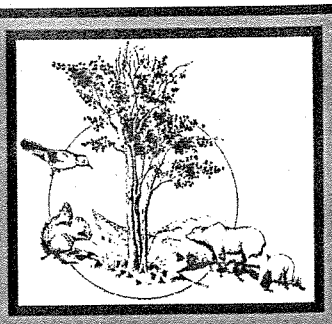


Issue 3

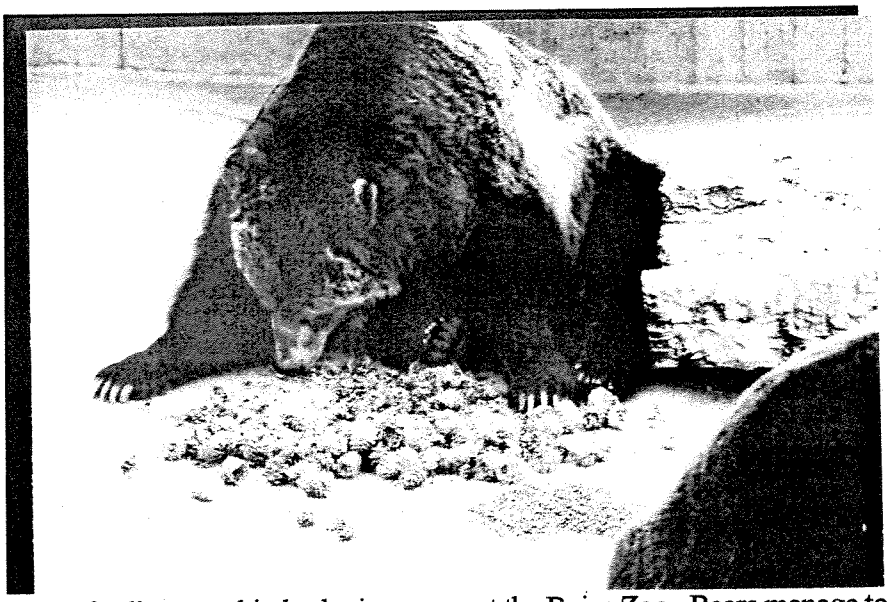
Topics

WPEF
P.O. Box 16775
Missoula, MT
59808

Fall | Winter 2002

Nutcracker Notes

Whitebark Pine Ecosystem Foundation



Grizzly bears feeding on whitebark pine cones at the Boise Zoo. Bears manage to eat the seeds and not the cone scales. (photo by Kate Kendall)

Bears & Whitebark Pine Photo Essay . . .

Paws and bellies of black bears studied in the Whitefish Range near Glacier National Park in ca. 1960 were coated with resin from feeding on whitebark pine cones. (photo by Charles Jonkel)

In spring, bears dig through deep snow to feed on whitebark pine cones remaining in middens from the previous autumn. (photo by Kate Kendall)

An overflowing squirrel midden resulting from the 1978 cone crop. (photo by Kate Kendall)

WPEF's Mission:

Counteract the decline of whitebark pine, a keystone species of high-mountain ecosystems in western North America.

Beetles Attack Whitebark Pine in Yellowstone National Park

Roy Renkin, Management Biologist,
Yellowstone National Park
Roy_Renkin@nps.gov

In 1999, small scattered pockets of orange-needled whitebark pine were observed throughout Yellowstone National Park. Over the next two years tree mortality caused by mountain pine beetles increased dramatically. In early September, 2002, a forest insect and disease aerial survey was conducted over the park. The data are still being compiled, but some general observations of beetle activity are worth mentioning.

Except for the Pitchstone Plateau, all of the high mountains and plateaus supporting whitebark pine had recent mortality resulting from mountain pine beetles. Mortality is greatest in the southeastern part of the park, where large continuous tracts of orange-needled whitebark pine were seen on the Two Ocean Plateau and in the Absaroka Range along the park boundary.

Les Koch of the Wyoming State Division of Forestry confirmed the situation is similar to the south and east of the park boundary as well. Many smaller pockets of mountain pine beetle caused mortality were observed in the southcentral portion of the park including Mt. Sheridan, the centrally-located Washburn Range, the Gallatin Range in the northwest, and the Absaroka-Beartooth Range along the park's northcentral boundary. Mortality in the Washburn Range is visible along the road over Dunraven Pass. With continued beetle attacks over the next few years, many of the small, scattered pockets of beetle-killed whitebark pine probably will coalesce into large contiguous patches especially in the northern portions of the park. The aerial survey found considerably less beetle-caused mortality in lodgepole pine. A few small patches were observed in the Hayden Valley and Arrow Creek Canyon areas.

Continued on Page 7 . . . .

State of the WPEF

Diana Tomback
Director of the Whitebark Pine Ecosystem Foundation

As of February 2003, the Whitebark Pine Ecosystem Foundation will be two years old. Although we are yet a fledgling (seedling?) organization, the enthusiasm and support from our members were vividly apparent at our annual meeting and field trip that visited Snow Bowl Ski Area on September 20th, 2002. Our thanks to Melissa Jenkins and members of the Whitebark Pine Committee of the Greater Yellowstone Coordinating Committee for joining us that day. Also, attending were two Canadian WPEF members: Andy Bower who is studying whitebark pine at the University of British Columbia, and Rob Walker who is with Parks Canada based at Radium Hot Springs in southeastern B.C. Concern for the deteriorating status and future of whitebark pine is clearly shared by our northern neighbors, and the WPEF should be acting internationally whenever possible. In fact, we have been asked to think about Canada for a future annual meeting. Our activities and accomplishments for the past year and future plans are outlined below.

This past year WPEF expanded its partnerships with northwestern ski areas, building on the initiative first begun at Missoula Snow Bowl. We are beginning partnerships with Big Mountain Ski and Summer Resort, Mt. Hood Meadows, Mt. Hood Ski Bowl, and Discovery Ski Area. In these partnerships, the WPEF provides educational displays about the decline of whitebark pine for their winter and summer visitors, and in some cases working with local national forests, we will design and help implement whitebark pine restoration projects. In all cases, we make our technical expertise available.

The WPEF and the Rocky Mountain Chapter of the Ecological Society of America jointly sponsored the symposium, "The Rapid Decline of White Pine Ecosystems of the West: Causes, Consequences, and Restoration Strategies," organized by myself and two colleagues affiliated with USFS Rocky Mountain Research Station, Anna W. Schoettle (Fort Collins, CO), and Geral I. McDonald (Moscow, ID). The symposium earned us some advance publicity, and subsequently the decline of whitebark pine was highlighted in a two-page feature article by Jessica Ruvinsky in *U.S. News and World Report* (Sept. 9, 2002).

