Issue No. 10: Spring/Summer 2006

Nutcracker Notes

Whitebark Pine Ecosystem Foundation

Whitebark pine near Galena Summit, site of WPEF's September 2006 field trip. Dana Perkins photo

Foxtail pine in Klamath Mountains, California - see Dunlop article. Deems Burton photo

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Whitebark Pine Ecosystem Foundation
***Nutcracker Notes*, Issue No. 10, Spring/Summer 2006**

TOPICS **Page**

Editors Note: Due to an emergency we had to switch print shops at the last minute; thus we have used a simplified display format for this issue.

Director's Message

Diana F. Tomback

Fifth anniversary of the WPEF!

This winter represented a small milestone--the Whitebark Pine Ecosystem Foundation's fifth anniversary. In five years we have raised awareness of whitebark pine and the challenges it faces. We now have about 120 members, including people and institutions from 7 western states and 2 Canadian provinces. We have partnered with agencies and other organizations on various projects, developed monitoring methods, and offered restoration funding. The most important reason for starting the WPEF was to promote and facilitate whitebark pine restoration projects. To reflect this crucial mission more succinctly, the board voted at our winter meeting to change our letterhead motto to "Working to restore whitebark pine ecosystems."

We have accomplished a lot for an organization that has no staff and depends on the volunteer time of its Executive Committee, Board of Directors, and several active members. There is more work to be done: We have not achieved restoration activities at any significant scale, nor secured dependable funding for restoration. We have a ways to go to educate the public, stewardship agencies, and politicians about the importance of whitebark pine. However, I have several WPEF activities to report that pertain to this crucial role and mission.

Restoration initiatives

Last spring, the restoration proposals submitted by the Powell Ranger District of the Clearwater National Forest, and the Flathead National Forest were selected as winners in our first competitive restoration initiative. We awarded a total of $16,000 for these restoration projects. Since that time, we have had several inquiries from various national forests and parks about future restoration initiatives. We are exploring the possibility of a new initiative in the near future, in partnership with The National Arbor Day Foundation. In the meantime, the WPEF has established the **Whitebark Pine Restoration Fund** (Please see the announcement elsewhere in this issue). We hope that members and non-members alike will contribute occasionally to this important fund, which will be used to fund various restoration projects.

Whitebark pine restoration and application for federal funding

The need for whitebark pine restoration management actions is growing more urgent in the northern Rocky Mountains of the U.S., where long-term blister rust presence and mountain pine beetle outbreaks are threatening the pine with local extirpation. To insure a future for whitebark pine in this geographical region, the most pressing need is for dependable restoration funding now, while we can still identify and protect potentially rust-resistant trees. To this end, board members Steve Arno, Carl Fiedler, and I met with Larry Anderson, Missoula field representative for Senator Conrad Burns. Larry, who has a background in forestry, then arranged for us to meet with Senator Burns. We had a very productive conversation with the Senator, who himself as a young man had worked eradicating *Ribes* to slow blister rust. We were invited by Senator Burns to submit a federal funding application for whitebark pine restoration in Region 1. We have submitted the application, which proposes $8 million in funding over 8 to 10 years for Montana, northern Idaho, and the Greater Yellowstone Ecosystem in Wyoming expressly for whitebark pine restoration. We have been informed that the Senator is strongly supporting this funding application. Meanwhile, Steve Arno and I have had fruitful meetings or phone conversations with staffers for the other Montana delegates---Senator Max Baucus and Congressman Denny Rehberg--and staffers with both the Idaho and Wyoming delegations. At this time, we have been informed that Senator Baucus (D-MT) and Senator Enzi (R-WY) will support this funding application, and we are hoping for support from other delegates as well. We are also notifying the federal agencies involved that this funding application exists, a key element to the success of this process. We are late for the 2007 budget, but believe that at the very least we are laying groundwork for 2008.

Reminders and update

The new WPEF by-laws were approved unanimously and are now officially in place. Furthermore, our website is getting an "Extreme Makeover," so please bear with us for the next few weeks. The entire board is involved in this major reconstruction, under the guidance of professional web designer Lisa McKinney, our own webmaster Chuck Crouter, and board member Dana Perkins. The symposium, Whitebark Pine: A Pacific Coast Perspective, will be held August 27 to 31, 2006, at Southern Oregon University. The WPEF is a co-sponsor of this symposium, which focuses on ecology, threats, and restoration of whitebark pine and other five-needled white pines in the coastal ranges from California north through British Columbia. There is still time to register: Google "Pacific Coast whitebark pine" to find the website and registration details, or go to www.fs.fed.us/r6/nr/fid/wbpine/index.shtml. I hope to see many of you at our WPEF 2006 annual meeting at Sun Valley, Idaho (see accompanying article for more information). I wish you all a productive field season! ■

WPEF's Annual Members' meeting and Field Trip: Sun Valley Area
Hailey, Idaho, September 29-30, 2006

This year's WPEF Annual Members' Meeting and science session takes place amidst the Sawtooth Mountains of central Idaho, a region that boasts extensive whitebark pine communities including 1,000-year-old trees. Our Whitebark Pine Science Mini-Symposium begins at 9:00 am on Friday September 29 at the Community Campus, Hailey, Idaho. On Saturday, September 30th we drive north (approximately 45 minutes) to 8700-foot Galena summit for a field tour of some very interesting whitebark pine stands located in one of the West's most celebrated scenic areas. For more information and registration consult our web site (www.whitebarkfound.org).

The Community Campus is located south of Hailey, east of the airport. If you are in Hailey, drive south on Hwy 75 (Main St.), go straight through the junction of Hwy 75 and Airport Way (signal light), continue for about 200 yards and turn left on Fox Acres Road. Drive approximately ¼ mile and you will see the Community Campus (old high school). If you go too far you will end up at the new high school. You will be in Quigley Canyon. See www.mapquest.com for a map. Use 'Wood River High School', 'Hailey, Idaho' and 'Highway 75' for the geographic fields.

The Hailey Chamber of Commerce encourages us to take advantage of the numerous Bed and Breakfast facilities. Restaurants and lodging facilities are listed at www.haileyidaho.com. Check out the Sun Valley area web site for additional dining and lodging. Sun Valley and Ketchum are 11 miles north of Hailey.www.visitsunvalley.com■

Whitebark Pine: A Pacific Coast Perspective
A Conference at Southern Oregon University, Ashland, Oregon
August 27-31, 2006

Whitebark pine is considered a keystone species throughout its range for its contributions to high elevation ecosystems including its value as a food source for wildlife, its ability to survive harsh environmental conditions, its effect of regulating snowmelt and reducing soil erosion, and for its aesthetic and symbolic values in the high mountains of western North America.

Much has been written about whitebark pine in the Rocky Mountains but comparatively little information has been compiled for whitebark pine in the Pacific Coast mountains. There is, however, substantial interest in the Pacific Coast high-elevation ecosystems. From the Coast Range of British Columbia, through the Cascades and Sierra Nevada and into Mexico, several species of five-needle pines are components of the forest. They are highly-valued for their aesthetic contribution to National Parks and Wilderness areas. High elevation five-needle pines contribute critical elements of habitat for many wildlife species. White pine blister rust, mountain pine beetle, and fire exclusion are all influencing ecosystem process and function. The potential influence of climate change is of concern. Numerous assessments of the status and health of whitebark pine and other high elevation five-needle pines have been recently completed. Restoration strategies are being developed, but the story of these ecosystems, from a Pacific Coast perspective, has not yet been told.

In October 2005, a whitebark pine workshop held at Crater Lake National Park brought together a small group of biologists, geneticists, ecologists, entomologists, and pathologists from California, Oregon, Washington and British Columbia.
The upcoming conference entitled *Whitebark Pine: A Pacific Coast Perspective* is a direct outcome of the workshop held in 2005. The working group concluded that while many of the issues are the same for the whitebark pine on the Pacific Coast and the Rocky Mountain whitebark, there are some unique characteristics which distinguish the Pacific Coast situation. The working group determined that a conference pertaining specifically to the whitebark pine and other high elevation five-needle pines on the Pacific Coast of North America was an important step towards informing a larger audience of the issues and concerns related to these species and in garnering support for restoration efforts.

The conference will have something for everyone, beginning on Sunday afternoon, August 27, with an optional field trip to Mt. Ashland lead by Dr. Frank Lang, noted botanist and Emeritus Professor, Southern Oregon University. That evening Dr. Diana Tomback, noted author and whitebark pine research professor at University of Colorado, will give a public presentation.

On Monday, invited speakers will outline what we know about the status, ecological relationships, disturbance agents, issues and concerns, and restoration strategies posed for whitebark pine and other high elevation five-needle pines in Pacific Coast ecosystems. Monday evening features a panel on Restoration in Wilderness.

