Our Threatened Timberlines: The Plight of Whitebark Pine Ecosystems

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The hardy whitebark pine endures harsh timberline conditions where other trees often fail. Tipsoo Peak, Mt. Thielsen Wilderness. Photo by Michael Murray.

Living in quiet solitude on Oregon's highest peaks is the whitebark pine - a tree whose story is as stunning as its timberline landscape. Virtually ignored by lumbermen, foresters, and scientists for decades, whitebark pine is now gaining widespread attention. At high elevations where conditions are too harsh for other trees to survive, the enduring whitebark pine forms pure stands on sites that would otherwise be devoid of tree growth. Here, whitebark pine is considered the keystone species in a community of dependent organisms. Now, these systems are threatened by a non-native fungus causing white pine blister rust (*Cronartium ribicola*).

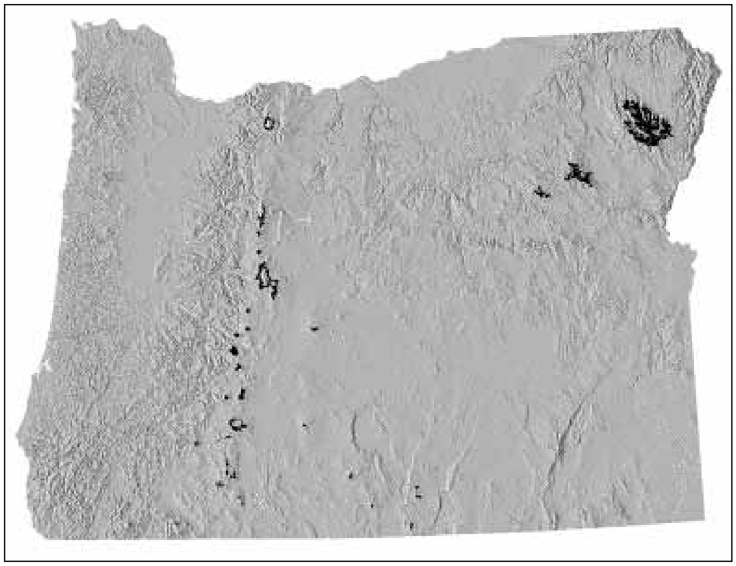
First described by George Engelmann (1863), whitebark pine has been acknowledged as the only North American representative of the stone pine subsection, *Cembrae*, within the larger subgenus of white pines—*Strobus,* 5-needle pines. Stone pines differ from other white pines by their large wingless seeds borne in cones that remain closed when mature. Not adapted for wind dissemination, seeds are distributed by a genus of specialized birds, nutcrackers (*Nucifera*), who pry cones open, extract the seeds, and store them in the ground in caches of one to fifteen seeds.

Natural History

Plant life at timberline is challenged by poorly developed soils, heavy snowfall, a short growing season, ice storms, and ferocious winds. In Oregon, subalpine soils are most commonly well-drained volcanic, sedimentary, or metamorphic, and in the Blue Mountains whitebark pine grow on calcareous substrates. Several physical traits permit whitebark pine to endure a harsh environment – flexible branchlets shed snow, stout stems, and well anchored root systems.

Apparently whitebark pine regeneration depends completely on Clark's nutcrackers who extract the pea-sized seeds from the cones and bury them for future use. Pine seeds are a major food source for the nutcrackers and a variety of other wildlife, big and small. The nutcracker's forgotten seed caches often germinate and develop into new trees: a true mutualistic relationship.

Although well-adapted to surviving at timberline, whitebark pine is not a strong competitor with other trees because of its relative shade intolerance and slow growth. Mountain hemlock (*Tsuga mertensiana*) and subalpine fir (*Abies lasiocarpa*) overtop whitebark pine on all but the most inhospitable peaks. Ironically, established whitebark pine contribute to the competitor's survival by sheltering fragile seedlings from the harsh elements. Common understory species of whitebark pine communities include smooth woodrush (*Luzula hitchcockii*), dwarf huckleberry (*Vaccinium scoparium*), Davidson's penstemon (*Penstemon davidsonii*), bottlebrush squirreltail (*Elymus elymoides*), Wheeler's bluegrass (*Poa wheeleri*), and Brainerd's sedge (*Carex brainerdii*).



Whitebark pine (*Pinus albicaulis*) is restricted to Oregon's highest mountain peaks. Map adapted from Kagan and others 1999.

