
Oregon

NATURAL
HERITAGE
PROGRAM



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Status of Whitebark Pine in Crater Lake National Park



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SUMMARY

- Blister rust currently infects up to 20% of the Park's whitebark pine, especially on the western rim.
- We predict a 46% decline in mature whitebark pine by 2050.
- Present and future mortality on Wizard Island appears to be mostly mistletoe-related.
- A mapping and monitoring program is needed to provide better understanding of infection and mortality rates.
- A local rust-resistance seed orchard program supplemented with nutcracker dispersal will counter impending pine population bottlenecks.
- Knowledge of natural fire regimes for the Park's whitebark pine is lacking and needs to be investigated before management can confidently use it as a conservation tool.

INTRODUCTION

Whitebark pine (*Pinus albicaulis*) is an important tree species that provides food and shelter to high mountain wildlife plus scenic woodlands for visitors. About 500 acres of whitebark pine thrive in Crater Lake National Park where the trees are found perched on crater rims and mountains higher than 7000 feet. An introduced fungus (*Cronartium ribicola*) infects whitebark pine and causes the disease, white pine blister rust, which is usually fatal. Because of the threat this disease poses to the Park, our objective was to assess its significance on the Park's whitebark pine. We provide a discussion of our results and management recommendations.

Natural History

Whitebark pine is a long-lived and hardy tree able to thrive at sites which experience harsh climatic forces. The pine's large and nutritious seeds are prized by Park wildlife including Clark's nutcrackers, black bears, and red squirrels. Elk and grouse use trees for shelter. Their canopies support arboreal lichens and understory flora such as woodrush and currants. Whitebark pine also stabilize soil and regulate snowmelt.

Although blister rust occurs on all five-needled pines, such as western white (*Pinus monticola*) and sugar (*P. lambertiana*), whitebark pine is by far the most susceptible. Spores of the fungus arrive in moisture-laden air and infect five-needled pines and currant bushes. It is not fatal to currants, but once the spores reach the needles of whitebark pine, the infection spreads to branches. Within a year or two, a canker is formed by the fruiting bodies thus destroying the tree's living tissue in the vicinity of the infection. If the infection is at or near the main stem of the tree, topkill will occur, seriously threatening the tree's ability to survive. Often, other damaging agents such as mountain pine beetle (*Dendroctonus rufipennis*), wind, and alternate fungi take advantage of the injured tree and contribute to its death. White pine blister rust has proven very lethal in other parts of North America where up to 90 percent mortality has been estimated (Kendall 1994).

Regional Surveys

Current knowledge of blister rust on whitebark pine in the Cascades is very rudimentary owing to little formal investigation. The disease was documented in the vicinity of the Park as early as 1935 (USDA 1949), however records of damage to whitebark pine are not clear. Bedwell and Childs (1943) observed no diseased whitebark pine south of Mt. Jefferson. Hoff and Hagle (1990) reported that between 52 and 100 percent of whitebark pine in the North Cascades have been infected since 1937. More recently, Hadfield and others (1996) documented 20 percent infection in Washington's Cascades.

During the summer of 1998, a survey effort determined an average of 52 percent of living whitebark pine were infected immediately north of the Park boundary extending along the Pacific Crest Trail to the southern boundary of the

Willamette National Forest (Goheen and others 1999). More work by Goheen was conducted during the summer of 2000 with some sampling inside the Park, however results are not yet reported. A survey initiated by the National Park Service in 1999 found no blister rust present on whitebark pine in the Cloucap – Mt. Scott area (Donahue 2000). Correspondingly, Bachelor Butte, located about 70 miles to the north, was reported to have “very light “ incidence (Lueck 1980).

METHODS

We inventoried survey transects within the whitebark pine zone of the Park (Figure 1). About half of the transect starting points and azimuths were not random because the pine’s distribution is sparse or restricted to small tree islands and the edge of craters where strict randomness would result in intersecting few pine individuals. Non-random transect starts were subjectively placed in central locations, that is surrounded by whitebark pine, ensuring a random azimuth would work. Non-random azimuths followed an elevational contour or the Rim Trail. At tree islands, a random island was usually 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 15 to 100 feet and lengths varied between 177 and 2,038 feet (Figure 1).