The lack of a rangewide assessment of blister rust damage presents a huge obstacle to obtaining funding for research and restoration related to whitebark and other white pines. To provide an on-going rangewide assessment based on uniform data collection, WPEF is organizing a blister rust monitoring workshop, Sept. 9-11, 2003, at the Holiday Inn at West Yellowstone. The workshop will consist of an evening reception (September 8th), an overview of blister rust's interactions with white pines, one day of indoor instruction on field methodology, and one day of hands-on application in the field where participants will actually gather data in blister rust-impacted whitebark pine stands. The invitation to participate will be extended to forest and park managers and workers throughout the range of whitebark pine, but the number of participants that we can accommodate may be limited. We are currently working with several agencies for joint sponsorship such as the National Park Service, the Greater Yellowstone Coordinating Committee, and the U.S. Forest Service. We are planning to hold both the fall, 2003, GYCC Whitebark Pine Committee meeting and the Annual Meeting of the WPEF in West Yellowstone the day after the workshop (Friday, Sept. 12th).

Thanks to a donation from Big Mountain Ski and Summer Resort, we have kicked off our Monte Dolack Poster Fund. However, we still have a ways to go to meet our financial goal. Recall that our plan is to commission Monte Dolack to paint an image of whitebark pine and its dependent species to be produced as a poster for fund-raising and educational purposes. Last March, Kate Kendall spearheaded a proposal to the joint National Endowment for the Arts/Forest Service Arts and Rural Community Assistance Initiative to fund the Monte Dolack painting. The WPEF proposal earned high praise, but the competition was stiff and funding available for these grants had been cut, thus we were not successful. We are currently exploring other funding possibilities, and encourage suggestions and volunteers from the membership to help with this cause.

More proposal writing is on the agenda for this fall. The WPEF would like to begin supporting restoration projects in the northern Rocky Mountains and the northwest. Again, we welcome help and ideas about good funding sources from our members.

The WPEF Board of Directors welcomes our newest member, Lars Halstrom of the Gallatin National Forest. Lars has considerable experience in reforestation including propagation of whitebark pine. He reestablishes our connection to whitebark east of the Continental Divide, after Ward McCaughey's relocation to Missoula this past summer.

Whitebark Pine Conservation in the Canadian Rocky Mountain National Parks

Robert C. Walker, Parks Canada, Box 220, Radium Hot Springs, BC, Canada, V0A 1M0, rob.walker@pc.gc.ca;

Brendan C. Wilson, Selkirk College, Castlegar, BC, Canada, V1N 3J1; and

G. Jon Stuart-Smith, Parks Canada, Radium Hot Springs, BC, Canada

In 1998, Parks Canada initiated a prescribed burning and monitoring program to aid in the restoration of whitebark ecosystems. This responded to a report (Stuart-Smith 1998) documenting up to 76 percent blister rust infection in the southern Canadian Rockies. Levels of rust infection decrease northward along the Great Divide towards Jasper National Park.

The primary aim of the prescribed burn program is to increase the area suitable for seed caching by Clarks nutcracker, and to create favorable sites for regeneration of new whitebark pine trees. Increased regeneration should allow for the naturally occurring rust resistant genetic traits to become more abundant and result in increasing populations of resistant trees.

So far one 12-hectare (30-acre) prescribed burn has been implemented at Helen Lake in 1998. The planning for 2 other prescribed burns is complete and they are ready to implement pending appropriate weather. Permanent monitoring transects have been established in four national parks at six locations covering most of the observed gradient of blister rust infection. Four of the transects are associated with planned burns.

A Conservation Strategy

A newly prepared conservation strategy for whitebark pine in the Canadian Rocky Mountain National Parks (Wilson & Stuart-Smith 2002) has the following key elements: 1) developing a detailed inventory of the species; 2) continuing prescribed burn restoration efforts and associated monitoring; 3) seed collection for gene conservation and future selective breeding; 4) analysing the geographic distribution of adaptive traits; 5) forming partnerships with other interested agencies and organisations; 6) additional research to generate hypotheses about relationships between the pine, its environment, and factors causing stress, and; 7) pursuing federal "Species at Risk" designation.

Stand inventory

Knowledge of where whitebark pine occurs within the Canadian Rocky Mountain National Parks is limited to local knowledge and the Ecological Land Classification (ELC) database and associated maps (e.g., Holland and Coen 1982). A survey of identified stands will be carried out to determine the extent of blister rust infection as well as stand structural characteristics.

Prescribed Burns

The prescribed burn program and associated monitoring are integral to Parks Canada's whitebark pine ecosystem conservation strategy. It is through the quantitative monitoring of fire effects that the goals and objectives of the program can be assessed.

Seed Collection

Seed collection for gene conservation will be included as part of the inventory. Programs to locate genetically resistant individuals have already commenced in British Columbia (Zeglen 1999, 2000) and outplanting programs of resistant progeny have started in the most heavily impacted areas of Montana and Idaho (Kendall and Keane 2001, McDonald and Hoff 2001). This element would build on existing programs.

Distribution of Adaptive Traits

Little information is available on how the patterns of genetic variation relate to phenotypic variation in whitebark pine. Some preliminary studies have been carried out in the United States (Howard 1999), but none have been conducted in Canada. Adaptive variation may suffer if genetic stock is moved across this range, or possibly further distances into the United States (Krakowski 2001). In order to determine how important these movements are, common garden type experiments need to be carried out.

Partnerships

There are a number of different government agencies, non-government organisations, and private individuals who are interested in the restoration of whitebark pine ecosystems. Cooperation with these groups will facilitate needed research, opportunities for funding, and development of solutions to the conservation problems facing whitebark pine ecosystems.

Additional Research

Inventory data and modelling of adaptive traits will likely generate a number of important questions about the relationships between stand conditions (age, structure, species composition), blister rust infection, and environmental factors. The database developed through the prescribed burn monitoring program will eventually provide the necessary confirmatory data with which to test many of these predictions, and through this process, provide new direction for the program.

Species at Risk Status

The Canadian Government is about to pass Federal Species at Risk legislation. The legislation will provide opportunities to pursue listing whitebark pine as endangered or threatened. Federal listing would enhance public awareness of the need for whitebark pine conservation and provide additional funding opportunities. An important unknown is whether Federal listing would also impose constraints on our ability to manipulate whitebark pine ecosystems.

Continued Page 7 . . . .

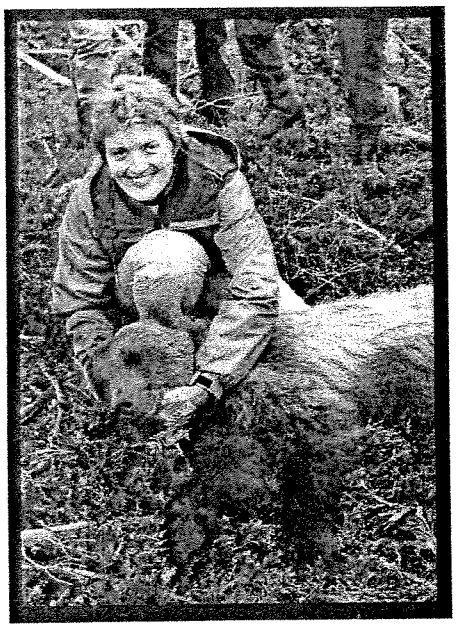
An Interview with Kate Kendall

Assistant Director of the
Whitebark Pine Ecosystem Foundation

Editor: When you began studying whitebark pine was it recognized as an important food for bears?
K. Kendall: I was assigned to the Interagency Grizzly Bear Study Team in 1977 specifically to study the relationship between bears, squirrels, and whitebark pine. It was known that pine "nuts" were an important autumn food for bears in the greater Yellowstone National Park ecosystem (GYE). Nearly 20 years earlier, Chuck Jonkel had found that whitebark pine seeds were a common food of bears in the Whitefish Range. However, little was known about how bears accessed the seeds and no one had studied squirrel behavior in whitebark pine stands. For instance, when bears feed on whitebark pine seeds, their droppings are filled with seed shells but typically do not contain cone scales. This prompted speculation that red squirrels or other mammals or birds make caches of seeds that bears feed on. Because the cones do not fall from the tree when they ripen, some people thought that seeds were consumed by black bears that obtained them by climbing trees. Grizzlies generally do not climb trees.

