Monitoring White Pine Blister Rust Infection and Mortality in Whitebark Pine in the Greater Yellowstone Ecosystem

Extended Abstract

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Background

There is a critical need for information on the status and trend of whitebark pine (*Pinus albicaulis*) in the Greater Yellowstone Ecosystem (GYE). Concerns over the combined effects of white pine blister rust (WPBR, *Cronartium ribicola*), mountain pine beetle (MPB, *Dendroctonus ponderosae*), and climate change prompted an interagency working group to design and implement a long-term monitoring program in the GYE. Our primary objective was to determine the status and trends in the proportion of trees >1.4 m tall infected with WPBR and to provide information to federal managers, at a regional scale, on estimates of tree survival, taking into account the presence of WPBR and MPB. Long-term monitoring of whitebark pine in the GYE and across its range is vital to understanding the ecological impact of forest insect and disease pathogens on this important high elevation species.

Methods

Details of our sampling design and field methodology can be found in the Interagency Whitebark Pine Monitoring Protocol for the GYE (GYWPMWG 2007). The target population addressed by this protocol includes whitebark pine growing in pure whitebark pine or mixed conifer stands on six national forests and two national parks (figure 1). In the GYE, whitebark pine grows on over 1 million ha (GYCCWPS 2010) of public land in Wyoming, Montana, and Idaho.

The sample frame for our monitoring program was stratified by the U.S. Fish and Wildlife Service Grizzly Bear Recovery Zone (RZ) boundary using two Geographic Information System (GIS) sources: inside the RZ the GIS vegetation layer used in the grizzly bear cumulative effects model (Dixon 1997) was used while outside the RZ, stands of whitebark pine mapped by the U.S. Forest Service were used. Forest stands that burned in the 1988 wildfires or later were excluded from the sample frame as these stands were considered too young to have whitebark pine trees >1.4 m tall.

We selected our sampling units using a 2-staged, probability based sampling design. Our primary sampling units are randomly selected forest stands approximately 2.5 ha in size or larger that have a component of whitebark pine in the species composition. Our secondary sampling units are 10 by 50 m transects randomly selected from each stand. At least one whitebark pine tree >1.4 m tall was required for a permanent transect to be established.

Transects were established in the RZ in 2004 and expanded to the surroundings forests the following years. After completing transect establishment in 2007, we adopted a "rotating panel" with a 4-year schedule as our default resurvey design. A panel is a subset of the total sample size that is visited within a given year. Transects were randomly assigned to one of four panels; each panel consists of approximately 44 transects which is the number that can be realistically visited in a given field season by one, two-person field crew.

The resurvey design ensures that the sampling units are revisited on the same time frame and facilitates useful statistical comparisons (Tomback and others 2005) of our monitoring data in the future. Based on the history of when transects were initially established, the interval between the first and second survey for WPBR will vary until 2011 when all the transects will have been surveyed twice for WPBR infection. After 2011, the time interval between resurveys will be 4 years unless a resurvey cannot take place due to fire, weather, wildlife encounters, etc. In these situations, the transect will be resurveyed the following year.

The 4-year resurvey schedule was chosen because WPBR spread is a slow process and the detection of annual change would not be effective or practical (GYWPWG 2008). MPB infestation is much more rapid and can causes mortality quicker than WPBR. In response to the current MPB outbreak we temporarily adopted a two-year resurvey design to report MPB infestation and whitebark pine mortality during the current epidemic. With this approach, two of the four panels are surveyed annually; one panel is subject to the full survey for WPBR infection, MPB infestation and tree mortality and the second panel is subject to a partial survey focused on MPB infestation and tree mortality.

Within the 5 by 10 m wide belt transect, we measured diameter breast height (DBH) and permanently marked live