A field trip to Crater Lake National Park takes place on Tuesday, August 29. National Park biologists will take us to whitebark pine stands along the caldera rim overlooking Crater Lake. Busses for the fieldtrip will depart from Southern Oregon University. Space is limited and participants are encouraged to register early.

Contributed papers and a poster session will be held on Wednesday, August 30, with a potential to expand through Thursday morning if there is a sufficient number of papers. We encourage those working on impact assessments and restoration projects and conducting research on habitat relationships, genetics, ecology, pathology, entomology, fire science, and other subjects related to whitebark pine and other high elevation five-needle pines along the Pacific Coast to share the details of their work. The deadline to submit abstracts for papers and posters is May 30, 2006.

Graduate students are encouraged to display their research, and students are invited to consider this important work when selecting graduate projects. A limited number of scholarships will be available to cover conference registration for students. University credit will likely be available for attending the conference and completing additional assignments. Seniors and students are offered a discount for registration.

To share the beauty of the high-elevation white pines and their environment, a photo contest will be held on Monday, August 28, and is open to all conference participants.

Cosponsors for the conference include the USDA Forest Service, USDI National Park Service, Southern Oregon University, Crater Lake Natural History Association, Crater Lake Institute, and the Whitebark Pine Ecosystem Foundation.

For more information and to register for the conference, go to: http://www.fs.fed.us/r6/nr/fid/wbpine/index.shtml.■

Announcing The Whitebark Pine Restoration Fund

Diana F. Tomback

WPEF established The Whitebark Pine Restoration Fund at our 2006 winter board meeting. Donations to this fund will be used specifically for whitebark pine restoration projects, such as the competitive restoration initiative that we held in 2004-05. Membership dues largely go to support production and mailing of *Nutcracker Notes* and the extremely modest overhead required to run the WPEF. The Restoration Fund allows members to contribute specifically to help the WPEF accomplish restoration, and the fund allows non-members and institutional donors to make a one-time or occasional contribution for restoration. For example, we are currently working with The National Arbor Day Foundation, which has expressed interest in contributing to this fund.

As we revamp our website, we will include information about how to contribute to the Restoration Fund. At this time, we encourage members to help us kick off this fund by sending a contribution to the Whitebark Pine Ecosystem Foundation, P.O. Box 16775, Missoula, MT 59808 with the notation "for the "Whitebark Pine Restoration Fund." Many thanks!■

What's Hot in Whitebark Pine Publications

Bob Keane, Missoula Fire Sciences Lab
Rocky Mountain Research Station

People interested in whitebark pine may want to check out the following new journal articles. In addition, a general interest story in *The Economist* (November 5 2005; entitled "Bearing Up") explains the effect of declining whitebark pines on grizzly bears in Yellowstone National Park.

Zambino, P. J., and G. I. McDonald. 2004. Resistance to white pine blister rust in North American five-needled pines and Ribes and its implications. Pages 111-125 in Fifty-First annual western International Forest Disease workshop Conference. Grants Pass, OR. USDA Forest Service Rocky Mountain Research Station.

Six, D. L., and M. Newcomb. 2005. A rapid system for rating white pine blister rust incidence, severity, and within-tree distribution in whitebark pine. Norhtwest Science 79:189-195.

Tomback, D. F., A. W. Schoettle, K. E. Chevalier, and C. A. Jones. 2005. Life on the edge for limber pine: Seed dispersal within a peripheral population. Ecoscience 12:519-529.

Tomback, D. F. 2005. The impact of seed dispersal by the Clark's Nutcracker on whitebark pine: Multi-scale perspective on a high mountain mutualism. Pages 181-201 in G. Broll and B. Kepline, editors. Mountain Ecosystems: Studies in treeline ecology. Springer.

The following paper makes recommendations for restoring forest ecosystems infected with white pine blister rust:

Sniezko, R. A., D. F. Tomback, R. M. Rochefort, E. Goheen, R. Hunt, J. S. Beatty, M. P. Murray, and F. Betlejewski. 2004. Exotic pathogens, resistant seed, and restoration of forest tree species in western North America. Pages 21-27 in K. L. Mergenthaler, J. E. Williams, and E. S. Jules, editors. Second conference on Klamath-Siskiyou Ecology. Siskiyou Field Institute, Cave Junction, Oregon.

Please mail the citations (or reprints) of any new papers on whitebark pine or limber pine to me (rkeane@fs.fed.us) or the WPEF P.O. box and I will make sure they are published in future issues of *Nutcracker Notes*.■

Non-*Ribes* Alternate Hosts of White Pine Blister Rust: What this Discovery Means for Whitebark Pine

By Paul J. Zambino, Bryce A. Richardson, Geral I. McDonald, Ned B. Klopfenstein, Mee-Sook Kim. USDA Forest Service Rocky Mountain Research Station - Forestry Sciences Laboratory,1221 S. Main St., Moscow, ID 83843

From early to present-day outbreaks, white pine blister rust caused by the fungus *Cronartium ribicola,* in combination with mountain pine beetle outbreaks and fire exclusion has caused ecosystem-wide effects for all five-needled pines (McDonald and Hoff 2001). To be successful, efforts to restore whitebark pine will require sound management decisions that incorporate an understanding of many interacting factors, including the biology and life cycle of the fungus, whether it may adapt and change its behavior when exposed to different environments and hosts, and mechanisms and predicted frequencies of resistance in current and regenerating stands and populations of its hosts. Despite the long history of white pine blister rust on whitebark pine, significant gaps in our knowledge of the pathogen, the disease, and resistance are increasingly apparent. Our recent discovery of non-*Ribes* alternate hosts for the white pine blister rust fungus is an illustration of this point.

What is an alternate host? This term refers to one of the two quite different hosts needed by many rust fungi to complete their complex life cycle. For *C. ribicola* in North America, whitebark pine and other five-needled pines are primary hosts. Infections on these hosts cause perennial cankers that produce two of the five stages of the life cycle (pycnial and aecial stages). Aeciospores, which form within blister-like structures on five-needled pines, cause annual infections on dicotyledonous plants. These latter hosts are referred to as alternate hosts. Alternate hosts produce urediniospores that cause cycles of infection on alternate hosts, and teliospores. Basidiospores produced by teliospores cause infections on five-needled pines (McDonald and Hoff 2001).

Until 2004, species of *Ribes* (currants and gooseberries) were the only known natural alternate hosts of *C. ribicola* in North America. That assumption shaped most efforts to control white pine blister rust and predict its spread and intensification. Those efforts included a 50-year program of *Ribes* eradication (Maloy 1997) estimated to cost over a billion US dollars in current valuation (McDonald et al. 2006).

In August of 2004, at a site about 1800 m in elevation west Bonners Ferry, Idaho, suspicious rust infections were found on several non-*Ribes* plant species. The plant species in question are all hemiparasitic on other plants and are in two different genera (*Castilleja* and *Pedicularis*) of the family Orobanchaceae (previously included in the Scrophulariaceae; see Olmstead et al. 2001). The infected species were very abundant on the site, which had been burned in a large fire 38 years before; wind-disseminated seed in these genera (Allard 2001) may have favored their dense establishment.

Teliospores observed on plants in the Orobanchaceae (Figure 1) resembled *C. ribicola* in morphology, but they were also indistinguishable from *C. coleosporioides*, a native fungus that causes a different rust disease that affects lodgepole pine (*P. contorta*), *Castilleja*, and *Pedicularis*. Both whitebark pine and western white pine (*P. monticola*) were present and heavily infected with white pine blister rust at this site; lodgepole pine was found at slightly lower elevations.

DNA-based methods provided a practical approach for identifying infections on these plants (McDonald et al. 2006). From repeated tests, two non-*Ribes* plant species were newly identified as natural hosts of *C. ribicola* in North America: sickletop lousewort (*Pedicularis racemosa*) and a species of Indian paintbrush (*Castilleja miniata*).

The ability of both *P. racemosa* and *C. miniata* plants to act as alternate hosts of *C. ribicola* was further proven by successfully infecting plants of both species in the laboratory using rust aeciospores from whitebark pines. Urediniospores from the artificially inoculated *P. racemosa* plants infected *Ribes*, showing that collections from whitebark pine at the discovery site were not specialized to just one alternate host genus (McDonald et al. 2006). Telia were then used to infect western white pine (*P. monticola*) seedlings, which produced pycnia to complete the life cycle. Lack of host specialization was also supported by studies that used molecular markers to measure differences in *C. ribicola* among primary (whitebark pine and western white pine) and alternate hosts (*Ribes* and *Pedicularis*) at the discovery site; genetic differences were minimal among rust collections from the different hosts (Richardson 2006).

More recently, in 2005, we demonstrated that aeciospores from western white pine at a second location in northern Idaho (ca 200 km south of the first site) would cause infections under natural field conditions when dusted onto local plants of *P. racemosa.* Also, spores from this site infected a second paintbrush species, *C. rhexifolia,* under laboratory conditions (Zambino et al. In Press). Infections of *P. racemosa* at an upper elevation site in northern California were also proven to be *C. ribicola* (D. Vogler, USDA-FS PSWS, pers. comm.).

