Assessing historical and contemporary rates of white pine blister rust incidence in naturally regenerated stands of western white pine for the prioritization of restoration sites under changing climate

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Introduction

Western white pine (WWP; *Pinus monticola*) is a keystone species in moist forests of western North America that displays adaptation to ranging climates and resilience to native root diseases. Since *Cronartium ribicola*, the cause of white pine blister rust (WPBR), was introduced to North America in the early 1900s, WBPR has caused dramatic reductions in WWP across its native range. Although WPBR is well established throughout WWP's range, observations have suggested some recent, naturally regenerated WWP stands in northern Idaho, USA display lower rates of WPBR incidence than was recorded historically in WWP stands that were established at similar sites. Analyses of recent WPBR incidence rates in regenerated WWP at these sites may be useful to determine if favoring natural WWP regeneration can aid restoration of WWP stands with reduced WPBR in some areas. Areas with reduced WPBR rates can be prioritized by forest managers for encouraging WWP regeneration and fostering forest resilience. Although WWP is considered a generalist with populations that exhibit relatively broad climatic adaptation, ongoing climate change will likely alter its geographic range. However, inclusion of WWP in future forests might offer some resilience to climate change, provided that WPBR rates allow for WWP survival to maturity.

Objectives

The objectives of this project are to 1) assess WPBR incidence over time in naturally regenerated WWP at diverse sites in northern Idaho; 2) compare recent WPBR incidence rates with that recorded in WWP that existed at the same locations ca. 80 years ago; and 3) identify areas where naturally regenerated stands of WWP are experiencing rates of WPBR that allow persistence of WWP as fully functioning component of the forest ecosystem. The long-term goal of this project is to characterize areas where WWP regeneration should be encouraged to increase forest resilience to climate change, root diseases, and other disturbances.

Materials and Methods

Surveys determined contemporary incidence of WPBR over time by determining approximate ages of all WPBR cankers based on their position in the branch whorls of each tree (representing the previous 15-year period) for ca. 30 naturally regenerated WWP within each stand at 26 sites [with the exceptions at two sites including the HM site (15 WWP trees) and CT site (16 WWP trees)] (Figure 1). Preliminary, historical WPBR progress curves were determined for nine these sites based on 1967 data in which WPBR canker numbers and ages were determined from felled WWP trees that had been growing since ca. 1940. The 15-year WPBR increase rates (1940-1954) from the historical records were used for comparison with contemporary 15-year (2006-2020) WPBR increase rates. Assigning years / ages for each the WPBR canker assumed that all *C. ribicola* infections had occurred in the first-year needles. The following current information was collected from each tree for all sites:

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- Age (yr), DBH (cm), height (m) of regenerated trees
- Counts of WPBR cankers, WPBR canker age, and *Ribes* spp. (alternate host) (Figure 2)

Preliminary Results

- From contemporary and historical WPBR incidence rates, WPBR rates have decreased at most sites (Figs. 3 and 4).
- WPBR incidence rate appears to vary among sites (Figs. 3 and 4)
- At most sites, WPBR rates appear to be low enough to allow sustainable growth of regenerated WWP. In these areas, WWP regeneration should be encouraged, provided that management to enhance regeneration does not adversely affect subsequent rates of WPBR incidence.

On-going Analyses

Areas where WWP has natural recovery that is exhibiting low WPBR incidence will be identified along with geographic areas where WWP is predicted to remain climatically adapted. The potential influence of climate on WPBR rates will also be examined, if significant differences in WPBR rates are found in a sufficient number of sites.

Management Implication

It is unknown if apparently lower WPBR incidence rates at most sites is due to increased WPBR resistance in WWP and/or *Ribes*, decreased *C. ribicola* virulence, interaction with other biotic components (e.g., endophytes or other biocontrol agents), interactions with *Ribes*, direct and indirect effects of changes in microenvironment and light conditions (e.g., contemporary denser canopies vs. historical open canopies), changes in general environmental conditions (e.g., climate or weather), or other unknown factors. However, it appears that rates of WPBR are low enough (less than 30%) in most sites that WWP regeneration should be encouraged, especially if the future climate is predicted to be suitable for WWP. This information may assist resource managers to prioritize areas that appear suitable for WWP restoration through natural regeneration, which will help to counteract anticipated losses in forest productivity and ecological diversity.

