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Natural Resource Stewardship and Science

Monitoring Whitebark Pine in the Greater Yellowstone Ecosystem

2015 Annual Report

Natural Resource Report NPS/GRYN/NRR—2016/1146

ON THIS PAGE
Wyoming Range in Wyoming
Photograph by: Erin Shanahan/NPS Photo

ON THE COVER
Cirque of the Towers, Wind River Range, Wyoming.
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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.

This report is available in digital format from the Greater Yellowstone Network website (http://science.nature.nps.gov/im/units/gryn/index.cfm), and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/). To receive this report in a format optimized for screen readers, please email irma@nps.gov.

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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 (Family: *Pinaceae*), it produces cones with wingless seeds and relies primarily on birds for seed dispersal.

In mixed and dominant stands, whitebark pine occurs in over two million acres within the five national forests and two national parks that make up the Greater Yellowstone Ecosystem (GYE). Currently, whitebark pine is impacted by multiple native and nonnative 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 2015 on Panel 4 of four total sample panels, and marks the twelfth year of monitoring.

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List of Acronyms

BLM	Bureau of Land Management
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
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 forests (*Pinus albicaulis*) are biologically significant components of high elevation regions in the U.S. northern Rocky Mountains. From an ecological perspective, whitebark pine is a keystone, high-elevation conifer that creates microhabitats for other vegetation (Keane and Arno 1993) and is an important food source for a variety of wildlife (Tomback et al. 2001). In addition to its ecological importance, whitebark pine is one of the most socially relevant and iconic tree species inhabiting high mountain ranges in the Greater Yellowstone Ecosystem (GYE). It is considered a symbol of a primitive America, a legacy of public land stewardship, and an ambassador for the conservation of subalpine environments (Tomback et al. 2001). With this 12th year of data collection on the health of whitebark pine in the GYE, the long-term Interagency Whitebark Pine Monitoring Program continues to provide science-driven resources to help guide management activities and regional policy decisions.

This annual report provides a summary of the data collected in 2015 as part of the long-term Interagency Whitebark Pine Monitoring Program for the GYE.

Healthy whitebark pine tree above Middle Piney Lake in the Wyoming Range of the Bridger-Teton National Forest, Wyoming.

Interagency Whitebark Pine Monitoring Program

Under the auspices of the Greater Yellowstone Coordinating Committee (GYCC) Whitebark Pine Subcommittee, the National Park Service (NPS) Inventory and Monitoring Program and several other agencies, a collaborative, long-term monitoring program was started 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), Bureau of Land Management (BLM), 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. After rigorous peer review, the Interagency Whitebark Pine Monitoring Protocol for the Greater Yellowstone Ecosystem was approved in 2007 and updated in 2011 (GYWPMWG 2011). The complete protocol is available from the GRYN Whitebark Pine Monitoring webpage, under Protocol Documents, at http://science.nature.nps.gov/im/units/gryn/monitor/whitebark_pine.cfm.

Monitoring Objectives

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 (*Cronartium ribicola*), attack by mountain pine beetle (*Dendroctonus ponderosae*), and impacts by other environmental and anthropogenic agents.

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

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

Objective 2 - Determine the relative severity of infection of white pine blister rust in whitebark pine trees >1.4 m tall.

Objective 3 - 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 - Assess and estimate survival rates of understory whitebark pine ≤1.4 m tall as influenced by overall species composition and species density, determine the proportion of trees ≤1.4 m tall infected with white pine blister rust, and estimate the rate at which infection of trees is changing over time. A pilot effort on this objective was conducted from 2012 to 2015. Finalized methodologies for this objective will be implemented in 2016.

Study Area

The GYE monitoring area includes five 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 2.0 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 in the mapping process, 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 vegetation layer, while outside the RZ, the sample frame includes whitebark stands mapped by each of the five separate USFS units (Dixon 1997; Landenburger et al. 2008). Areas that burned after 1970 were excluded from the sample frame.