Editor: How did you come to recognize that whitebark pine provides a critical food source for bears?
K. Kendall: Luckily, during the first year of my field study, in 1978, whitebark pines produced a bumper cone crop throughout the GYE. Once cones began ripening in August, I had abundant opportunities to observe animals caching and feeding on the cones and seeds. Squirrels harvested huge quantities of cones before nutcrackers could get them. Squirrels felled the cones in the tree tops and then gathered and buried them in middens—heaps of cone debris that accumulate where squirrels feed over many years. Eventually they ran out of room in their middens and piled cones around logs, stumps and at the base of trees.

I found that whitebark pine seeds were a favored food of both grizzlies and black bears and that both species obtained most of this food from squirrel middens. Squirrels would sometimes extract seeds from a cone and make small caches near their midden; but this could account for only a tiny fraction of the seeds bears consumed. In the spring of 1979 I fed whitebark pine cones to two grizzly bears in the zoo at Boise, where the bears had resided since they were yearlings, eight years earlier. Evidently the bears had experienced whitebark pine cones with their mother because they dove right in and fed on them as if they had been doing it for years. They bit the cones to break them open, then spread out the contents and carefully licked up the seeds, adroitly spitting any cone scales out the side of their mouth.



One of the most interesting aspects of the bear, squirrel, pine seed relationship that I was able to document was the repercussions of very large whitebark pine cone crops. After bears gorged on whitebark pine seeds throughout the fall of 1978 and squirrels fed on them all winter, cones were still so abundant in middens the next spring that they formed the bulk of bear diets from den emergence until denning in the fall of 1979.

Editor: You have reported a drastic decline in cone-bearing whitebark pine in Glacier National Park during the past 40 years; nevertheless Glacier retains a large population of grizzly bears. If whitebark pine in the GYE becomes similarly devastated by blister rust and beetle epidemics would you expect this to have much effect on grizzly bear populations there?
K. Kendall: Due to large differences in habitat and resulting bear diets between the two ecosystems I think the impact would be much greater in the GYE. Glacier's moist climate and rugged topography result in productive habitat with abundant high-quality foods such as cow parsnip, huckleberries, serviceberries, hawthorn fruits. Thus when whitebark pine seeds were lost, bears had alternative foods. With a drier climate, the GYE produces few alternative high-caloric foods. I suspect that if whitebark pine were drastically diminished, the GYE would not be able to support as many bears as it currently does.

Editor: Studies of subalpine forests in the Northern Rockies and inland Northwest show that whitebark pine is being replaced in a large part of its former habitat by shade-tolerant fir and spruce. What implications of this trend do you see for wildlife habitat?

Continued on Page 12 . . . .

Membership News

As of October, 2002, WPEF has a total of 80 members, up from 54 in June, although 18 members (who have been notified) need to renew by December. By fall 2003 our goal is to have 120 members. Next September's blister rust workshop, annual meeting, and field tours at West Yellowstone should help us attain this goal.

The WPEF board updated and clarified membership policies as follows: The membership year is October 1st through September 30th, allowing people to renew memberships at the annual meeting (in September) each year. Those who do not renew by December 31st will be dropped from membership rolls.

Membership categories are as follows:

Student:	$15 (must show proof of enrollment, such as a student ID card)
Whitebark:	$25 (regular annual membership)
Nutcracker:	$75 (sustaining membership level)
Grizzly:	$1000 (lifetime membership)
Institutional:	$150 (designed for organizations and companies)

All membership categories receive an annual subscription to *Nutcracker Notes* magazine and notices of special activities and events. Initial membership at the Nutcracker, Grizzly, or Institutional levels include a copy of the authoritative book: **Whitebark Pine Communities: Ecology and Restoration**. (WPEF is a tax exempt 501-c-3 nonprofit organization and contributions to it are tax-deductible to the full extent of the law.)

The easiest way to join WPEF is to go to our website (www.whitebarkfound.org) and click the "Join Us" button on the opening page. Select one of the membership categories, print off the form, fill it out, and mail it along with a check to the address listed. People without internet access can write or phone membership coordinator:

Bryan Donner
P.O. Box 1617, Columbia Falls, MT 59912
(406) 863-5408

Continued from page 5. . . .

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Personnel who monitor fires on the ground observed tree mortality due to mountain pine beetles (as well as the scattered occurrence of white pine blister rust) in the southeast portion of the park. Two vegetation monitoring plots installed in the whitebark pine zone on the Lynx Creek-Phlox Creek divide near the 2001 Falcon and 2002 Phlox fires reveal some interesting conditions and trends. The first plot, established in 2001 in a pure whitebark pine stand, shows a density of mature whitebark pine trees at 231 trees per acre. All of the trees were alive at the time, but 46% showed signs of beetle attack. The second plot was established in a mixed stand of whitebark pine, Engelmann spruce, and subalpine fir in advance of the 2002 Phlox fire. Here, mature whitebark pine densities were 260 per acre along with 70 Engelmann spruce and 59 subalpine fir. Of the whitebark pine, 56 percent had orange needles and were dead. Half of the remaining whitebark pine showed evidence of incipient beetle activity suggesting they will probably die within a year. Interestingly, 69 percent of the Englemann spruce were standing dead and the remaining 31 percent all showed signs of spruce or western balsam bark beetle activity, whereas 99 percent of the subalpine fir were alive and unaffected. The plot near the 2001 Falcon fire did not burn, but the 2002 Phlox fire plot was consumed by crown fire. Both of the plots will be revisited in the 2003 field season.

It appears that whitebark pine stands in Yellowstone Park are experiencing levels of mountain pine beetle activity comparable to the major epidemic of the early 1930s. The first mention of "bark beetles" in the park occurred in 1925 near Dunraven Pass where 42 infected whitebark pine trees were felled and burned in an attempt to control what was later identified as mountain pine beetle activity. Continued beetle attacks in whitebark pine in that area, along with beetle activity in lodgepole pine in the southwest corner of the park, led to widespread survey and control measures (burning and felling/burning) performed by CCC crews in 1934 and 1935. There was concern that much of the park would become "denuded" if the epidemic spread from whitebark pine into the continuous stands of lodgepole pine. By the late 1930s mountain pine beetle activity subsided. It experienced a resurgence in lodgepole pine in the late 1960s. By the mid-1980s, much of the lodgepole and whitebark pine in the western half of the park had been injured or killed.

