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Non-native Blister Rust Disease on Whitebark Pine at Crater Lake National Park

Abstract

Crater Lake National Park supports one of the largest aggregations of whitebark pine in the southern Cascades. The pine is valued by Park visitors and is considered a keystone species in local ecosystems. Although white pine blister rust has been in the region since the early 1900s, no formal survey of whitebark pine infection in the Park has been conducted to date. We sampled 1,200 whitebark pine trees with 24 transects to measure incidence of disease and other damaging agents in the Park. Blister rust is currently the most ubiquitous source of mortality for the Park's pines, outweighing all other biotic agents combined. The National Park Service is initiating actions to conserve whitebark pine.

Introduction

Whitebark pine (*Pinus albicaulis*) is an extremely valuable asset of the southern Cascades. This long-lived and hardy tree thrives at sites with harsh climatic forces. The pine's large and nutritious seeds are prized by wildlife including Clark's nutcrackers (*Nucifraga columbiana*), black bears (*Ursus americanus*), and golden-mantled ground squirrels (*Spermophilus lateralis*). Elk (*Cervus elaphus*), blue grouse (*Dendragapus obscurus*), and bats use trees for shelter. Their canopies support arboreal lichens and understory flora such as woodrush (*Luzula* spp.) and currants (*Ribes* spp.). Whitebark pines also stabilize soil and regulate snowmelt. These values are acknowledged by natural scientists in defining the tree as a keystone species (Tomback et al. 2001). Every year, nearly 500,000 people view southern Oregon's Crater Lake from its pine-clad rim where the picturesque trees are the subject of postcards, artwork, and exhibits.

Many pines at Crater Lake National Park have been suspected of dying from an introduced fungus (*Cronartium ribicola*) which causes the disease known as white pine blister rust. This pathogen arrived in western North America at British Columbia in 1910. Although blister rust can infect the other five-needled pines in the Park, [western white (*Pinus monticola*) and sugar pine (*P. lambertiana*)], whitebark pine is by far the most susceptible (Bingham 1972). Blister rust has proven lethal in other parts of North America where up to 90% mortality of whitebark pine has been estimated (Kendall 1994).

Understanding of blister rust on whitebark pine in the southern Cascades is rudimentary because of little formal investigation. The disease was documented in the vicinity of the Park as early as 1935 (US Department of Agriculture 1949), however, historic records of damage to whitebark pine are absent. Bedwell and Childs (1943) observed no diseased whitebark pine south of Mt. Jefferson. Correspondingly, Bachelor Butte, located about 110 km to the north, was reported to have very light incidence (Lueck 1980).

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Growing concern in the region (Juillerat 2000) combined with our increasing awareness of infection on sugar and white pines catalyzed a whitebark pine survey in the Park. Our objective was to detect and estimate the incidence of white pine blister rust on the Park's whitebark pine. For the purpose of this study, we define incidence as the percentage of trees within a sample that exhibits blister rust.

Methods

Our study area consisted of Crater Lake National Park, Oregon (74,132 ha) which is located on the crest of the Cascades in southern Oregon (Figure 1). The mean January and July temperatures at Park Headquarters are 13.7°C and 29.6°C. The moderate seasonal extremes in temperature contrast with the precipitation. Approximately 70% of total amount occurs between November and March as snow, which usually accumulates to nearly 5 m. Whitebark pine populations are restricted to the upper elevational limits of the Park (2,800 – 3,600 m) on the rim of Crater Lake's caldera, Mount Scott, and several other peaks. Pure stands of trees occur above 3,240 m while lower stands are codominated by mountain hemlock (*Tsuga mertensiana*), and occasionally lodgepole pine (*Pinus contorta*) and Shasta red fir (*Abies x shastensis*). The eastern side of the Park is cooler and drier as affected by easterly movement of storm masses and a more continental climate.