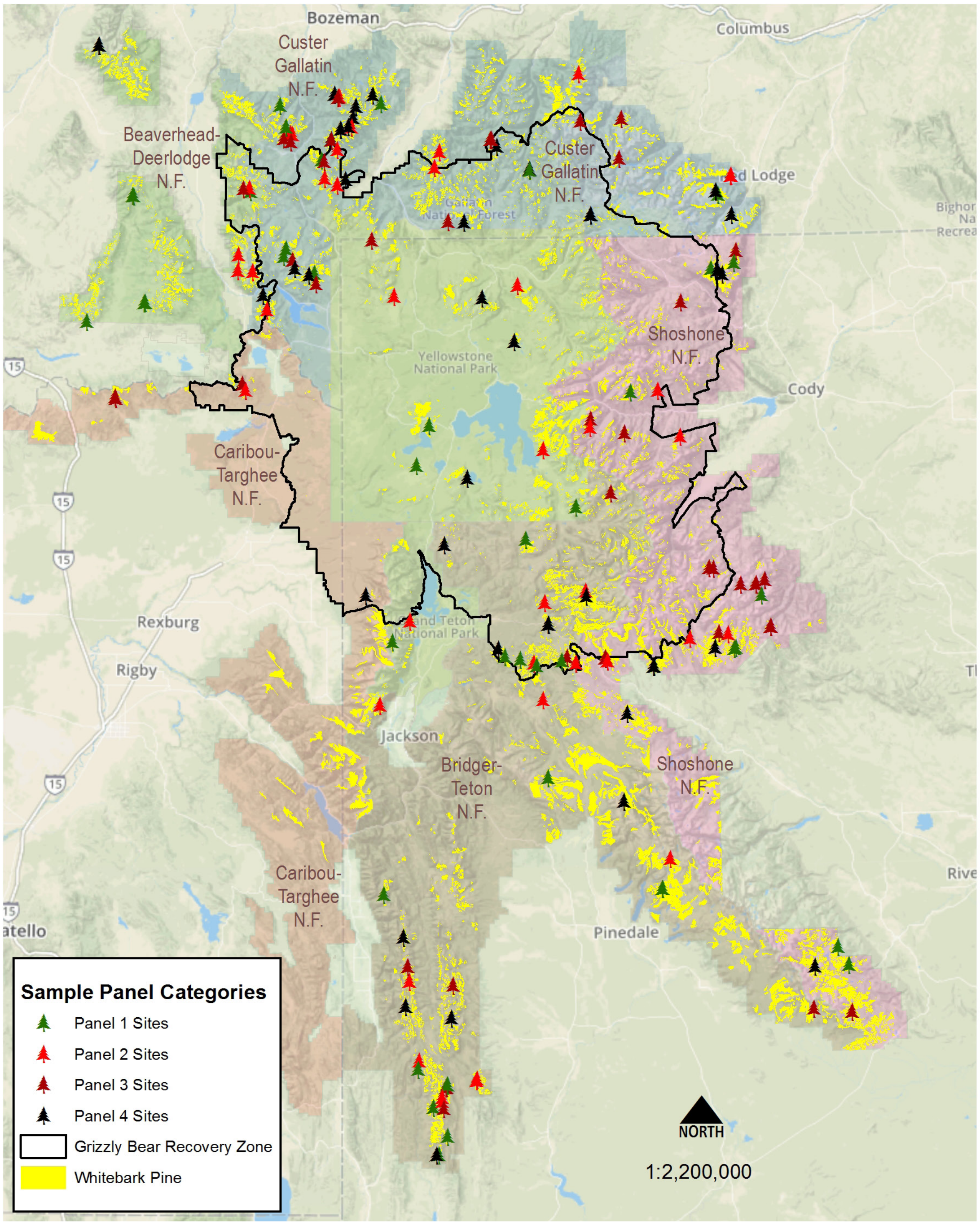

Figure 1. Location of whitebark pine survey transects, Greater Yellowstone Ecosystem.

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 2007 and 2011 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 10 × 50 m 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 (GYWPMWG 2011); however, sites 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. In 2015, we completed a full survey of Panel 4.

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 composed of Panels 1 through 4 that were revisited between 2008 and 2011. Time-step 2 (T2) was initiated in 2012 and was completed in 2015 following successful revisits to all four panels (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 included flagging, rodent chewing, oozing sap, roughened bark, and swelling (Hoff 1992). To document the severity of infection, the location of a blister rust canker is recorded as occurring in the canopy or on the bole of an infected tree.

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 beetle attack.

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).

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).

Recruitment and Understory Individuals

There are three indices 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 tagged 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 transect are counted and observed for white pine blister rust infection. Once a tree has reached a height >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 and species composition (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 were produced using Microsoft Excel and the statistical computing language R (R Development Core Team 2011).