Some observers have asked why the current activity is greater in whitebark than lodgepole pine. Preliminary research by Dr. Diana Six at the University of Montana, suggests that whitebark pine is experiencing a greater degree of cumulative drought stress as indicated by lower sapwood moisture content compared to lodgepole pine. Low sapwood moisture results in decreased ability of living trees to produce enough pitch to expel the adult beetles as they bore into the tree. Perhaps beetle activity will also increase in lodgepole pine if drought conditions continue over the next few years.

Wilson, B.C. and Stuart-Smith, G.J. 2002. Whitebark Pine Conservation for the Canadian Rocky Mountain National Parks. An unpublished conservation plan prepared for Parks Canada, Lake Louise and Yoho and Kootenay National Parks Field Unit, Radium Hot Springs, BC.

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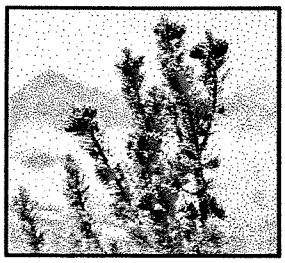
Zeglen, S. 2000. Whitebark pine and white pine blister rust in British Columbia. Interim report. BC Ministry of Forests, Vancouver Forest Region, Vancouver, BC.

What's happening to Whiteba

Whitebark Pine Ecology

Whitebark pine grows at high elevations in the Rocky, Cascade, and Sierra Nevada mountain ranges.



Whitebark pine, a critical ecosystem component, helps stabilize watersheds by growing on harsh sites at high elevation. It helps reduce avalanche danger, regulate snow melt, and prevent soil erosion. Mature trees produce abundant cones with seeds that are a key food for many animals.

This whitebark pine is over 1300 years old.

Pine squirrels gather cones and store them in middens on the forest floor.

These middens provide food for black and grizzly bears.

Clark's nutcrackers harvest whitebark pine seeds for food and cache them in the soil, especially in open areas. Many of the buried seeds germinate, becoming future whitebark pine trees.

Whitel

Whitebark pir
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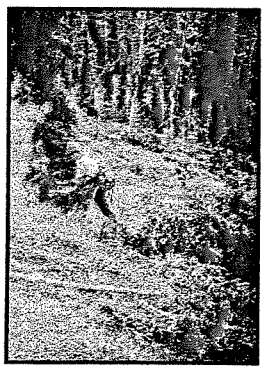
What Can Be Done ?

Current research projects are designed to restore the whitebark ecosystem.

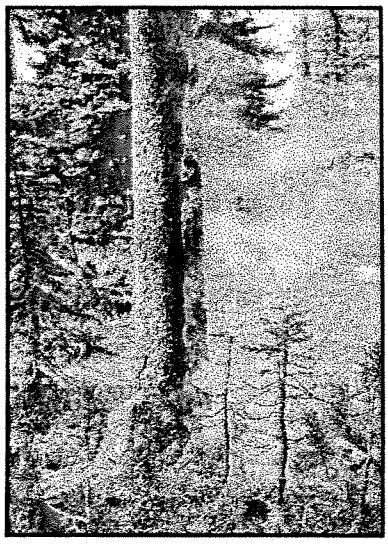
Scientists use cutting and prescribed fire to:

* Provide openings for nutcracker seed caches
* Enhance survival of whitebark pine seedlings
* Retain seed-producing trees and remove competing trees

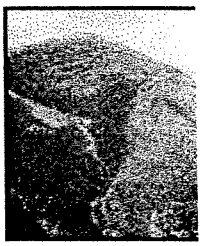


Fire and Whitebark Pine

Fire plays an important role in the ecology of whit



Low-severity fires kill many competing trees, but mature, cone-bearing whitebark pines often survive.



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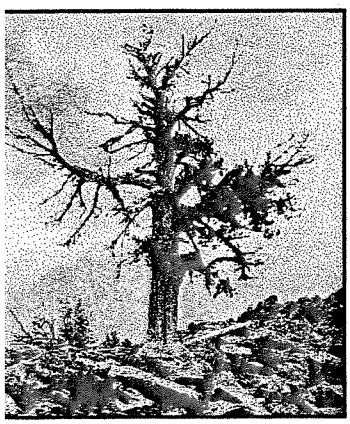
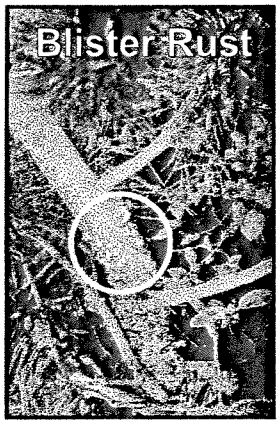
A large, full color version of this poster (36x56 inches) is available to download (50mb) at www.whitebarkfound.org/Happening.html

rk Forests in Trouble

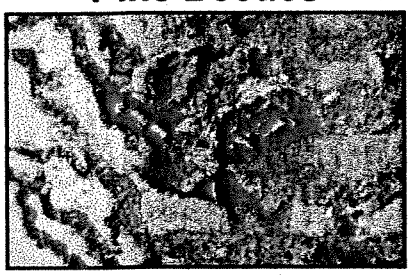


rapidly declining across
ın of its range. **Why?**



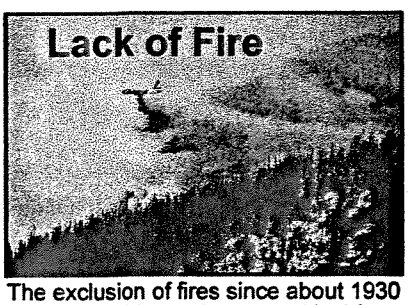
White pine blister rust, a disease introduced to the U.S. in 1910, is killing whitebark pine trees in the northwestern United States and southwestern Canada. The rust now occurs throughout the range of whitebark pine.

Pine Beetles



Mountain pine beetle epidemics in the 1930s killed many cone-producing whitebark pines in the northern Rockies. Mountain pine beetle infestations are currently increasing.

Lack of Fire



The exclusion of fires since about 1930 has reduced burned areas, critical for regeneration.

Whitebark pine can grow to a tall vigorous tree and live for many centuries. But, trees like this are increasingly hard to find.
Photo by Morton J. Elrod, Glacier National Park, 1912.

The Whitebark Pine Ecosystem Foundation

The Foundation's purpose is to inform people about the importance of whitebark pine ecosystems and to promote and support restoration activities. Members include research scientists, natural resource managers, biologists, and concerned members of the public.

Through cooperative efforts we will be able to do together what we cannot do alone.

If you are interested in the Foundation, please visit our website for more information

www.whitebarkfound.org

or write us at P.O. Box 16775, Missoula, MT 59808

FireLab

Testing Natural Selection as a Means of Restoring Whitebark Pine

Shawn T. McKinney
University of Colorado, Denver;
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Henry David Thoreau's dictum "In wildness is the preservation of the world" resonates with astounding relevance to the fate of whitebark pine. It is within wild populations of whitebark pine that resistance to the introduced disease white pine blister rust resides, and this resistance is paramount for the preservation of whitebark pine.