The finding of multiple sites where *C. ribicola* infects non-*Ribes* hosts shows that utilization of these hosts is not just a concern for northern Idaho. Additional studies will be needed to determine whether different populations of the rust fungus differ in their capacity to infect non-*Ribes* alternate hosts, and whether local populations of alternate hosts differ in their susceptibility to blister rust. Such studies will be important for answering the critical questions of 1) whether this newly discovered infection of non-*Ribes* alternate hosts represents a new adaptation in *C. ribicola* that may arise in different locations, or a widespread and inherent trait that may have been previously overlooked, and 2) whether non-*Ribes* alternate hosts are more important for causing pine infections at some locations than at others.

The ability to adjust to new environments is a common, if not critical trait of invasive species, including pathogens (McDonald et al. 2005). However, some evidence indicates that infection of *Pedicularis* spp. and *Castilleja* spp. could represent a natural ability of the rust that pre-dates its introduction to the western United States. A related species, *P. resupinata*, is known to be an alternate host for some strains of blister rust in Asia, which is a putative origin for the blister rust fungus in Europe and North America (reviewed in McDonald et al. 2005).

Regardless of the source of this ability, the utilization of non-*Ribes* alternate hosts by *C. ribicola* may be useful for explaining high rates of infection at some sites on which *Ribes* are rare or lacking. We speculate that non-*Ribes* alternate hosts may be particularly important for causing blister rust infection within whitebark pine ecosystems, as *Pedicularis* and *Castilleja* species can be very abundant at high elevations. Also, as-yet undetected hosts species could also be involved in spreading infection to whitebark pines. However, surveys will be needed to determine the occurrence and prevalence of blister rust on non-*Ribes* species. These efforts could be aided by readers of Nutcracker Notes and others who frequent high-elevation pine stands. Rust-infected samples of *Pedicularis* and *Castilleja* species that are collected along with GPS coordinates and sufficient floral or seed capsule structures to identify the plants to species will expand our knowledge of where such infections occur. They may even allow a short "first report" note to be published that documents the occurrence of *C. ribicola* on a host not previously listed for a state. To contribute non-*Ribes* samples for DNA-based verification of *C. ribicola* infections, please phone or e-mail Paul Zambino (208-883-2334; pzambino@fs.fed.us) or Bryce Richardson (208-883-2311; brichardson02@fs.fed.us).

The roles of the newly discovered hosts in the infection cycle in pine stands represent a primary research issue that will be important to management. Roles could range from simply increasing leaf tissue for colonization and production of pine-infecting spore stages, to complex and synergistic interactions among different hosts, as has been suggested for some combinations of *Ribes* species (Van Arsdel et al. In Press). As an example, observations at the first site in 2004 and 2005 appeared to show that *P. racemosa* was producing fresh leaves that could be infected by rust even late in the season, but teliospores important for pine infection were typically the only spore stage found; whereas, one *Ribes* species (*R. inerme*) was predominantly producing alternate host-infecting urediniospores. Having urediniospores and teliospores predominating on different hosts may have the potential to broaden the period within the growing season when whitebark pine infection is possible.

Finally, if non-*Ribes* alternate hosts are significant sources of pine infection, then management that creates openings for pine regeneration may need to account for complex interactions with these alternate hosts. Research studies aimed at understanding the dynamic interactions of *C. ribicola* with its non-*Ribes* alternate hosts are therefore necessary to develop effective management and restoration for whitebark pine.

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Figure 1.
The underside of a leaf of *Pedicularis racemosa* showing an infection caused by the white pine blister rust fungus, *Cronartium ribicola*. The hair-like structures are columns of teliospores, and are the most prevalent sign of infection on non-*Ribes* alternate hosts. (Photo: J. Hanna).

Blister Rust in California's High-Elevation Pines

Joan Dunlap, Manager, Blister Rust Resistance Program, Region 5, USDA Forest Service, Camino, California

During the summers of 2004 and 2005 the Pacific Southwest Region (Region 5) of the USDA Forest Service ran field surveys in California to evaluate the incidence and severity of white pine blister rust (WPBR) on the five high-elevation white pine species. The objectives were to provide baseline information on rust levels and to establish plots for long-term monitoring in limber (*Pinus flexilis*), foxtail (*P. balfouriana*), bristlecone (*P. longaeva*), whitebark (*P. albicaulis*), and western white (*P. monticola*) pine stands. Simultaneously, a variety of data sources including the field data were used to develop GIS-based files that would provide mapping information on the distribution of white pines and blister rust in the State.

A stratified random sampling method was employed with two plots established every 10 to 20 minutes in latitude within the ranges of each species' distribution. In the Sierra Nevada, plots were distributed along both the west and east side of the Pacific Crest at each latitudinal designation to capture climatic and landscape differences. White pine populations were found by examining vegetation and topographic maps, contacting local natural resource personnel, and from descriptions in publications. Each plot was established within a distinct watershed using 7 $^{1/2}$ minute topographic maps. A total of 116 plots were established for all five white pine species, with about 75% of those being for whitebark and western white pine. Generally, plots were 30 by 50 m, with size being adjusted to accommodate site factors as needed, and contained at least 30 live white pines out of 50 trees total that were surveyed. Individuals ≥ 1.37 m tall were counted as trees and as seedlings/saplings, if < 1.37 m.

For each white pine tree the field crew recorded diameter at breast height, species, tree status (live, dead) and if alive, crown class (1≤10% dead, dying, damaged, or infected; 2≤11-20%, etc.), and the presence or absence of WPBR. Disease was determined by the presence of swollen cankers, fresh and old, and the presence of aecia on stems and/or branches. Canker location, numbers, and status (active with aecia, inactive without aecia) were also recorded. Individuals with conspicuous dead "flagged" branches but no aecia were noted as having unconfirmed WPBR. In addition, data were taken on other "unknown" flagging, pests or pathogens such as mountain pine beetle (*Dendroctonus ponderosae*), and on cone production. At the plot level, seedlings/saplings were counted as live or dead, and whether infected with blister rust, and *Ribes* species, percent cover, and WPBR infection were noted. Information was recorded on plot characteristics, GPS location, slope characteristics, associated tree species, aecia phenology, and presence or absence of *Castilleja*, *Pedicularis*, and Clark's nutcrackers.

Two years of field work yielded a large amount of biological and environmental data, much of which will be examined more intensively this year. To date, we have the following summary information on the five species:

1. Great Basin bristlecone pine: Five plots were established in the White Mountains, Death Valley NP, and Inyo NF. No rust was observed on trees in any of the plots.
2. Limber pine: Fourteen plots were established in locations from the southern Sierra Nevada to the Santa Rosa Mountains in Riverside County. No rust was observed on trees in any of the plots.
3. Foxtail pine: This endemic species has a disjunct distribution with relatively small ranges in the northern and southern part of California. Six plots were established in each of the two regions. Although rust was not found on trees in the southern plots, it was observed in all six northern plots where infection levels varied from 2 to 33% (mean: 15%).
4. Western white pine: Rust-infected trees were found in 25 of 43 plots. Infection levels ranged from 0 to 92% and averaged 15%. Data from a subset of plots suggests that the highest rust levels were in northwestern California (mean: 48%, n≤5 plots) and in the central Sierra (mean: 22%, n≤13 plots) although some infected trees were found on the Sequoia NF and Sequoia Kings Canyon NP in the southern Sierra.
5. Whitebark pine: Rust-infected trees were found in 18 of the 44 plots. Infection levels varied from 0 to 71% (mean: 12%). Data from a subset of plots suggests that the highest rust levels were in the central Sierra where, on average, 36% of the trees across 13 plots had active rust infections. Further south, two rust-infected trees were found in a plot located on the Sierra NF, but no rust was observed on trees in two plots located south of there in Sequoia and Kings Canyon NPs.

Given the two-year time-frame of the survey and the extensive distances or distributions of these species in California, we did not intensively sample specific areas within their respective ranges, e.g., two whitebark plots were established in the Warner Mountains of northeastern California. For whitebark and western white pine, both widely distributed in the State, the approach was to put in enough plots to reveal broad regional patterns, if they existed. The data indicates that WPBR levels were higher west of the Pacific Crest in the Sierra than east of it. However, the Pacific Crest (or environmental conditions associated with it) does not appear to be a strong barrier to rust, as indicated by the presence of rust in the Lake Tahoe Basin. WPBR was found on whitebark pine near but just west of the Pacific Crest on the Sierra NF, notably farther south than Ebbetts Pass where it was observed by Smith and Hoffman (2000).

