beetle Only' surveys, during which this attribute is not observed or recorded. For records with -999 from survey type = 'Full Survey' it means that the ground was covered with snow, preventing the small tree tally.	number	integer, zero decimal	fixed	Within a range of zero to all positive integers -999 for 'Mountain Pine Beetle Only' surveys during which this attribute is not observed or recorded.
SMU_Total	SMU	RETIRED FIELD: Squirrel Middens Undisturbed Total	RETIRED FIELD: The total count of undisturbed squirrel middens observed in and around the site and en route to the site This field is used for 2004 through 2007 only. The instructions changed starting in 2008 to count active and disturbed middens separately, and only those visible from or within the survey plot. 5/20/08 email from Chuck Schwartz (IGBST): "the reason we had the crews track middens was to see if they found grizzly bear sign outside of the known range of the current distribution. Hence they were told to track middens on their treks in and out and especially record if they were dug by bears. I don't think this ever provided the kind of data we expected."	number	Long Integer	positive integer values or zero	Within a range of zero to all positive integers
SME_Total	SME	RETIRED FIELD: Squirrel Middens Excavated Total	RETIRED FIELD: The total count of excavated squirrel middens observed in and around the site and en route to the site This field is used for 2004 through 2007 only. The instructions changed starting in 2008 to count active and disturbed middens separately, and only those visible from or within the survey plot. 5/20/08 email from Chuck Schwartz (IGBST): "the reason we had the crews track middens was to see if they found grizzly bear sign outside of the known range of the current distribution. Hence they were told to track middens on their treks in and out and especially record if they were dug by bears. I don't think this ever provided the kind of data we expected."	number	Long Integer	positive integer values or zero	Within a range of zero to all positive integers

SMU_A_Total	SMU_A	Total Undisturbed Middens (active)	The total count of Active Undisturbed Squirrel Middens observed in and around the plot. Added in 2008 for observations within and visible from the plot (not enroute to), and to distinguish active/inactive for undisturbed middens.	number	Long Integer	positive integer values or zero	Within a range of zero to all positive integers
SMU_INA_Total	SMU_INA	Total Undisturbed Middens (not active)	The total count of INActive Undisturbed Squirrel Middens observed in and around the plot. Added in 2008 for observations within and visible from the plot (not enroute to), and to distinguish active/inactive for undisturbed middens.	number	Long Integer	positive integer values or zero	Within a range of zero to all positive integers
SME_A_Total	SME_A	Total Excavated Middens (active)	The total count of Active Excavated Squirrel Middens observed in and around the plot. Added in 2008 for observations within and visible from the plot (not enroute to), and to distinguish active/inactive disturbed (excavated) middens.	number	Long Integer	positive integer values or zero	Within a range of zero to all positive integers
SME_INA_Total	SME_INA	Total Excavated Middens (not active)	The total count of INActive Excavated Squirrel Middens observed in and around the plot. Added in 2008 for observations within and visible from the plot (not enroute to), and to distinguish active/inactive disturbed (excavated) middens.	number	Long Integer	positive integer values or zero	Within a range of zero to all positive integers
Obs_Comment	ObsCom	Comments	Narrative about the general nature of the transect or related pertinent information	Memo		Normal Case	From a range of alphanumeric characters
DataCollMethod	DataMthd	*<not on data collection form>*	Title, version number, and date of protocol by which data were collected	text	200	Normal Case	From a range of alphanumeric characters
DataEntryBy	EntryBy	*<not on data collection form>*	Full Name of person entering data from field sheets into database.	text	50	Normal Case	From a range of alphanumeric characters (name of person)
DateCreated	<not used>	*<not on data collection form>*	Application-generated date (when using appropriately-configured form for data entry) when observation record was created	date/time	not applicable	MS Access default, like: '9/27/2004'	<system date and time>

