WHITEBARK PINE—AN IMPORTANT BUT ENDANGERED WILDLIFE RESOURCE

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ABSTRACT

Whitebark pine (Pinus albicaulis) *is a valuable wildlife resource in the western United States and southwestern Canada. Its large seeds are a preferred food for a variety of birds and mammals, especially Clark's nutcrackers* (Nucifraga columbiana), *red squirrels* (Tamiasciurus hudsonicus), *and bears* (Ursus *spp.*). *Whitebark pine communities provide food and shelter for nongranivorous species as well.*

In many areas, whitebark pine populations are being depleted by advancing forest succession and insect and disease epidemics. Extensive but unknown numbers of whitebark pine were lost to mountain pine beetle (Dendroctonus ponderosae) *in the Intermountain West in the 1970's and early 1980's. Dwarf mistletoe* (Arceuthobium *spp.*) *is a significant source of mortality in some parts of California, Oregon, Nevada, and Wyoming. White pine blister rust* (Cronartium ribicola) *has killed much of the whitebark pine in portions of the Inland Northwest.*

This paper summarizes available information on the status and health of whitebark pine and on its importance to wildlife. Widespread losses of this species have a variety of implications for management issues such as the restoration of grizzly bear (U. arctos horribilis) *populations. The need for better information on the status of whitebark pine is discussed.*

INTRODUCTION

Whitebark pine (*Pinus albicaulis*) is a valuable resource for a variety of birds and mammals in the western United States and southwestern Canada. Its large, wingless seeds are a preferred, high-energy food source, and whitebark communities provide other foods and shelter for several wildlife species inhabiting a harsh environment. The importance of whitebark pine to wildlife, however, has only recently been recognized. While useful research on red squirrels (*Tamiasciurus hudsonicus*), Clark's nutcrackers (*Nucifraga columbiana*), and bears (*Ursus* spp.) in whitebark pine communities has been conducted in the last decade, information is scarce on many aspects of wildlife ecology in these forests.

Recently, Arno (1986) warned that whitebark pine appears to be threatened by the effects of fire suppression and insect and disease epidemics. Because whitebark pine occupies cold, high-elevation sites, it grows and matures very slowly. Most trees are about a century old before they produce significant cone crops. Thus, whitebark pine stands are especially slow to recover from damage and slow to respond to management measures. In this paper, we summarize currently available information on the status and health of whitebark pine (little of which is published) and on the importance of whitebark pine to wildlife.

IMPORTANCE TO WILDLIFE

Whitebark pine forests appear to be significantly more productive, in terms of mass of seed produced per unit area, than most other temperate coniferous forests (Forcella 1977). The importance of whitebark pine as a wildlife food arises from the large size (0.1 to 0.2 g/seed; Krugman and Jenkinson 1974; McCaughey and Schmidt, this proceedings) and high lipid content (78 percent; Mealey 1980) of its seeds. The seeds are a concentrated, high-quality food source that can be stored for 12 months or more in squirrel middens or nutcracker caches; other high-elevation foods are more ephemeral. Typically, birds and mammals harvest almost all the viable seeds produced.

Red squirrels concentrate their foraging activities on whitebark pine seeds when they are available, virtually ignoring other foods. They are the most efficient of all whitebark pine seed predators because they can cut down and cache cones quickly. Squirrels also guard their caches from most other seed harvesters except bears. In a mixed stand of whitebark pine in Squaw Basin, WY, red squirrels accounted for 63 percent of all whitebark pine seeds taken by vertebrates (Hutchins and Lanner 1982). However, in nearly pure stands of whitebark pine, squirrel densities tend to be low (Mattson and Reinhart 1987) and Clark's nutcrackers harvest most of the seeds. Apparently, squirrel populations are highest where mature whitebark pine is mixed with other conifers. In these stands, alternate foods are available during years of low whitebark pine cone production.

Whitebark pine cones do not open and fall from the tree upon ripening in September. Cones are available to bears in some areas on stunted trees. Typically, however, bears obtain seeds from squirrel caches. The whitebark pine stands that are most valuable to bears, then, are those inhabited by large populations of red squirrels.