On a more local scale, plot to plot variation in rust infection ranged widely, as shown in two western white pine plots (92% vs. 8%) of the Dardanelle – Eagle Peak area of the Stanislaus NF. Similarly, in northwestern California, three times more infection was found in a plot of western white pine (72%) than in a foxtail plot (24%) further uphill about a half mile away. The abundance of *Ribes* along with the current infection levels point to the likelihood that the percentage of rust-infected foxtail trees will increase in that plot. Given the small number of plots in this area for both species, additional plots would be needed to more fully ascertain the severity of the rust impact. The area has particular ecological and genetic value for both species: In this northern California – southern Oregon region, western white pine makes a genetic transition from the northern populations of the Pacific Coast and Rockies to the southern populations of California (Steinhoff et al. 1983; Rehfeldt et al. 1984). Also, for foxtail pine, this northern ecotype is at its ecological margin--limited to isolated, genetically-differentiated populations growing at the highest elevations in northwestern California (Oline et al. 2000).

Limber and Great Basin bristlecone pine have small distributions in California. Both species occupy the high elevations in the mountains east of the Pacific Crest and the southern Sierra. Limber pine also occupies some high-elevation areas of the southern California mountains. Plots were established across the ranges of both species, but the numbers were low and more plots would be needed to reveal patterns if they exist. However, our plots did not reveal any rust on either species.

The establishment of these permanent plots will allow us to follow the impact of blister rust on the high elevation five-needle white pines of California. Already, the data has given us information about areas where trees appear to be more severely affected by rust. Additional plots in specific areas would be useful for more in-depth assessments. More work is needed in the area of genetics, demography, and epidemiology to better understand the dynamics of this disease across the California montane landscapes.

Acknowledgments

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Blister Rust Monitoring in Glacier National Park

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Prior to the build-up of white pine blister rust (*Cronartium ribicola*) in the mid-1900s, it is estimated that whitebark pine was a significant component on 15-20% of forested lands within Glacier National Park. By 1927 the disease had spread to five-needle pines in northwest Montana, although it was 1939 before there was a documented reporting from Glacier. At that point, Glacier wasted no time in joining the effort to eradicate the alternate host for blister rust, *Ribes* spp. Between 1939 and 1965 more than 4½ million *Ribes* bushes were removed from Glacier N. P. alone, representing about 1% of the total removal effort in northwestern states between 1923-1965. By the mid-60s the futility of this effort was recognized and *Ribes* eradication was discontinued.

Thirty years later Kate Kendall of the U.S.G.S. Glacier Field Station obtained funding to assess the status of whitebark pine in areas ranging from the Waterton-Glacier International Peace Park to Yellowstone N. P. Her work, conducted between 1995 and1997, documented 44% mortality in whitebark pine trees in Glacier N. P., while living trees had 78% average infection rates with 26% crown loss (Kendall and Keane 2001).

In cooperation with Cyndi Smith, Conservation Biologist at Waterton Lakes N. P., we tested the blister rust monitoring methodology developed by the Whitebark Pine Ecosystem Foundation (Tomback et al. 2004). In 2003-2004, we sampled 2,181 trees in 55 plots in Glacier N.P. A summary of our results is found in Tables 1 and 2.

Table 1. Glacier National Park Whitebark Pine Status 2003-2004

Tree Status	# of Trees	% of Total	% of Live Trees
Healthy	518	23.8	43.1
Sick	685	31.4	56.9
Recently Dead	97	4.4	n/a
Dead	881	40.4	n/a
Total	2181 trees surveyed	55.2% live 44.8% mortality	1203 live trees

Table 2. Glacier National Park Whitebark Pine Blister Rust Infection 2003-2004

Tree Status	% Infected*	%Infection Uncertain**	% Probable Infection*** High / Low	Mean % Canopy Kill
Healthy	28.6	7.3	2.7 / 1.9	18.7
Sick	74.0	10.5	4.8 / 4.5	42.3
All Live	54.4	9.1	3.9 / 4.2	32.1

*Active or inactive stem or branch blister rust cankers present.
**Could not confirm presence or absence of cankers.
***Trees with uncertain or no canker presence that had heavy (high probability of infection) or light (lower probability) bark stripping as a percentage of all live trees.

Although most plots were located in the same stands sampled by Kendall, we were unable to precisely duplicate Kendall's plots, and our sample size was much smaller. There was also some bias in our plot selection, especially in 2003, due to an emphasis on aiming to capture at least 10-30 live trees in a plot. Although the data gives the appearance that mortality and infection may have decreased in the 6-9 years between sampling periods, a subsample of Kendall's data including 48 plots which occurred in the same stands where data was collected in 2003-2004 showed a mean of 29% whitebark mortality and a 38% blister rust infection rate. However, caution is recommended before making trend inferences and data comparisons, as we were not sampling the same plots. The new plots have been permanently marked to allow long-term monitoring which will make comparisons and trend analysis easier in the future. This also highlights the need for maximizing the number of stands covered by sampling as small sample sizes may not give us a clear picture of current whitebark status overall.

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Whitebark Pine Monitoring Update: Greater Yellowstone Area

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Greater Yellowstone Whitebark Pine Monitoring Working Group

Forest monitoring has shown a decline of whitebark pine in varying degrees throughout its range due to non-native white pine blister rust and native mountain pine beetle. Given the ecological importance of whitebark pine in the Greater Yellowstone Area (GYA) and that 98% of whitebark pine occurs on public lands, the conservation of this species depends heavily on the collaboration of all public land management units in the GYA. The Greater Yellowstone Whitebark Pine Committee is comprised of resource managers from eight federal land management units and has been working together to ensure the viability and function of whitebark pine throughout the region.

As a result of this effort, an additional working group was formed to integrate the common interests, goals and resources into one unified monitoring program for the Greater Yellowstone area. The Greater Yellowstone Whitebark Pine Monitoring Working Group consists of representatives from the U.S. Forest Service, National Park Service, U.S. Geological Survey, and Montana State University. The Monitoring Group has been developing a protocol for monitoring whitebark pine in a consistent manner throughout the entire GYA. This monitoring program will facilitate a more effective effort to understand the status and trends of whitebark on a comprehensive, regional scale.

Our objectives are to monitor the health of whitebark pine relative to levels of white pine blister rust and to a lesser extent mountain pine beetle. Our study area includes 6 National Forests and 2 National Parks in the GYA. The habitat types from which our sample was selected covered whitebark pine dominated sites within the GYA including forest habitat and cover types ranging from relatively pure whitebark pine stands that occur at higher elevations, to mixed-species stands that occur at lower elevations within the range of whitebark.

During 2004, all whitebark stands sampled were within known whitebark stands within the Grizzly Bear Primary Conservation Area (PCA). Our sample during 2005 extended outside of the PCA to the boundaries of the GYA. Future samples over the next few years will encompass the entire region. Our sampling methods approximated protocols for range-wide monitoring of whitebark pine established by the Whitebark Pine Ecosystem Foundation. Variations from these methods were implemented when we selected for a more statistically-based sampling approach. General details of our sampling design and field methodology can be found in GYWPMWG (2005, 2006), and our full protocol is currently under review with completion anticipated before the end of 2006. Transects and individual trees within each transect were permanently marked in order to estimate changes in infection and survival rates over an extended period. Transects will be revisited approximately every 5 years to determine changes in blister rust and survival since the previous visit.

A total of 51 transects was surveyed within 45 stands of whitebark pine in 2004, and 76 transects were surveyed in 55 stands in 2005. We observed some level of blister rust on 71% and 86%, respectively. The proportion of infected trees on a given transect ranged from 0 to 1.0. The number of live trees per transect for each year ranged from 1 to 219 for a total of 1,012 live trees examined during 2004 and 2,732 during 2005. Taking into account both within and between-stand variation, our preliminary estimates of the proportion of live trees infected with white pine blister rust was 0.17 ± (0.062 se) within the PCA, 0.27 ± (0.036 se) outside the PCA, and 0.25 ± (0.031 se) for the overall GYE.

The total number of cankers observed on infected live trees in 2004 and 2005 combined was 2,425, of which 1,942 (80%) were located on branches and 483 (20%) were located on a main bole. The total number of cankers per infected tree ranged from 1 to 35. Bole cankers that are located on the lower portion of the bole (middle to bottom third) are generally considered lethal to trees. Cankers that are found in the upper third of the bole are not necessarily lethal but can have a negative impact on cone production. Such cankers were less numerous than branch cankers and ranged from 0 to 7 per infected tree; whereas branch cankers ranged from 0 – 32 per infected tree.

Of the stands visited in 2004, 22% had evidence of mountain pine beetle attacks in live or recently dead (i.e., with intact needles) trees. Of the 1,062 live or recently dead trees we sampled in these stands, 30 (3%) had evidence of mountain pine beetle attacks. In 2005, 22% of the stands had evidence of mountain pine beetle attacks and of the 2,827 live or recently dead trees, 26 (1%) had evidence of mountain pine beetle attacks.

