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Natural Resource Stewardship and Science

Monitoring Whitebark Pine in the Greater Yellowstone Ecosystem

2013 Annual Report

Natural Resource Data Series NPS/GRYN/NRDS—2014/631

ON THIS PAGE

Salt Range in Wyoming.
Photograph by: Erin Shanahan

ON THE COVER

Arrastra Creek in Montana.
Photograph by: Erin Shanahan

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols. This report received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

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Abstract

Whitebark pine (*Pinus albicaulis*) occurs at high elevations and in subalpine communities in the Pacific Northwest and Northern Rocky Mountains. It is a key component in the upper ranges of these ecosystems where it provides a variety of ecological roles, including regulating snowpack and providing high-energy food sources to birds and mammals. As a stone pine species, it produces indehiscent cones and relies primarily on birds for seed dispersal.

In mixed and dominant stands, whitebark pine occurs in over two million acres within the six national forests and two national parks that comprise the Greater Yellowstone Ecosystem (GYE). Currently, whitebark pine is impacted by multiple ecological disturbances. White pine blister rust (*Cronartium ribicola*), mountain pine beetle (*Dendroctonus ponderosae*), wildfires, and climate change all pose significant threats to the persistence of healthy whitebark pine populations on the landscape. Substantial declines in whitebark pine populations have been documented throughout its range. In 2004, an interagency whitebark pine long-term monitoring program was established. The objectives of the whitebark pine monitoring program are to detect and monitor changes in the health and status of whitebark pine populations across the GYE due to infection by white pine blister rust, attack by mountain pine beetle, and damage by other environmental and anthropogenic agents. This report is a summary of data collected in 2013 on Panels 2 and 4 and marks the tenth year of monitoring.

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List of Acronyms

BR	blister rust
CI	confidence interval
DBH	diameter at breast height
GRYN	Greater Yellowstone Inventory & Monitoring Network
GYCC	Greater Yellowstone Coordinating Committee
GYCCWPS	Greater Yellowstone Coordinating Committee Whitebark Pine Subcommittee
GYE	Greater Yellowstone Ecosystem
GYWPMWG	Greater Yellowstone Whitebark Pine Monitoring Working Group
IGBST	Interagency Grizzly Bear Study Team
MPB	mountain pine beetle
MSU	Montana State University
NPS	National Park Service
RZ	Recovery Zone (grizzly bear)
SE	standard error
USFS	United States Forest Service
USGS	United States Geological Survey

Introduction

Whitebark pine (*Pinus albicaulis*) occurs in the Pacific Northwest and northern Rocky Mountains where it is a foundation species in the subalpine zone due to the important role it plays in regulating the biodiversity of these areas. Whitebark pine influences multiple species and processes in montane ecosystems by acting as a food source for a variety of wildlife, facilitating the establishment of other vegetative species in otherwise inhospitable habitat, and assisting in the regulation of soil erosion and snow pack retention (Tomback and Kendall 2001).

Declines in the whitebark pine population have occurred on both public and private lands throughout the Greater Yellowstone Ecosystem (GYE). Increases in mortality, driven by upsurges in insect and pathogen outbreaks, wildland fire events, and a changing climate, have elicited considerable concern regarding the fate of whitebark pine in the ecosystem. This interest has triggered numerous investigations on the projected survival of whitebark pine on a landscape level, including the potential trophic and ecological consequences (effects) that a decreasing whitebark pine population may have on other species.

This annual report provides a summary of the data collected in 2013 as part of the long-term interagency whitebark pine monitoring program for the GYE.

Interagency Whitebark Pine Monitoring Program

Under the auspices of the Greater Yellowstone Coordinating Committee (GYCC), the National Park Service (NPS) Inventory and Monitoring (I&M) Program, and several other agencies began a collaborative, long-term monitoring program to track and document the health and status of whitebark pine across the GYE. This alliance resulted in the formation of the Greater Yellowstone Whitebark Pine Monitoring Working Group (GYWPMWG), which consists of representatives from the U.S. Forest Service (USFS), NPS, U.S. Geological Survey (USGS), and Montana State University (MSU). A protocol for monitoring the health and status of the whitebark pine population in the GYE was developed between 2004 and 2007 by the GYWPMWG. After rigorous peer review, the Interagency Whitebark Pine Monitoring Protocol for the Greater Yellowstone Ecosystem received final approval in 2007 and was updated in 2011 (GYWPMWG 2011). The complete protocol is available at: https://irma.nps.gov/App/Reference/Profile/660369 (accessed January 15, 2014).

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Tom Miner Basin, Gallatin National Forest.

Monitoring Objectives

Generally, the objectives of the whitebark pine monitoring program are to detect and monitor changes in the health and status of the whitebark pine population across the GYE due to infection by white pine blister rust, attack by mountain pine beetle, and impacts by other environmental and anthropogenic agents.