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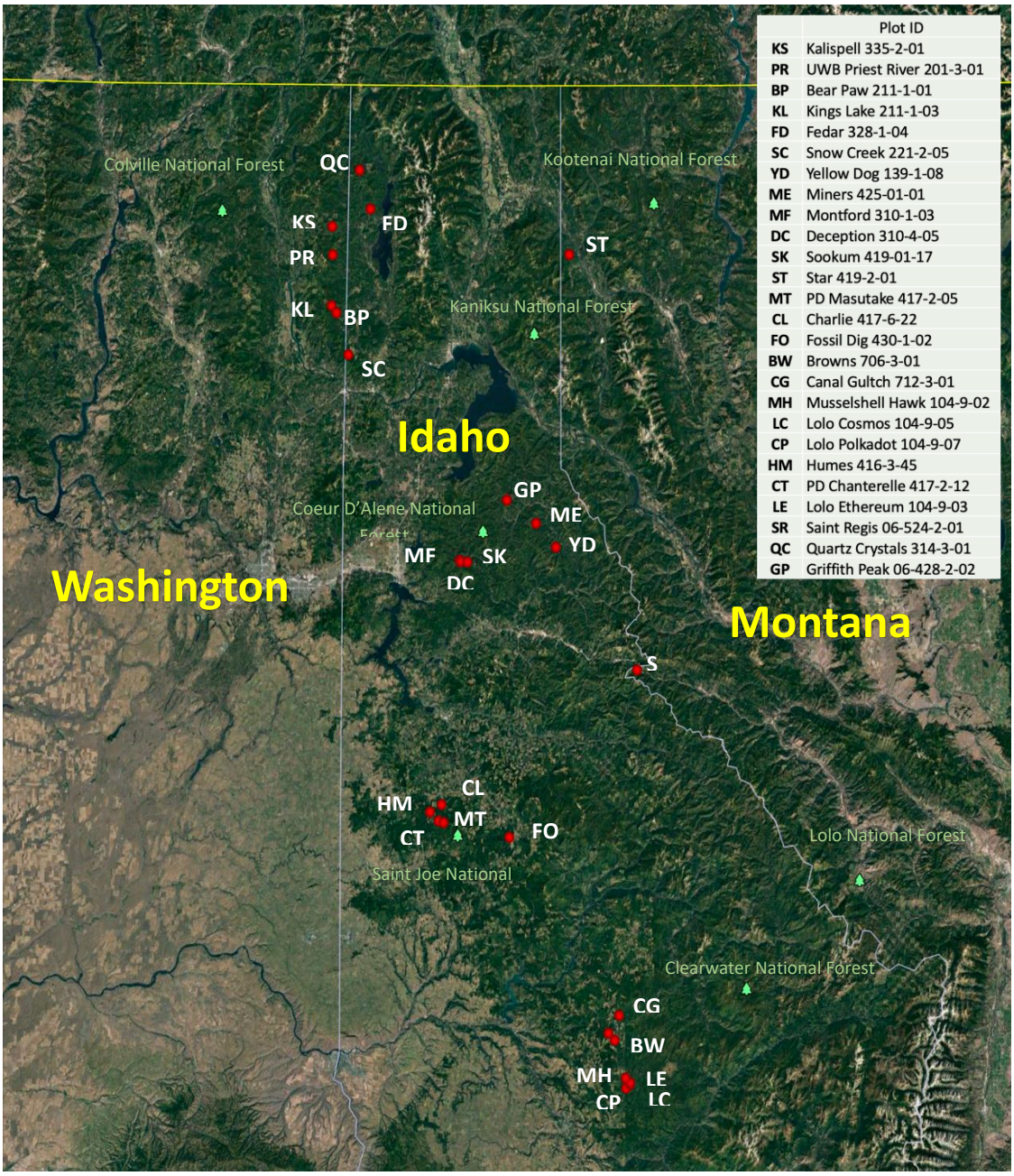

Figure 1. White pine blister rust (caused by *Cronartium ribicola*) survey sites in western white pine (*Pinus monticola*) stands of northern Idaho.

Figure 2. White pine blister rust (caused by *Cronartium ribicola*) canker with aeciospores present in orange pustules on western white pine (*Pinus monticola*).