LastUpdate	<not used>	*<not on data collection form>*	Application-generated date (when using appropriately-configured form for data entry) when observation record was changed	date/time	not applicable	MS Access default, like: '9/27/2004'	<system date and time>

Table A2-3. Greater Yellowstone Ecosystem whitebark pine tagged trees

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Data Type	Field Size	Format	Valid Field Values or lookup source
TreeTag_ID_DB (PK)	Tree_ID_DB	*<not on data collection form>*	primary key for this table	autonumber	Long Integer	Long Integer	<positive integer value>
Site_ID_DB	Site_ID_DB	*<not on data collection form>*	foreign key for link to tbl_GYE_WBP_Sites	number	Long Integer	Long Integer	values existing in tbl_GYE_WBP_Sites.Site_ID_DB

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Data Type	Field Size	Format	Valid Field Values or lookup source
TreeID	Tree	Tree ID (tag no.)	Foreign key, in combination with related site and survey identifiers, to tbl_GYE_WBP_Tree_Data_Multi_Obs and tbl_GYE_WBP_Tree_Data_Single_Obs Numeric value (positive integer value) from the metal tag fastened to each tree. TreeID values are not necessarily sequential and do not always start with '1' in each transect because crews sometimes didn't carry enough sets of sequential tags. In 2004 only (first year of project) some dead trees were tagged in the field. Only some of these dead, tagged trees were entered as records in the survey database. Records for untagged trees (TreeID = 0 or -1) are stored in a separate table: tbl_Archive_GYE_WBP_Untagged_Trees Tagged trees with a positive integer TreeID value can be recorded as dead (D) or recently dead (RD) in the TreeStatus field if the tree is recorded as dead on a subsequent visit.	number	long integer	Long Integer	<positive integer value>

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Data Type	Field Size	Format	Valid Field Values or lookup source
ClumpNumber	ClumN	Clump Number	Sequental number starting at 1 for clumps of trees within a transect. All trees in a single clump receive the same Clump Number. Each clump as a whole receives a different number. A value of -999 means the tree is not part of a clump	number	integer, zero decimal	numeric	<positive integer value> or -999
ClumpLetter	ClumL	Clump Letter	Sequental letter assigned to each invididual stem (tree) within a given clump.	text	2	UPPER CASE	<single alphabetic character> or -999
TreeAddDate	<not used>	*<not on data collection form>*	Beginning for tree data entered in 2009, this is a code-generated date (when using appropriately-configured form for data entry) when tree record was added to this table. Blank values exist for records entered before 2009.	date/time	not applicabl e	MS Access default, like: '9/27/200 4'	<system date and time> or blank
LastUpdate	<not used>	*<not on data collection form>*	Beginning for tree data entered in 2009, this is a code-generated date (when using appropriately-configured form for data entry) when tree record was changed or 'touched' via the data entry form. Blank values exist for records entered before 2009.	date/time	not applicabl e	MS Access default, like: '9/27/200 4'	<system date and time> or blank

Table A2-4. Greater Yellowstone Ecosystem whitebark pine tree data, multiple observer