Specifically, the Interagency Whitebark Pine Monitoring Protocol (GYWPMWG 2011) addresses the following four objectives:

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

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

Objective 3 - To estimate survival of individual whitebark pine trees >1.4 m tall explicitly taking into account the effects of white pine blister rust infection rates and severity, mountain pine beetle activity, and fire.

Objective 4 - To assess and estimate survival rates of understory whitebark pine ≤1.4m tall as influenced by overall species composition, species density, and canopy cover and to determine the proportion of trees ≤1.4m tall infected with white pine blister rust and estimate the rate at which infection of trees is changing over time. This objective is currently under development and awaiting peer review.

CHAD HOCKENBARY

Whitebark pine with cones in the Beartooths, Montana.

Study Area

The study area is within the GYE and includes six national forests and two national parks (the John D. Rockefeller, Jr. Memorial Parkway is included with Grand Teton National Park; Figure 1). The target population is all whitebark pine trees in the GYE. The sample frame includes stands of whitebark pine approximately 2.5 hectares or greater within and outside of the grizzly bear recovery zone (RZ). A total of 10,770 mapped whitebark polygons or stands were identified with 2,362 located within the RZ and 8,408 located outside of the RZ. Stands within the RZ were derived from the cumulative effects model for grizzly bears, while outside the RZ, the sample frame includes whitebark stands mapped by each of the six separate USFS units (Dixon 1997, pers. com. L. Landenburger, January 2012). Areas that burned after 1970 were excluded from the sample frame.

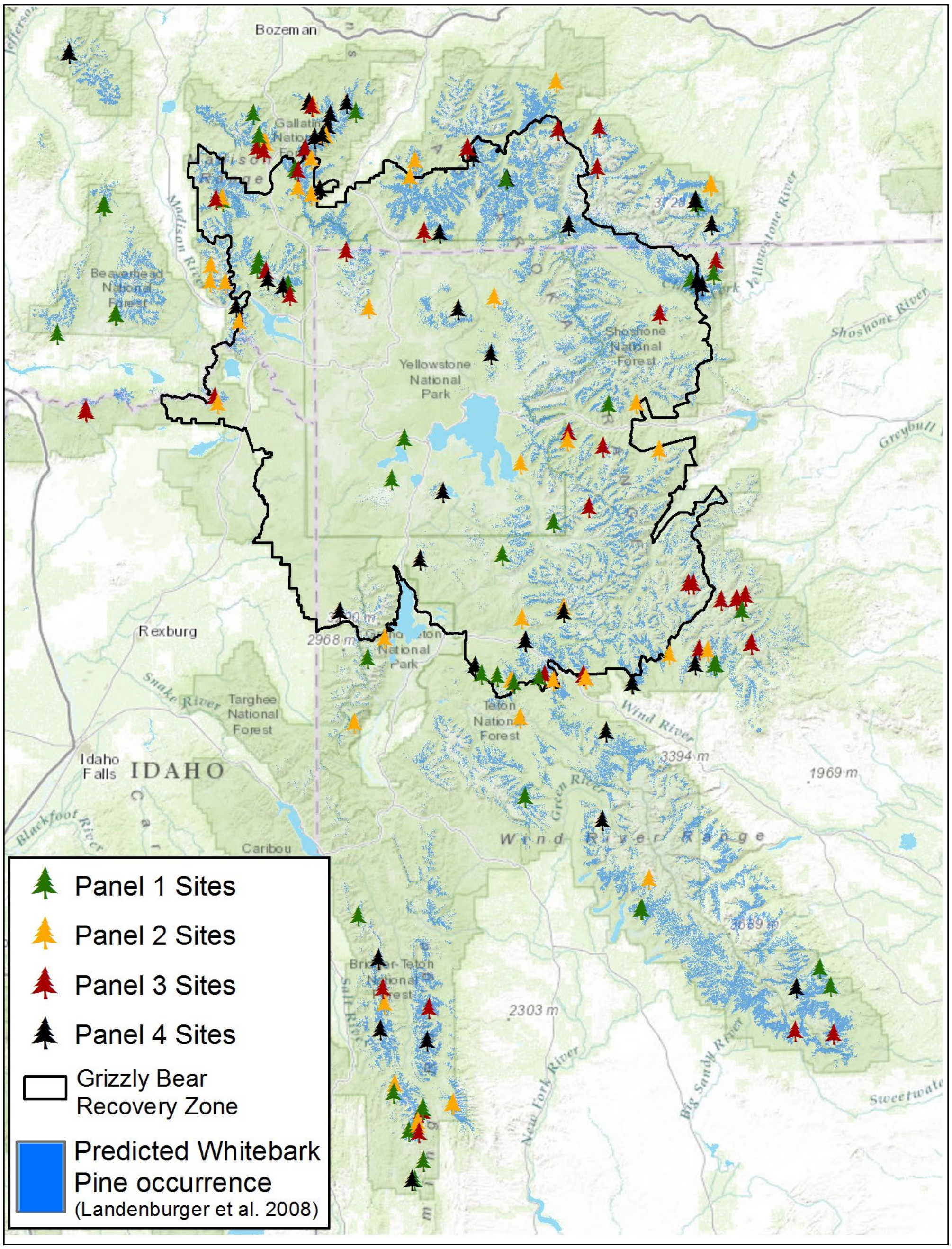

Figure 1. Location of whitebark pine survey transects, Greater Yellowstone Ecosystem.