Based on field observations in the early 1990s, USDA Forest Service plant geneticist Raymond J. Hoff outlined a scenario in which the process of natural selection would refine the genetic makeup of populations of whitebark pine resulting in a new variety of rust-resistant trees. In several areas of northwestern Montana, mature whitebark pines were identified that did not exhibit external symptoms of blister rust infection despite exposure to the disease. These apparently resistant individuals were found in forest stands where mortality due to blister rust exceeded 80 percent. In areas adjacent to these high mortality stands there were large openings created by clearcut logging. Clark's nutcracker, the agent of seed dispersal for whitebark pine, prefers to cache seeds in forest openings, and Hoff found an abundance of young whitebark pines growing in the clearcuts. In view of the above observations it seems plausible that the new generation of whitebark pine growing in these areas will have a higher frequency of rust resistance than the previous one. Over time, successful regeneration of rust resistant individuals will result in a stabilized rate of infection spread and a new variety of rust-resistant whitebark pine. This concept is known as the natural selection stand model.

The seeds of whitebark pine do not ripen until at least mid-August. Around this time, nutcrackers will extract seeds from a cone, place them in their throat pouch, then fly to a suitable location and deposit the seeds in a cache in the ground they created with their beaks. Those seeds that are not recovered later by the nutcracker may germinate and produce whitebark pine seedlings. Prior to mid-August, however, nutcrackers along with other forest vertebrates, particularly pine squirrels, consume whitebark pine cones and seeds. The consumption of seeds prior to ripening could have drastic effects on the potential for natural regeneration to take place. In years when only a small cone crop is produced, the loss of cones and seeds may be so great that few remain in mid-August when nutcrackers would begin caching, and thus seeds of rust resistant trees will not be dispersed and allowed to germinate.

I investigated whether forest characteristics such as the degree of blister rust infection and the presence of forest seed predators would influence the chance of whitebark pine seeds surviving until the time of caching (mid-August) by nutcrackers. I hypothesized that whitebark pines located in areas with high levels of blister rust infection and mortality would have a lower proportion of seeds surviving until time-of-caching by nutcrackers than areas with low levels of infection and mortality.

In both 2001 and 2002, in locations where blister rust infection and whitebark pine mortality were high I did not observe nutcrackers filling their throat pouch or caching seeds and the chances of seeds surviving to time-of-caching were very low. In other areas where blister rust infection was moderate and mortality very low, I observed nutcrackers pouching and caching seeds and seed survivability was much higher. These results could be due in part to the effects of pine squirrels. In areas where the density of cones is low due to rust damage, squirrels could be consuming nearly all of the diminished cone crop, resulting in fewer seeds available for nutcrackers to cache.

These results suggest that blister rust infection and whitebark pine mortality do influence the chances of whitebark pine seeds being cached and thus of natural selection aiding whitebark pine restoration. Where infection and mortality are low, seed survivability and thus, regeneration potential are high. Where infection and mortality are high, seed survivability is low and therefore, there is little chance of nutcrackers caching seeds. However, in northwestern Montana, whitebark pine mortality exceeds 80 percent across a large spatial area and there is considerable whitebark pine regeneration. This fact implies that even though there are few living mature whitebark pines present, seed survival must be high.

These results are relevant to an assessment of whether the natural selection stand model can account for the creation of a new variety of rust-resistant whitebark pine. The factors influencing seed survivability are blister rust infection, whitebark pine mortality, and the density of seed predators; the importance of these factors will change with changing spatial scale. Therefore, various regions of whitebark pine distribution will have different chances of their seeds surviving to

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Cross-dating Tree Rings in Whitebark Pine

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If you climb up toward the alpine treeline in the northern Rockies, you'll likely encounter groves of whitebark pine. These will be the dominant pines of the upper treeline in patchy stands bordered by rocky ridgetops and talus slopes. You may find some very old trees; however the oldest trees that provide the most intriguing historical records may not be largest ones. Squatty, contorted trees with heavy limbs, a wind-battered, flattened top, and exposed roots are often the most venerable. Ancient trees may be relatively small, and if they inhabit a steep, stony slope exposed to desiccating summer sun and ice-blasting blizzards you have found the kind of "forest" that dendrochronologists like to study.

Dendrochronology, literally "tree" (dendro) and "time" (chronology), is the study of tree-ring patterns. These studies involve features within an annual ring as well as differences between rings. Trees are commonly sampled with an increment borer to obtain a core that slices through all the growth rings. The core is sanded to allow detailed examination of the rings. Samples are "crossdated," by aligning patterns of wide and narrow rings that reflect changes in growing conditions in a given area over long periods of time. This assures accuracy despite the confounding effects of "missing" annual rings and extra or "false" rings in some samples. Cores from trees in the same stand are combined to develop the tree-ring chronology that reflects conditions at the site. For details see *Tree-Rings and Climate*, H. C. Fritts, 1976 or *Methods of Dendrochronology*, E.R. Cook and L. A. Kairiukstis, 1990. These chronologies are useful tools for ecological studies that can identify and date events like insect epidemics, fires, and landslides, and they may be correlated with past climatic changes.

With some difficulty whitebark pines do indeed crossdate and can yield tree-ring chronologies stretching back many centuries. Consider that many trees grow in sites with suitable water, nutrients and light and are able to accumulate annual growth (xylem) without much variation from year to year. This is termed a "complacent" growth pattern. Dendrochronologists look for trees whose growth is "sensitive" to environmental changes or stress as exhibited by the presence of some rings that are exceptionally narrow as contrasted with average widths. Sequences of very narrow rings are used to match and correlate growth ring patterns among different trees and to establish a master chronology not prone to errors caused by missing or false rings on some trees.

Sensitive trees tend to occur on poor sites such as at the lower limits of forest adjacent to grass- or shrublands or sites near the alpine tree line. Growth ring patterns in such sites are considered "climatically sensitive" because they reflect annual variations in precipitation and growing season temperature. Whitebark pines often inhabit areas where both moisture and temperature are limiting, and this produces some complex variations in patterns of annual growth.

Another thing that makes crossdating problematic in whitebark pine is the lack of uniformity in ring width around the tree's circumference due to the stem's origin as part of a cluster of seedlings that germinated from a Clarks nutcracker seed cache. Clumped stems to grow faster on the sides facing away from the other trees. Also, growth rings of clustered trees may respond dramatically to death or injury of an adjacent tree, and this may confound crossdating among trees from different clusters. Heart rot is another complicating factor for crossdating whitebark pine. When you hit heart rot with an increment borer, the continuity of the core is often broken and, worse, the borer may jam with a twisted plug that is difficult to remove. (Don't insert a metal tool into the cutting tip of the borer, as it is easy to chip the tip and thus ruin the borer. See: J. K. Agee and M. H. Huff. 1986. "The care and feeding of increment borers," National Park Service, Cooperative Studies Unit, Publ. 86-3. University of Washington., Seattle).

A small but ancient whitebark pine. Photo by Dana Perkins

How far back can we hope to explore climatic records using whitebark pine? Whitebark pines at upper treeline are long-lived and slow growing. In the semi-arid mountains of south-central Idaho and northern Nevada, trees have been sampled that are over 1,000 years old. Growth ring patterns from some of these trees have been compiled into chronologies and are archived with the International Tree Ring Data Bank (http://www.ngdc.noaa.gov/paleo/treering/). I have developed four whitebark pine tree-ring chronologies from the Sawtooth-Salmon River region of Idaho (archived as above), and am currently developing a regional chronology to reconstruct patterns of spring temperatures. But this is the subject matter for another article.