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Whitebark pine seeds are an important autumn food for grizzly (*U. arctos*) and black (*U. americanus*) bears wherever whitebark pine is common in Montana and Wyoming. This has been confirmed for the Whitefish Range (Tisch 1961), East Front of the Rocky Mountains (Aune and Kasworm in preparation), Scapegoat Wilderness (Craighead and others 1982), and Yellowstone National Park (Knight and others 1988).

Whitebark pine seed consumption by grizzly bears in the Yellowstone area is closely correlated with cone crop size (Knight and others 1988). During good cone crop years, Yellowstone bears feed almost exclusively on pine seeds in autumn (Knight and others 1985). Furthermore, seeds from the exceptionally heavy 1978 cone crop were the dominant bear food consumed in the spring and summer of 1979 (Kendall 1983). Good cone crops appear to be positively correlated with grizzly bear cub production and early weaning of young (Blanchard 1989; Knight 1989); poor whitebark pine cone crops are associated with increased grizzly bear mortalities and conflicts with humans (Knight and others 1988).

In the Soviet Union, brown bears (*U. arctos*) feed on the seeds of the closely related Siberian stone pine (*P. sibirica*). During years of massive cone crop failure, large numbers of emaciated bears make long migrations in search of food, frequently entering villages and killing livestock and occasionally attacking people (Pavlov and Zhdanov 1972; Ustinov 1972).

The Clark's nutcracker has evolved mutualistic relationships with pines that have large, wingless seeds. Whitebark pine is a preferred food for the nutcracker which, in turn, is responsible for most whitebark pine dispersal and regeneration. Nutcrackers cache seeds up to 14 mi away from a seed source (Vander Wall and Balda 1977). They bury more whitebark pine seeds than they require for winter and spring food, and many seed caches are in sites suitable for whitebark pine establishment (Tomback 1982). Nutcrackers are so dependent on whitebark pine and other conifer seeds that years of widespread cone crop failure cause nutcracker irruptions in which the birds may move hundreds of miles from their normal range (Davis and Williams 1964). Use of pine seed caches to feed nestlings and fledglings enables Clark's nutcrackers to nest earlier than other passerines, which must wait until insects are available for feeding. By the next winter, the more mature and experienced nutcracker offspring may be better able to survive (Tomback 1978).

Other birds and mammals are relatively minor consumers of whitebark pine seeds compared to the species discussed above (Hutchins and Lanner 1982; Tomback 1978). Golden-mantled ground squirrels (*Spermophilus lateralis*) and several species of chipmunk (*Eutamias* spp.) harvest seed from cones on the ground. Chipmunks also gather seed from cones in trees. The following birds are reported to feed on whitebark pine seeds: hairy and white-headed woodpeckers (*Picoides villosus* and *P. albolarvatus*), Williamson's sapsucker (*Sphyrapicus thyroideus*), mountain chickadee (*Parus gambeli*), white- and red-breasted nuthatches (*Sitta carolinensis* and *S. canadensis*), Steller's jay (*Cyanocitta stelleri*), raven (*Corvus* spp.), pine grosbeak (*Pinicola enucleator*), red crossbill (*Loxia curvirostra*), and Cassin's finch (*Carpodacus cassinii*).

The significance of whitebark pine to wildlife extends beyond its seeds as food. Its community structure is also valuable to wildlife. The openness and influence of fire in some whitebark pine stands provide conditions for abundant wildlife forage. Whitebark pine will grow in high-elevation, exposed sites where it modifies the microclimate and allows other less hardy vegetation to establish (Habeck 1969; Snethen 1980). In winter, blue grouse (*Dendragapus obscurus*) often roost at timberline in the dense protective crown of whitebark pine, which provides thermal and hiding cover. The grouse also feed on whitebark pine buds and needles (Arno 1970). Cavities in whitebark pine snags provide favored nest sites for mountain bluebirds (*Sialia currucoides*) and northern flickers (*Colaptes auratus*) (McClelland 1989).

