Whitebark Pines at Rim Village in Crater Lake National Park, Oregon

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Introduction

Whitebark pine (*Pinus albicaulis*) is a high-elevation conifer that, over the last one hundred years, has increasingly been affected by the introduction of white pine blister rust (*Cronartium ribicola;* Figure 1). As the spread of blister rust increases, concern for the fate of whitebark pines also increases. Both private and public land managers predict that without comprehensive management intervention, whitebark pines face "continuous decline, functional extinction, and local extirpation" (Kendall and Keane 2001:237). Because whitebark pines are considered keystone species for subalpine ecosystems, the loss of these important trees may also cause population declines for Clark's nutcrackers (*Nucifraga columbiana*), grizzly bears (*Ursus arctos*), red squirrels (*Tamiasciurus vulgaris*), and other subalpine species.

Whitebark pines at Crater Lake National Park in Oregon have been impacted by the combined effects of fire suppression, mountain pine beetles (*Dendroctonus pondersae*), dwarf mistletoe (*Arceuthobium cyanocarpum*), and white pine blister rust. The whitebark pines at the historic Rim Village in the park commonly frame visitors' photos and are an important part of both the scenic and historic value of the area (Figure 2). The whitebark pines along the promenade at Rim Village were surveyed in July of 2006. The results demonstrated that the whitebark pines at Rim Village had similar infection rates to those found in park-wide surveys. Blister rust has infected approximately 20% of all whitebark pines in the park (Murray and Rasmussen 2000) while 19.4% of the trees at Rim Village were infected. Of the 124 trees surveyed on the promenade, 88 were alive.

Continued monitoring of the health of these trees will be an important aspect of park management and will hopefully contribute to the longevity of the whitebark pine species both in Crater Lake National Park and elsewhere.

Whitebark pines

Upper subalpine ecosystems are characterized by short growing seasons, rocky and low-nutrient soil conditions, exposure to extreme winds and low temperatures, pummeling by heavy ice and snow, and high-elevation locations. Whitebark pines not only survive under these conditions but are the symbol of tenacity in the face

Figure 1. Whitepine blister rust on a whitebark pine. Photo by Carrie Wittmer.

Figure 2. Whitebark pines frame Crater Lake at Crater Lake National Park, Oregon. Photo by Carrie Wittmer.

of such adversities. "Tenacious" is defined as having the ability to cling to or hold on to something. "Tenacious" aptly describes whitebark pines that are perched on the edge of deep precipices, clinging to rocky outcrops, and thriving despite conditions that discourage other types of growth or life. In fact, whitebark pines often exhibit "Krummholz," which is the name given to crooked, wind-beaten timber (Murray and Rasmussen 2000), and their bent forms are common in high-elevation forests from British Colombia through Wyoming, down into California and up to Washington.

Whitebark pines are part of the white pine family, which all have needles in bundles of five. Whitebark pines can reach heights of up to 70 feet (Peattie 1981), but in extreme environments, even old trees may never grow higher than five feet. Adaptations that allow the species to cope with subalpine conditions include flexible branches, short stems, solidly anchored root systems (Murray 2005), thick bark, and seedlings that are able to tolerate full-sun conditions.

Keystone species

Whitebark pines' tenacity and ability to colonize harsh environments have made it a keystone species of subalpine and alpine ecosystems. The services it provides to these ecosystems include:

- Symbiotic collaboration with Clark's nutcracker: the nutcrackers harvest and cache whitebark pine seeds. The nutcrackers benefit from the large, nutritious seeds and the whitebark pines benefit from regular and discriminating seed dissemination.
- Several other species also depend on whitebark pine seeds including red squirrels, flickers, blue birds, and grizzly bears who seek out squirrel middens for stored seeds (Zeglen 2002).
- Nurseries for shade-dependent and wind-sensitive species such as subalpine fir, Engelmann spruce, and mountain hemlock (Zeglen 2002).
- Stabilization of rocky soils, allowing for establishment of other species. Soil stabilization also allows for better seepage of snowmelt, regulating spring run-off and erosion (Tomback and Kendall 2001).
- Provides substrates for mycorrhizae, fungi, bacterial communities, and lichens (Kendall and Keane 2001).