ERIN SHANAHAN

MCLEAN WORSHAM

TYSON ROTH

Photos from top: Commissary Ridge, Wyoming; Crater Lake, and Rendezvous Peak, both in the Bridger-Teton National Forest.

Methods

Details of the sampling design and field methodology can be found in the Interagency Whitebark Pine Monitoring Protocol for the GYE (GYWPMWG 2011) and in the 2008 and 2012 annual reports (GYWPMWG 2008 and 2012). The basic approach is a two-stage cluster design in which stands of whitebark pine are the primary units, and 10x50 meter transects within stands are the secondary units. Initial establishment of permanent transects took place between 2004 and 2007; during this period, 176 permanent transects in 150 whitebark pine stands were established and all individual whitebark pine trees >1.4 m tall were permanently marked in order to estimate changes in white pine blister rust infection and survival rates over an extended period. The sample of 176 transects is a probabilistic sample that provides statistical inference to the GYE.

In 2008, individual transects were randomly assigned to one of four panels; each panel consists of approximately 44 transects. This is the number of transects that can be realistically visited in a given field season by a two-person field crew. Sampling every four years is sufficient to detect change in blister rust infection; however, transects in each panel were surveyed every other year from 2008 through 2013 to incorporate the dynamic nature of the recent mountain pine beetle epidemic. These extra surveys focused on mountain pine beetle indicators (Figure 2). Both surveys record tree status as live, dead, or recently dead.

Time-Step Assignment

In order to evaluate step-trends in white pine blister rust infection, infection transition, and overall mortality, every four-year revisit period is classified as a time-step (T#) interval. Time-step 0 (T0) consists of the 176 transects established in the period from 2004 to 2007 and is considered the baseline. Time-step 1 (T1) is comprised of Panels 1 through 4 that were revisited between 2008 and 2011. Time-step 2 (T2) was initiated in 2012 and will be completed in 2015, once all four panels are revisited (Figure 2).

Full Survey: White Pine Blister Rust and Mountain Pine Beetle Surveys (BR&MPB)

During a full survey visit, the presence or absence of white pine blister rust infection is recorded for all live trees in the transect. A tree is considered infected if either aecia or cankers are present. For a canker to be conclusively identified as resulting from white pine blister rust, at least three of five ancillary indicators need to be present (GYWPMWG 2011). Ancillary indicators of white pine blister rust includ flagging, rodent chewing, oozing sap, roughened bark, and swelling (Hoff 1992). For each live tree, observers record whether pitch tubes and frass are present from mountain pine beetle activity. Pitch tubes are small, popcorn-shaped resin masses produced by a tree as a means to stave off a mountain pine

Survey Schedule		Time0	Time1				Time2				Continued Monitoring 2016 Forward
Sample Panel	Sites per panel	2004 thru 2007	2008	2009	2010	2011	2012	2013	2014	2015	
1	43	initial surveys for all 176 transects	BR & MPB		MPB only		BR & MPB				
2	45			BR & MPB		MPB only		BR & MPB			
3	44		MPB only		BR & MPB		MPB only		BR & MPB		
4	44			MPB only		BR & MPB		MPB only		BR & MPB	

Figure 2. Panel sampling revisit schedule that includes full surveys for blister rust (BR) and mountain pine beetle (MPB) and mountain pine beetle/mortality only surveys (MPB only). This table denotes the designated time series for each Time-Step assignment (Time0 [T0]: 2004-2007, Time1 [T1]: 2008-2011, Time2 [T2]: 2012-2015).

beetle attack. Frass or boring dust is created during a mountain pine beetle attack and can be found in bark crevices and around the base of an infested tree. A section of bark is removed from dead trees to observe and record whether J-shaped galleries exist, which indicate that adult mountain pine beetle and their larvae occupied the tree (GYWPMWG 2011).

Mountain Pine Beetle Only/ Mortality Survey (MPB only)

For mountain pine beetle only/mortality surveys, data are collected on mountain pine beetle indicators and tree health status. As described above, each live tree is examined for pitch tubes and frass, while all dead trees are investigated for J-shaped galleries.