Monitoring concentrates on the health and status of whitebark pine in the Greater Yellowstone area. We consider the proportion of transects that show the presence of blister rust as an indication of how widespread blister rust is. Preliminary results indicate that blister rust is widespread throughout the GYE (i.e., 80% of all transects had some level of infection). We consider the proportion of trees infected and the number and location (branch or bole) of cankers as indicators of the severity of blister rust infections. By these measures, the severity of infections was less alarming than the spatial extent, with an estimated 25% of the trees in the GYA estimated as having some level of infection. In most cases, the number of cankers per tree was low with approximately 73% of the infected trees having less than 2 cankers observed, 80% of which were branch cankers. Branch cankers are generally considered to be less lethal.

The results presented here are preliminary and some caution in interpretation is warranted. We have not yet completed a full sample of the ecosystem. Our sampling design is such that a full sample is achieved over several years, after which the samples are revisited. Thus, our estimates to date comprise only a subset of what will be a complete sample of the ecosystem. It should also be noted that our estimates from 2004 and 2005 do not represent an annual change in blister rust infection. Rather, these samples were taken from different parts of the ecosystem and are more likely to reflect spatial variation rather than an annual change. Our estimates of change in infection within the GYA will be derived from repeated sampling of our selected sites over time.

Our overall estimate of blister rust infections is likely conservative. Our criteria of having aecia or at least three of the other indicators (rodent chewing, flagging, oozing sap, roughened bark or swelling) present to confirm infection, may result in the rejection of questionable cankers (GYWPMWG 2005). We are continuing to evaluate the efficacy of these criteria for future sampling. Our data also suggests that observer variability may be quite important. This result has broad implications for all monitoring efforts of whitebark pine where observer differences are not considered. For monitoring efforts to be reliable, differences in infection rates observed over time should not be confounded with observer differences. Finally, although whitebark pine is important to an array of wildlife including the grizzly bear, it is important that the focus of this project is on whitebark pine as opposed to any of the species with which it may be associated.

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Mountain Pine Beetle Outbreak in Whitebark Pine

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Mountain pine beetle (MPB), *Dendroctonus ponderosae*, outbreaks are occurring throughout western North America. More than one million acres of host stands, mostly lodgepole pine, are infested in the northern Idaho and western Montana. Almost 143,000 of those acres are whitebark pine (WBP).

In 2005, we observed the highest recorded single year of MPB-caused WBP mortality. Unpublished office reports indicate equally devastating outbreaks existed in the 1930s—the warmest decade of the twentieth century and very close to extremes recorded in the past 5 years—in the vicinity of Yellowstone National Park (NP); however the extent of those outbreaks is unknown. Furniss and Renkin (2003) quoted a 1934 report for Yellowstone NP: "The mountain pine beetle epidemic is threatening all of the white bark and lodgepole pine stands in Yellowstone Park. Practically every stand of white bark pine is heavily infested…and will be swept clean in a few years. If the insects spread from the white bark pine to the lodgepole stands, it seems inevitable that much of the park will be denuded." So, while present outbreaks are unusual, they are apparently not unprecedented.

In the Greater Yellowstone Ecosystem (GYE)—Yellowstone NP and surrounding forests—there are approximately 1,064,600 acres of WBP-dominated forests.

Presently, about 171,200 (16%) of those contain MPB-caused mortality. Nearly 720,000 MPB-killed WBP faders (trees attacked in 2004) were recorded (Meyer 2006) (Table 1).

Administrative Unit	Acres of WBP	MPB-Infested Acres (2005)	Estimated Faders
Yellowstone NP	218,700	29,215	365,200
Grand Teton NP	9,300	Not flown	Not flown
Gallatin NF	256,100	20,316	37,500
Beaverhead NF	108,800	42,441	136,600
Custer NF	68,700	1,087	1,300
Bridger-Teton NF	115,000	34,373	131,100
Caribou-Targhee NF	56,000	1,982	3,900
Shoshone NF	232,000	41,746	43,700
Total	**1, 064,600**	**171,160**	**719,300**

Table 1. MPB-Infested WBP, Acres and Trees, GYE; Recorded in 2005 (ADS Data)

Recent observations suggest atypically warm temperatures have increased MPB-caused impacts by enhancing beetle survival; and in some cases shortening their life cycles. At present, WBP stands are experiencing higher-than-normal levels of MPB activity, supporting the supposition that climatic conditions have contributed to current outbreaks.

Aerial detection survey (ADS) data for the GYE indicate MPB populations have been recorded in most areas only during the past 4-5 years. For the decade prior to 2000, only minor amounts of beetle-caused mortality were recorded in most of the area surveyed.

Data from beetle-infested stands, obtained to supplement ADS data, was collected from plots in Yellowstone NP and adjacent Gallatin NF in 2004. Similar data for other stands in the area are not available; however, these are likely representative of MPB-caused mortality throughout the GYE.

In twenty plots near Avalanche Peak (Yellowstone NP), WBP killed by MPB within the past 2-3 years averaged 96 trees per acre—80% of WBP, over 5 inches diameter (breast height). Near Lightning Lake (Gallatin NF), ten-plot average mortality, for past 3 years, totaled 162 WBP per acre—74% of WBP over 5 inches. In those areas, mortality levels are already declining due to host depletion.

WBP is one of the hardiest of the pine species and disturbance is an integral part of their ecosystems. Today, however, fire suppression and non-native pests are exposing WBP to threats never before encountered. Long-term survivability is especially threatened by the introduced fungal disease, white pine blister rust.

MPB, a native pest presents an even more serious short-term threat to WBP. Occasional outbreaks can kill thousands of mature trees within a few years. Warmer- and drier-than-normal conditions often make outbreaks even more devastating. In unmanaged WBP stands, epidemics last until suitable hosts no longer remain or environmental conditions become less favorable to MPB.

We can silviculturally reduce beetle-caused mortality in some stands (McGregor, et al 1987). How affective those strategies, and others to include prescribed fire, may be in WBP is not fully known (Tomback, et al 2001). In addition, we have learned to use beetle-produced pheromones to our advantage. Attractants have been used to manipulate beetle populations (Borden, et al 1983); and verbenone, an anti-aggregation pheromone, has been used to protect high-value trees (Bentz, et al 2005). Protective treatments with insecticides have also prevented beetle-caused mortality.

Breeding programs to forestall affects of white pine blister rust, and other restoration projects; will be especially dependent upon cone-bearing and rust-resistant trees. Success will require their protection from MPB. Only the combined efforts of many will preserve and restore WBP throughout its historic range.

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Verbenone Reduces Mountain Pine Beetle Attacks

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Mountain pine beetle (*Dendroctonus ponderosae*) is one of the most aggressive bark beetles in North America, attacking healthy green host trees. Populations build up to outbreak levels every 20-40 years and outbreaks may last for 20 years or more. As much as 70-90 % of the lodgepole pine (*Pinus contorta* var. *latifolia)* over 13 cm (5 inches) in diameter at breast height (dbh) may be killed over vast areas (McGregor et al, 1987). Large diameter trees are the preferred host because they provide thick phloem that enables beetle progeny a higher probability of survival (Amman 1969). Forest structure, stand composition, and fire regimes may be adversely affected by mountain pine beetle outbreaks (Safranyik et al. 1974).

Verbenone is the principal antiaggregative pheromone produced by mountain pine beetles. In essence, verbenone sends a signal to flying beetles telling them "this tree is full, go find another tree." Recently, emphasis has been placed on deterring beetle attack using verbenone alone and in combination with nonhost volatiles.

To test the ability of verbenone to deter mountain pine beetle attack for the duration of a beetle outbreak, verbenone pouches were applied each year to trees in campgrounds surrounding Redfish and Little Redfish Lakes in the Sawtooth Recreation Area near Stanley, Idaho, from 2000-2004. During the first two years of the study a median of 12% of the host trees >13cm dbh were attacked and killed on the treated plots, whereas trees on the untreated plots incurred a median mortality of 59%. When approximately 50% of the trees on the untreated plots were killed by mountain pine beetle, the response of beetles to verbenone on the treated plots dramatically declined. After five years, MPB had killed a median of 87% of the lodgepole pine trees >13 cm in untreated plots and 67% in plots containing verbenone pouches. Beetle pressure was higher on untreated plots in 2000 and 2001, nearly equal between treatments in 2002, higher on verbenone treated plots in 2003 and similar between treatments in 2004. It is hypothesized that the lack of response to verbenone after two years may be related to both population size and spatial scale, i.e. large numbers of vigorous beetles in a local area with a reduced number of preferred large-diameter trees become crowded and stressed, causing a decline in the response of beetles to verbenone.