WPEF's Meeting Sets Record

About 65 people attended the Whitebark Pine Ecosystem Foundation's second annual meeting (September 20th) and toured a whitebark pine restoration project on the Lolo National Forest at the Snow Bowl Ski Resort. The day's activities began at the Fire Sciences Lab with a presentation on ancient whitebark pines of central Idaho by Dana Perkins, who brought along the fascinating cross-section from a 1,150-year old tree felled by a firewood cutter.

Andy Bower, a Ph.D. student at the University of British Columbia, described studies of whitebark pine being done under the leadership of Dr. Sally Aitken. Seedlings from whitebark pine populations scattered about the West are being planted in a common garden to examine the species' genetic variation throughout its distribution. These studies have discovered that whitebark pine seeds can be stored in a freezer for at least 10 years with little effect on germination. Efforts are being made to identify the gene(s) responsible for blister rust resistance.

After these presentations, the group climbed aboard a bus and other vehicles for the short, steep ascent nearly to the top of Point Six Mountain (7900 feet). Due to reluctance of both the bus and driver we all hiked the last half mile to the chilly summit. Here we lunched in a sunny, wind-sheltered patch of beargrass overlooking mountains and valleys. Most of the craggy, 500+ year old whitebark pines near us had died in the past 25 years from damage inflicted by blister rust and mountain pine beetles. Director Diana Tomback and other officers gave a short review of WPEF business at our lunch overlook, and copies of the books "Whitebark Pine Communities" and "Flames in Our Forest" were given away in a drawing.

Descending to about the 7200-foot level we toured a whitebark pine restoration project in a mixed stand of whitebark pine, lodgepole pine, and subalpine fir with trees mostly 100 to 150 years old. Cathy Stewart from the Lolo National Forest and Bob Keane from the Rocky Mountain Research Station explained the project, which involves about 150 acres in four treatment units. These consist of a control with no treatment, a unit treated only with prescribed fire, a unit where firs are felled to enhance burning in a prescribed fire, and a unit that will have selective logging to retain whitebark pine along with slashing of competing firs and burning. The project is laid out on the ground, has been approved, and hopefully can be implemented in 2003.

The project's primary objectives are (1) to allow whitebark pine to regenerate by providing suitable openings for seed caching by nutcrackers and successful growth of saplings, and (2) to enhance vigor of remaining rust-resistant trees through removal of competing tree species. Secondary objectives are to reduce the hazard of severe fires and improve skiing opportunities.

While inspecting the stand we had a chance to hear from Dr. Diana Six of the University of Montana's School of Forestry who is studying recent attacks by mountain pine beetle. About one third of the mature whitebark pines have been killed by beetles in the last two years, mostly after trees were initially weakened by blister rust and presumably by drought and competition. These studies revealed that whitebark is more susceptible to beetle damage than the accompanying lodgepole pine, which is not susceptible to the rust. We were encouraged to find significant numbers of healthy younger whitebark pines in parts of the area, evidently as a result of a fire about a century ago that "thinned" the stand, and left fire scars on surviving trees.

Please keep in mind WPEF' plans for its next annual meeting September 12, 2003, at West Yellowstone, Montana, hosted by the Greater Yellowstone Coordinating Committee. We have reserved the Holiday Inn at West Yellowstone and will have special rates on lodging there. We are considering an optional second day (Sept. 13th) of field trips to whitebark pine habitat in the Yellowstone area. Full details of the program will appear in the spring 2003 issue of this magazine.

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K. Kendall: The same implications as with the loss of whitebark pine due to blister rust. Carrying capacity and biodiversity will decline for all sorts of mammals and birds with the loss of this nutritious food source. This is true for the animals that feed on seeds directly and indirectly such as those that can only get seeds by foraging on bear scats full of whitebark pine nuts. Forest diversity will decline as the whitebark pine trees and their associated plant assemblages disappear and this will impact wildlife populations as well.

Editor: What was the most surprising finding in your graduate studies?

K. Kendall: Following the large cone crop in the GYE in 1978, I observed that grizzly and black bears when they emerged from their dens in spring were able to locate whitebark pine cones under six feet of snow. By April, the snow in whitebark pine stands was pock-marked with craters and stained from bears digging up cones and spreading cone debris about. Bears in the GYE ate little else beside whitebark pine seeds from August 1978 through fall 1979. We hadn't realized that high cone production provided such an immense benefit for wildlife during the following year.

Clinging to the Volcano: Whitebark Pine on Mount Hood

Steve Arno, Editor

A few years ago I attended an evening banquet at the historic Timberline Lodge high up on the southwest slope of Mount Hood (11,245 feet), the snowy volcano that forms a spectacular backdrop for Portland, Oregon. I drove up the steep road with trepidation in fading evening light through a blustery spring snowstorm. Finally I reached the lodge, a splendid old log and stone hotel situated among patches of stunted trees at the 6000-foot level. Walking into the magnificently hand-crafted building I was soon struck by the view through a picture window. Here were whitebark pines, living trees and snags, bathed in a few rays of evening sun that somehow managed to penetrate the storm. Soon darkness fell, and after the banquet we all departed the mountain in the snowy night. However, the intriguing view from that window brought me back to Mount Hood in the years that followed to get acquainted with the volcano's whitebark pine communities. These proved to be a fascinating contrast to whitebark pine of the Rockies and other inland mountains.

Whitebark pine at Timberline Lodge. Photo by Steve Arno.

On the inland mountains whitebark pine's poor ability to compete with other conifers for growing room is counterbalanced by its superior performance colonizing areas burned by large fires. This results from seed dispersal by Clarks nutcracker and whitebark's superior hardiness on exposed sites. The high maritime Cascades have less fire and whitebark pine faces faster growing competitors. On Mount Hood the highest elevation forest is dominated by mountain hemlock (*Tsuga mertensiana*), noble fir (*Abies procera*), and Pacific silver fir (*A. amabilis*). It appears that excessively well-drained, loose volcanic soil (volcanic ash and pumice) and rocky outcrops near tree line are key to whitebark pine's success. Despite abundant snow and rainfall (100 inches of precipitation or more annually), ground cover is relatively sparse in whitebark pine communities and rivulets are scarce.

On Mount Hood, scattered patches of stunted whitebark pines often extend higher up the slopes than other conifers. Perhaps the most extensive whitebark pine community covers a steep southwest-facing slope that drops off into the raw rubble-filled gorge of the White River, about 1.3 miles east of Timberline Lodge. This nearly pure stand consists of whitebark pines of various ages extending from about 5000 feet elevation near the White River up to 6200 feet on a rounded spur ridge projecting from the south side of the huge mountain. Above 6000 feet whitebark pines are reduced to sprawling multi-stemmed trees and shrub-like forms (krummholz), but the whitened, weathered remains of larger erect pines lie here as testimony to a higher tree line in past centuries. This "fossil tree line" may have been caused by volcanic eruptions, climatic changes, or perhaps severe weather events or fires.