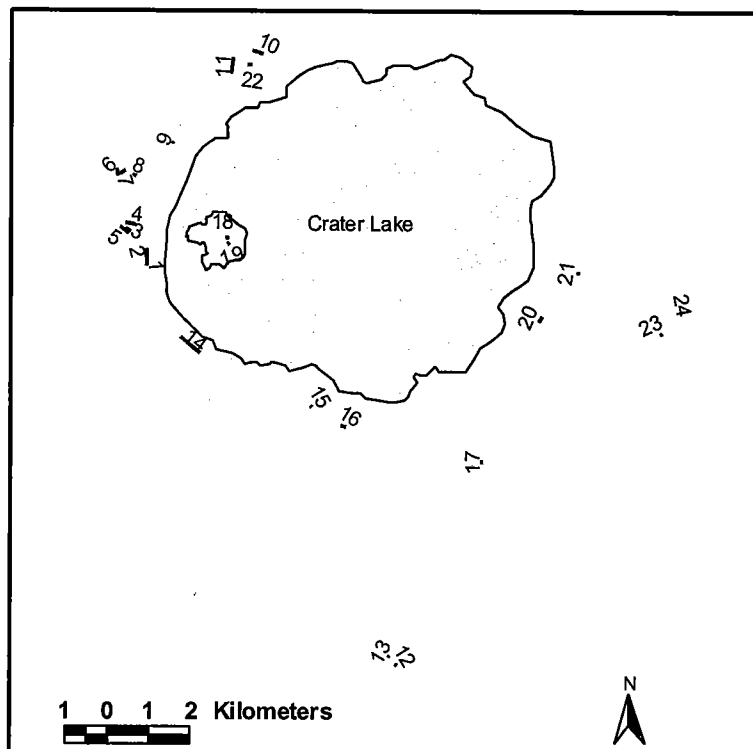


Figure 1. Location of twenty-four inventory transects.

The first fifty live and dead trees along a transect were measured for diameter, live crown ratio, canopy dominance, and damaging agents. Because whitebark pines often occur in clusters of same-aged individuals (former nutcracker seed caches), this was also noted. When a pine was determined to have blister rust, we recorded the percent of crown killed, canker distance to main stem, canker height above ground, and a rough estimate of the age of the most recent canker. Trees that had inactive or dead blister rust cankers were noted separately and not considered as infected, but resistant.

At every transect additional observations were noted. Dominant understory flora were identified and the abundance of currant shrubs (*Ribes* spp.) was described. The beginning and ending of each transect was georeferenced using a handheld global positioning system (gps) receiver. The slope and aspect were measured at each end of the transects.

RESULTS and DISCUSSION

A total of twenty-four transects, consisting of 1200 trees, were inventoried. Blister rust was detected on all transects except three. The disease infects up to 20 percent of trees at some sites (Table 1). Disease was found on all size classes of pine. About 8 percent of trees greater than 25 cm dbh (diameter at breast height) were infected (Figure 2). Trees between 0.1 cm and 24 cm dbh exhibited infections at 12 percent. Nearly 3 percent of saplings (trees less than breast height) were infected. Infections are more difficult to detect on both saplings and very large trees, so incidence may be slightly higher.

Because currant shrubs are alternate hosts of the blister rust fungus, we hypothesized that transects with currants were more likely to have higher pine infection rates. Eleven transects had currants and proved to support significantly greater incidence ($U=22$; $P<0.05$, Mann-Whitney U -test). Transects without currants averaged 4 percent infection while currant-populated transects showed 12 percent infection, on average.

Although presence of currants appears related to diseased trees, this is not conclusive. Even though all four transects from the Mt. Scott – Cloudcap area were currant-free, the low incidence of rust may be more related to a cooler, drier weather pattern in this portion of the Park.

Blister rust poses a significant long-term threat to the Park's whitebark pine population. Trees along the west caldera rim are dying the quickest. Annual loss is difficult to estimate without regular fixed-plot monitoring. Based on tallies of mature trees (≥ 7 cm dbh) killed during the past year, we estimate the current rate on the western rim at 0.7 percent per year. Taking into account an optimistic estimate of recruited mature trees every year (0.3 percent) based on our inventory of size classes, we predict an overall decline of 0.4 percent for mature trees annually. Assuming that the disease has been in the Park since

Table 1. Incidence of blister rust on whitebark pine in Crater Lake National Park.