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
TreeDataM_ID_DB (PK)		*<not on data collection form>*	Primary key for this table. Uses Microsoft Acces Autonumber data type. Each new record is automatically assigned a unique integer value.	all years	AutoNumber	Long Integer	Long Integer	<positive integer value>
TreeTag_ID_DB	Tree_ID_DB	*<not on data collection form>*	foreign key for link to tbl_GYE_WBP_Tagged_Trees	all years	Long Integer	Long Integer	<positive integer value>	Values existing in tbl_GYE_WBP_Tagged_Trees
Obs_ID_DB	Obs_ID_DB	*<not on data collection form>*	foreign key for link to tbl_GYE_WBP_Site_Surveys	all years	number	Long Integer	Long Integer	values existing in tbl_GYE_WBP_Site_Surveys.Obs_ID_DB
Observer_ID		OBS	foreign key for link to tbl_GYE_WBP_Project_Personnel	all years	number	long integer	Long Integer	<positive integer value>
UBrC_A	UBrC_A	Branch Cankers - Upper Third - Aecia	After 2004 this is the count of blister rust cankers observed on branches in the top one third of the tree that have aecia present. For 2004 the value is -999 meaning not collected/recorded. The value -999 is used because summary results from unintended operations will be well out of the expected range and will draw attention to the data values and field description.	2004-present	text	3	lower case	<positive integer value> If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
UBrC_I	UBrC_I	Branch Cankers - Upper Third - Indicators	After 2004 this is the count of blister rust cankers observed on branches in the top one third of the tree that do not have aecia present, but were determined via secondary indicators (flagging, swelling, oozing sap, rodent chewing, roughened bark). If 3 of 5 secondary indicators are present in the same spot on the tree, a canker is counted. Do not confuse 'indicator' cankers with 'inactive' cankers recorded on other studies. The monitoring protocol methods state that cankers based on secondary indicators should not be counted for when aecia is present on the canker. For 2004 the value is -999 meaning not collected/recorded. The value -999 is used because summary results from unintended operations will be well out of the expected range and will draw attention to the data values and field description.	2004-present	text	3	lower case	<positive integer value> If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
UBrC_Total	UBrC_T	*<not on data collection form>*	For 2004 this is the count of blister rust cankers observed on branches in the top one third of the tree. After 2004 this value is the sum of values in fields 'UBrC_A' and 'UBrC_I'. REQUIRES CAUTION when analyzing data between year 2004 and other years.	2004 Calculated for subsequent years	text	3	lower case	<positive integer value> If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable
MBrC_A	MBrC_A	Branch Cankers - Middle Third - Aecia	After 2004 this is the count of blister rust cankers observed on branches in the middle one third of the tree that have aecia present. For 2004 the value is -999 meaning not collected/recorded. The value -999 is used because summary results from unintended operations will be well out of the expected range and will draw attention to the data values and field description.	2004-present	text	3	lower case	<positive integer value> If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
MBrC_I	MBrC_I	Branch Cankers - Middle Third - Indicators	After 2004 this is the count of blister rust cankers observed on branches in the middle one third of the tree that do not have aecia present, but were determined via secondary indicators (flagging, swelling, oozing sap, rodent chewing, roughened bark). If 3 of 5 secondary indicators are present in the same spot on the tree, a canker is counted. Do not confuse 'indicator' cankers with 'inactive' cankers recorded on other studies. The monitoring protocol methods state that cankers based on secondary indicators should not be counted for when aecia is present on the canker. For 2004 the value is -999 meaning not collected/recorded. The value -999 is used because summary results from unintended operations will be well out of the expected range and will draw attention to the data values and field description.	2004-present	text	3	lower case	<positive integer value> If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
MBrC_Total	MBrC_T	*<not on data collection form>*	For 2004 this is the count of blister rust cankers observed on branches in the middle one third of the tree. After 2004 this value is the sum of values in fields 'MBrC_A' and 'MBrC_I'. REQUIRES CAUTION when analyzing data between year 2004 and other years.	2004 Calculated for subsequent years	text	3	lower case	<positive integer value> If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable
BBrC_A	BBrC_A	Branch Cankers - Bottom Third - Aecia	After 2004 this is the count of blister rust cankers observed on branches in the bottom one third of the tree that have aecia present. For 2004 the value is -999 meaning not collected/recorded. The value -999 is used because summary results from unintended operations will be well out of the expected range and will draw attention to the data values and field description.	2004-present	text	3	lower case	<positive integer value> If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
BBrC_I	BBrC_I	Branch Cankers - Bottom Third - Indicators	After 2004 this is the count of blister rust cankers observed on branches in the bottom one third of the tree that do not have aecia present, but were determined via secondary indicators (flagging, swelling, oozing sap, rodent chewing, roughened bark). If 3 of 5 secondary indicators are present in the same spot on the tree, a canker is counted. Do not confuse 'indicator' cankers with 'inactive' cankers recorded on other studies. The monitoring protocol methods state that cankers based on secondary indicators should not be counted for when aecia is present on the canker. For 2004 the value is -999 meaning not collected/recorded. The value -999 is used because summary results from unintended operations will be well out of the expected range and will draw attention to the data values and field description.	2004-present	text	3	lower case	<positive integer value> If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
BBrC_Total	BBrC_T	*<not on data collection form>*	For 2004 this is the count of blister rust cankers observed on branches in the bottom (lower) one third of the tree. After 2004 this value is the sum of values in fields 'BBrC_A' and 'BBrC_I'. REQUIRES CAUTION when analyzing data between year 2004 and other years.	2004 Calculated for subsequent years	text	3	lower case	<positive integer value> If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable
UBoleC_A	UBoC_A	Bole Cankers - Upper Third - Aecia	After 2004 this is the count of blister rust cankers observed on the bole of the tree in the top one third of the tree that have aecia present. For 2004 the value is -999 meaning not collected/recorded. The value -999 is used because summary results from unintended operations will be well out of the expected range and will draw attention to the data values and field description.	2004-present	text	3	lower case	<positive integer value> If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable

Database Field Name	Databas e Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorde d for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
UBoleC_I	UBoC_I	Bole Cankers - Upper Third - Indicators	After 2004 this is the count of blister rust cankers observed on the bole of the tree in the top one third of the tree that do not have aecia present, but were determined via secondary indicators (flagging, swelling, oozing sap, rodent chewing, roughened bark). If 3 of 5 secondary indicators are present in the same spot on the tree, a canker is counted. Do not confuse 'indicator' cankers with 'inactive' cankers recorded on other studies. The monitoring protocol methods state that cankers based on secondary indicators should not be counted for when aecia is present on the canker. For 2004 the value is -999 meaning not collected/recorded. The value -999 is used because summary results from unintended operations will be well out of the expected range and will draw attention to the data values and field description.	2004-present	text	3	lower case	<positive integer value> If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
UBoleC_Total	UBoC_T	*<not on data collection form>*	For 2004 this is the count of blister rust cankers observed on the upper one third of the bole of the tree. After 2004 this value is the sum of values in fields 'UBoleC_A' and 'UBoleC_I'. REQUIRES CAUTION when analyzing data between year 2004 and other years.	2004 Calculated for subsequent years	text	3	lower case	<positive integer value> If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable
MBoleC_A	MBoC_A	Bole Cankers - Middle Third - Aecia	After 2004 this is the count of blister rust cankers observed on the bole of the tree in the middle one third of the tree that have aecia present. For 2004 the value is -999 meaning not collected/recorded. The value -999 is used because summary results from unintended operations will be well out of the expected range and will draw attention to the data values and field description.	2004-present	text	3	lower case	<positive integer value> If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
MBoleC_I	MBoC_I	Bole Cankers - Middle Third - Indicators	After 2004 this is the count of blister rust cankers observed on the bole of the tree in the middle one third of the tree that do not have aecia present, but were determined via secondary indicators (flagging, swelling, oozing sap, rodent chewing, roughened bark). If 3 of 5 secondary indicators are present in the same spot on the tree, a canker is counted. Do not confuse 'indicator' cankers with 'inactive' cankers recorded on other studies. The monitoring protocol methods state that cankers based on secondary indicators should not be counted for when aecia is present on the canker. For 2004 the value is -999 meaning not collected/recorded. The value -999 is used because summary results from unintended operations will be well out of the expected range and will draw attention to the data values and field description.	2004-present	text	3	lower case	<positive integer value> If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
MBoleC_Total	MBoC_T	*<not on data collection form>*	For 2004 this is the count of blister rust cankers observed on the middle one third of the bole of the tree. After 2004 this value is the sum of values in fields 'MBoleC_A' and 'MBoleC_I'. REQUIRES CAUTION when analyzing data between year 2004 and other years.	2004 Calculated for subsequent years	text	3	lower case	<positive integer value> If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable
BBoleC_A	BBoC_A	Bole Cankers - Bottom Third - Aecia	After 2004 this is the count of blister rust cankers observed on the bole of the tree in the bottom one third of the tree that have aecia present. For 2004 the value is -999 meaning not collected/recorded. The value -999 is used because summary results from unintended operations will be well out of the expected range and will draw attention to the data values and field description.	2004-present	text	3	lower case	<positive integer value> If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
BBoleC_I	BBoC_I	Bole Cankers - Bottom Third - Indicators	After 2004 this is the count of blister rust cankers observed on the bole of the tree in the bottom one third of the tree that do not have aecia present, but were determined via secondary indicators (flagging, swelling, oozing sap, rodent chewing, roughened bark). If 3 of 5 secondary indicators are present in the same spot on the tree, a canker is counted. Do not confuse 'indicator' cankers with 'inactive' cankers recorded on other studies. The monitoring protocol methods state that cankers based on secondary indicators should not be counted for when aecia is present on the canker. For 2004 the value is -999 meaning not collected/recorded. The value -999 is used because summary results from unintended operations will be well out of the expected range and will draw attention to the data values and field description.	2004-present	text	3	lower case	<positive integer value> If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
BBoleC_Total	BBoC_T	*<not on data collection form>*	For 2004 this is the count of blister rust cankers observed on the bottom (lower) one third of the bole of the tree. After 2004 this value is the sum of values in fields 'BBoleC_A' and 'BBoleC_I'. REQUIRES CAUTION when analyzing data between year 2004 and other years.	2004 Calculated for subsequent years	text	3	lower case	<positive integer value> If no cankers are observed, a N (no), dash (-), or zero (0) is acceptable