Salt Range in Bridger-Teton National Forest, Wyoming.

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 accumulated 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 as each panel is composed of an entirely different set of transects. Data summaries from transects surveyed in 2015 (Panel 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 2015.

Monitored Transects

In 2015, all 44 transects assigned to Panel 4 were resurveyed between June and September by a two-person NPS crew. This marks the second revisit to Panel 4 in our time-step series (T2) for full survey data collection (blister rust and mortality). Additionally, one transect from Panel 3 was resurveyed in 2015. The Panel 3 transect was not visited in its regular panel schedule due to roadway obstruction issues in the summer of 2014 and was therefore, per protocol instructions, surveyed the following year.

White Pine Blister Rust Infection—Panel 4

A total of 1,009 live tagged trees in 44 transects from Panel 4 were examined for blister rust infection in 2015. This total included 27 new trees added during the 2015 survey. Results from a Wilcoxon Signed-Rank test comparing the proportion of infected trees on Panel 4 in 2011 (n = 44 stands) to the proportion of trees infected on Panel 4 in 2015 (n = 44 stands) suggests a decrease in the proportion of trees infected between T1 and T2 (P-value = 0.003). There was only 1 live tree from the Panel 3 transect and it was not included as part of this analysis.

Infection Transition

Of the 970 live trees that were surveyed in Panel 4 transects in 2011 and again in 2015, approximately 67% (650) had no evidence of blister rust infection, 23% (225) were infected in both years, 4% (34) transitioned from no evidence of infection to infected, and 6% (61) went from infected to uninfected (Table 1). A transition from infected to uninfected could be the result of factors such as observer variability, an earlier-documented infection based on indicators that upon resurvey no longer meet the established standards of three indicators in the same location, or infected branches that self-pruned.

Table 1. Blister rust infection transition among live tagged trees on Panel 4 transects in 2011 and again in 2015.

Transition	Number of live trees
Remained Uninfected	650
Remained Infected	225
Uninfected to infected	34
Infected to uninfected	61

Mortality on Panel 4

In 2015, we observed a total of 61 newly dead tagged trees from Panel 4. Of the 61 dead trees, 25% (15 trees) were >10 cm in diameter at breast height (DBH), with approximately 7% (1 tree) of those having died exhibiting only evidence of mountain pine beetle infestation. The remaining 93% (14 trees) of the >10 cm size class died with signs of blister rust, mountain pine beetle, and/or wildfire; or from other factors, such as wind or 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 2015, we tagged a total of 27 new trees. In addition, 1,946 understory whitebark pine trees (≤1.4 m tall) were counted on 44 of the Panel 4 transects. This equates to a density of about 44 small trees per transect.

In 2015, 132 recruitment plots (three per transect) were surveyed. 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 613 reproducing live, tagged trees across the four panels. The majority of the reproducing trees have a DBH between 10 cm and 30 cm. Based on monitoring observations, trees ≤2.5 cm DBH had evidence of reproduction. 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.

