Aerial spore sampling to assess white pine blister rust risk in western white pine (*Pinus monticola*) and whitebark pine (*P. albicaulis*) stands at Priest River Experimental Forest in northern Idaho

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Introduction

Cronartium ribicola is an invasive forest pathogen that causes white pine blister rust, which threatens the health and productivity of five-needled white pines including iconic species, such as western white pine (WWP; *Pinus monticola*) and whitebark pine (WBP; *P. albicaulis*) in western North America. The pathogen has invaded most of the natural ranges of WWP and WBP and has dramatically altered forest composition and structure across the landscape (Neuenschwander et al. 1999). In recent decades, efforts to increase resilience of forest landscapes have led to a renewed interest in restoring WWP as a component of mesic and early seral forest ecosystems in the Northern Rockies, where WWP is a keystone species (Chmura et al. 2011, Bollenbacher et al. 2014). The widespread distribution of *C. ribicola* presents a challenge to these restoration efforts, even with the increased use of blister rust-resistant planting stock. In higher elevation ecosystems, *C. ribicola*, fire, beetles, and climate change threaten the existence of WBP in its role as a foundational and keystone species (Tomback et al. 2016). However, a better understanding of the factors affecting the growth and development of *C. ribicola* and its infection processes is needed to guide both management and conservation efforts of WWP and WBP.

The complex life cycle of *C. ribicola* requires two separate hosts, a primary/aecial host (e.g., white pine) and an alternate/telial host (e.g., *Ribes*, *Castilleja*, and *Pedicularis*). Basidiospores produced on the alternate host(s) can initiate an infection on white pine needles, aeciospores produced on stems and branches of infected white pines can only initiate infections on the alternate host(s), and urediniospores produced on the alternate hosts can only initiate subsequent infections on the alternate hosts, leading to an increase in inoculum potential (Zambino 2010). The risk of infection and disease development is strongly associated with inoculum (i.e., spore) abundance, environmental conditions, and topography (Zambino 2010). Assuming that a susceptible host is present in a conducive environment, the probability of infection is directly related to the amount of *C. ribicola* inoculum present.

Objectives

The objectives of this study are to 1) develop protocols for detecting and quantifying aerial inoculum (i.e., spores) of *C. ribicola*; and 2) incorporate environmental and topographic data to assess the risk of white pine blister rust in stands where planned management activities include restoration and/or conservation of five-needled white pines. These tools will support continued efforts by land managers to restore and conserve WWP and WBP in their native ecosystems.

Methods

A pilot study was initiated at Priest River Experimental Forest (PREF) in northern Idaho, starting in 2023 (Figure 1A). *C. ribicola* spores were collected using a rotating-arm impaction sampling device based on a design by Dr. Walt Mahaffee (Oregon State University) (Figure 2). The spore traps are powered by a 12V battery with a small motor driving a rotating arm that holds glass slides coated with petroleum jelly. DNA will be extracted from the

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petroleum jelly recovered from glass slides, and *C. ribicola* inoculum density will be quantified via real-time polymerase chain reaction (qPCR) using *C. ribicola*-specific primers.

