Rapid Decline of Whitebark Pine in Western Montana: Evidence from 20-Year Remeasurements

Robert E. Keane *and* **Stephen F. Arno,** *Intermountain Research Station, USDA Forest Service, Intermountain Fire Sciences Laboratory, P.O. Box 8089, Missoula, MT 59807.*

ABSTRACT. *Whitebark pine* (Pinus albicaulis), *an important producer of food for wildlife, is decreasing in abundance in western Montana due to attacks by the white pine blister rust fungus* (Cronartium ribicola), *epidemics of mountain pine beetle* (Dendroctonus ponderosae) *and successional replacement mainly by subalpine fir* (Abies lasiocarpa). *Plots established in 1971 were remeasured in 1991 and 1992 to determine the rate and causes of whitebark pine mortality. Mortality rates averaged 42% over the last 20 yr, indicating a rapid decline in whitebark pine populations of western Montana. This decline is most pronounced in northwestern Montana with the southward extension of heaviest mortality centered along the continental divide and Bitterroot Mountain range. Management treatments such as prescribed fire can serve to maintain whitebark pine in the landscape. West. J. Appl. For. 8(2):44-47.*

In recent years whitebark pine *(Pinus albicaulis)* has become recognized as an important component of high-elevation ecosystems in western North America. Its periodic crops of large wingless seeds provide a major food source for several species of birds and mammals including the black bear *(Ursus americanus)* and threatened grizzly bear *(U. arctos)* (Schmidt and McDonald 1990). Biologists have noted that for several months after production of a large whitebark pine cone crop, bears concentrate their feeding on cone caches made by squirrels and tend to stay away from humans and their habitations (Kendall 1980). Moreover, use of cone caches for food is extremely important when other fruit crops such as huckleberries are limited. Whitebark pine is also important in protecting watersheds by stabilizing soil and rock on the harshest sites and by catching and retaining snowpack (Arno and Hoff 1989).

Unfortunately, whitebark pine stands have experienced heavy mortality in many areas as a result of both natural and human-induced factors (Figure 1) (Arno 1986). The principal agents in this decline are the introduced disease white pine blister rust (caused by *Cronartium ribicola*), epidemics of mountain pine beetle *(Dendroctonus ponderosae),* and successional replacement by shade-tolerant trees in the absence of fire. No quantitative data have been reported on the rate of this whitebark pine decline. Recently, however, we remeasured 17 inventory plots established in whitebark pine stands in 1971. We present here a summary of our findings so land managers and biologists will have some quantitative information on the rate of whitebark pine's decline, and to show some apparent geographic trends in mortality rates.

Methods

During the summers of 1971 and 1972, the Montana forest habitat type classification study recorded site and vegetation information on 4026 ft^2 (0.09 ac) circular plots established throughout forested parts of Montana (Pfister et al. 1977) Numerous plots were located in whitebark pine forests. The center of each plot was marked with a wooden surveyor's stake for short-term relocation purposes. The information recorded for each plot included an inventory of all trees and snags by

Figure 1. Whitebark pine mortality caused by white pine blister rust and mountain pine beetle attacks on Beaver Ridge, Montana.

species and diameter class as well as observations concerning tree health and stand history. This information provides a means of assessing mortality rates for whitebark pine across a large area.

During the summers of 1991 and 1992, we revisited 17 of these habitat type plots (hereafter referred to as our study plots) in western Montana forests that originally contained significant amounts of whitebark pine (Figure 2). Wooden stakes marking plot centers were located using the written instructions, plot photos, and tree information taken during the 1971 project. New wooden stakes were driven into the ground, and a global positioning system (GPS) was used to determine latitude and longitude of each plot center. Diameters at breast height (dbh), height, and crown characteristics were measured by species for all live and standing dead trees taller than 4.5 ft using ECODATA techniques within original plot boundaries (Keane et al. 1990, Hann et al. 1989).

Blister rust and mountain pine beetle evidence was recorded for each whitebark pine tree inside plot boundaries, and also rated for the stand represented by the plot. Blister rust severity was evaluated for each tree from the number of visible cankers per tree and the amount of tree foliage killed by the rust (Hoff 1992, Keane and Morgan, in press). Causes of mortality were determined whenever there was sufficient evidence.