Significant reductions in whitebark pine cone production may lower the wildlife carrying capacity of an area. Fewer whitebark pine seeds should result in fewer seed consumers and a decline in the number of their predators. Bears are both primary and secondary consumers in this system; they feed directly on pine nuts and on animals, such as red squirrels, that preferentially feed on pine nuts. In areas where whitebark pine is a major forest component, bears have been implicated as a factor in regulating red squirrel populations (Mattson and Reinhart 1987). Grizzly bears also prey on ungulates, especially elk (*Cervus canadensis*) calves (French and French in press). Because grizzly bear reproductive and mortality rates are correlated with whitebark cone crops in Yellowstone, long-term declines in cone production may lower bear population levels and could result in a decline in ungulate predation.

THREATS TO WHITEBARK PINE

Insect and disease epidemics and successional replacement by other conifers have reduced the numbers of whitebark pine throughout its range in the last 80 years (Arno 1986). In most communities (mixed stands) where whitebark pine provides food for squirrels and bears, it is a seral species perpetuated primarily by fire. Fire suppression has favored shade-tolerant conifers. Prior to the early 1900's, average natural fire intervals for whitebark pine stands were 50 to 350 years (Arno and Weaver, this proceedings; Morgan and Bunting, this proceedings), but under current management policies a seral whitebark pine stand would burn at 3,000-year intervals (Arno 1986).

Fire control has apparently increased the damaging effects of mountain pine beetle (*Dendroctonus ponderosae*) and dwarf mistletoes (*Arceuthobium* spp.), all native species, on whitebark pine. Even without the effects of fire suppression, mountain pine beetle epidemics killed large numbers of whitebark pine between 1909 and 1940 in Idaho and Wyoming (Arno 1970). With fire control, however, more extensive areas of old lodgepole pine (*P. contorta*) have developed. These support severe mountain pine beetle epidemics that spread to higher elevations and result in greater whitebark pine mortality than under natural fire regimes. Mountain pine beetles can also cause more mortality in the older whitebark pine stands that result from fire suppression.

Because dwarf mistletoe is controlled by stand-replacing fire, it is now more prevalent in undisturbed stands than in the past (Alexander and Hawksworth 1976). Whitebark pine is a principal host of limber pine dwarf mistletoe (*A. cyanocarpum*) and is heavily parasitized by leafless mistletoe (*A. americanum*) (Jackson and Faller 1973; Mathiasen and Hawksworth 1988). Both can reduce growth rates of heavily infected hosts, increase mortality rates, reduce seed and cone production, and increase vulnerability to other diseases and insects (Hawksworth and Wiens 1972).

White pine blister rust (*Cronartium ribicola* Fisch.), native to Europe, was accidentally introduced to western North America in 1910 and has since infected whitebark pine throughout its range (Hoff and Hagle, this proceedings). It attacks all North American five-needled pines, but whitebark pine is the most susceptible (Hoff and others 1980). The disease often first kills the upper, cone-bearing branches, and can eventually kill the entire tree. Seedlings and saplings are readily infected. Thus, white pine blister rust can significantly decrease whitebark pine seed production and regeneration (Arno and Hoff 1989). Blister rust infection also makes trees more susceptible and attractive to other diseases and insects, including mountain pine beetle. Blister rust control efforts, begun in the late 1930's, were largely unsuccessful and were abandoned in the 1970's.

Fires in whitebark pine stands normally are beneficial to regeneration of the species. Some large, severely burned areas, however, have failed to regenerate whitebark pine (fig. 1). The proposed Great Burn Wilderness in the Clearwater National Forest in northern Idaho, and the Lolo National Forest in western Montana supported extensive ridgetop stands of whitebark pine that were burned by the severe Great Idaho Fire in 1910 (Cohen and Miller 1978). Recent reconnaissance (by Arno) in different parts of this old burn revealed little or no regeneration of whitebark pine on sites (above 6,500 ft; 1,980 m) where snags confirm that it was once a dominant species. Other subalpine conifers have become reestablished (fig. 2). Two plausible explanations for the negligible reestablishment of whitebark pine are: (1) inadequate whitebark pine seed source survived the 1910 fire and (2) white pine blister rust has killed most of the seedlings and much of the seed source.