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
AeciaPresent	Aec_P	*<not on data collection form>*	For 2004, this repesents whether any amount of aecia was observed or not observed in any part of the tree. yes=aecia present, no=aecia not present. After 2004 this value is generated by an update query based on the contents of tree branch and tree bole 'aecia' fields (six fields) 'n/a' was added as a legal data value in 2008 to represent tree records for 'pine beetle only' surveys where blister rust was not surveyed. Starting with 2009 data entry, values in this field are populated using VBA procedures as data are entered. Update Query 'qupd_AeciaPresent' can be used to update values in this field. REQUIRES CAUTION when summarizing and analyzing values from this field between year 2004 and other years because values may not be current after 2004. Check first! See Database Design Notes for update process.	2004 Calculated for subsequent years	text	12	lower case	yes' or 'no' or 'n/a'

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
InfectionPresent	Inf_P	*<not on data collection form>*	Starting with 2009 data entry, values in this field are populated using VBA procedures as data are entered. See Database Design Notes. Run query 'qry_upd_InfectionPresent' to update values in this field AFTER values in field 'AeciaPresent' are updated. yes=white pine blister rust present in tree based on observed presence of aecia AND/OR observed presence of at least three of the five other indicators of infection (rodent chewing, flagging, swelling, roughened bark, oozing sap), no=neither aecia nor at least three indicators of infection were observed on tree 'n/a' was added as a legal data value in 2008 to represent tree records for 'pine beetle only' surveys where blister rust was not surveyed.	2004 Calculated for subsequent years	text	12	lower case	yes' or 'no' or 'n/a'