We inventoried survey transects within the whitebark pine zone of the Park (Figure 1). Due to the patchy distribution of whitebark pine, we combined both random and non-random sampling. About half of the transect starting points and azimuths were not random because the pine was restricted to small tree islands and the narrow edges of craters where strict randomness would result in intersecting few pine individuals. Non-random transect starts were subjectively placed in central locations, that were surrounded by whitebark pine, ensuring a random azimuth would work. Non-random azimuths followed an elevational contour or the established Rim Trail. For tree islands, a random island was chosen from which a random transect azimuth was followed. Often, these transects extended over meadows to other tree islands. Transects had variable widths depending on the density of whitebark pine trees. Widths ranged from 5 to 30 m and lengths varied between 54 and 612 m.

The first 50 live and dead trees along each transect were measured for diameter at breast height (dbh), live crown ratio, canopy dominance, and damaging agents. We noted when whitebark pine occurred in clusters of same-aged individuals. When we determined that a pine had active or inactive canker(s), we recorded percent of crown killed, canker distance to main stem, canker height above ground, and an estimate of the age of the most recent canker based on bark decay. Where more than one canker occurred on a tree, we chose the active canker nearest the stem and base, respectively, to describe. Trees that supported only cankers lacking any apparent fungal activity as indicated by the absence of all external symptoms (fungal fruiting structures, seeping sap, orangish bark) were recorded as infected individuals and also noted as possible resistant individuals (Hoff 1992).

At every transect slope, aspect, and elevation were recorded. Slope and aspect were measured at each end of the transects. Dominant understory flora were identified and the presence of currant shrubs was noted. The beginning and ending of each transect was georeferenced using a handheld global positioning system receiver. Analysis consisted of calculating the proportion of trees infected with blister rust (incidence) at each transect. Because currant shrubs transmit the fungal spores to trees, we compared incidence between transects with and without the shrub. We used the non-parametric Mann-Whitney U-test, which is appropriate for comparing proportional data (i.e. incidence values) (Fowler and Cohen 1990).

Results

We inventoried twenty-four transects totaling 1,200 whitebark pine trees. Blister rust was detected at all but three transects. The disease infected up to 20% of trees (Table 1). Disease was found on all size classes (<0.1 cm, 0.2 - 25.0 cm, and >25.0 cm) of pine at dbh. About 8% of trees >25 cm dbh were infected. Twelve percent of trees 0.1-24 cm dbh were infected. Nearly 3% of saplings (trees less than breast height) were infected. On many of the largest trees, more than one canker was observed. In addition to possessing active cankers, these trees often had deteriorating tops