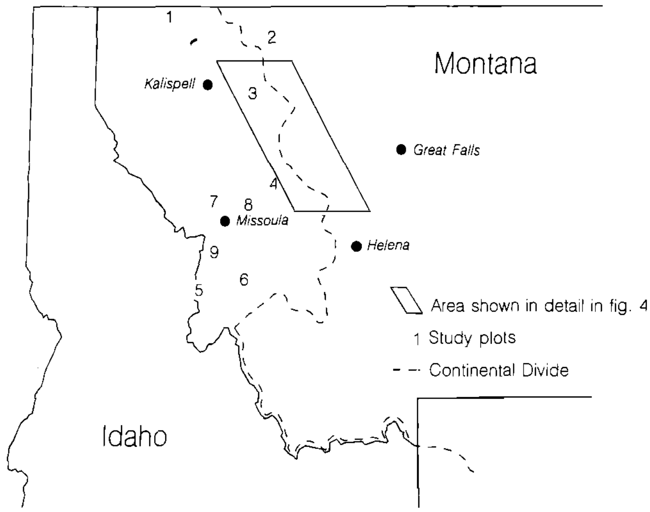

Figure 2. Location of study areas. 1—Mt. Marston, 2—Divide Mt., 3—25 Mile Creek, 4—Morrell Mt., 5—Twin Lake, 6—Skalkaho Pass, 7—Point Six, 8—Mineral Peak, 9—St. Mary's Peak.

Results

Blister rust evidence was recorded as being prominent in only one plot during 1971, but 20 yr later it was prominent in all 17 of the re-examined study plots. Moreover, blister rust had infected all the whitebark pine trees in 60% of the study plots. Whitebark pine basal area decreased an average of 42% between 1971 and 1991, or at a rate of about 2.1% per year (Table 1). When the severely damaged (estimated to die within 5 yr) trees were included with dead trees, the casualty estimate increases to 65% over 20 yr. Blister rust has infected an average of 89% of all remaining live overstory whitebark pine trees measured; and an average of 46% of the uppermost foliage of these living trees is now dead (Table 1). Evidence of mountain pine beetle attack was present only on rust-infected trees in the study plots. It is therefore considered unlikely that any of the study trees were killed solely by the beetle.

Whitebark pine mortality rates are distinctly related to geographical location (Figure 3 and Table 1). Northwest Montana whitebark pine forests have significantly higher mortality rates than those in southwest Montana. When mortality estimates of the study areas are plotted on a map along with other observations made during the last year, we found a southern limit of heavy whitebark pine mortality crossing west-central Montana (Figure 3).

Discussion

Our 20-yr plot remeasurements and additional observations (Figures 3 and 4) indicate a high level of recent crown damage and tree mortality in whitebark pine in western Montana. The most widespread damage was initially associated with blister rust infection, although mountain pine beetles often killed the rust-weakened trees. Our field experience leads us to believe that blister rust will kill nearly all infected trees within 2 or 3 decades. Cone crops are effectively eliminated once a tree becomes significantly infected because blister rust kills the topmost, conebearing branches first (Arno and Hoff 1989).

Whitebark pine's decline is a result of insect, disease, and succession acting in concert. Blister rust caused most damage but mountain pine beetles appear to have played a secondary role by entering and killing already stressed trees. In some subalpine

Table 1. White pine blister rust-caused mortality of whitebark pine between 1971 and 1991 averaged at nine western Montana locations, and extent of crown damage to live trees.

Location	Map designation	Number study plots	Whitebark pine basal area (% change)	1991 live tree crown damage (%)	
				Infection rate	Crown kill
Mt. Marston	1	2	-39	100	68
Divide Mt.	2	2	-73	94	68
25 Mile Creek	3	2	-41	95	57
Morrell Mt.	4	3	-57	96	49
Twin Lake	5	1	-26	33	8
Skalkaho Pass	6	1	+25	75	17
Point Six	7	4	-50	100	46
Mineral Peak	8	1	-32	90	36
St. Mary's Peak	9	1	-21	8	40
Averages			-42	89	46

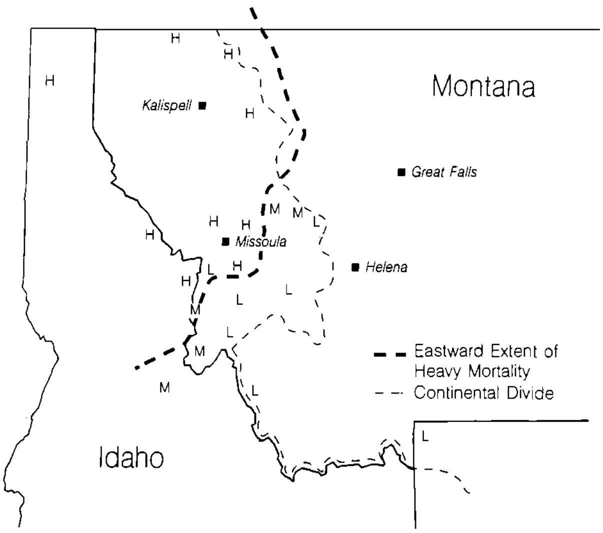

Figure 3. Geographic pattern of whitebark pine rust severity. Severity levels are L—low; 0 to 20% whitebark pine basal area loss over 20 yr, M—Moderate; 20-50% basal area loss, and H—High; greater than 50% basal area loss.