Location	Blister Rust Incidence	Transects
Rim Trail (southern flank of The Watchman)	18 – 20 %	1, 2
Rim Trail (south of Discovery Point)	18 %	14
Williams Crater	14 – 18%	6, 7
Hillman Peak	14 %	8
Appelgate Peak	12 %	16
Devils Backbone (West of Rim Trail)	12 %	9
Llao Rock	4 – 12%	10, 22
The Watchman	2 – 12 %	3, 4, 5
Crater Peak	4 – 10%	12, 13
North Junction	4 %	11
Dutton Ridge	8 %	17
Cloudcap	2 %	21
Garfield Peak	2 %	15
Wizard Island	2 %	18, 19
Castle Rock	0 %	20
Mount Scott	0 %	23, 24
TOTAL	0 – 20%	24

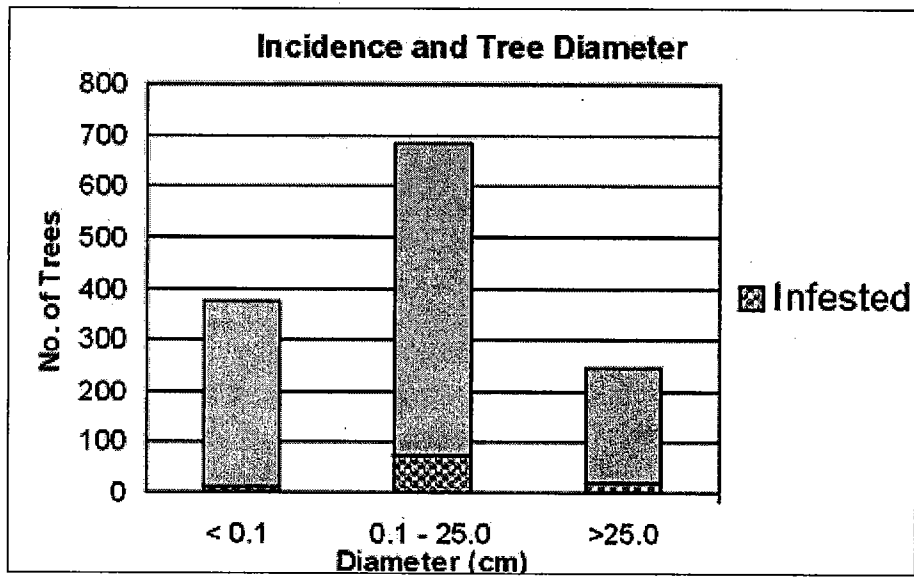


Figure 2. Blister rust incidence and tree diameter within Crater Lake NP.

detected in the area during 1935 (USDA 1949), then at 0.4 percent annual mortality, current conditions may represent an overall shortfall of trees by 26 percent. That is, we would expect 26 percent more live and mature whitebark pine trees today.

This doesn't appear alarming, however, this gradual decline will become more noticeable as time passes. At the current rate, within fifty years, there will be an additional 20 percent less whitebark pine on the western rim than today. This translates to whitebark pine obtaining nearly half of its historical abundance.

These estimates of whitebark pine decline should be considered conservative. Our ability to estimate long-term trends is limited because we don't know how much rust mortality is associated with seedlings. This is difficult to diagnose and has strong implications on the number of survivors reaching mature stages. Furthermore, infection can be linked with regional climate changes, where under a general warming scenario we expect greater blister rust incidence, especially in the eastern portion of the Park.

Most whitebark pine trees showed signs of other damage (Figure 3). The most common maladies are leaning boles and sweeping tops. Damage signs which were detected are often interrelated and should not be considered independent. For instance, sweeping tops are generally weather related, but these trees were not noted as weather damaged because misidentifying the cause of common physical maladies is easy to do. Although 80 percent of trees showed signs of damage, in the vast majority of these, the injuries are not life-threatening. Physical defects such as the loss of a tree's top are endemic to whitebark pine. They have evolved in a harsh environment to be resilient to weather's heavy forces.

