Can the Fire-Dependent Whitebark Pine Be Saved?

Robert E. Keane

High atop the western ranges traversed by some of America's most intrepid explorers, the whitebark pine (*Pinus albicaulis*) is making a last desperate stand. Captains Meriwether Lewis and William Clark, passing through the Bitterroot Mountains in 1805–06 on their historic expedition to the mouth of the Columbia River, saw the whitebark pine in its prime. Gifford Pinchot, who later became the first Chief of the USDA Forest Service, noted the tree while surveying the forest reserves in 1897.

In recent decades, whitebark pine has been declining due to epidemics and fire exclusion (Keane and Arno 1993; Kendall and Arno 1990). In the northern Rocky Mountains, a project is underway to explore the feasibility of using fire and silviculture to restore the tree's high-elevation habitat.

Fire Ecology

Whitebark pine historically comprised about 10 to 15 percent of the forests in the Western United States (Arno and Hoff 1989) (fig. 1). Although long-lived (the oldest identified living individual is more than 1,300 years of age), whitebark pine is eventually replaced, in the absence of fire, by more shade-tolerant species, such as subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), and mountain hemlock (*Tsuga mertensiana*) (Arno and Hoff 1990).

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Three types of fire regimes govern whitebark pine forests (Morgan and others 1994; Arno and Hoff 1990). The most common is the mixed-severity fire regime, where fire intensity and frequency vary widely, creating complex patterns of tree survival and mortality. Most fires in the mixed-severity regime include both nonlethal underburns and stand-replacing blazes (Morgan and others 1994). In sparse surface fuels, fires burn at low severities, killing the smallest trees and the most fire-susceptible overstory species, often subalpine fir; severities increase in areas with high fuel loads or where winds drive the fire into tree crowns. Mixed-severity fires can occur at intervals of 60 to 300 years (Arno and Hoff 1990; Morgan and others 1994). Burned patches are often 2.5 to 120 acres (1–50 ha) in size, depending on topography and fuels (Norment 1991; Tomback and others 1990).

Whitebark Pine: An Invaluable High-Mountain Resource

Whitebark pine (*Pinus albicaulis*) is an important tree in upper subalpine forests of the northern Rocky Mountains, Sierra Nevada, and Cascades (Arno and Hoff 1990). Of limited commercial value, whitebark pine produces large seeds that feed at least 110 different species, including the threatened grizzly bear (*Ursus arctos horribilis*), the red squirrel (*Tamiasciurus hudsonicus*), and the Clark's nutcracker (*Nucifraga columbiana*) (Tomback 1989). Nutcrackers cache the seeds in loose mountain soils, particularly on burn sites, where unclaimed seeds germinate and grow to form the next generation of whitebark pine. Squirrels cache whitebark pine cones in places called middens; in summer, bears travel to the high country in search of the middens. Whitebark pine also protects snowpack in high-elevation watersheds and delays snowmelt, providing high-quality water to valleys below (Arno and Hoff 1990; Hann 1990).

Bob Keane is a research ecologist for the USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT.

Figure 1—*Historical range of the whitebark pine. More than 60 years of fire exclusion have allowed fir and spruce to displace whitebark pine as the dominant species in much of its historical range. Illustration: Arno and Hoff (1990).*

Some whitebark pine stands experience recurrent nonlethal underburns due to sparse fuel loads, mostly in the southern parts of the pine's range in the Rocky Mountains. By contrast, most whitebark pine forests in northwestern Montana, northern Idaho, and the Cascades originated after large, stand-replacing fires that occur at intervals of 250 years or more (Morgan and others 1994). Stand-replacing fires are usually wind driven and often start in lower elevation stands.

Whitebark pine is more capable of surviving low-severity fires than its competitors due to its thicker bark, thinner crowns, and deeper roots (Arno and Hoff 1990). Whitebark pine readily recolonizes large, stand-replacing burns because its seeds are transported from great distances by Clark's nutcracker (*Nucifraga columbiana*)—up to 100 times farther than wind can disperse the seeds of fir and spruce (Tomback and others 1990). Nutcrackers cache whitebark pine seeds on the ground for future consumption when other foodstuffs become rare. Essentially all regeneration comes from unclaimed nutcracker caches, where seeds eventually germinate and grow into seedlings. Nutcrackers prefer open sites with many visual cues for seed caching. Burn sites are ideal.

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Whitebark Pine Decline

More than 60 years of fire exclusion have allowed fir and spruce to replace whitebark pine as the dominant species in many subalpine forests (Arno 1986; Keane and others 1994). The successional process in these slow-growing, high-elevation forests was accelerated by two types of epidemics:

- In the 1930's, white pine blister rust (*Cronartium ribicola*), an exotic disease from Europe, started killing whitebark pines in northwestern Montana, northern and central Idaho, and the Cascades.
- In the 1930's and 1940's, the native mountain pine beetle (*Dendroctonus ponderosae*) killed many whitebark pines in western Montana and central Idaho.

The epidemics had a cumulative impact: The rust weakened many trees, preventing them from defending themselves against beetle attack. Both the rust and the beetle kill mature, cone-bearing trees, thereby accelerating succession to the more shade-tolerant fir and spruce.