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Recruitment and Understory Individuals

There are three indicators of whitebark pine recruitment derived from the transect surveys: the number of trees ≤1.4 m tall, the number of trees that grow to >1.4 m tall, and the number of live trees, regardless of height, that show signs of reproductive activity. During a full survey visit, all whitebark pine trees ≤1.4 m tall on a given transect are counted and observed for white pine blister rust infection. Once a tree has reached a height greater than 1.4 m, it is permanently tagged and assessed in a manner consistent with all other live, marked trees in the sample frame. In addition, three nested circular plots at the beginning, center, and end of the transect (1/300th acre for each circle), are evaluated for the occurrence and infection status of whitebark pine ≤1.4 m tall, species composition, ground cover and vegetative dominance, and canopy cover (GYWPMWG 2012). Finally, all live, tagged trees are assessed for indication of past or present reproduction as evident by the presence of cones or cone scars.

Data Management

Prior to analysis, all data are subjected to rigorous quality assurance and quality control (QA/QC) procedures as outlined in the protocol (GYWPMWG 2011). Due to minor retroactive updates to the master database as part of ongoing quality controls, there may be an insignificant amount of variability (typically <1% difference) when comparing data reported in previous years. All computational analyses and corresponding charts and graphs are produced using Microsoft Excel and the statistical computing language R.

Whitebark pine with aecia spores.

Results

Time-step Considerations for Whitebark Pine Health and Status

Status and trend assessments are more meaningful after many years of monitoring with comparable data accumulate over time (Witwicki 2012). For the Whitebark Pine Monitoring Program, more intensive evaluation of monitoring data is scheduled at four-year intervals after all 176 transects are resurveyed. Comparisons between years based on a single panel revisit are misleading, because each panel is comprised of an entirely different set of transects. Data summaries from transects surveyed in 2013 (Panels 2 and 4) do not reflect the entire sample of transects, and therefore, do not represent the estimated status or long-term trend of the overall GYE population of whitebark pine. The reader is cautioned not to draw wide-reaching conclusions from the summary of data collected in 2013.

Monitored Transects

In 2013, 88 transects were resurveyed between June and September from Panels 2 and 4 by a two-person crew led by the NPS I&M Greater Yellowstone Network (GRYN) and another two-person crew led by the USGS Interagency Grizzly Bear Study Team (IGBST). This marks the second revisit to Panel 2 in our time-step series (second panel resurveyed in T2) for full survey data collection (blister rust and mortality), and the third revisit to Panel 4 for MPB only/ mortality.

White Pine Blister Rust Infection in the GYE

Based on the ratio estimator derived from the live trees remaining at the end of T1 on Panels 1 through 4, our results indicate that the proportion of trees infected with blister rust in the GYE ranges between 20% to 30% (3% SE; Shanahan et al. in prep). This range illustrates the variability of infection across the study area and captures the extremes of the confidence intervals.

White Pine Blister Rust Infection on Panel 2

Approximately 815 live tagged trees in 44 transects from Panel 2 were examined for blister rust infection in 2013. This number includes the new trees added during the 2013 survey to Panel 2. Results from a Wilcoxon Signed-Rank test comparing the proportion of trees infected with blister rust in each stand (n=37 stands) for Panel 2 suggest some evidence of a difference in the proportion of live trees >1.4 m tall infected with blister rust between T1 and T2 (P-value=0.05022).

Infection Transition

Of the 770 live trees that were surveyed in Panel 2 transects in 2009 and again in 2013, approximately 61% (468) had no evidence of blister rust infection, 24% (186) were infected in both years, 7% (54) transitioned from no evidence of infection to infected, and 8% (62) went from infected to uninfected (Table 1). A transition from infected to uninfected could be the result of factors such as observer error, an earlier-documented infection based on indicators

Table 1. Blister rust infection transition among live tagged trees on Panel 2 transects in 2009 and again in 2013.

Number of Live Tagged Whitebark Pine Trees and Blister Rust Infection Transition for Panel 2 Trees Between T1 (2009) and T2 (2013).				
Transition	**Remained Uninfected**	**Remained Infected**	**Uninfected to Infected**	**Infected to Uninfected**
Number of Live Trees	468	186	54	62

that upon resurvey no longer met the established standards of three indicators in the same location, or infected branches that self-pruned.

Mortality on Panels 2 and 4

In 2013, we observed a total of 1,827 live tagged trees and 277 newly dead tagged trees from Panels 2 and 4. Of the 277 dead trees, 37% or 122 trees were >10 cm diameter breast height (DBH) with approximately 12% (15) of those having evidence only of mountain pine beetle infestation. The remaining 88% (107) of the trees in the >10 cm size class died with signs of fire; blister rust; a combination of fire, mountain pine beetle, or blister rust; or with other factors, such as wind damage, animal damage, or unknown (Figure 3).