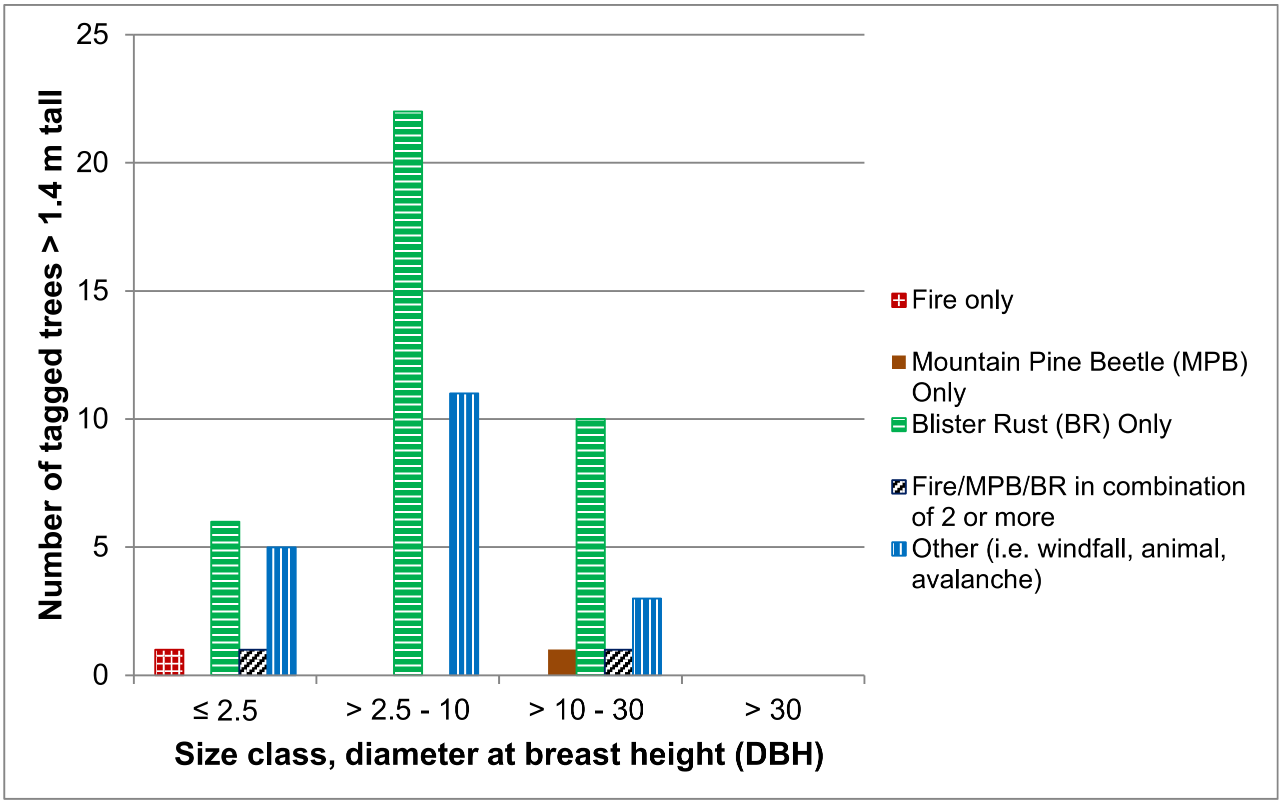

Figure 3. Size class and mortality influencing agents observed for 61 dead tagged trees in Panel 4.

Discussion

White pine blister rust infection is ubiquitous but variable across the GYE (Figure 4). Based on monitoring data collected from 2008 to 2011, estimated rates of infection among whitebark pine ranged from 20% to 30%. An update of this estimate is currently under analysis and will be forthcoming following the second step-trend (T2) analysis report in 2016.

Mortality attributable to mountain pine beetle attack continues to decrease in the GYE. Of the 61 tagged trees that were recorded as dead on Panel 4 transects, three exhibited sign of mountain pine beetle presence. Similar to blister rust infections, mortality from mountain pine beetle is widespread and variable across the GYE. Of the 176 established transects, 127 had recorded evidence of mountain pine beetle infestation, while 49 had no observed evidence of mountain pine beetle by the end of 2015 (Figure 5). There was an increase of one transect with evidence of mountain pine beetle since 2014. This transect was on the Beartooth Plateau and only had one tree with recent mountain pine beetle evidence.

Though wildland fire continues to affect forests throughout the GYE, only one of the 61 dead tagged trees was affected by fire in 2015. Since 2008, approximately 251 tagged trees on 15 transects have experienced damage by wildland fire. The majority of these burns have been stand-replacing fires (Figure 6).

Preliminary analysis suggests a decrease in the proportion of trees infection with blister rust on Panel 4 transects between the 2011 and 2015 survey periods. This observed decrease may have occurred due to the self-pruning or scarring over of cankers that were recorded as active in 2011, the aging and weathering of once viable cankers such that they no longer meet protocol infection standards (three of five indicators = canker), the mortality of once infected trees between T1 and T2 sampling periods, the addition of 27 uninfected trees, and finally observer variability between survey visits may be influencing this finding. We will continue to investigate the nuances related to changes in the proportion of and severity of infection with more detailed analysis presented in the 2016 step-trend report.

While analysis and interpretation of overall blister rust infection is investigated following the collection of data on all four panels, our interim data suggest that the rate of mortality of tagged trees with sign of blister rust may be more pronounced than recent mortality of tagged trees with evidence of mountain pine beetle as compared to previous years (Figure 3).