Today, the introduced white pine blister rust is challenging the whitebark pine on Mount Hood, but despite extensive damage and mortality there are many healthy trees, and a cone crop was evident in 1999 and 2001. Competition is a daunting problem for this tree whose occurrence is inherently so restricted. Competition effects seem evident along the narrow road that winds its way up the northeastern slope of the mountain to Cloud Cap Inn. The inn is a log structure built in 1889 at the 6000 foot level in the mountain's relatively dry "rain shadow" zone. Along the road, scattered old western larch extend above the 4000 foot-level in the dense fir and hemlock forest, testifying to regeneration opportunities created by pre-1900 fires. Near the upper limits of these larch, scattered snags of mature whitebark pine appear, and they occur with surprising frequency in the uppermost 1000 feet of the dense forest zone.

Cloud Cap Inn is perched atop a small rocky outcrop covered with large spreading whitebark pines probably hundreds of years old. Many of these pines are dying apparently in response to rust damage, but many of the younger pines look vigorous. Climbing just 100 yards downslope, firs and hemlock are crowding out the whitebark pines, and another 100 yards below whitebark remains only as snags long since overtopped by firs and hemlock.

It has become obvious to me that on this volcano whitebark pine is a scarce and special feature and its continued existence may be at risk due to blister rust and perhaps fire suppression. This warrants study of whitebark pine's ecological relationships. Such knowledge could evaluate need and possible approachs for restoration efforts. Whitebark pine is also a notable inhabitant of tree lines on other Cascade range volcanoes including Mount Rainier and Mount Shasta. Whitebark pine occupies the rim of Crater Lake caldera where it frequently frames the scenic views captured by amatuer and professional photographers.

In October 2002, I visited Mount Hood's whitebark pine with research ecologist Bob Keane and foresters Doug Jones and Nancy Lankford of the Mount Hood National Forest. We hope to be able to spur interest in and support for ecological studies that can advance knowledge and perpetuation of whitebark pine communities on Mount Hood and other Cascade volcanoes.

Burning for Whitebark Pine

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Since 1996 our whitebark pine restoration studies at the Missoula Fire Sciences Laboratory have burned 14 units totaling over 500 acres. Fall 2002 produced excellent conditions for prescribed burning in whitebark pine habitats. Moderately moist conditions this summer in the Northern Rockies were followed by very dry weather in September and October, producing many days suitable for burning.

We burned more than 200 acres at the Beaver Ridge study site on the Clearwater National Forest during four days of actual ignition. (This is the study area WPEF's annual tour visited in September, 2001.) The fires produced a highly variable mosaic including torched out patches of trees, lethal surface burning, low-intensity underburning, and unburned patches.

Burning in whitebark pine habitats presents challenges. There is seldom a burning season in spring because by the time snow melts it is summer and undergrowth is green and has a high moisture content. In summer, whitebark pine habitats only become dry enough to burn when forests at lower elevations are in danger of severe wildfire, and thus prescribed burning is not allowed. Therefore, prescribed burning is generally limited to early fall. The success of prescribed burning in whitebark pine habitats depends on many factors being favorable, including relative humidity, temperature, available fuel, fuel moistures, wind, and slope. For a prescribed fire to kill the competing subalpine fir and leave most mature whitebark pine trees alive these factors must be optimal.

First and foremost, the fuel that allows the fire to spread must be dry and combustible. In most cases, fires in whitebark pine stands are carried by low shrubs and herbs often consisting largely of grouse whortleberry (*Vaccinium scoparium*) and beargrass (*Xerophyllum tenax*). Such undergrowth plants will not be dry unless there has been an exceptional summer drought, in which case prescribed burning won't be allowed, or the plants have gone into dormancy. Dormancy at high elevations is usually triggered by cold weather, specifically a hard frost down to about 23 degrees F (-5 C). This causes leaves to fall from the whortleberry and other deciduous plants and the beargrass and other evergreen plants to decrease photosynthesis. Once dormancy has been initiated, the moisture contents of undergrowth vegetation often plummets to 40 or 50 percent, which is low enough to sustain a fire.

Second, relative humidity must be quite low, definitely below 40 percent and preferably below 30 percent. Direct sunlight also aids burning. Often, parts of the stand that lie in shade never get burned because of difference in temperature and relative humidity. Moderate winds can disperse the smoke column and aid in fire spread thereby resulting in fire visiting more parts of the stand. Whitebark pine stands often burn for weeks so large rotting logs and duff mounds provide a place for fire to smolder and burn more of the stand during subsequent afternoon burning periods.

Last, it appears that strip headfires that are 10 to 30 feet wide work best in stands that have sparse fuels. This lighting pattern reduces fire intensity if there are heavy fuels, and in light fuels it results in more of the stand receiving fire. Despite the narrow window of opportunity for burning in whitebark pine habitats, the fire management staffs of the Clearwater, Bitterroot, Targhee, and Salmon-Challis National Forests have proven that prescribed fire can be applied successfully.

See photo on next page . . . . . .

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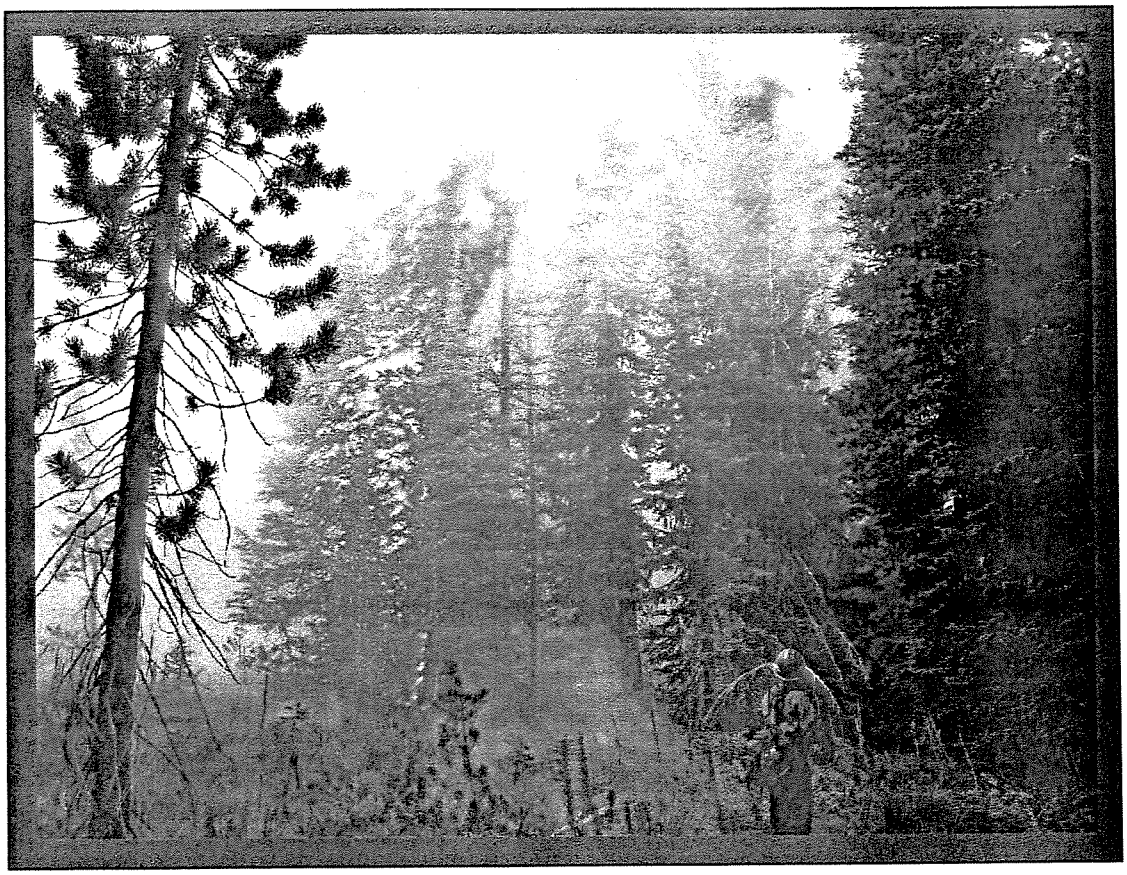
time-of-caching by nutcrackers. In the future, public land managers should consider site-specific conditions when deciding whether to rely upon natural selection for whitebark pine restoration. Even though preservation of whitebark pine is rooted in resistance found in wild populations, it will take the aid of humans to foster its spread.