Recruitment and Understory Individuals

While transects are experiencing varying degrees of mortality, they are also experiencing varying degrees of recruitment. Once a whitebark pine tree within the transect boundary reaches a height >1.4 m tall, it is permanently tagged and included in the live tree sample. In 2013, we tagged a total of 31 new trees (15 on Panel 2 and 16 on Panel 4). In addition, approximately 2,700 understory whitebark pine trees (≤1.4 m tall) were counted on 87 of the transects (one transect was partially covered in snow, and therefore not surveyed for understory individuals). This equates to a density of about 30 small trees per transect.

A total of 258 recruitment plots (three per transect) were completed on Panels 2 and 4. Results from the initial establishment of these plots will be summarized when all four panels have been surveyed at the end of the 2015 field season. Analysis of overall recruitment change (step trend) will be conducted at the end of T3 (2019), which will be the first possible comparison interval.

Currently, there are just over 700 reproducing live, tagged trees across the four panels. The majority of the reproducing trees have a DBH between 10 cm to 30 cm, but based on monitoring observations, trees ≤2.5 cm DBH can reproduce (GYWPMWG 2014). It will be informative to track how this metric changes as more data are collected in future years, particularly with the waning mountain pine beetle outbreak.

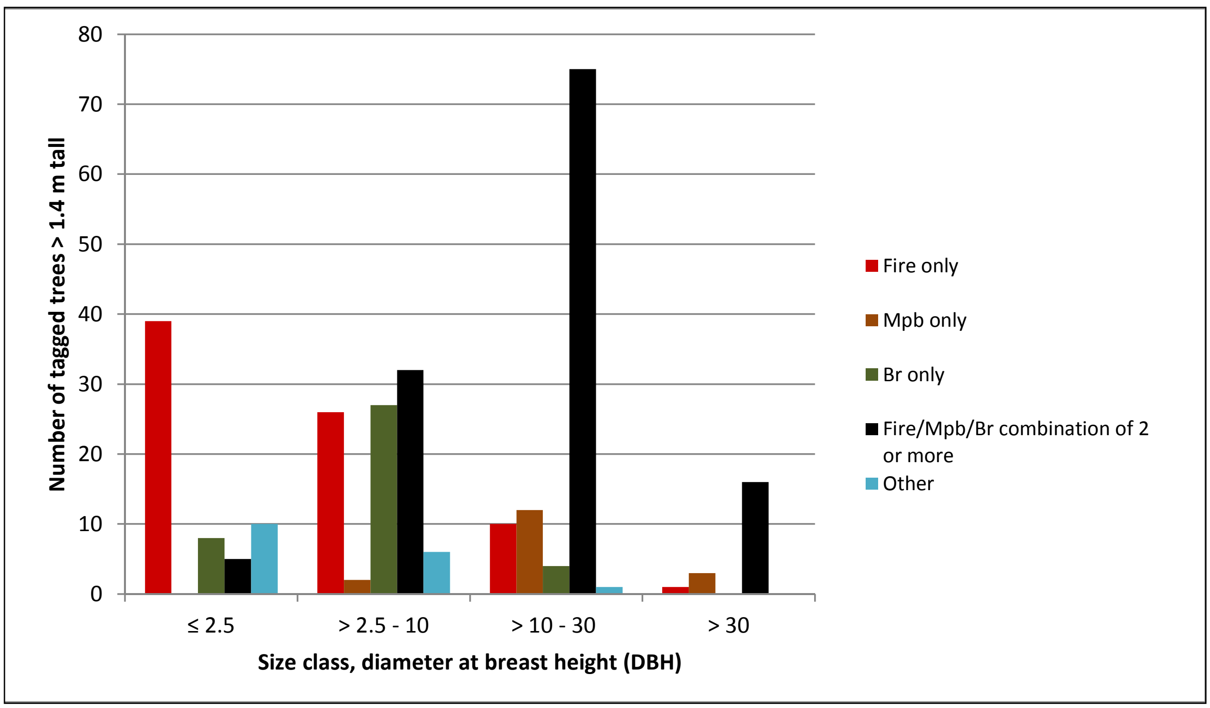

Figure 3. Size class and health status indicators observed for 277 dead tagged trees in Panels 2 and 4.

Discussion

White pine blister rust infection remains widespread and variable across the ecosystem with an estimated 20% to 30% infection rate among whitebark pine trees in the GYE (Figure 4).

Similar to white pine blister rust infection, the mountain pine beetle infestation is widespread and varies in severity throughout the GYE. Of the 176 established transects, 126 have recorded evidence of mountain pine beetle infestation, while 50 have no observed evidence of mountain pine beetle infestation by the end of 2013 (Figure 5).

Whereas mountain pine beetle exhibit a selective preference for larger DBH trees (Amman et al. 1977), wildland fire is indiscriminant with mortality occurring across all size classes. Since 2008, approximately 240 tagged trees on 14 transects have been affected by wildland fire. The majority of these burns have been stand-replacing fires. Of the 277 trees that were newly dead on Panels 2 and 4 in 2013, 170 were burned in the 2012 Millie Fire on the Gallatin National Forest (Figure 6).