Moderate levels of whitebark pine mortality may benefit some species of wildlife. Mortality from mountain pine beetle, mistletoe, and blister rust opens the forest canopy. This may result in increased undergrowth vigor and forage production. For instance, berry production is often negatively correlated with canopy closure. Forcella (1977) studied the productivity of 28 stands in the *P. albicaulis-Vaccinium scoparium* association with varying amounts

Figure 1—Remains of a nearly pure whitebark pine stand killed in the Great Idaho Fire of 1910. Site is in the upper subalpine zone (Pfister and others 1977); the poorly developed postfire regeneration is composed of lodgepole pine and subalpine fir. Scene is at about 7,300 ft (2,225 m) elevation on Granite Peak, on the Idaho-Montana divide 8 air miles northwest of Lolo Pass. (Photo by S. Arno.)

Figure 2—Along the Idaho-Montana divide 7 miles northwest of figure 1 (west of Kid Lake). Large snags are mostly whitebark pine that survived a low-intensity fire in the mid-1800's but were killed in the severe 1910 fire. Regeneration of subalpine fir and lodgepole pine has been successful at the more moderate elevations in the foreground (about 6,500 ft; 1,980 m); but very little regeneration has taken place above 7,000 ft (2,130 m) (background) where nearly pure whitebark pine groves formerly existed. (Photo by S. Arno.)

of tree canopy cover. He identified three significant wildlife foods other than pine nuts: *V. scoparium* berries, *Carex geyeri*, and *Arnica* spp. He found, however, that whitebark pine produced 2 to 35 times as many kcal/m^2/yr of wildlife forage as these other species and was by far the most important wildlife food source in all stands studied.

EXTENT OF DECLINE

Because whitebark pine has limited value in timber production, data on its status are sparse. Foresters may have difficulty distinguishing between whitebark and limber pine, and many are unfamiliar with the remote high-mountain country where whitebark pine is found. Insect and disease surveys often fail to cover the whitebark pine zone or lump information on whitebark pine with other species. Therefore, available information is sketchy and relies on personal observation. Nevertheless, we believe there is enough evidence to justify concern for the perpetuation of whitebark pine as an important wildlife resource.

Some indirect evidence for a decline in whitebark pine comes from a comparison of past and recent bear studies and observations. R. Daubenmire (1989) encountered squirrel caches of whitebark pine cones that had been excavated by bears in the Selkirk Range of northern Idaho in the 1940's. A 1984 bear study in the Selkirks found no squirrel caches of whitebark pine cones and no whitebark pine seeds in bear scats, although three scats contained a small number of western white pine (*P. monticola*) seeds (Almack 1989). During a black bear study in the southern Whitefish Range of northwestern Montana in the early 1960's, all bears handled in the autumn showed signs of feeding on whitebark pine seeds (Jonkel 1989) (fig. 3). Whitebark pine seeds occurred in 30 percent of fall bear scats collected during that study (Tisch 1961) but in no bear scats observed in this area in the 1980's (Hadden 1989; Jonkel 1989; Kendall, personal observation). In the Mission Range, south of Flathead Lake, MT, most bear droppings observed during fall between 1925 and the late 1930's were entirely composed of whitebark pine seeds (Cheff 1984). Observations of

Figure 3—Black bear captured during a bear ecology study in the southern Whitefish Range, MT, in the early 1960's. The hair on its paws and stomach is matted with pitch from handling whitebark pine branches and cones. All bears trapped in autumn showed similar signs of feeding on whitebark pine seeds, but this has not been seen in the 1980's. (Photo by Charles Jonkel.)

grizzly bears and excavated squirrel middens were common in the whitebark pine zone during this time. No bear feeding activity on whitebark pine has been reported in this area in recent years. More of this sort of comparative information would be helpful.