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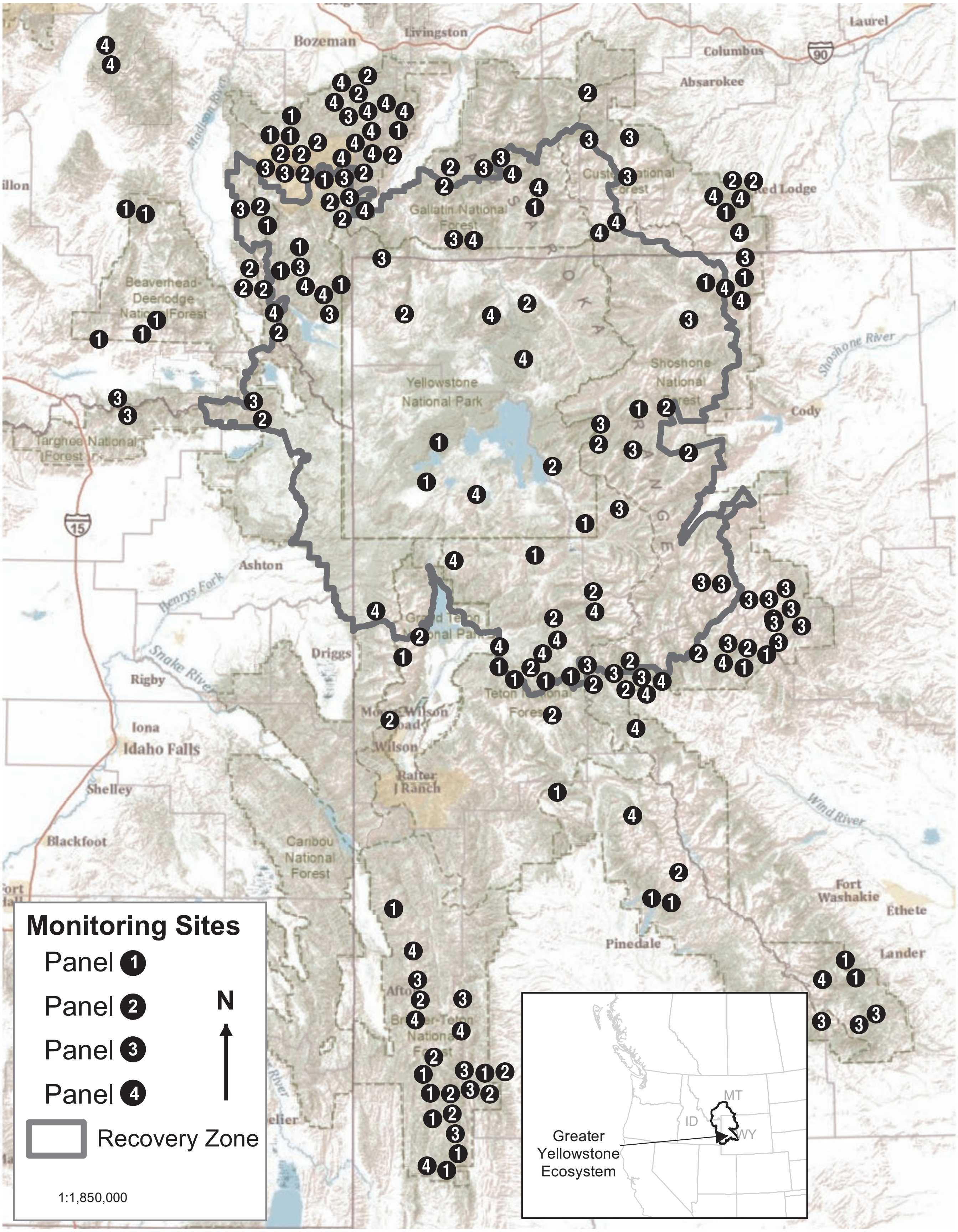

Figure 1. Location of whitebark pine survey transects (n=176) in the Greater Yellowstone Ecosystem in Idaho, Montana, and Wyoming, USA. In 2008 and 2009, 175 transects were surveyed for tree status and indicators of mountain pine beetle infestation.

Table 1. Design based ratio estimates for the proportion of live whitebark pine trees > 1.4 m tall infected with white pine blister rust in the Greater Yellowstone Ecosystem (GYE), 2004-2007, within and outside the grizzly bear recovery zone (RZ).

	Within RZ	Outside RZ	Total for GYE
Total number of mapped stands	2362	8408	10770
Number of stands sampled	64	86	150
Number of transects	66	110	176
Number of trees sampled	1307	3467	4774
Proportion of transects infected	0.79	0.86	0.84
Proportion of live trees infected	0.14	0.217	0.20
Proportion of live trees infected standard error	0.044	0.035	0.037

Figure 2. Proportion of live, dead and recently dead tagged and untagged whitebark pine >1.4 m tall within the monitoring transects by size class. Categories show the 2009 status of trees that were alive and permanently tagged and also trees that were recently dead but not tagged when transects were first established between 2004 and 2007. A recently dead tree has persistent non-green needles and a dead tree has shed all its needles. Numeric values on the bars represent the numbers of trees in each category.

whitebark pine trees >1.4 m tall with an aluminum tag so that we can follow the incidence of WPBR and survivorship of individual trees over time. We also measured the DBH of standing dead and recently dead whitebark pine trees >1.4 m tall within the transect but did not permanently tag these trees.