Preliminary analysis suggests a change in blister rust infection on Panel 2 transects between the 2009 and 2013 survey periods. Analysis and interpretation of overall blister rust infection will be investigated following the collection of all four panels at the end of 2015. Our recent data suggest that the rate of mortality of tagged trees has decreased overall on the transects as compared to mortality levels from previous years. As articulated by other federal agencies and private entities, the mountain pine beetle outbreak appears to be waning in intensity in the GYE (Hayes 2013, Olliff et al. 2013).

In 2014, we will return to the original revisit schedule where only Panel 3 transects will be surveyed. We will continue to collect data on Objective 4 of the protocol to assess and monitor the recruitment of whitebark pine understory individuals.

In addition to the regular whitebark pine monitoring in 2013, we successfully established four permanent whitebark pine/limber pine monitoring transects and evaluated fifty-one rapid assessment plots on Bureau of Land Management (BLM) lands in five locations in Wyoming. As part of the 2014 field season, we will continue to collaborate with the BLM in their monitoring efforts. Additional permanent plots will be installed and rapid assessment efforts will continue. A summary on these initial BLM endeavors will be presented in a separate report. And finally, we will continue to collaborate with other research efforts that are taking place in the ecosystem as well as participate on the Greater Yellowstone Coordinating Committee Whitebark Pine Subcommittee.

This long-term monitoring program provides critical information that will help determine the likelihood of whitebark pine persisting as a functional and vital part of the ecosystem. In addition, data from this program are currently being used to inform managers, guide management strategies and restoration planning, inspire other whitebark pine research, and substantiate conservation efforts throughout the GYE. A summary report of the preliminary step trend analysis of the data (GYWBPWG 2014) was recently included as part of a comprehensive report assessing the response of grizzly bears to changes in food resources (Interagency Grizzly Bear Study Team 2013). The interagency protocol has also been a valuable resource for a variety of agencies initiating five-needle pine monitoring, including the Greater Yellowstone Coordinating Committee's Whitebark Pine Strategy for the Greater Yellowstone Area (GYCCWPS 2011).