Adapted to cyclical beetle epidemics, the whitebark pine ecosystem could easily have recovered if fires had been allowed to burn the beetle-killed forests. But, coupled

Whitebark pine (Pinus albicaulis) *ecosystem. An important upper subalpine forest tree in much of the West, whitebark pine has declined in recent decades due to epidemics and fire exclusion. Photo: Steve Arno, USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT, 1996.*

with the lack of fire as a recycling agent and the introduction of the exotic rust, the epidemics have caused a major shift in landscape composition and structure from early-seral whitebark pine to late-seral fir and spruce. In Montana's Glacier Nat-ional Park, for example, whitebark pine is down to 5 percent of its historical range; in places near Missoula, MT, 60 to 80 percent of the trees have died (Kendall and Arno 1990).

Clark's nutcracker (Nucifraga columbiana). *Nutcrackers cache whitebark pine seeds in loose mountain soils, particularly on burn sites, thereby planting the next generation of whitebark pines. Photo: Steve Arno, USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT, 1996.*

Restoring Whitebark Pine Ecosystems

On five research sites in or near the Bitterroot Mountains of Montana and Idaho, the Forest Service's Fire Sciences Laboratory, Rocky Mountain Research Station, is investigating methods of restoring whitebark pine (Keane and Arno 1996) (fig. 2). Researchers are using prescribed fire and silvicultural harvest to counter the effects of blister rust and advancing succession. The sites represent different biophysical environments, degrees of rust infection, and stand structures.

Prescribed Fire. Four study areas (Smith Creek, Beaver Ridge, Coyote Meadows, and Bear Overlook) are in the mixed-severity fire regime, where fires before 1900 occurred at intervals of 100 to 200 years. Keane and Arno (1996) designed treatments to mimic historical fire effects. A low- to moderate-severity prescribed burn was conducted on a treatment unit in each of the four study areas. The primary objective was to kill all fir and spruce, sparing as many whitebark pines as possible.

Parts of the Musgrove, Beaver Ridge, Coyote Meadows, and Bear Overlook study areas did not have sufficient fuels to carry the fire to all parts of the stand. Therefore, an adjacent treatment unit was created in each area where standing firs were cut and left on the ground to augment fuel beds. Then fire was applied at the intensity appropriate for each site.

Silvicultural Cuttings. In three study areas (Smith Creek, Beaver Ridge, and Bear Overlook), Keane and Arno (1996) designed silvicultural cuttings to mimic patchy mixed-severity burns. On parts of the Smith Creek site, all trees were commercially cut except for healthy, cone-bearing whitebark pine, creating quarter-acre (0.1-ha) circular openings where nutcrackers could cache whitebark pine seeds (Norment 1991; Tomback

Whitebark pine ecosystem in decline. White pine blister rust often weakens individual trees, preventing them from exuding enough sap to defend themselves against attack by the mountain pine beetle. In beetle-killed forests, fire exclusion has eliminated fire as a recycling agent, accelerating the succession from early-seral whitebark pine to late-seral fir and spruce. Photo: Bob Keane, USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT, 1996.

Figure 2—*Sites in Montana and Idaho where Forest Service researchers are investigating methods of using prescribed fire and silvicultural treatments to restore whitebark pine. Illustration: Bob Keane, USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT, 1996.*

1998). In the forested areas between the openings, all fir and spruce were removed, leaving some healthy lodgepole pine and all living whitebark pine. The purpose was to limit wind-dispersed seed from competitor species.

On the Beaver Ridge site, similar "nutcracker openings" were created by cutting all fir, spruce, lodgepole pine, and dying whitebark pine in patches of 2.5 to 5 acres (1–2 ha). The felled trees were left onsite, with their branches piled to clear the ground for nutcracker seed caching. Half of the 75-acre (30-ha) harvest area was then burned, and half of all nutcracker openings (burned and unburned) were planted with rust-resistant whitebark pine seedlings.

On the Bear Overlook site, a treatment unit was thinned to remove all lodgepole pine, fir, and spruce, leaving healthy whitebark pine uncut. The purpose was to enhance whitebark pine cone production.

Natural Fire Needed

Labor-intensive restoration efforts, such as those described here, are possible only in small, easily accessible areas. In most of the whitebark pine's range, inaccessible stands will likely continue to decline unless natural fire is allowed to return. Nutcrackers like to cache white-bark pine seeds in openings, especially those created by wildland fires (Tomback and others 1990). The chances for whitebark pine seedlings are best in large burned areas where competition is minimal (McCaughey and Schmidt 1990).

Fire exclusion prevents large natural openings from forming. Without fire, there are fewer places where seeds from rust-resistant trees (up to 5 percent of the whitebark pine population) can grow into viable, seed-producing, rust-resistant individuals. The most important management action for conserving and maintaining vital whitebark pine forests is to avoid extinguishing all fires in wilderness areas and other remote settings.

For more information on the whitebark pine restoration project, contact Bob Keane, USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, P.O. Box 8089, Missoula, MT 59807, 406-329-4846 (voice), 406-329-4877 (fax), rkeane@fs.fed.us (e-mail).

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