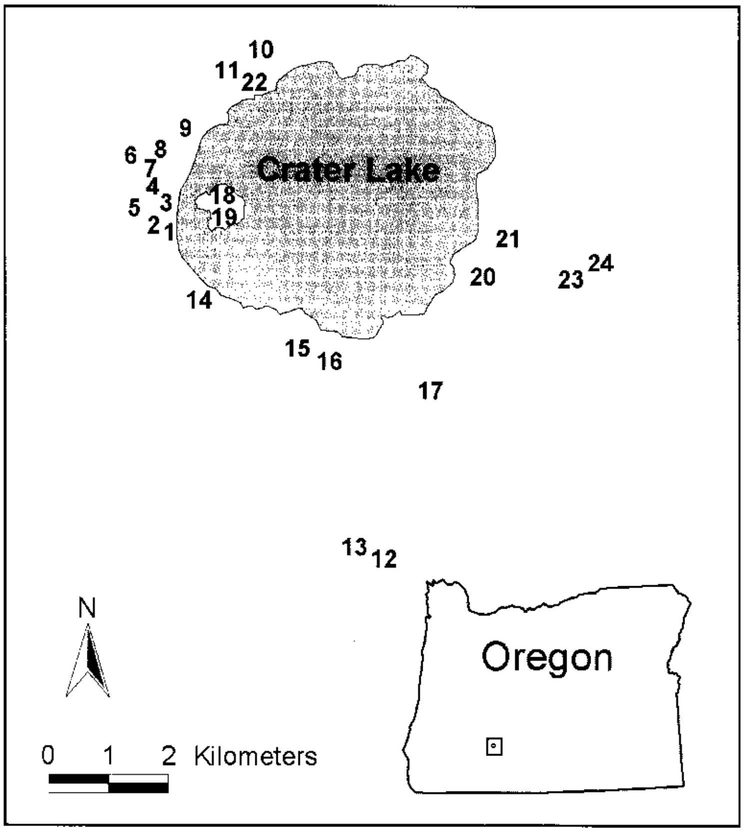

Figure 1. Location of twenty-four inventory transects within Crater Lake National Park, Oregon.

TABLE 1. Percentage of live trees (incidence) with blister rust on whitebark pine in Crater Lake National Park.

Location	Transect No.	Trees Infected (%)
Rim Trail (Southern flank of The Watchman)	1	20
	2	18
Rim Trail (South of Discovery Point)	14	18
Williams Crater	6	14
	7	18
Hillman Peak	8	14
Applegate Peak	16	12
Devils Backbone (West of Rim Trail)	9	12
Llao Rock	10	12
	22	4
The Watchman	3	10
	4	2
	5	4
Crater Peak	12	10
	13	4
North Junction	11	4
Dutton Ridge	17	8
Cloudcap	21	2
Garfield Peak	15	2
Wizard Island	18	2
	19	2
Castle Rock	20	0
Mount Scott	24	0

that appeared to have been dead for years. Trees possessing only inactive or dead cankers were rare, accounting for 0.67% of sampled trees. Additional agents of mortality were mountain pine beetle (*Dendroctonus ponderosae*) and dwarf mistletoe (*Arceuthobium* sp.), whose incidence was restricted to less than 2%, all on the summit of Wizard Island.

The 11 transects with currants supported significantly greater incidence of blister rust. Transects without currants averaged 4% infection while currant-populated transects averaged 12% infection.

Discussion

Blister rust poses a long-term threat to the Park's whitebark pine populations. This disease is currently the most copious source of mortality in the Park's pines outweighing all other biotic agents combined. The most rapidly declining populations are along the west caldera rim. The low incidence of rust on the east side of the Park may be related to a cooler, drier weather pattern that can limit the pathogen's abundance (Hoff and Hagle 1990). The absence of currant shrubs from all eastern transects may further limit spread.

Annual loss is difficult to estimate without regular fixed-plot monitoring. Based on tallies of trees >7 cm dbh killed during the past year, we estimate the current rate of mortality on the western rim at 0.7% per yr. Taking into account an optimistic estimate of 0.3% recruited mature trees every year, based on our inventory of size classes, we predict an overall decline of 0.4% for mature trees annually. We can assume that the fungus has infected the Park's whitebark pine since its detection on other trees in the area during 1935 (USDA 1949). Therefore, at 0.4% annual loss current conditions may represent an overall shortfall of trees by 26% since 1935. That is, we would expect 26% more live and mature whitebark pine trees today. This gradual decline will become more pernicious as time passes. At the current rate, within 50 yr, there will be 20% fewer whitebark pine on the western rim than today. This value is about half of the historical abundance.

Our estimates of whitebark pine decline should be considered conservative. A separate survey in the Park during 2000 estimated 32-67% incidence (Ellen Goheen, USDA Forest Service, Medford, personal communication) with a lower sample size. Moreover, cankers are not easily distinguished on the oldest and youngest trees. Large trees support thick coverings of lichens that conceal the bark while cankers on seedlings are not reliably swollen.

As both a keystone species in Park habitats and a resource valued by the visiting public, the pine's precarious status warrants managerial attention. Park staff have initiated mapping, long-term monitoring, research, and disease resistance testing as preliminary steps towards protecting and restoring these valuable trees.

Acknowledgements

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