Examination of pollen deposits in boggy soils and lakebeds reveals whitebark pine paleohistory. The oldest probable whitebark pine pollen (as well as pollen from spruce and fir) sampled from Yellowstone National Park was deposited during the Illinoian glacial period about 140,000 years ago (Baker 1981). (Pollen of all white pines is similar, and generally indistinguishable, thus probable species determinations are made from associated vegetation and other evidence.) In Oregon, it is hypothesized that whitebark pine is a more recent immigrant from both the northern Cascades and Idaho populations (Richardson and others 2002). Curiously, no evidence of whitebark pre-dating the Wisconsin ice age (which ended about 10-12,000 years ago) has been found in Oregon, although habitat was available prior to and during the glaciation. Whether the species is a late arrival here, or simply that earlier field evidence has not yet been discovered in Oregon, the range of whitebark pine has remained fairly static since continental glaciers receded about 10,000 years ago.

Timberline Communities

Whitebark pine is limited to high mountain environments of western North America, from the Coastal and Rocky Mountain Ranges of British Columbia and Alberta south through the Cascade and Sierra Nevada ranges. Small populations are scattered through the Klamath Mountains in California. To the east, Rocky Mountain whitebark pine extends south into Yellowstone National Park and Wyoming's Wind River Range, but does not reach Utah or Colorado. Many isolated populations in the Intermountain Region and Great Basin have only recently been documented. Numerous populations in Oregon have not been described in any detail or mapped.

Whitebark pine communities are found in four of Oregon's ecoregions: Blue Mountains, Klamath Mountains, Eastern Cascade Slopes and Foothills, and Cascades (Loy et al. 2001). Cascade Mountain populations occur sporadically along the volcanic spine stretching from Mt. Hood south to the Mountain Lakes Wilderness above Klamath Lake. To the east, stands persevere above junipered basins at Paulina Peak (Newberry Crater National Monument), the Gearhart Mountain Wilderness northeast of Bly, and the Strawberry, Elkhorn, and North Warner mountain ranges. The Wallowa Mountains also support extensive timberline forests of whitebark pine, including the alleged largest-known individual in the state (ODF 2002). Recently, Frank Lang documented a small collection of whitebark pine on Mt. Ashland (Lang 2003). It is the only known population from the Klamath-Siskiyou Region in Oregon. Fortunately, none of the trees would be destroyed under the preferred alternative in a planned expansion of the Mount Ashland ski area.

At two of the highest elevations, Mount Scott and Eagle Cap, whitebark pine barely survives in stunted clumps known as *krummholz*, a German word meaning "crooked wood" (Arno and Hammerly 1984). It's difficult to distinguish one tree from the other in these weather-battered patches of sprawling branches. Oregon's most accessible stands are located on Mt. Hood near Timberline Lodge, along the Rim Drive at Crater Lake National Park, Paulina Peak, and at the gondola summit of Mt. Howard in the Wallowa Mountains. Collectively, nearly 2.5 million people visit Oregon's whitebark pine stands annually.

The Human Influence: Decades of Quiet Decline

Restricted to remote lofty highlands, the hand of humanity has increasingly encroached on timberline habitats. Native Americans gathered the large nutritious seeds for food (Losensky 1990) and co-existed with the pines for centuries. Around 1860 high mountain hardrock mining operations began utilizing trees to fuel steam engines and wood stoves. Further damage started at the turn of the 20th century with bands of livestock trampling seedlings and overgrazing subalpine grasslands, which reduced the frequency of wildfires by removing grassy fuels (Skovlin and others 2001). In the early 1900s the federal government began a program of extinguishing all fires. As a consequence, the less fire-resistant fir and mountain hemlock began replacing whitebark pine. Nutcrackers, which are attracted to burned sites for caching seeds, had fewer options. Fire, however, is a complex force and can both benefit and damage whitebark pine. With unfavorable stand and fuel conditions, fire kills the trees, or leaves weakened survivors vulnerable to attack by native mountain pine beetles which tend to kill mature trees that are the best cone producers. And lastly, stands of whitebark pine have succumbed to a variety of road-building and development projects such as at Timberline Lodge, Crater Lake's Rim Drive, and several ski areas.

Above and beyond all other human-induced harm to whitebark pine populations has been the introduction of white pine blister rust, a non-native fungal affliction. It arrived on eastern white pine *(Pinus strobus)* seedlings grown in France and imported into Vancouver, British Columbia in 1910, despite warnings from European and American plant pathologists (Hadfield 2000, McDonald and Hoff 2001). By 1920 the epidemic had spread to western white pine (*P. monticola*) and sugar pine (*P. lambertiana*) in the southern Cascades. Diseased whitebark pine were first recorded in Oregon in the early 1930s near Mount Hood (Hadfield 2000). Blister rust completes part of its life-cycle on currant shrubs (*Ribes* spp.), thus removal of *Ribes* plants from the forests was attempted as a form of rust control. Detection and eradication efforts were directed primarily towards saving commercially-important western white and sugar pine, but they had only limited effectiveness and were abandoned in the 1960s.