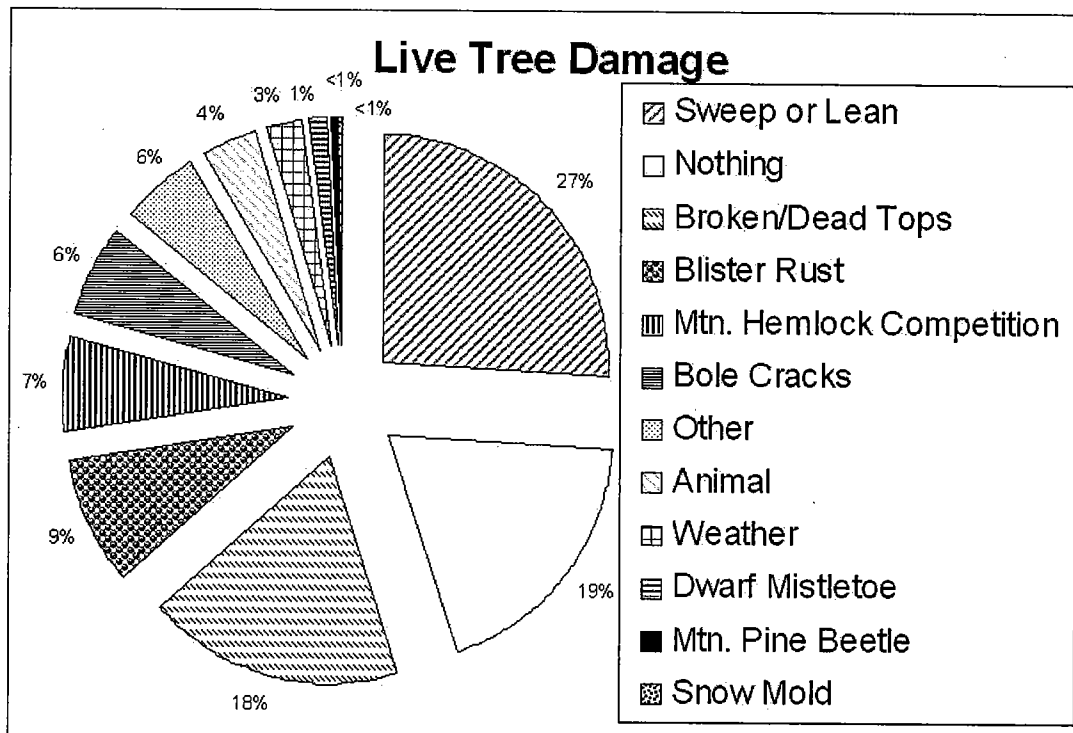


Figure 3. Surveyed damage to whitebark pine within Crater Lake NP.

The most lethal agents are generally blister rust, mountain pine beetle, and dwarf mistletoe (*Arceuthobium* sp.). Beetles and mistletoe are restricted to less than 2 percent of the Park's trees – detected only on Wizard Island's summit. Their damage is very visible to the visiting public who enjoy viewing Wizard Island from the caldera rim. We surveyed 100 trees (two transects), finding a species of mistletoe (probably *A. americanum*) to be the most important agent of damage on the island (Table 2). It appears that mistletoe activity on the island is not a recent phenomenon. Jackson and Faller (1973) observed many infested trees during the late-1960's and recorded that 45 percent of trees greater than 10 cm dbh were dead. Why mistletoe and mountain pine beetle are restricted to Wizard Island is not known. The trees here may be under greater stress due to their open exposure to the elements. Soils are young and undeveloped, perhaps providing scant nutrients. Water availability is also very low at the summit.

Table 2. Wizard Island's biotic and potentially lethal agents of disturbance on whitebark pine (>0.1 cm dbh and mature krummholz). Seedlings are not included.

	Status	Percent of Trees
Mortality Risk Increases 	Live – without biotic damage	21%
	Rodent Gnawing	22%
	Mistletoe	15%
	Mistletoe and Beetle	4%
	Blister Rust	2%
	Dead	32%

MANAGEMENT IMPLICATIONS

In the short-term, the Park's whitebark pine populations appear to be only gradually declining and do not correspond to steeper downtrends elsewhere in the Cascade region. However, populations in the Park are under a significant long-term threat due to several factors. First, as illustrated, whitebark pine may have already decreased by 26 percent with an additional loss of 20 percent by the year 2050. Second, global warming probably favors conditions for survival and spread of the blister rust fungus and increases competition with mountain hemlock, lodgepole pine and shasta fir – further stressing whitebark pine. Third, whitebark pine does not mature and produce seeds until the age of 20-50 years. Therefore, any management scenarios must consider a time lag resulting in population bottlenecks before pine numbers can rebound.

Based on our findings, we outline the following actions aimed at maintaining whitebark pine populations in the Park.

Mapping

In order to periodically assess the status of whitebark pine in the Park, populations must be found and mapped. We recommend an on-the-ground survey to verify and map its distribution. Aerial photographs, expert knowledge, and a computerized geographical information system (GIS) can be used to identify potential sites supporting whitebark pine. These locations should be infection and mortality. Transects should be

located throughout the Park and represent the different communities that whitebark pine supports. Moreover, a climate station in the eastern portion of the Park would be useful for comparing fine-scale weather effects with the west side while also providing an enhanced account of overall, broad-scale trends in Cascadian climate.

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