Mountain Pine Beetle

Some of the only quantitative information on mountain pine beetle mortality in whitebark pine comes from the Northern Region, Forest Service, U.S. Department of Agriculture (headquarters at Missoula, MT). In the Flathead National Forest in this Region, 225,000 acres of whitebark pine suffered some mortality from mountain pine beetle 1975-1988 (Gibson 1988). Most of this occurred in the Whitefish Range, which lost one-half to two-thirds of its whitebark pine in the last 10 years to the combined effects of mountain pine beetles and white pine blister rust (Wilson 1988). Damage to whitebark pine stands ranged from very little mortality to almost 100 percent loss. The mountain pine beetle epidemic in the Whitefish Range originated from a severe infestation in lodgepole pine in adjoining Glacier National Park. Between 1979 and 1985, over 25,000 acres of whitebark pine, primarily in the North Fork of the Flathead River drainage, were infested with mountain pine beetle (Gibson 1988). Much of the whitebark pine in this area was killed, including the oldest whitebark pine trees known in the Park (DeSanto 1989).

Aerial surveys of mountain pine beetle infestations in the Forest Service Intermountain Region (headquarters at Ogden, UT) are for commercial timber only. Thus, substantially more whitebark pine mortality occurs than is indicated in insect damage figures (Knapp 1989). Heavy infestations in the Bridger-Teton and Targhee National Forests are killing large but unknown numbers of whitebark pine. For example, Knapp (1989) estimated that 50 to 75 percent of the whitebark pine on Signal Mountain was killed in recent years. Mountain pine beetle infestations are implicated in whitebark pine cone production decline in the Yellowstone ecosystem between 1980 and 1987 (Knight and others 1988).

The Forest Service Rocky Mountain Region (headquarters at Denver, CO) includes expanses of whitebark pine in the Absaroka and Wind River Ranges of western Wyoming (Steele and others 1983). Little is known about mountain pine beetle damage in those stands except that mortality has been high along the Continental Divide in the Wind River Range (Lister 1989).

In the Forest Service Pacific Northwest Region (headquarters at Portland, OR) whitebark pine is abundant at high elevations along and east of the Cascade Crest in Washington and in the highest mountains of central and eastern Oregon (Arno and Hammerly 1984). It is identified on mountain pine beetle survey maps but is not distinguished from western white pine when damage figures are tallied. It is known that a mountain pine beetle outbreak in northeastern Oregon killed substantial amounts of whitebark pine in the 1970's (Bridgewater 1989).

Dwarf Mistletoe

The few references available on whitebark pine infection by dwarf mistletoe indicate it causes significant mortality in some areas. Cooke (1955) reported "ghost forests" of whitebark pine resulting from dwarf mistletoe on the northwest slopes of Mount Shasta, CA. In the same area, Mathiasen and Hawksworth (1988) found that 96 to 98 percent of the whitebark pine was infected and half had been killed by limber pine dwarf mistletoe. Heavy infections of whitebark pine were also reported in the Copper Mountains, Elko, NV, and near South Pass, Fremont County, WY (Mathiasen and Hawksworth 1988). Whitebark pine has dominated the crater rim community of Wizard Island, Crater Lake National Park, OR, for several centuries. However, recent mortality (45 percent of standing whitebark pine stems less than 4 inches d.b.h. were dead) and little regeneration have diminished the population (Jackson and Faller 1973). Because many living whitebark pine are heavily parasitized by leafless mistletoe, this was suggested as the primary cause of mortality.

White Pine Blister Rust

White pine blister rust is a major source of whitebark pine mortality in areas humid enough to support the spread of spores from one host (*Ribes* spp.) to the other (whitebark pine). Whitebark pine is afflicted by blister rust wherever it is found with infected western white pine. Blister rust has caused heavy losses of whitebark pine from the crest of the northern Cascade Range in Washington to Glacier National Park, MT, and south to Lewiston, ID (Arno, personal observation; Layser 1989). In drier climates, such as the Yellowstone area, whitebark pine is experiencing only minor mortality from blister rust.