The spread of the disease is a dynamic process that depends on clouds, fog, wind, and the alternate host—*Ribes*. As an airborne pathogen, spores travel great distances in humid air masses. Spores that connect with the undersides of *Ribes* leaves multiply and spread during cool wet summer days. By late summer, a new type of spore is formed on the leaves called a basidiospore. Breezes carry these to neighboring whitebark pine where the basidiospores enter needle stomata, grow hyphae, and start to spread internally through the phloem. The result is a swelling canker which can strangle the tree, killing all tissue above it. Usually, cankers are first noticed on branches, but they can also form on the main stem. The invading fungus fruits at the canker, producing more spores. It is only at this stage that disease can be confidently diagnosed, by the orange-yellow fungal tissue that blisters from the canker. Squirrels and other rodents often chew off the bark that covers cankers to obtain the sap that contains a high concentration of sugar. Aerial spores are disseminated from the blister fruits (see photo), remaining viable for weeks in the atmosphere while traveling hundreds of miles to distant *Ribes* where the cycle is repeated. After infection, mature trees can probably survive several years to decades, depending on size, number, and location of cankers. However, experts warn that only 0 to 5% of the whitebark pine population will survive the alien pathogen (Hoff and others 1994).

Fruiting structure of the blister rust fungus (*Cronartium ribicola*) emerges on branch of whitebark pine. As the tissue grows, the tree's living cells are damaged and a swollen canker often forms. Photo courtesy of National Park Service.

The magnitude of whitebark pine loss in Oregon is now being revealed (Table 1). In the Blue Mountains, disease-induced mortality varies greatly among locations (Schmitt and Scott 1998). Very high infection rates have been found at Mt. Howard in the Wallowas and the more remote Marble Point in the Elkhorn Range. Little to no infection was detected in the Wallowas at Sheep Creek and Mount Russell. The Strawberry Range population has also proven to be in good health. Apparently, all

Table 1. **Impacts of blister rust on Oregon's whitebark pine based on surveys between 1997 and 2004**

Oregon Location*	Infected Trees	DeadTrees	Reference
Mount Hood	28-83%	2-54%	J. Rice (pers. comm. 2004)
Badger Creek Wilderness (Mt. Hood NF)	49-90%	2-21%	J. Rice (pers. comm. 2004)
Blue Mountains	"none to severe"	–	Schmitt and Scott (1998)
Southern Cascades (north of Crater Lake)	46%	10%	Goheen and others (2002)
Crater Lake NP	0-20%	0-26%	Murray and Rasmussen (2003)
Mount Ashland	44% (4 of 9 ind.)	0%	Murray and Lang (unpubl. data 2004)

*Surveys conducted at a variety of sites for each location, except Mount Ashland – single site.

regions of the Oregon Cascades are besieged. Nearly half of the whitebark pine on the west side of Crater Lake National Park are dead or dying. There, blister rust is the most ubiquitous cause of mortality, outweighing all other biotic agents combined (Murray and Rasmussen 2003). The increasing number of dead trees has gained the attention of the visiting public, media, and scientific community.

Unless actions are taken, whitebark pine will continue to decline. With resistance levels estimated to be less than 5%, we can anticipate 95 to 99% mortality without management intervention. Because warmer environments favor the fungus, death rates are predicted to accelerate with regional warming trends. Thus, in the cooler, drier east part of Crater Lake National Park, where infection rates are less than 2%, pines will be at increasing risk.

A Lifeline To the Future

In the face of disheartening declines, public land stewards are heeding a call for action. With easy year-round access to Crater Lake's Rim, this National Park's whitebark pine ecosystems are perhaps the best studied in Oregon. Here, the Forest Service is joining the National Park Service in a conservation partnership. The most widely accepted strategy for retaining whitebark pine ecosystems is through facilitating natural selection of rust-resistance. Seedlings with enhanced resistance need to be produced and nurtured so they can become established and attain maturity. The process hinges on finding rust-resistant candidate trees occurring naturally (Sniezko and others 2004).