Each live whitebark pine tree >1.4 m tall was surveyed for WPBR cankers based on aecia (the active, fruiting body of the canker) which is the definitive symptom of WPBR (Tomback and others 2005) and also for auxiliary signs of WPBR infection. These signs include: rodent chewing, branch flagging, swelling, roughened bark and oozing sap (Hoff 1992). If three of the five auxiliary signs occurred in the same spot on a tree, that location was noted as having WPBR infection based on the auxiliary signs rather than the active canker. The numbers of branch and trunk cankers were recorded for each of the tree sections. For analysis purposes, we considered an individual whitebark pine tree infected with WPBR if one canker (aecia or three auxiliary signs) on either the tree bole or branch was observed.

We also surveyed trees for evidence of MPB infestation based on the presence of pitch tubes and boring dust in live trees and the presence of J-shaped galleries beneath the bark of dead trees. Pitch tubes are small, popcorn-shaped resin masses produced by a tree at the beetle entry hole as a means to stave off a MPB attack. Boring dust is created during a mountain pine beetle mass attack and can be found in bark crevices and around the base of an infested tree. J-shaped galleries are created by adult MPB and are used by adults to live and feed.

During resurveys, each permanently tagged tree was evaluated for its status as live (green needles present), recently dead (having non-green needles present) or dead (needles are absent). Live trees with a fading crown were noted in the tree comment field.

The proportion of trees infected with WPBR was calculated using a design-based ratio estimator that accounts for the total number of mapped stands within the sample frame and stratified by within and outside the RZ (GYWPMWG 2007). We used data from repeat surveys to document rates of tree mortality. Tree mortality, expressed as a percent, was calculated by dividing the total number of tagged dead and recently dead trees observed between 2007 and 2009 by the total number of live trees tagged between 2004 and 2007 and multiplied by 100.

Results

Between 2004 and 2007, we established 176 permanent transects in 150 randomly selected whitebark pine stands, and permanently marked 4,774 individual live trees >1.4 m tall. Following transect establishment we calculated the baseline estimate for WPBR infection rate within the GYE as 20 percent (±4 percent) (table 1). In the GYE, we found WPBR to be widespread and highly variable in intensity and severity (GYWPMWB 2008).

Beginning with our first resurvey and continuing through 2009 we observed mortality of whitebark pine within our monitoring transects. Mortality at the end of 2009 among trees that were tagged during transect establishment and resurveyed (n = 4748) was 10 percent (*n*=491) with 62 percent of dead trees containing J-shaped galleries consistent with MPB attack. Mortality was greater in the larger size classes where 36 percent of trees >30 cm DBH had died.

The MPB epidemic was well underway when we began establishing permanent monitoring transects in 2004. To illustrate cumulative mortality within our monitoring transects, we added the standing dead trees that still had persistent non-green needles at the time of transect establishment to calculate the proportion of live and dead trees (>1.4 m tall) by size class (figure 2). This dataset was used to recalculate the percent of dead trees >30 cm DBH that died over approximately the last 10 years. Cumulatively, 52 percent (n = 291) of the trees >30 cm DBH within our monitoring transects were dead. Field crews also recorded fading crowns, pitch tubes, and boring dust, as indicators of MPB attack on at least 8 percent of the live trees. Based on tree size alone, 38 percent of the remaining live whitebark pine trees in the monitoring sample were in the size class (≥12 cm DBH) that is most susceptible (Furniss and Carolin 1977) to MPB attack.

Conclusion

Whitebark pine health in the GYE is currently affected by WPBR and MPB as well as other stressors such as fire management and climate change conditions. Long-term monitoring of whitebark pine in the GYE and across its range is vital to understanding the ecological impact these stressors have on this highly important high elevation species. Initial results from our project provide a baseline of current infection and distribution of WPBR and will allow us to continue to document changes in WPBR and mortality rates in whitebark pine during the current and future outbreaks of MPB.

Whitebark pine trees surviving the current MPB outbreak will continue to be stressed by WPBR, which can affect all aspects of forest regeneration and could impair ecosystem recovery long after the current MPB epidemic retreats to endemic levels (Schoettle and Sniezko 2007). The whitebark pine monitoring program provides valuable information to help guide management strategies, restoration planning, and application of scarce funding and other resources (Schwandt 2006, GYWPWG 2007). Moreover, the collaborative, interagency approach of monitoring and management of whitebark pine in the GYE and in other regional ecosystems will be the best strategy to allow this important high elevation species to persist across the landscape and maintain its ecological function.

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