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
RodentChewing	RodCh	Rodent Chewing	The observed count of separate chewed areas observed on the entire tree, -999=not on data sheet at the time these plots were visited in 2004	2004 - present	number	integer	integer	<positive integer value> If no indicators are observed, a N (no), dash (-), or zero (0) is acceptable
Flagging	Flag	Flagging	The observed count of separate flagging areas observed on the entire tree, -999=not on data sheet at the time these plots were visited in 2004	2004 - present	number	integer	integer	<positive integer value> If no indicators are observed, a N (no), dash (-), or zero (0) is acceptable
Swelling	Swell	Swelling	The observed count of separate swelling areas observed on the entire tree, -999=not on data sheet at the time these plots were visited in 2004	2004 - present	number	integer	integer	<positive integer value> If no indicators are observed, a N (no), dash (-), or zero (0) is acceptable
RoughBark	RoughB	Roughened Bark	The observed count of separate roughened bark areas observed on the entire tree, -999=not on data sheet at the time these plots were visited in 2004	2004 - present	number	integer	integer	<positive integer value> If no indicators are observed, a N (no), dash (-), or zero (0) is acceptable
OozingSap	OozS	Oozing Sap	The observed count of separate oozing sap areas observed on the entire tree, -999=not on data sheet at the time these plots were visited in 2004	2004 - present	number	integer	integer	<positive integer value> If no indicators are observed, a N (no), dash (-), or zero (0) is acceptable
UprLiveCnpyVol	ULCV	Live Canopy Volume (%) - Upper Third	The percent of canopy in the upper one third of the foliage that is alive.	2004 - present	number	single, zero decimal	percent	0 - 100; dash (-) or N (no) acceptible for no canopy obs.

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
MtnPineBeetle	MPB	Mountain Pine Beetle <removed from data collection form starting in 2008>	Y = observed evidence of Mountain Pine Beetle on tree N = MPB evidence not observed on tree. REQUIRES CAUTION when summarizing data from the 2004-2007 period with data from 2008 forward. Normally this field would be derived from values in related quantitative and categorical fields, but for 2004 through 2007 this was the only field for mountain pine beetle. Starting in 2008 the Working Group added three MPB-related data fields that effectively replace this field from 2008 forward. Users can output 'yes/no' MPB values from this field for the 2004 - 2007 period, and for 2008 and beyond can generate 'yes/no' MPB values from values in fields 'PitchTubeCat', 'MpbGalleries', and 'MpbFrassCat'. Starting with 2009 data	2004-2007	text	5	upper case	'Y' or 'N'

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
			entry, values in this field are populated using VBA procedures as data are entered.					
PitchTubeCat	PT_CAT	Pitch Tube Category (0-2) <added to data collection form in 2008>	Field added in 2008 to reflect evidence of mountain pine beetle activity. 0 = zero pitch tubes 1 = 1 - 5 pitch tubes 2 = more than 5 pitch tubes 'x' is used for all records before 2008 when this attribute was not recorded.	2008 - present	text	25	numeric	0, 1, 2, x A dash (-) or N (no) is acceptable to indicate no pitch tubes observed.
MpbGalleries	MPB_GAL	MPB-Galleries Present (yes/no) <added to data collection form in 2008>	Field added in 2008. Instructions are to record this for dead or recently dead trees only. yes = at least one gallery observed on a dead or recently dead tree. no = zero galleries observed on a dead or recently dead tree. n/a = tree was live when surveyed so no assessment made for galleries. 'x' is used for all records before 2008 when this attribute was not recorded.	2008 - present	text	5	numeric	yes, no, x, n/a; a dash (-) or zero (0) is acceptable to indicate that no J-shaped galleries are observed or that this field was not active due to tree status

Database Field Name	**Database Field Caption (when used)**	**Field Name (label) on most recent hardcopy data collection form**	**Field Description**	**Period of Record (recorded for these years)**	**Data Type**	**Field Size**	**Format**	**Valid Field Values or lookup source**
MpbFrassCat	MPB_FR	MPB-Frass Category(0-2) <added to data collection form in 2008>	Field added in 2008. 0 = frass absent 1 = frass less than 30% 2 = frass more than 30% 'x' is used for all records before 2008 when this attribute was not recorded.	2008 - present	text	25	numeric	0,1,2,x A dash (-) or N (no) is acceptable to indicate no frass observed.
DateCreated	<not used>	*<not on data collection form>*	Application-generated date (when using appropriately-configured form for data entry) when observation record was created	2007 - present	date/time	not applicable	MS Access default, like: '9/27/2004'	<system date and time>
LastUpdate	<not used>	*<not on data collection form>*	Application-generated date (when using appropriately-configured form for data entry) when observation record was changed	not used	date/time	not applicable	MS Access default, like: '9/27/2004'	<system date and time>