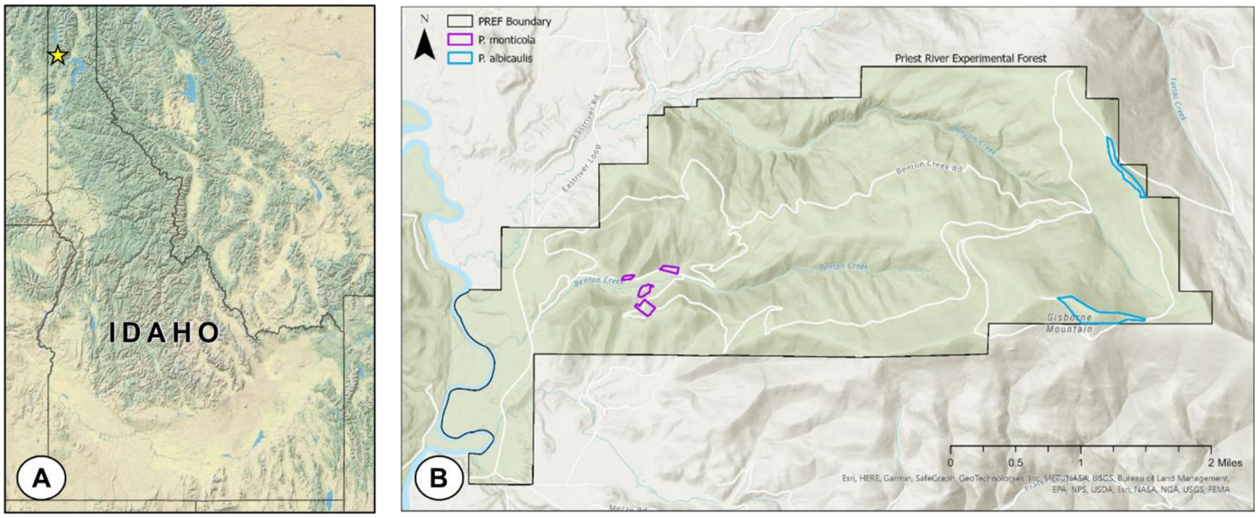

Figure 1: A) Map showing the location of Priest River Experimental Forest (PREF) in northern Idaho. B) Map showing study sites within PREF. Purple polygons represent sites in the western white pine forest type. Blue polygons represent sites in the whitebark pine forest type.

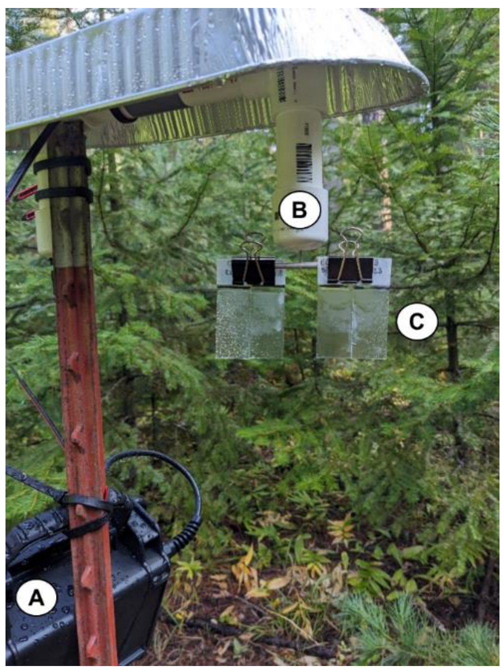

Figure 2: Mechanical spore trap (based on a design by Dr. Walt Mahaffee, Oregon State University). A) 12-Volt battery enclosed in a waterproof plastic case. B) Battery-powered spinning motor attached to an aluminum sampling arm. C) Rotating arm holding four glass slides coated with petroleum jelly that are attached using binder clips.

Spore traps were installed in four stands in 2023 – three in western white pine stands and one in a mixed whitebark pine stand on Gisborne Mountain [approx. elev. 1,700 m (5,600 ft)] (Figure 1B). The spore-trapping sites were arranged along an elevational gradient with variability in topography, microclimate, host abundance, and existing blister rust levels. Environmental factors, such as wind speed, wind direction, temperature, and relative humidity, are measured continually using weather stations in the selected stands, along with *C. ribicola* spore dispersal. Stands will be surveyed in conjunction with spore trapping to assess white pine blister rust incidence and severity in local populations of both the primary host (WWP or WBP) and alternate host (e.g., *Ribes*). This study will also leverage new and existing light detection and ranging (LiDAR) data for acquiring topography and vegetation information (Bright et al. 2020).

Ongoing Work and Future Directions

Data collection using the methods described above will continue over the next 2-4 years. These various data sources will be integrated and applied to develop models of local spore dispersal. A white pine blister rust risk assessment framework will be developed based on a combination of variables, such as *C. ribicola* inoculum density, environmental data, and site data (e.g., stand size/structure, stand age, species composition, site topography including slope, aspect, and elevation). This framework will allow for site-specific estimates of *C. ribicola* infection risk, which will serve as a decision-support tool for land managers in their restoration and/or conservation plans for WWP and/or WBP. Management decisions, such as project placement, unit boundaries, stand composition, planting density, pruning, and harvest parameters, will be informed by these risk assessments.

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