In 2016, we initiate the third time-step series with surveys conducted on Panel 1 transects. In addition, data will be collected on Objective 4 of the protocol to monitor the recruitment of whitebark pine understory individuals. Information on changes in recruitment will be assimilated into the step-trend report in 2019. 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. Data from this program are currently being used to inform managers, to guide management strategies and restoration planning, to support other whitebark pine research, and to substantiate conservation efforts throughout the GYE. A summary report of the first step-trend analysis (Shanahan et al. 2014) is available from GRYN or the Integrated Resource Management Applications website (https://irma.nps.gov/DataStore/DownloadFile/504276). A second step-trend report will be available in 2016. The interagency protocol has also been a valuable resource for other entities embarking on five-needle pine monitoring and has helped inform the Greater Yellowstone Coordinating Committee's Whitebark Pine Strategy for the Greater Yellowstone Area (GYCCWPS 2011).

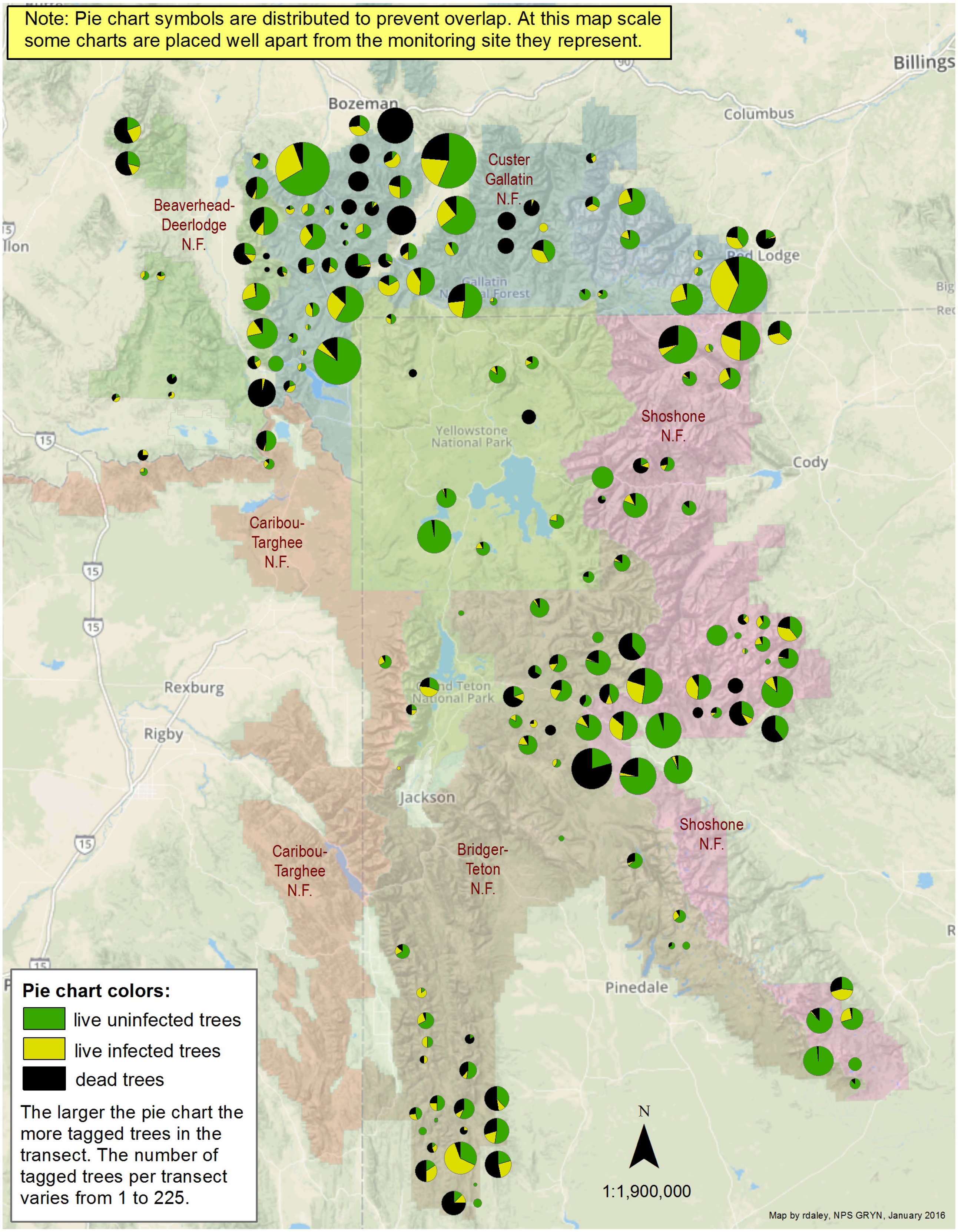

Figure 4. Preliminary map of the ratio of whitebark pine trees within each transect as alive, dead, or with presence of blister rust infection from surveys 2012-2015. The infection status ranges from a tree with a single canker on a branch to a tree with a bole canker.