The future of whitebark pines

Is tenacity, however, enough to save this species? Whitebark pines survive where other trees cannot: they sit patiently through brutal wind storms, extreme temperatures, and heavy snowpack. They often have a ragged, scarred, wind-blown appearance and lack a full crown of branches or have broken tops. Bark is often picked at by bears, squirrels, and hares (Zeglen 2002). Their tenacity and patience, thick bark, and flexible branches are proving insufficient to resist the combined onslaught of several factors: fire suppression, mountain pine beetles, dwarf mistletoe, and white pine blister rust. According to Kendall and Keane in "Whitebark Pine Decline: Infection, Mortality, and Population Trends" (2001:221), "throughout major parts of their range, whitebark pine communities have declined dramatically over the past fifty years from the combined effects of disease, insects, and successional replacement."

The last 100 years of fire suppression have had a severe impact on whitebark pine regeneration. Clark's nutcrackers favor open caching areas and whitebark pine seedlings are typically the first growth in fire-scarred landscapes at high altitudes. The lack of fires has benefited more shade-tolerant species such as mountain hemlocks and subalpine firs while also contributing to fuel-buildup, leading to stand-replacement fires.

Mountain pine beetles appear in periodic outbreaks and usually attack trees that have been weakened by other factors. Male and female beetles tunnel into live tree bark, mate, produce eggs which produce larvae. The larvae eventually create characteristic "J" tunnels under the tree's bark (Leatherman 2005). Trees usually die from the infestation if they are not capable of resisting the attack.

Limber pine dwarf mistletoe is a parasitic plant that threatens whitebark pines by penetrating tree bark and taking water and nutrients from the host. Infections can persist for years and eventually kill the host tree (Jacobi and Swift 2005). (Dwarf mistletoe is a particular problem for whitebark pines on Wizard Island at Crater Lake.)

Finally, white pine blister rust weakens and kills whitebark and other white pines. Blister rust is an Asian fungus that was accidentally introduced in Vancouver in 1910, and since that time, has made steady progress through stands of white pines throughout the Pacific Northwest and the southwestern United States. Whitebark pine is the most susceptible of the white pines to blister rust (Maloy 1997) and, despite millions of dollars spent on blister rust control programs, whitebark pine deaths attributed to the fungus are expected to rise considerably over the next 30 years. In fact, Baskin (1998, 52) reports that "from Glacier National Park west across northwest Montana, Idaho, Washington, and up into Southern Alberta and British Colombia, 40–100% of whitebark pines are dead. Most of the rest are infected, and many of these have stopped producing cones." Kendall and Keane (2001) predict severe declines in whitebark pine survival and possible extirpation unless there is widespread management intervention.

Whitebark pines at Crater Lake National Park

As elsewhere in the Cascade Mountain Range, whitebark pines at Crater Lake National Park are being adversely affected by white pine blister rust. A survey from 2000, where 1,200 trees in the park were inventoried, showed 20% infection rates (Murray and Rasmussen 2000). In 50 years at projected rates of loss, there will be half the original number of whitebark pines in the park (Murray and Rasmussen 2000). Park ecologist Michael Murray writes (2005:28), "Unless actions are taken, whitebark pine will continue to decline. With resistance levels estimated to be less than 5%, we can anticipate 95–99% mortality without management intervention."

Scarcity of mature, cone-producing trees may impact populations of Clark's nutcrackers which in turn, will limit the nutcracker's ability to cache and disseminate tree seeds. As a result, smaller populations of trees will trigger an "extinction vortex," caused by combinations of reduced population sizes, fragmentation of tree distributions, inbreeding, and finally loss of genetic variation (Tomback and Kendall 2001), ultimately leading to extirpation. As an ecosystem "keystone species," the loss of even half of the park's whitebark pines may ultimately affect bird and squirrel populations and soil stabilization. The loss will not only change the composition of subalpine ecosystems in the park, but will also negatively affect the historic and aesthetic values of the park.