A bird-proof cage is installed over a cone cluster at Crater Lake's Rim Village while a Clark's nutcracker watches. Photo courtesy of National Park Service.

During the summer of 2003, I began Crater Lake National Park's first effort to select for the rust resistant gene pool. Rim Village was chosen as the selection site for several reasons: 1) disease had already killed many trees, 2) heavy visitation and high value to the public, 3) easy access, and 4) need to establish vegetation at a planned deconstruction project at the site. Ten healthy trees which exhibited few or no cankers were identified, measured, tagged, mapped, and photographed in anticipation of cone collection. One important obstacle remained, however, to ensure that the cones wouldn't be harvested by squirrels or nutcrackers before we could get them. To reserve our share, we placed mesh cages over branch tip cone clusters during mid-summer before cones ripening. For harvesting in late September, a boomlift (a.k.a, 'canopy crane'), proved to be a safer and more efficient method than climbing. The nutcrackers scolded us from nearby tree tops, as we stole what they considered their natural rights.

A sixty-foot boomlift is used to lift biologists to the cone-bearing branches of whitebark pine. Trees are being tested along the historic Promenade Walk for possible resistance to blister rust. Photo courtesy of National Park Service.

The whitebark pine seeds we collected are being prepared for planting at the Forest Service Dorena Tree Improvement Center near Cottage Grove. Seedlings will be exposed to the blister rust fungus and observed to determine survival during a five year period. Similar testing of whitebark pine in the Rocky Mountains indicated that between 1 and 44% of seedlings may survive the first several years – suggesting resistance (Hoff and others 2001).

Staff at Crater Lake National Park are also investigating other forces affecting the survival of whitebark pine, specifically fire and pine beetles. A fire history study is revealing the frequency and severity of subalpine fires among the three Cascade National Parks and neighboring National Forests. Although evidence of ancient fire (e.g. charcoal, fire scars, and post-fire age groups) has been found in most whitebark pine stands examined, no evidence of fire since the 1930s has been detected. When complete, this research can help direct the process of appropriately re-introducing fire to whitebark pine communities in the Cascades.

During the past several years, mountain pine beetle outbreaks have erupted leading to noticeable loss of whitebark pine in the southern Cascades. Consulting with the Deschutes National Forest, Crater Lake National Park is experimenting with a natural insect pheromone to ward off new attacks of this insect at Rim Village. Small packets infused with the pheromone are stapled to the bark of uninfected trees. The idea is that the pheromone signals to arriving beetles that the tree is already infested, causing them to pass it by. This is a costly and meticulous procedure, and is not practical to apply to hundreds of remaining acres throughout the Park. The Park's staff will continue to observe growth, infection, mortality and other tree dynamics with careful monitoring of permanent measuring plots at places such as Mt. Scott, The Watchman, and Llao Rock.

Resources for Further Information

Whitebark Pine Ecosystem Foundation – www.whitebarkfound.org

"Whitebark Pine Communities: Ecology and Restoration" (book, 2001) – islandpress.com or www.whitebarkfound.org

WBP Email Discussion List – www.srs.fs.usda.gov/list/usdafs.htm

"Crater Lake's Dying Forest" – Oregon Public Broadcasting: Oregon Field Guide episode #1405 (available through most public libraries)

"Made for Each Other: A symbiosis of birds and pines" (book, 1996, by Ronald Lanner) Oxford Univ. Press

Conclusion

The prognosis for Oregon's whitebark pine is bleak. With mortality outpacing the ability of the forests to self-replenish, the loss of these distinctive timberline communities will continue. As the keystone whitebark pine dwindles, we expect the web of dependent living organisms to suffer. Addressing the predicament, ecologists, geneticists, managers, and other concerned professionals are beginning to pool their expertise in a coordinated effort. Long-standing knowledge gained from protecting sugar and western white pines from blister rust is very useful. Identifying naturally occurring resistant trees is critical. Although blister rust appears to be a permanent element of Oregon, tenacious attention can ensure that healthy timberlines will persist.

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Dr. Murray has held several positions as a plant ecologist, including Oregon Natural Heritage Program, Wrangell-St. Elias National Park and Preserve in Alaska, and at the University of Idaho. His interests during the past fifteen years have been related to subalpine ecology. His education includes an MS from Humboldt State University for which he studied meadows in the Marble Mountain Wilderness, California, and a PhD from the University of Idaho, for which he researched whitebark pine fire ecology in the Rocky Mountains. He has served as terrestrial ecologist at Crater Lake National Park for almost four years, where he is responsible for research and management in the areas of wildlife, plants, and fire.