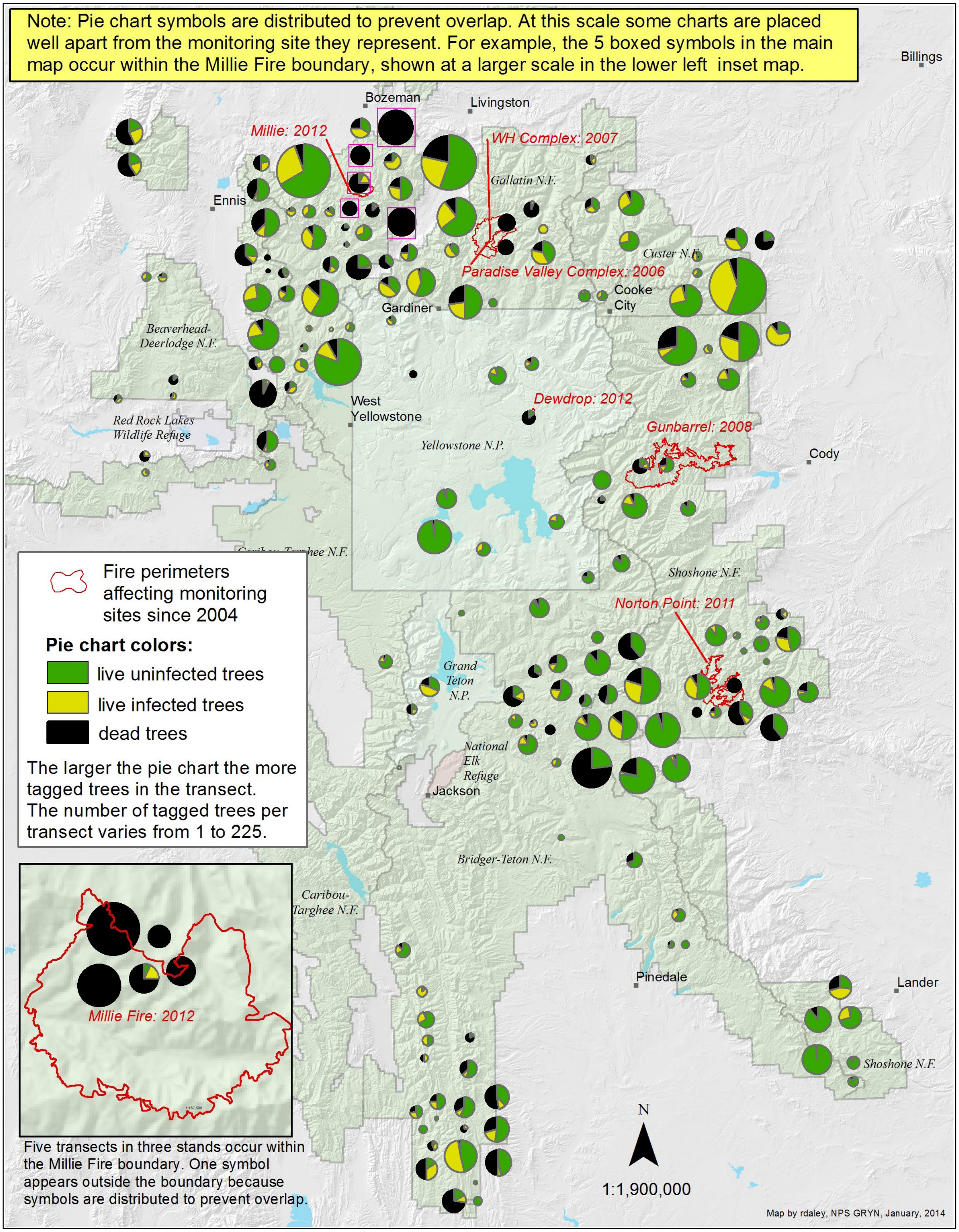

Figure 4. Preliminary map of the ratio of whitebark pine trees within each transect as alive, dead, or with presence of blister rust infection from surveys 2010-2013. The infection status ranges from a tree with a single canker on a branch to a tree with a bole canker.

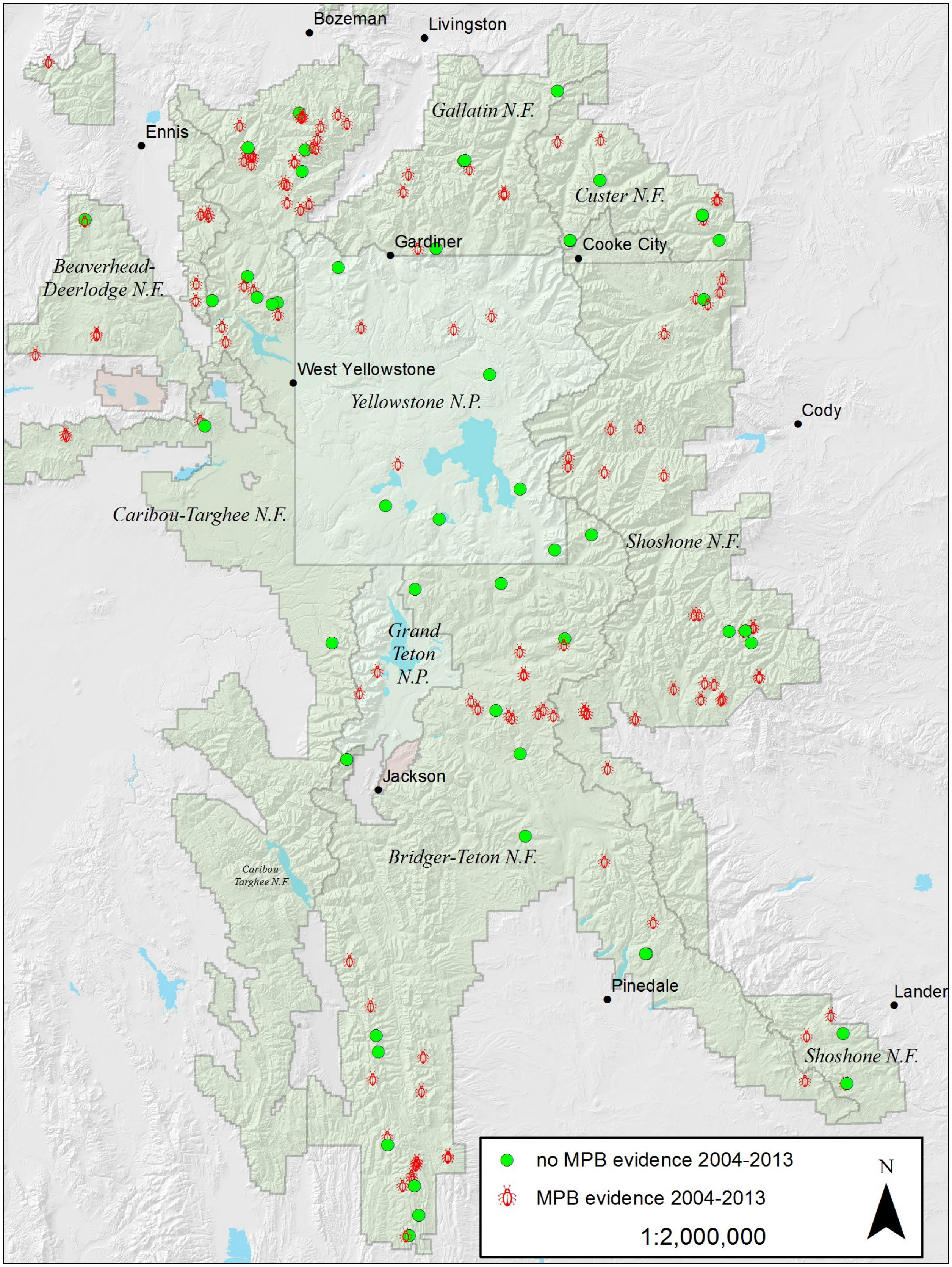

Figure 5. Location of transects throughout the Greater Yellowstone Ecosystem with and without evidence of mountain pine beetle infestation as of 2013.