Some of the most severe blister rust damage to whitebark pine has occurred in the Forest Service Northern Region, especially in the Cabinet Mountains in northwestern Montana and the Selkirk Range and Bitterroot Mountains (Selway and North Fork of the Clearwater drainages) in northern Idaho (fig. 4) (Arno, personal observation; Hagle 1988). For example, observations and photographs by Arno (1984) indicate that more than 90 percent of the whitebark pine along the Selkirk Crest east of Priest River Experimental Forest was killed by blister rust by the early 1980's. This, no doubt, explains the absence of seeds in bear scats in the Selkirks discussed earlier. A substantial amount of whitebark pine was killed by blister rust in the Whitefish Range, MT, including an area south of Werner Peak in which virtually all the whitebark pine is now dead (Wilson 1988). In the past, this area produced large cone crops that attracted bears. Whitebark pine was a major component of high-elevation forests in portions of Glacier National Park, but blister rust has killed significant numbers, especially on the east side of the park where more than 90 percent has been lost (Buchholtz 1989). Extensive whitebark pine mortality has occurred since the 1930's in the Mission Mountains due to blister rust and mountain pine beetle. Since 1960 there has been continual blister rust mortality of whitebark pine on Desert Mountain south of West Glacier, MT (Schmidt 1989), whereas southward near Observation Peak in the Bob Marshall Wilderness, whitebark pines are just beginning to die from this disease (Keane 1988).

In Washington and Oregon, whitebark pine is damaged by white pine blister rust, but there is no measure of the extent of the problem (Russell 1989). Blister rust has caused significant whitebark pine mortality in the Crater Lake area of Oregon (Harvey 1989). In the Olympic Range, whitebark pine inhabits only the northeastern portion, but some stands, for example, at Constance Pass, have been killed by white pine blister rust (Arno and Hammerly 1984). Whitebark pine is common in northeastern Washington and has died or is dying in many places from blister rust (Layser 1980).

In California, whitebark pine occurs primarily in designated Wildernesses, and there are no quantitative data on distribution or mortality. White pine blister rust had infected whitebark pine in northern California by the 1950's. Increasing amounts of blister rust have been found in the Sierra Nevada in central California in the last 10 years. The rust is beginning to attack sugar pine (*P. lambertiana*) and western white pine at midelevations, so whitebark pine will probably be next (DeNitto 1989). A similar pattern is developing in the Lake Tahoe Basin and on the Lassen National Forest. Western white pine is beginning to contract blister rust, and whitebark pine is expected to follow suit (Kinloch 1989).

IMPLICATIONS FOR MANAGEMENT AND RESEARCH

Widespread loss of whitebark pine has a variety of implications for wildlife management. For example, it may limit efforts to restore grizzly bear populations in areas where, in the past, whitebark pine seeds were an important food. In the Selway-Bitterroot Wilderness, northern Cascade Range, and the Cabinet, Selkirk, and Mission Mountains, grizzly bear and whitebark pine numbers are greatly reduced. With other historically important food sources for bears gone or diminished—for example, depletion of salmon (*Oncorhyncus* spp.) and forage lost to agriculture—whitebark pine cone crops may be a factor in the continued survival or restoration of grizzly bear populations. Yet, this food source (and its decline) is often overlooked in bear habitat evaluations.

Current trends suggest continuing losses of whitebark pine in many areas. Lodgepole pine established after the 1910 fires will be vulnerable to mountain pine beetle attack 10 to 15 years from now (Gibson 1988). Intense infestations are likely to result in high mortality of whitebark pine. Extensive fires and drought create conditions favorable for bark beetle infestations. Mountain pine beetle populations increase in fire-scorched and drought-weakened trees and then spread to adjacent trees.