Whitebark pine (*Pinus albicaulis*) does not grow in contiguous forest across the landscape like lodgepole pine. Rather, it occurs at high elevations in dispersed small stands or as open-growing individuals. The lack of stand connectivity could help verbenone to be more effective in deterring mountain pine beetle attack in whitebark pine than lodgepole pine.

Several studies have been conducted using verbenone to divert mountain pine beetle from attacking whitebark pine. Kegley and others (2003, 2004) showed that verbenone could deter beetles from attacking individual trees in year-long studies. Schen and Bentz (unpublished data 2006) conducted a 2-year trial combining a trap-out/antiaggregation strategy using baited funnel traps and verbenone + non-host volitiles. Perkins (unpublished data 2006) is using verbenone pouches in central Idaho over multiple years. Gillette and Hanson (unpublished data 2006) treated stands of whitebark pine with verbenone flakes in 2005.

An active management regime may be the best approach to protect whitebark from attack by mountain pine beetle. The ability of verbenone to divert mountain pine beetles seeking a suitable host may be most effective in isolated stands and where the beetles have an alternate source of attraction. Individual tree protection with verbenone may be of merit for small patches or isolated individuals. In these areas, the application of verbenone in combination with a beetle sink (trap trees or baited traps) and removal of currently infested trees, would most likely show the most promise.

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Whitebark and Limber Pine Restoration in Glacier National Park:

Monitoring Results

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Glacier National Park began establishing a whitebark pine (*Pinus albicaulis*) and limber pine (*Pinus flexilis*) restoration program in 1997 (Williams and Kendall 1998; Williams 2001). While the precarious status of whitebark pine was well documented (Kendall and Keane 2001), limber pine was included in the program due to its susceptibility to white pine blister rust (*Cronartium ribicola*) and the uncertainty of its future status.

Our protocol has been to collect seeds from trees with relatively healthy crowns that are producing cones amidst stands heavily hit by blister rust (most whitebark stands in the park would qualify). Between 1997 and 2000 we collected more than 22,500 whitebark pine seeds and more than 23,000 limber pine seeds. Whitebark had an average of 35 seeds per cone, and we collected an average of 20 cones per tree that we climbed, while limber pine averaged 46 seeds per cone and 28 collected cones per tree.

From these seeds, seedlings have been raised in our own nursery and in cooperation with the USDA Forest Service in their Coeur d'Alene Nursery. We had an excellent whitebark cone crop in 1998, and percent fill of the lots in this batch of seeds ranged from 72 to 96%. These seeds averaged 67% germination. We were pleased to discover that 86% germination could be obtained from a lot of 2½ year old whitebark seed. Limber pine had a bumper year in 2000. Average germination for limber pine was 23%. We have not been able to track germination rates in subsequent years. At least 75% of the germinants could be expected to develop into seedlings ready for planting.

Between 1999 and 2005 almost 6,000 whitebark and more than 5,000 limber pine were produced and planted. Most of the whitebark was planted in the 1998 Kootenai Complex burn on West Flattop Mountain. Not included in the monitoring are a number of trees planted cooperatively on the Blackfeet Indian Reservation immediately east of the park, and a couple hundred trees planted on Grinnell Point and Dutch Ridge shortly after burns in those locations. Limber pine was planted in groups of 100-800 seedlings scattered across 13 different planting sites on the east side of the park. Some trees were also shared with the Blackfeet and with Waterton Lakes National Park. Due to the extreme fire season in 2003 and unexpected early snows in 2004, we were not able to monitor the whitebark pine plantings for those years. Results of the monitoring we completed are shown in Table 1.

Table 1. Monitoring results for whitebark and limber pine planted in Glacier National Park.

	Year planted	Trees planted	Trees monitored	1 Year survival	2 Year survival	3 Year survival	4 Year survival
Whitebark pine	2001 spring*	1500	348	44%	--	--	34%
	2001 fall	1438	282	49%	--	--	33%
	2002	2222	281	--	--	47%	--
Total		5160	911	45%	--	47%	34%
Limber pine	2002	2732	562	49%**	0.5%	--	--
	2003	25	25	92%***	0*****	--	--
	2004	1150	143	54%****	--	--	--
	2005	700	147	--	--	--	--
Total		4607	877	51%	0.5%	--	--

*Planted shortly after snow melt (July). All other plantings were in the fall (September).
**94% of surviving plants were classified as "almost dead."
***Plants by Two Medicine Campstore were watered during their first year.
****87% were in good or fair condition (73% good).
*****Second hand report. Plants were not monitored.
--Plants were not or have not been monitored.

We made the decision to stick with fall plantings due to the unpredictability of summer precipitation, so we were surprised to find no real difference in survival between the spring and fall whitebark plantings after four years. We were delighted to have 47% survival after three years, especially given the extremely dry conditions during the summer of 2003 (Table 2).

We were initially discouraged with the limber pine plantings, which fared poorly after the dry summers of 2002 and 2003 (Table 2). Finding suitable planting sites in the exposed, rocky, shallow soils where limber pine grows was a challenge. Following the wet fall of 2004 and wet spring of 2005 (Table 2), it was encouraging to not only see more than 50% survival, but that the majority of the trees were in healthy condition. We found that planting trees in microsites where partial shading could be provided such as near stumps, rocks, or logs appeared to contribute to survival. As long as we have surviving trees, we plan to continue monitoring the planted trees in years 1, 2, 3, 5, 10, 15, and 20. We also plan to continue seeking ways to improve and maintain our whitebark and limber pine restoration program.

Table 2. Monthly total precipitation (inches) for West Glacier, Montana 2001-2005

Year	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Ann
2001	1.36	1.89	1.83	3.01	1.28	3.99	0.58	0.12	1.17	3.81	2.26	2.89	24.19
2002	4.16	2.38	2.46	2.37	2.66	2.97	1.48	0.69	1.70	0.49	2.51	3.08	26.95
2003	3.59	1.25	4.82	1.36	1.92	1.84	0.04	0.08	1.95	2.74	4.08	2.36	26.03
2004	4.58	1.52	1.30	2.23	2.36	2.22	2.45	4.41	3.71	4.30	3.21	2.97	35.26
2005	2.78	0.50	3.17	1.67	2.06	6.99	0.53	1.14	4.40	4.62	3.03	3.35	34.24
50yr $\bar{x}$	3.39	2.30	1.94	1.84	2.53	3.31	1.68	1.61	2.11	2.41	3.1	3.27	29.48

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Whitebark Pine Restoration on the Bonners Ferry Ranger District

Patrick Behrens, Silviculturist

Whitebark pine grows in harsh environments generally above 6,000 feet on the Bonners Ferry Ranger District of the Idaho Panhandle National Forests. The District has approximately 32,500 acres capable of supporting substantial populations of whitebark pine, the majority of this being in the Selkirk Mountains.

Whitebark pine is shade-intolerant and requires canopy openings in order to regenerate. Where it grows in mixed species stands, if there is no significant canopy-opening disturbance over a long time, whitebark pine will eventually be replaced by other species. Historically, fire played a major role in perpetuating whitebark pine, and in mixed species stands fire is essential to maintain whitebark.

In the Idaho Panhandle National Forests, observations show that as much as 95 percent of the whitebark pine has died in stands where it used to be a major component of the vegetation. White pine blister rust has caused the most precipitous reductions in whitebark pine here. Fire suppression is the second most important factor causing the decline. Finally, mountain pine beetle outbreaks over the last decade in the Selkirk Mountains have killed a high percentage of the mature whitebark pine trees. When blister rust mortality, the effects of fire suppression, and the impact of mountain pine beetle come together, whitebark pine can be virtually eliminated from some mountain ridge systems.

To address these concerns in the whitebark pine ecosystem the Bonners Ferry Ranger District is in the process of implementing restoration treatments in the Selkirk Mountains. An Environmental Assessment was completed in the summer of 2004. Ultimately, pending the availability of funding, more than 1,700 acres of whitebark pine restoration will be accomplished through non-commercial vegetation treatments and prescribed fire. Approximately 1,300 acres will be treated using a combination vegetation treatments and prescribed burning and nearly 400 acres will be treated using vegetation treatments methods that reduce competition from other tree species without use of prescribed burning. ■

Fire Regimes of Cascadian Whitebark Pine Revealed

Michael Murray, Terrestrial Ecologist
Crater Lake National Park, Oregon

The historic relationships between fire and whitebark pine remain poorly understood in the Cascade Range. I was unable to find any literature relating fire history to whitebark pine in this region. A common perception is that fire scars are very rare in Cascadian whitebark pine and therefore fires are not as important as similar habitats in the Rocky Mountains.

Spanning about 600 miles from Southwest B.C. to Northeast California, the Cascades are a significant portion of whitebark pine's distribution. Inspired by the opportunity to learn about Cascadian timberlines, a funding proposal was successfully sought from the Interagency Joint Fire Sciences Program in 2002.