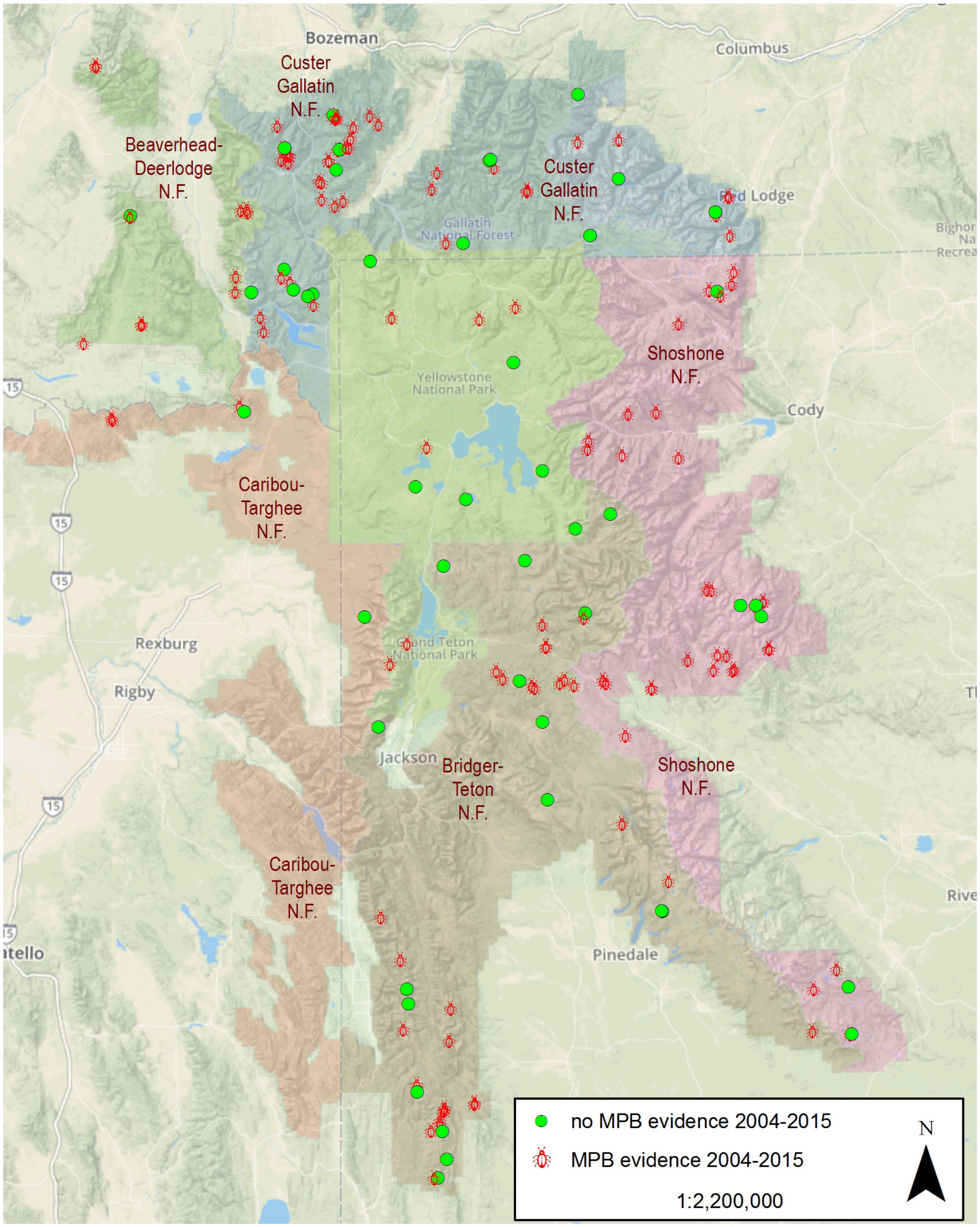

Figure 5. Location of transects throughout the Greater Yellowstone Ecosystem with and without evidence of mountain pine beetle infestation as of 2015.