National Park managers are charged with conserving natural ecosystems including pristine genetic pools. Because white pine blister rust is not native to North America and is causing significant ecological changes, blister rust is of special concern to National Park management. The possibility of an experimental program in

Figure 4—Typical whitebark pine mortality caused by blister rust and possibly mountain pine beetle in the northern portion of the Selway-Bitterroot Wilderness, ID. Scene is on Beaver Ridge, 9 air miles southeast of Lolo Pass. (Photo by S. Arno.)

National Parks to enhance whitebark pine's natural resistance by selecting for resistant genotypes has not yet been considered, but should be.

Our extensive contacts with scientists familiar with whitebark pine communities and the effects of insects and diseases have left little doubt that there is cause for concern about the continuing productivity of this tree. Although a downward trend in whitebark pine abundance is apparent, it is also clear that better information is needed. The first step should be to conduct comprehensive surveys to assess the extent of damage to whitebark pine throughout its range and in various habitat types. Whitebark pine stands should be included in insect and disease surveys.

Additional information on wildlife ecology in whitebark pine communities is also needed. Because of whitebark pine's reliance on Clark's nutcrackers for seed dispersal, it would be useful to know if nutcrackers are no longer attracted to whitebark pine stands with little cone production or at what level of cone production there is not enough seed to cache or virtually all pine nuts are recovered by seed predators.

We must develop management techniques to counteract the problems besetting whitebark pine. We need to find ways to reintroduce fire or mimic its effects in allowing establishment of seral whitebark pine. Techniques for widespread propagation of whitebark pine are needed for a variety of site conditions.

Simulation modeling confirms the observational evidence of decline in whitebark pine in the inland Northwest (Keane and others, this proceedings). Whitebark pine's status as an important mast producer is precarious or already lost in many areas. Wildlife concerns alone make massive cone reductions unacceptable.

Whitebark pine was dominant over a much larger area in the early 1900's than today. A continuation of current successional patterns and mortality trends bodes poorly for whitebark pine. Unless resistant strains can be developed and introduced in large quantities, white pine blister rust will further reduce whitebark pine cone production in moist regions. Whitebark pine often occurs in small geographically isolated populations, which can be destroyed by blister rust or endangered by successional replacement. This, coupled with longer fire intervals, could result in local extinctions and loss of genetic variation. As we seek to mitigate the effects of human activities on wildlife populations, we should make rejuvenation of whitebark pine stands an urgent priority.

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Speakers answered questions from the audience following their presentations. Following are the questions and answers on this topic:

Q. (from Penny Morgan)—Is a major effort to regenerate whitebark pine justified given the loss of whitebark pine as a resource, especially where we can document loss due to white pine blister rust?

A.—Given the importance of whitebark pine to wildlife, regeneration efforts definitely warrant consideration. Other values include whitebark pine's role in the hydrologic cycle and as a structural component of timberline communities, as well as its esthetic qualities. There is not currently enough information on many aspects of whitebark pine and white pine blister rust to decide if a major effort is justified. The first step toward answering this question should be to get better information on the status of whitebark pine throughout its range and in a variety of habitat types.

Q. (from Anonymous)—What is the cone crop frequency of whitebark pine? Is it different throughout its range?

A.—Little information is available on annual variation in whitebark pine cone production. According to Bailey (1975), whitebark pine stands tend to cone profusely and simultaneously over large areas at infrequent intervals with very little cone production in the intervening years. However, good cone crops may be produced more frequently in the southern parts of its range. In a Sierra Nevada study area, moderate to heavy whitebark pine cone crops were produced in each of 4 years cone production was rated (Tomback 1978). Data from the greater Yellowstone area suggest that while excellent cone crops are infrequent, moderate as well as poor cone crops are common (Knight and others 1987). Annual cone production was estimated for 29 whitebark pine stands in the northern Rockies (Weaver and Forcella 1986). Excellent cone years were preceded in 20 of 29 cases by average or poorer cone years. Poor cone years were not significantly correlated with yields in any previous year. There is no information on cone crop periodicity in the northwest range of whitebark pine where it is more immediately threatened by disease and successional replacement.