forests west of Glacier National Park, mountain pine beetle caused massive whitebark pine mortality in the 1970s, spreading upslope from lodgepole pine *(Pinus contorta)* forests. Successional replacement of whitebark pine by the shade tolerants subalpine fir *(Abies lasiocarpa)* and Engelmann spruce *(Picea engelmannii)* is an ongoing natural process that is accelerated by the rust and beetle damage, and the general lack of fire or other disturbance that would open new sites suitable for whitebark pine regeneration (Arno 1986). At three sites (Twin Lake, Skalkaho Pass and Saint Mary's Peak, Figure 2) whitebark pine exhibited little blister rust damage, but still experienced an average of 9% decline in basal area over the 20 yr (Table 1). This

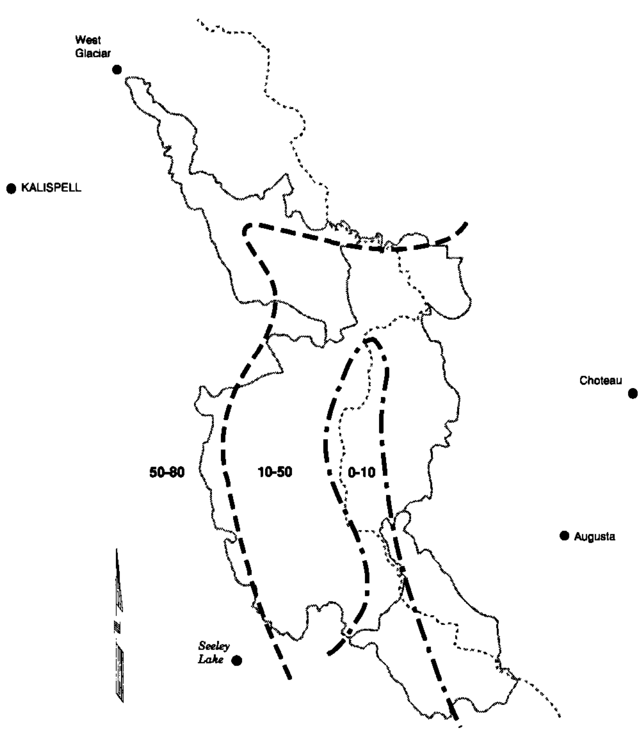

Figure 4. Bob Marshall Wilderness Area showing isolines of percent blister rust-caused mortality on whitebark pine.

decline is probably a result of the inability of whitebark pine to compete with subalpine fir which increased its basal area from +10% to +285% over 20 yr for these three sites. The dramatic whitebark pine decline on the remaining six sites (average of 85% loss of basal area) is mostly attributable to blister rust. Although the Saint Mary's and Twin Lakes plots did not experience heavy rust damage, the surrounding whitebark pine stands, especially those a few kilometers to the west, had a high proportion of rust-killed trees.

Whitebark pine exhibits a low level of natural resistance to the rust (Hoff et al. 1980), but the combination of intensifying rust damage and associated beetle outbreaks can cause a rapid long-term decline in whitebark pine vigor and abundance. Even long-term recovery of whitebark pine is threatened because fire suppression has greatly reduced opportunities for successful regeneration (Arno 1986). Whitebark pine benefits from fire because it is more resistant than associated shade-tolerant conifers. Also, whitebark pine readily recolonizes even large stand-replacement burns because its seeds are brought in from adjacent areas and planted (as seed caches) by Clark's nutcrackers (Tomback 1990).

The geographic trend in whitebark pine mortality agrees with the observations from an intensive study of whitebark pine in the Bob Marshall Wilderness Complex, where blister rust damage is most severe in the northern and western portions of the area (Figure 4) (Keane and Morgan, in press). Kendall and Arno (1990) estimated whitebark pine mortality exceed 90% in Glacier National Park, which is located in northwestern Montana. They also point out that heavy whitebark pine blister rust-caused mortality had already occurred in northern Idaho by the late 1960s. A comparable southward advancement by blister rust has occurred in sugar pine in California (Kinloch and Dulitz 1990). If rust infection continues southeastward into the greater Yellowstone National Park ecosystem, it could have a devastating effect on grizzly bear habitat. The geographical expansion of rust infection apparently depends on occasional episodes of humid weather coinciding with the time of spore dissemination (Arno and Hoff 1989). Based on past history, blister rust biology, and evidence from this study, we feel there is a strong possibility of further southward and eastward advancement of heavy rust mortality in whitebark pine.