Whitebark pines at Rim Village: A survey

Project scope. Visitors from around the world congregate year-round at Rim Village in order to gaze in wonder at the stunning beauty of Crater Lake. During the summer months, they stroll along the promenade from West Rim Drive up to the historic Crater Lake Lodge. Thousands of photographs of the lake are framed by the crooked, bent, and wind-whipped boughs of the 5-needled whitebark pines. These trees cling to the northern aspect of the stone wall built by the Civilian Conservation Corps in the 1930s and some hang precipitously out over the caldera rim. Clark's nutcrackers croak and cry overhead to each other as they pick at cones high in the trees for seeds. Whether visitors recognize the trees as whitebark pines or not, the trees (and the birds) are an integral part of both the historic and aesthetic beauty of the visitor's experience. As outlined in the "Status of Whitebark Pine in Crater Lake National Park" by Murray and Rasmussen (2000), one of the key components of managing and mitigating whitebark pine loss, both at Rim Village and in the entire park, is mapping and monitoring the park's trees. Toward this end, a survey was conducted in July of 2006 to assess and map both the live and dead whitebark pines at Rim Village.

Methods. Over three days of surveying, each whitebark pine along the promenade at Rim Village was assessed as either alive or dead; its location was noted using a global positioning system (GPS) device; its height (feet), diameter at breast height (inches), maximum crown width (feet), minimum crown width (feet), live crown ratio (%), height to live crown (feet), and number of cone clusters were measured and recorded; a photo was taken; inactive and active blister rust cankers were observed; and any other damage to the tree was recorded. This information was collected in a spread sheet, and each tree location was mapped from the promenade's intersection with West Rim Drive to approximately 300 feet past the lodge. It should be noted that numerous whitebark pines were observed below the rim, but because of the dangers involved in scrambling down the side of the caldera, they were not inventoried. Also, many of the surveyed individuals were difficult to identify as either one tree with several main branches or a cluster of genetically different trees cached in the same hole by Clark's nutcrackers. In order to provide clarity for future monitoring, trees in clusters were given the same number but different letters so that they could be differentiated by their characteristics and measurements.

Results. One hundred twenty-four whitebark pines were found along the promenade at Rim Village. Of the trees surveyed, 36 (29%) were dead and 88 (71%) were alive. Of the live trees, 64 had no observable blister rust infections and 24 had either inactive or active cankers. Of the total number of whitebark pines along the promenade, 19.4% of the trees were infected by white pine blister rust, indicated by either active cankers, indicated by stem swelling and orange football-shaped aecia, or by blistering caused by old cankers. This infection rate closely reflects the 20% infection rates found in the park-wide survey of whitebark pines in 2000 (Murray and Rasmussen 2000).

The future of whitebark pines at Crater Lake National Park

Monitoring and mapping the whitebark pines at Crater Lake is only part of an overall management plan to mitigate the impacts of fire suppression, dwarf mistletoe, mountain pine beetles, and, of course, white pine blister rust. It is a critical feature of being able to monitor both long-term successes and failures of management practices in the park. In addition, two other essential components to preserving whitebark pine's long term viability are fire use (Figure 3) and propagating rust-resistant trees.

Because of its clear mission "to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (National Park Service Organic Act, 16 U.S.C. 1), the National Park Service is in a good position to use fire to preserve and restore whitebark pine ecosystems. Fires not only clear out competing species of trees but also provide preferred caching areas for Clark's nutcrackers. Crater Lake National Park is currently experimenting with fire use to restore the park's ecosystems which are evolutionarily adapted to periodic burning from lightening strikes.

Additionally, methods of mitigating the impacts of white pine blister rust must be found. In 2003, whitebark pines at Rim Village were assessed for resistance to blister rust. Ten trees with few or no blister rust cankers were identified and their cones were harvested in late

Figure 3. Fire use at Crater Lake National Park. Photo by Michael Murray.

September. These seeds are being germinated at the U.S. Forest Service's Dorena Tree Improvement Center near Cottage Grove, Oregon (Murray 2005). The seedlings will be tested for resistance to blister rust and, hopefully, resistant seedlings can be transplanted back into the park, or seeds from resistant trees can be provided for Clark's nutcrackers to cache.

It is uncertain in this case whether human efforts can stop an introduced epidemic; the one thing that is certain is if nothing is done, whitebark pines, both at Crater Lake National Park and in North America, face eventual extinction. As with numerous other examples of extraordinary effort, species can be brought back to healthy populations. Hopefully, through persistent, thoughtful, and well-researched management efforts, whitebark pines can continue to frame photos of Crater Lake and perhaps even conservation efforts of other species in other places.

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