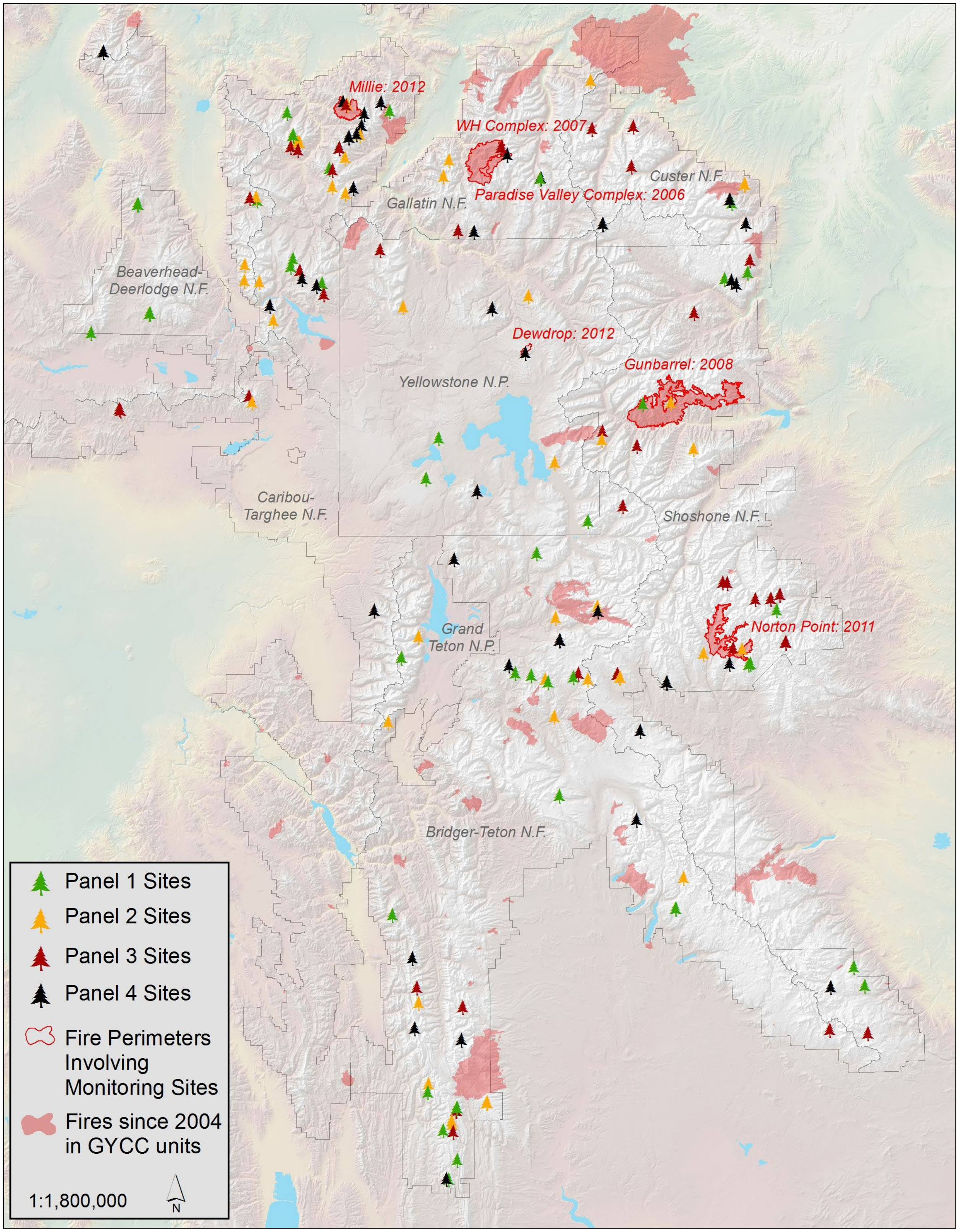

Figure 6. Location of transects throughout the Greater Yellowstone Ecosystem affected by wildland fire as of 2013.

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The Millie Fire, located on the Gallatin National Forest, ignited as a result of a lightning strike on August 28, 2012. In total, the Millie Fire burned approximately 10,500 acres of subalpine fir and mixed conifer timber. Mountain pine beetle mortality in whitebark pine and lodgepole pine occurred in this area prior to the fire.

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