Management to restore damaged whitebark pine stands is being attempted in a few areas. For example, in a rust-infected area, management seeks to enhance the pine's natural rust resistance by thinning out competing trees to provide growing room for adjacent whitebark pines that show apparent rust resistance. Providing sites for whitebark pine regeneration can be done through various cutting and burning strategies, and artificial regeneration with an enhanced level of natural rust resistance can be obtained by using seeds from healthy trees in heavily infected stands. We are beginning a demonstration study to test alternative techniques for perpetuating whitebark pine in a blister rust-infected area of the Bitterroot National Forest in Montana. This area will probably experience heavy blister rust-caused mortality within the next few decades. We encourage other similar efforts since results of this study suggest that whitebark pine will have a very bleak future without management intervention.

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Editorial

Is It Doomsday for Whitebark Pine?

The lead article by Keane and Arno in this issue of the *Western Journal* should alarm all foresters, especially those who work with whitebark pine. This high-elevation white pine, they report, is under heavy simultaneous attack by white pine blister rust and mountain pine beetle. To make matters worse, fire control on federal lands is curtailing the species' opportunity to regenerate. The result over a documented 20-year period has been a severe population decline in western Montana. Their study was facilitated by the availability of inventory plots that happened to have whitebark pine growing on them.

This is not the first time this issue has been raised in these pages. Arno (1986) sounded the alarm in our first volume, and it now appears his dire predictions are coming true. Further evidence was recently presented by Kendall and Despain (1992) that in many areas in Glacier National Park, mortality of whitebark pine has exceeded 90%, and large-scale mortality has been observed in Idaho as well. For the third time in a generation, a major American forest tree is in danger of becoming too rare to continue as a functional member of its ecosystem. The others have been American elm and the American chestnut, which were, like whitebark pine, victims of introduced diseases.

Whitebark pine is not well known to many foresters, because it is of little commercial value and grows in high, inaccessible places. But it is a species of major importance to the biological integrity of its ecosystem. The nonopening cones and heavy, wingless seeds of whitebark pine force it to rely on a bird—Clark's nutcracker—for seed dispersal. Because the nutcracker caches them just below the soil surface, the whitebark pine seeds can germinate, and seedlings can become established. Only the nutcracker provides that essential service for whitebark pine. Red squirrels compete with nutcrackers by cutting down great numbers of cones and stockpiling them for later use. Unfortunately for the squirrel, grizzly bears in need of dietary fat prior to hibernation tear into the squirrels' food hoards and eat the lipid-rich seeds of whitebark pine. In whitebark pine areas in the Rockies—including Yellowstone and Glacier National Parks and adjacent national forests—whitebark pine nuts are the critical prehibernation foodstuff for grizzlies. Bears unable to find such nuts are more likely to forage in garbage dumps and campgrounds, increasing the risk of death or injury for both bears and humans.

If whitebark pine is extirpated over a large area, there will be no pine nuts there, therefore no foraging grizzly bears. Once the pine population is reduced to an unknown minimum density, there will be no nutcrackers to disperse seeds and establish seedlings because there will be too few cones to attract them. Isolated surviving trees will be subject to self-pollination, reducing both their seed set and the competitive ability of their seedlings. With fires excluded, there will be fewer cache sites attractive to nutcrackers. Thus the local loss of whitebark pine means lessened biodiversity in the subalpine zone, and it sets in motion a positive feedback loop that makes the pine increasingly unable to become re-established. Even in the Sierra Nevadan range of whitebark pine where the species was earlier considered safe from blister rust, it is now believed to be at risk from new strains of the fungus.

It would be ironic if after having rendered the three premier white pines of North America marginally commercial, *Cronartium ribicola* completes its destructive work by decimating a species whose value lies in the realms of esthetics and biological integrity. This is no idle threat that confronts us—whitebark pine is the most susceptible of five-needle pines to white pine blister rust, and has already been devastated over much of its range (Hoff et al. 1992).

Can anything be done to guarantee whitebark pine's continued survival in the long term? Perhaps. Hoff et al. (1992) have evidence of a low level of rust resistance in whitebark pine, about like that in western white pine. This allows speculation about natural selection of a more resistant pine, or of selective breeding for rust resistance. Other possibilities, by no means certain, are the replacement of dead whitebark by hybrids of whitebark pine

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