This study is part of my thesis research under the direction of Dr. Diana F. Tomback and was funded by the USDA Forest Service's Fire Sciences Laboratory in Missoula, MT. The study will be completed in May 2003.



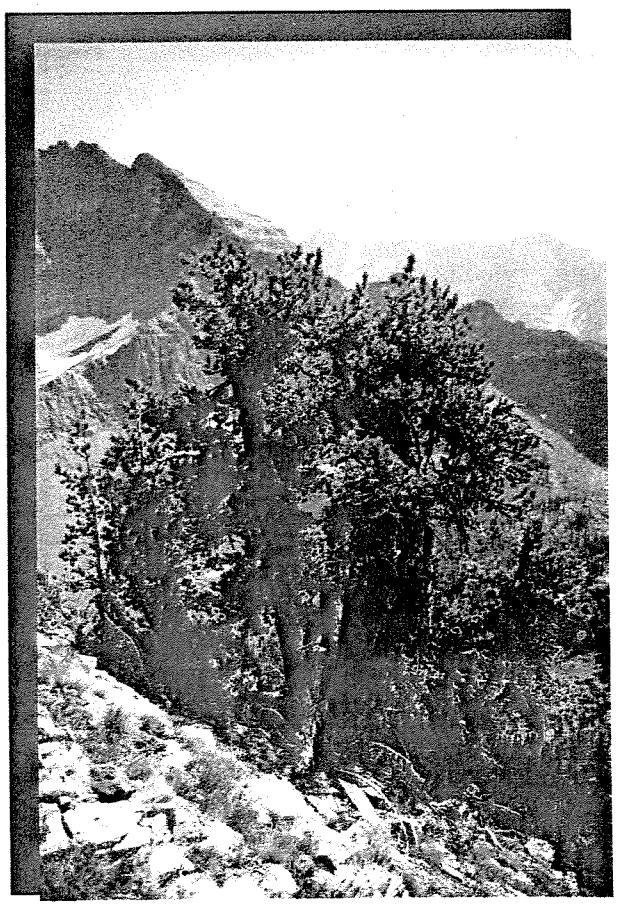
Prescribed fire torches a cluster of subalpine fir on Beaver Ridge. Photo by Bob Keane.

Web Site News—www.whitebarkfound.org

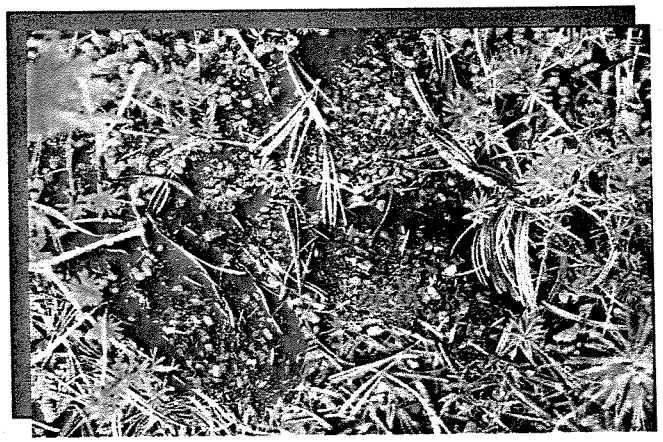
Chuck Crouter; chuck@crouter.com

Have you noticed a difference in our web site? Although we have cut the cost for hosting the site, we have moved to a more efficient server. We now have a tremendous amount of available space (over 5 gigabites) on one of the fastest servers in the United States. The site has educational information about different features of the whitebark pine ecosystem including recent popular and scientific articles. Photos show the many growth forms of whitebark pine and other important features of its ecosystem. There is information about the Whitebark Pine Ecosystem Foundation including recent and upcoming activities and forms to be fills for all different levels of memberships. Best of all, the site is updated frequently and we welcome your suggestions for new information that can make the site more useful.

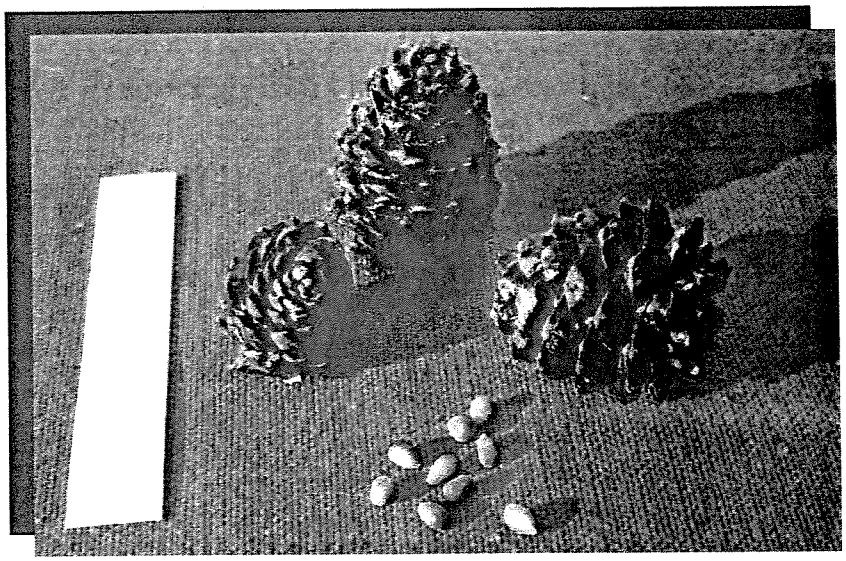
Bears & Whitebark Pine Photo Essay . . . .



Healthy mature whitebark pine trees are now a rare sight in Glacier National Park, Montana, because of blister rust and bark beetle mortality. (photo by Dave Schirokauer)



Bear scat made up of remains from whitebark pine seeds. Seed shells are visible. (photo by Steve Arno)



Whitebark pine cones and seeds.