Table A2-5. Greater Yellowstone Ecosystem whitebark pine tree data single observer

Database Field Name	**Database Field Caption (when used)**	**Field Name (label) on most recent hardcopy data collection form**	**Field Description**	**Period of Record (recorded for these years)**	**Data Type**	**Field Size**	**Format**	**Valid Field Values or lookup source**
TreeDataS_ID_DB (PK)		*<not on data collection form>*	Primary key for this table. Uses Microsoft Acces Autonumber data type. Each new record is automatically assigned a unique integer value.	all years	AutoNumber	Long Integer	Long Integer	<positive integer value>
TreeTag_ID_DB	Tree_ID_DB	*<not on data collection form>*	foreign key for link to tbl_GYE_WBP_Tagged_Trees	autonumber	Long Integer	Long Integer	<positive integer value>	not applicable
Obs_ID_DB	Obs_ID_DB	*<not on data collection form>*	foreign key for link to tbl_GYE_WBP_Site_Surveys	all years	number	Long Integer	Long Integer	values existing in tbl_GYE_WBP_Site_Surveys.Obs_ID_DB
DBH_cm	DBHcm	DBH(cm)	Tree diameter in centimeters measured at breast height. Blank spaces denote multi-observer trees for which DBH was not re-recorded following the first observer. DBH values were not remeasured during 2007 visits to sites established in 2004. 4/15/2008 WBP Working Group Decision: DBH will be remeasured every 12 years. 12/20/2008 Project Coordinator Erin Shanahan notes that 1.0 was entered for some	all years	number	double, one decimal	fixed	Within a range of positive numeric values to include one decimal place, or -999 for NODATA -999 means no data value. This occurs for records created during surveys conducted between the 12-year DBH measurement interval, and for multi-observer records where only one of the independent observers records DBH, or because the surveyor did not record a value on the field data sheet.

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
			recorded values less than 1 due to a data entry limitation that prohibited entering a value less than 1.0. Note that a recorded DBH value can be less than a value previously recorded for the same tree because measurements can be made at a different height on the trunk, or not read and recorded with the same level of precision between surveys. However, the differences should be reasonably small between surveys.					
HeightClass	HGT	Height Class	tree height class code. A blank space denotes multi-observer trees for which height class was not re-recorded following the first observer. 4/15/2008 WBP Working Group Decision: Tree Height class will be remeasured every 12 years	all years	text	1	numeric	code 1 = (1.4>=5 m) code 2 = (5>=10 m) code 3 = (>10 m)

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorde d for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
TreeStatus	Status	Tree Status	tree health status code Trees that die after the first visit to the site will retain their positive integer TreeID value. Prior to the first site revisits in 2007 all dead trees were entered with TreeID = 0.	all years	text	1	numeric	L: Live (green needles present) RD: Recently Dead (non-green needles present) D: Dead (needles absent)
dropped this field after 2005	not applicable	Crown Ratio (%)	estimate of the portion of the tree bole supporting live, healthy foliage. Expressed as a percent of the actual tree height	2004 - 2005	number	single, zero decimal	percent	0 - 100