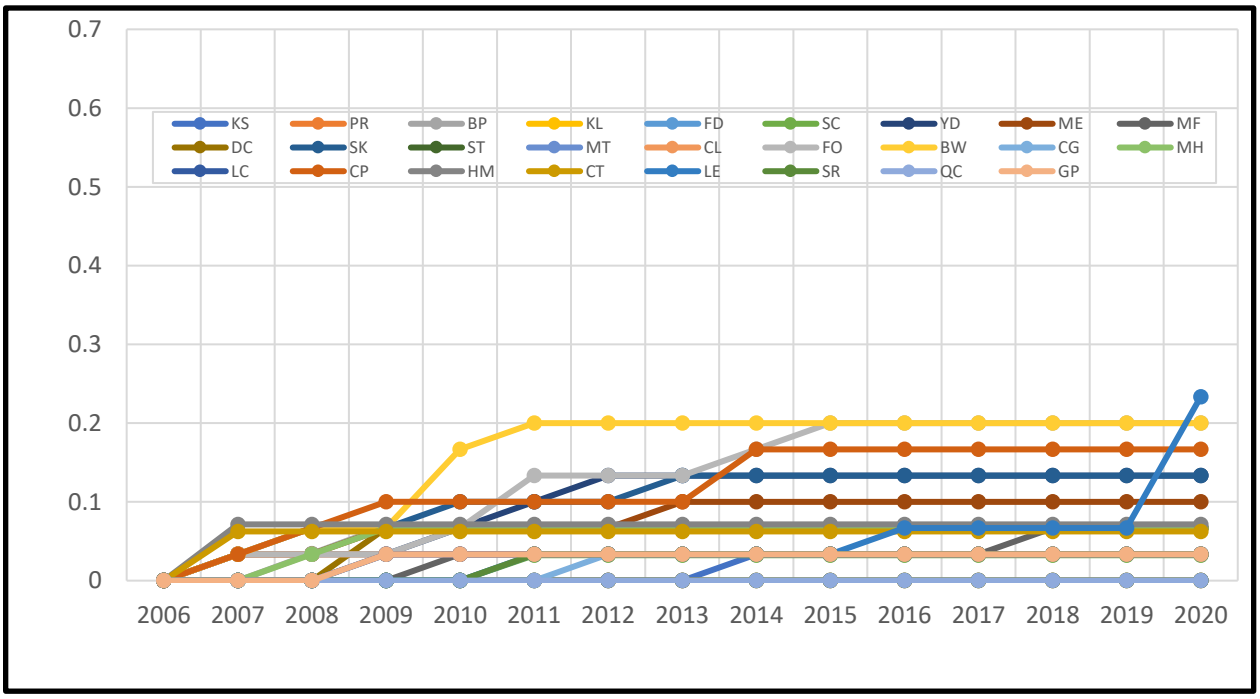

Figure 3. Contemporary rates of white pine blister rust (caused by *Cronartium ribicola*) canker incidence increase (% infected trees of the surveyed trees). Site (plot) locations and abbreviations are shown in Figure 1.

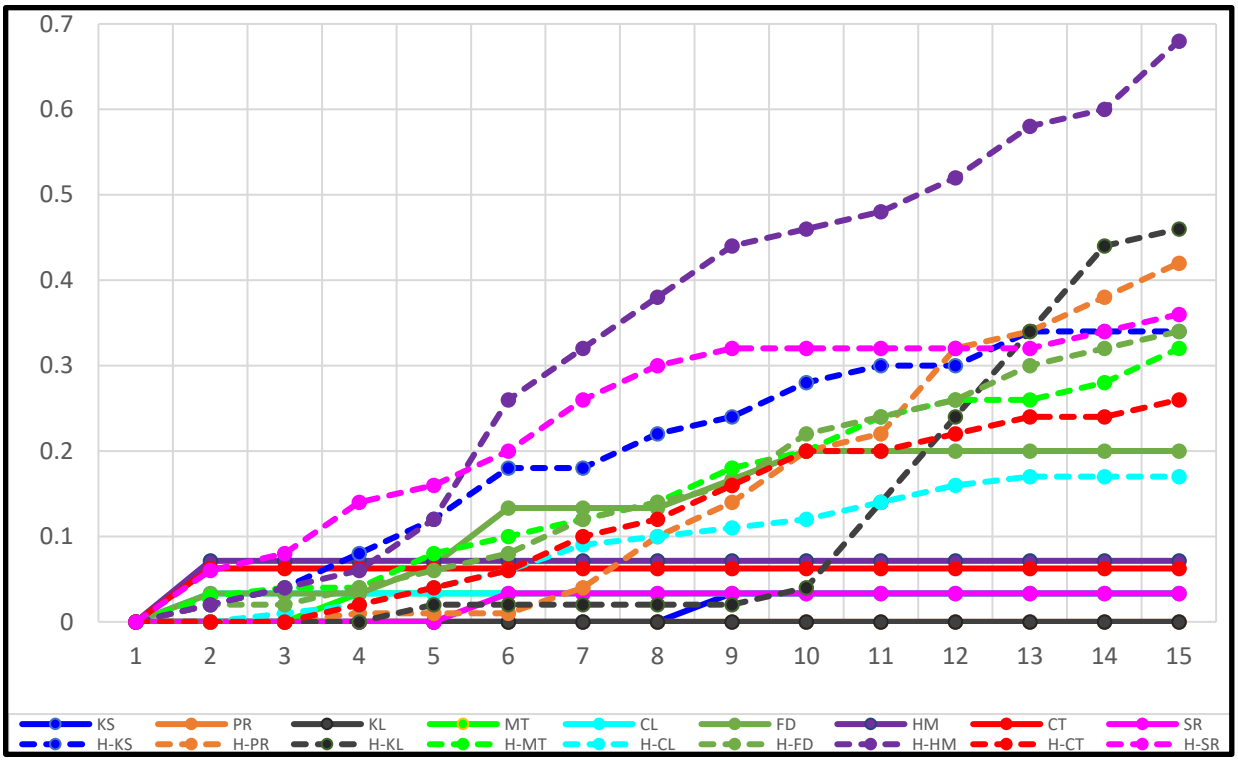

Figure 4. Comparisons of white pine blister rust (WPBR; caused by *Cronartium ribicola*) canker incidence rates over a 15-year period for contemporary (2006-2020; solid lines) and historical (1940-1954; dashed lines) time periods at nine sites. WPBR incidence rates, on average, were 40% less in recently regenerated western white pine (WWP; *Pinus monticola*) stands, compared to historical WPBR incidence rates in the historical WWP stands at the similar site. Site (plot) locations and abbreviations are shown in Figure 1. Solid lines are WPBR determined from the recent (2020) survey and dashed lines are the historical WPBR incidence rates that were determined ca. 55 years ago for the ca. 1940-1954 time period.

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