Under the field leadership of NPS Biologist, Joel Siderius, we researched three National Parks and their adjacent National Forests: 1) Crater Lake NP – Winema NF, 2) Mount Rainier NP – Okanogan and Wenatchee NFs (OWNF), and 3) North Cascades NP - OWNF. Our immediate observations indicated that charcoal was present at most (88%) whitebark pine stands we visited. Further examination revealed that forty-three (78%) of sites had other evidence of historic fire (scars, age-class, archives). Of the 101 fire events we detected, 57% were evident from fire scars and often reinforced by age classes. Thirty-seven percent were revealed by age class alone. The remaining 6% were from historic records verified by field observations.

A wide range of fire intervals was determined. For example, Stormy Mountain (OWNF), with its grassy understory, exhibited non-stand replacing fires in 1929,1895,1867,1848, 1837, 1820, and 1781 equating to a 25-year frequency. At the other end of the spectrum, some sites (22%) had no dateable evidence other than charcoal, suggesting long fire-free intervals. These sites typically had very sparse undergrowth (Table 1). Overall, we found a negative correlation between latitude and frequency of non-stand replacing fires. This modest correlation is significant (r_s=.453 at P=0.10) and indicates that fire intervals shorten with higher latitudes (Figure 1).

Table 1. Comparison of fire intervals for each Cascadian whitebark pine forest community types based on dominant understory.

Dominant Understory Vegetation	No. of Sites	No. of intervals	MSAFI* Years (range)	Standard Deviation (of the intervals)
PIAL/CARU	3	9	44 (11-134)	39
PIAL/VASC	20	25	55 (9-196)	48
PIAL/JUCO	3	5	64 (33-140)	44
PIAL/FEVI	5	9	84 (11-164)	57
PIAL/Dryland Grass	12	10	93 (13-120)	86
PIAL/ARNE	4	1	130	-
Minimal Vegetation	8	0	>250 years	-

*Multiple Site Average Fire Interval (Barrett and Arno 1988)

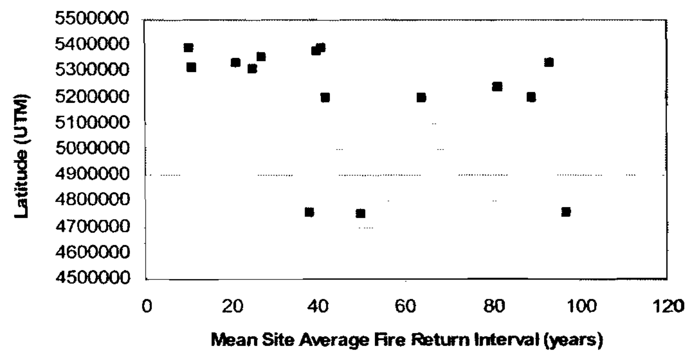


Figure 1. A moderate correlation between latitude and fire intervals in the Cascades. For reference a UTM of 4500000 is equivalent to 42+ deg. N. latitude and UTM 5500000 equates to 49+ deg. N. latitude.

We also estimated fire severity for each site's most recent fire event. If there was more than one tree that survived a fire within our 400 m² plot, the fire regime was considered low severity. Almost half (44%) of fires were found to be low severity. Mount Rainier was unique in showing a preponderance of high severity (75%) fires.

During the 1900s, only 22 fires were found as opposed to 51 fires in the 1800s. This significant difference (X^2 = 10.73, p=0.01) suggests management and/or climate may be playing a role in lessening the incidence of fires.

We also examined how whitebark pine stands may have changed as expressed by proportional abundance of tree species. Using our increment bore samples we reconstructed stand histories for all mixed-species sites. We found that volume for all species began to dramatically increase during the 1920s and continues. Lateseral species, typically low in fire resistance, have increased at greater rates than whitebark pine suggesting fire exclusion as a facilitating agent of change.

During the spring of 2006, we are visiting managers to convey results specific to each study area. Our findings - which indicate highly variable fire regimes present both challenges and opportunities for the careful reintroduction of fire in the Cascade Range. ■

Whitebark and Limber Pine Information System now available!

Blakey Lockman, Forest Health Protection
US Forest Service, Northern Region, Missoula, MT 59807

Whitebark and Limber Pine Information System (WLIS) is a database of basic plot information on whitebark and limber pines from numerous surveys and studies that have been completed in the United States and Canada. This compilation of summary data will permit rangewide assessments of whitebark and limber pines. Forest Inventory and Analysis (FIA) plot data are part of the database. The data can be queried to provide a spatial summary of the condition of these two species. The US National Park Service has created an interface for simplifying field entry of future survey/study data by individuals using the survey design developed by the Whitebark Pine Ecosystem Foundation as a template.

WLIS was tested by selected individuals prior to release. Following testing and revisions, it has been made available to those interested. The system can be downloaded from the web (http://www.fs.fed.us/r1-r4/spf/fhp/prog/programs2.html) or a CD can be requested from Blakey Lockman (blockman@fs.fed.us) or Gregg DeNitto (gdenitto@fs.fed.us). Surveyors and researchers collecting data on whitebark and limber pines are encouraged to enter their data and make it available for inclusion in WLIS. Periodic requests for new data will be made using a mailing list created when users download WLIS or request a CD. Users will be notified as updates of the database are made available through the website.■

Does Whitebark Pine Release After Cutting Treatments?

Robert E. Keane, Rocky Mountain Research Station
Missoula Fire Sciences Lab, rkeane@fs.fed.us,

Recent research efforts are testing methods designed to restore whitebark pine communities declining because of blister rust, mountain pine beetles, and successional replacement triggered by fire exclusion (Keane and Arno 1996, Keane and Arno 2001). Silvicultural cutting or in some cases prescribed fire treatments could be implemented in stands where there is advance regeneration of whitebark pine in the understory or stagnated pole-sized whitebark in the overstory. These suppressed trees are often quite old since the species can survive under partial shade for many decades. Other subalpine tree species appear to respond with accelerated growth (growth "release") when competing trees are cut (McCaughey and Schmidt 1982). However, no published studies have explored the ability of crowded whitebark pine trees to release in response to removal of competing trees. Managers need to know if stagnated whitebark pines have the ability to release after silvicultural cuttings and eventually grow into healthy cone-bearing trees.

In a reconnaissance study, we located 21 high-elevation sites across the Rocky Mountains in Montana where commercial logging had in the past removed competing trees and left residual whitebark pines in place. These sites had a wide variety of pre-harvest densities and stand ages. It was difficult to find suitable sites that contained healthy, residual trees after logging because there are very little logging has been conducted in the high elevation forests where whitebark pine is present, due to difficult access and low value timber. Moreover, many of the whitebark pines in western Montana logged areas were severely infected with blister rust.

Nevertheless, we were able to sample 59 whitebark pine trees that had survived logging on the 21 sites. These trees had a wide range of diameters (1-63 cm DBH) and ages (51 to 395 years) A total of 14 trees had to be removed from the statistical analysis because they did not contain a sufficient number of tree rings (at least 40 rings prior to harvest date) to adequately perform the analysis that judged whether their growth released or not. We used a statistical technique called intervention analysis (Sridharan et al. 2003) to test for a significant release or change in tree ring growth after the year in which logging occurred and to estimate the magnitude and significance of the release.

We measured annual ring growth rates for all trees in the study from cross sections taken at breast height. Most trees (>90%) showed a statistically significant increase in ring growth after the cuttings while only one tree (2%) showed a significant decrease in ring growth, and this was a small, suppressed sapling. The increase in ring growth for some trees was dramatic, often doubling, and several trees showed a quadrupling of ring growth. Two-thirds of the sample trees showed an increase in ring growth immediately after release, but some trees did not increase diameter growth until 10 to 15 years elapsed. The delay in release may be due to error in the estimated date of release, or from the shock of sudden removal of competition (McCaughey and Schmidt 1982). The period of significantly higher ring growth rates was more than 20 years for 30% of the sampled trees. The growth release did not seem to be linked to more favorable climate, as judged by a review of patterns of precipitation or growing season temperatures.

We then performed regression and correlation analysis of ring growth release with stand- and tree-level variables. This showed that pre-logging stand density and basal area were significantly related to the magnitude of ring growth release. Also, tree age and DBH were significantly related to duration (in years) of release and magnitude of growth release. We found that greatest release was in dense stands and in older, larger trees. Young trees and smaller trees did not release as well as the older, larger trees perhaps because the younger trees had developed under lower light conditions and did not have the morphology to take full advantage of the increase in light and resources after they were freed from competition.

The large magnitude and long duration of growth release for most sampled trees indicate that most whitebark pine can benefit from restoration treatments that remove competing species. Managers should consider advanced regeneration of whitebark pine as a possible source of recruitment in stands targeted for restoration.