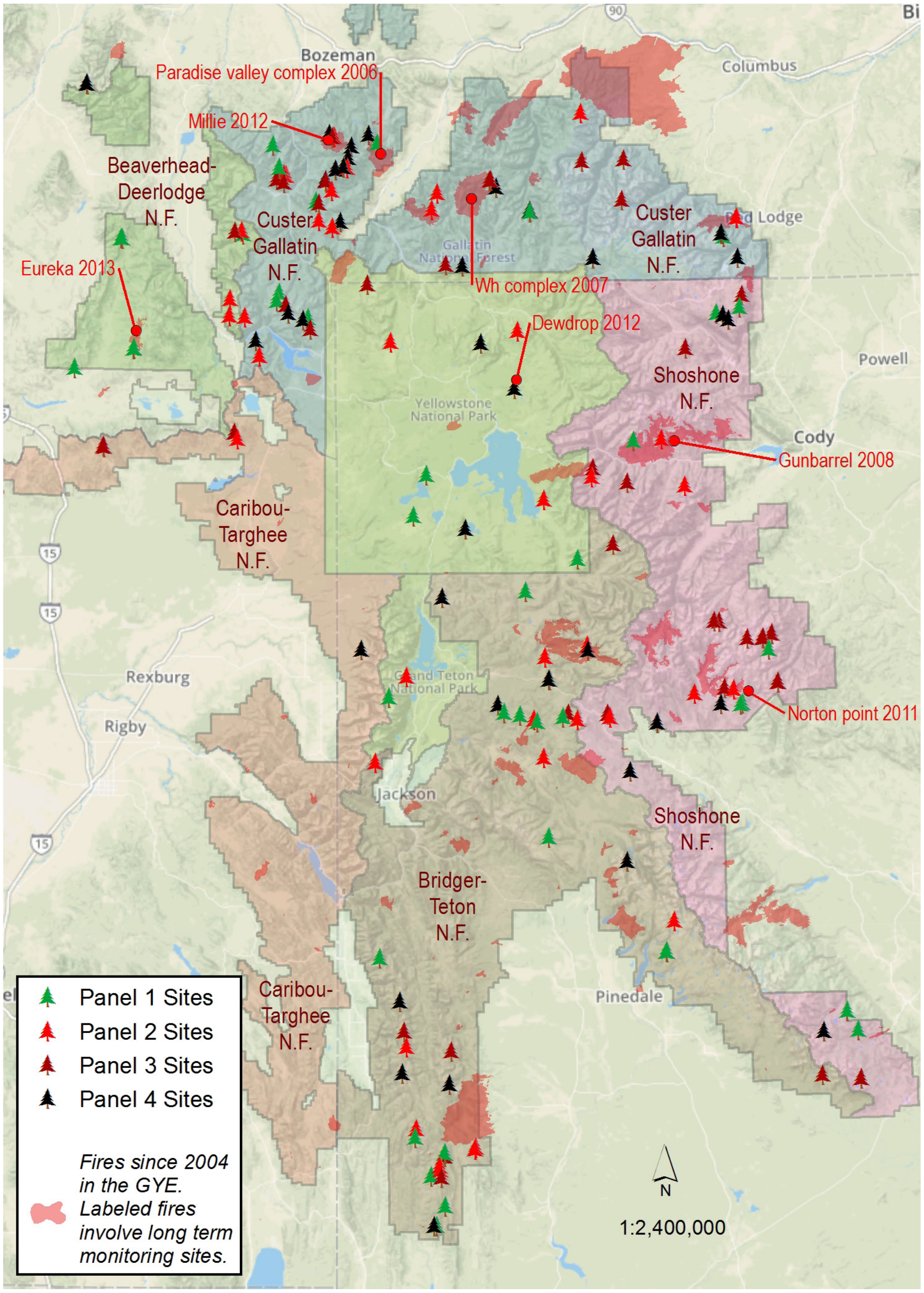

Figure 6. Location of transects throughout the Greater Yellowstone Ecosystem affected by wildland fire as of 2015.

Wind River Range on the Shoshone National Forest, Wyoming.

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