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
ConeProducing	ConePr	Cone Producing	Added beginning in 2007 as directed by the Whitebark Pine Monitoring Working Group. 'yes' = at least one cone or cone scar is observed in the tree. Note that presence of a cone is definitive whereas a cone scar could be missed. 'no' = no observed evidence of cone production 'unk' = unknown - assigned primarily to trees tagged before this field was added and observations began in 2007.	2007 - present	text	5	lower case	yes no(n, '-', 0) unk
HealthIndexOld	Hi_Old	Health Index *(2004 only)*	Experimental attribute. Not on Data Collection form after 2004, Retained in database for 2004 data.	###	text	50	lower case	n=no infection, l=, m=, s=, na=not in use at the time of data collection or it is a dead tree
field not in database as of 12/2005	not applicable	Live Canopy Volume (%) - Middle Third		n/a	number	single, zero decimal	percent	0 - 100
field not in database as of 12/2005	not applicable	Live Canopy Volume (%) - Bottom Third		n/a	number	single, zero decimal	percent	0 - 100

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
TreeDescription		Tree Comments	Field added in 2006 by project crew leader. Not added by concensus of the Monitoring Working Group to address a well-defined need or objective. Values in this field may be similar to those in field 'TreeHlthComment'.	2006 - present	memo	not applicable	Normal Case	
TreeHlthComment	Health	Comments	general observed health of tree not intended for quantitative analysis. f = flagging h = healthy uh = unhealthy (reason unknown) dt = dead top bt = broken top bg = branch girdling db = dead branches tg = trunk girdling ns = needle shed us = understory (tree is shaded by other trees) md = mechanical damage, including windthrow ad = animal damage e.g. elk rub nfp = needle and/or foliage problems fc = 'fading crown' (definition pending from WBP Monitoring Working Group)	all years	text	250	lower case	From the list of factors identified in the GYE Whitebark Pine Montioring Protocol (methods).

Database Field Name	**Database Field Caption (when used)**	**Field Name (label) on most recent hardcopy data collection form**	**Field Description**	**Period of Record (recorded for these years)**	**Data Type**	**Field Size**	**Format**	**Valid Field Values or lookup source**
DateCreated	<not used>	*<not on data collection form>*	Application-generated date (when using appropriately-configured form for data entry) when observation record was created	2007 - present	date/time	not applicable	MS Access default, like: '9/27/2004'	<system date and time>
LastUpdate	<not used>	*<not on data collection form>*	Application-generated date (when using appropriately-configured form for data entry) when observation record was changed	2007 - present	date/time	not applicable	MS Access default, like: '9/27/2004'	<system date and time>

Table A2-6. Greater Yellowstone Ecosystem whitebark pine tree exceptions

Database Field Name	Database Field Caption (when used)	Field Name (label) on most recent hardcopy data collection form	Field Description	Period of Record (recorded for these years)	Data Type	Field Size	Format	Valid Field Values or lookup source
TreeException_ID_DB	<not used>	*<not on data collection form>*	Primary key for this table. Uses Microsoft Acces Autonumber data type. Each new record is automatically assigned a unique integer value.	all years	autonumber	Long Integer	Long Integer	<positive integer value>
TreeTag_ID_DB	<not used>	*<not on data collection form>*	Link to tbl_GYE_WBP_Tagged_Trees	all years	number	Long Integer	Long Integer	Values existing in tbl_GYE_WBP_Tagged_Trees
Obs_ID_DB	<not used>	*<not on data collection form>*	Link to tble_GYE_WBP_Surveys	all years	number	Long Integer	Long Integer	Values existing in tbl_GYE_WBP_Surveys
ExceptionAddDate	<not used>	*<not on data collection form>*	Default-generated date when record was added to this table.	all years	date/time	not applicable	MS Access default, like: '9/27/2004'	=Now()
LastUpdate	<not used>	*<not on data collection form>*	Code-generated date when tree record was changed.	all years	date/time	not applicable	MS Access default, like: '9/27/2004'	valid date/time calculated by data entry function
ExceptionType	<not used>	*<not on data collection form>*	Type of exception from Lookup Value List	all years	text	50		unable to locate tree; accidentally skipped tree; other (see explanation)
ExceptionText	<not used>	*<not on data collection form>*	Description of exception	all years	text	##		explanatory text