Keane, R. E., and S. F. Arno. 1996. Whitebark pine (Pinus albicaulis) ecosystem restoration in western Montana. Pages 51-54 *in* S. F. Arno and C. C. Hardy, editors. The use of fire in forest restoration-- USDA Forest Service General Technical Report INT-GTR-341, Ogden, UT USA.

Keane, R. E. and S. F. Arno. 2001. Restoration concepts and techniques. Pages 367-400 *in* Whitebark pine communities: ecology and restoration. Island Press. Washington D.C. USA

McCaughey, W. W., and W. C. Schmidt. 1982. Understory tree release following harvest cutting in spruce-fir forests of the Intermountain West. USDA Forest Service Intermountain Forest and Range Experiment Station Research Paper INT-285, Ogden, Utah USA. 19 pages.

Sridharan, S., S. Vujic, and S. J. Koopman. 2003. Intervention time series analysis of crime rates. TI 2003-040/4, Tinbergen Institute, Amsterdam, The Netherlands. ■

Carlton Ridge Research Natural Area:
A Place to Study Whitebark Pine

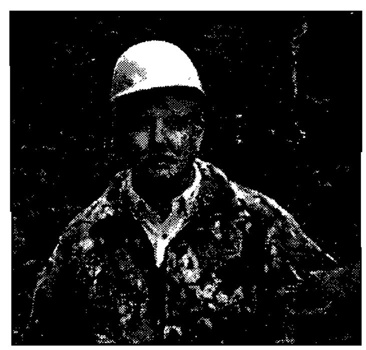
Steve Arno, WPEF editor

The proposed Bitterroot Resort ski area in the vicinity of Lolo Peak, promoted as a national attraction, would displace and eliminate the Carlton Ridge Research Natural Area (RNA), home of extensive stands of alpine larch and whitebark pine. Now it appears that the proposed resort and real estate development may instead produce the opposite outcome. As a result of extensive public comment, natural resource analysis, and a Forest Service study that found no need for another ski resort, the Lolo National Forest has proposed that the Carlton Ridge RNA be enlarged by about 60% to include the entire area originally proposed for RNA status by Forest Service researchers in 1973. This enlarged Carlton Ridge RNA would contain approximately 600 acres of whitebark pine communities, largely on well-developed subalpine soils. Although this RNA is best known for its alpine larch and alpine larch x western larch hybrid communities, it also represents an unusually good area for research on whitebark pine.

Carlton Ridge is the northern-most subalpine ridge of the 65-mile-long Bitterroot Range fault-block that extends southward from Lolo, Montana. Unlike the rest of this mountain range, the north-facing slope of Carlton Ridge was not scoured by Pleistocene glaciers. Thus, it retains a relatively well-developed soil mantle supporting unusually well-developed subalpine forest communities. The 946 acre RNA and its proposed 595 acre extension to the west (in section 23) covers most of the north slope of Carlton Ridge from its summit above 8300 feet in elevation, down to about 5800 feet. The uppermost 250 acres or so consists of alpine larch communities with whitebark pine as the secondary species, but with some whitebarks in a variety of ages including some 500+ year old trees (see figure). Below the ridgetop larch-dominated forest lies approximately 600 acres of whitebark pine communities extending down to about 7000 feet. Below that, down to about 6500 feet, whitebark pine has been a significant component of post-fire communities but has been largely replaced successionally by competing conifers.

The RNA has an unusually extensive area of well-developed whitebark pine communities covering a gradient from their lower to upper elevational limits. Mortality from blister rust and mountain pine beetle is substantial but not yet as severe as in some other areas. Proposed management being considered includes making provisions for allowing natural fires and using prescribed fire as a substitute. The western part as well as the crest of the RNA (the proposed addition) is accessed via a good hiking trail that begins at the 5800-foot roadhead at Mormon Peak saddle. Past research at this RNA has produced several publications and theses; but none of these dealt specifically with whitebark pine.

Persons wishing a list of the above publications or other general information about the RNA can contact me (arnos@mcn.net). Those inquiring about research possibilities and procedures should contact the Forest Service's regional RNA coordinator, Steve Shelly (sshelly@fs.fed.us). People wishing to see or express support for the Lolo National Forest's proposal to expand the RNA can find the information at [www.fs.fed.us/r1/wmpz]. The Lolo NF is accepting public comments on the proposal until the end of July. ■



An Interview with Ward McCaughey: WPEF's Associate Director

Editor's Note: Ward McCaughey is a Research Forester with the USDA Forest Service's Rocky Mountain Research Station, Missoula, MT

Editor: What sparked your interest in studying whitebark pine?

McCaughey: While hunting, fishing, and enjoying the beautiful mountain areas of Montana in the 1970s I started taking an interest in the big whitebark pines growing on ridges near timberline. While taking forestry classes at the University we briefly discussed whitebark pine in dendrology class, but never talked about it in other classes. After joining the Silviculture Research Work Unit at the Intermountain Forest and Range Experiment Station (now part of the Rocky Mountain Research Station) in the mid 1970s, I started working on forest management research projects. I had heard that whitebark pine was an important tree for wildlife habitat, but knew that it was little-known to forest managers. Still, because it was a non-commercial tree I never thought that I'd get the chance to study it in any detail. Then, in the mid-1980s my mentor Dr. Wyman Schmidt and I started talking about the need for better knowledge of this tree to aid forest management and understand its response to fire. Soon I began a Ph.D. project at Montana State University that examined regeneration processes in whitebark pine.

Editor: What did your early research reveal and what further questions did this raise about whitebark pine?

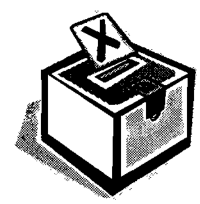
McCaughey: My early research showed that, unlike other western conifers, the seeds of whitebark pine could lay dormant in the soil or duff for up to at least three years after being planted and still germinate. I also found some interesting wildlife aspects of whitebark pine regeneration. Aerial seeding had been practiced for some conifers such as western larch and was a viable method for regenerating certain areas. I found that when whitebark pine seeds were scattered on the ground like the Forest Service does with other conifer seeds, the rodents ate 100 percent of them. Those big, juicy, pea-sized seeds were a prized morsel for most rodents. One question that came up on regeneration was, can we treat the seeds to reduce rodent predation? I didn't get a chance to work on this but John Schwandt has recently initiated a pilot study that should help answer this question.

Editor: What changes if any have you observed in the condition of whitebark pine in the Greater Yellowstone ecosystem?

McCaughey: I was in Bozeman working on whitebark pine studies yearly from 1987 to 2002. During that period I only saw a slow increase in the incidence of blister rust and mortality due to rust. Mountain pine beetle and wildfires caused more mortality during that period. Nevertheless, since rust infection has been slowly increasing I have seen a slow decrease in cone production in some of my study areas. With global warming I would have to believe that the rate of rust infection and resultant mortality and reduction in cone production will increase over time. This future loss along with the already high mortality from mountain pine beetle and wildfires may begin to have a significant effect on this important food source for grizzlies in the Greater Yellowstone Area.

Editor: Do you feel that artificial reforestation is a viable management tool for restoring whitebark pine communities?

McCaughey: Most definitely, especially if it involves planting of blister rust resistant varieties of whitebark pine seedlings. The early plantations of whitebark pine came from seeds collected in areas near the plantations and neither the parent trees nor the seedlings went through any type of formal rust screening. In those early years we were criticized for putting in those plantations because the trees were non-resistant to blister rust, but we felt that by planting trees in these high elevation environments we were gaining invaluable information. Also, there would probably be a low percentage of natural resistance in the planted population. These early plantations are now providing us with a matrix of planted sites that allow us to evaluate success of planting during different seasons and use of different planting techniques. It has taken several years of research and work in the nursery to finally produce seedlings that have rust resistant characteristics. Mary Mahalovich at the Forest Service's Coeur d'Alene nursery has done an excellent job in directing this work. What we have leaned from the early years of relatively inexpensive plantings will help guide managers in where, when, and how to plant the expensive and long-awaited rust resistant trees. ■



It's official! The Whitebark Pine Ecosystem Foundation bylaws have been approved.

Forty votes were received from the general membership by the January 2006 deadline and they were all in favor of accepting the bylaws. A few cards had comments about typos that needed correcting, but there was nothing of substance that necessitated another vote. The Board of Directors thanks everybody who took the time to read the bylaws and vote. And, we all thank Bob Keane, who wrote the draft bylaws and the other Board members who fine-tuned them!

Elections for major offices are scheduled for next year

With the ratification of the bylaws, a number of actions are now set in motion for the foundation, and one of the most critical actions is the election of Board Members and Executive Committee offices. The first election for the Foundation will be held next year, and it will be for the following positions: two board members, the Director, and Secretary. Nominations will be requested via *Nutcracker Notes* in the Fall-Winter issue, and those nominations will be due by January 1st, 2007 to the post office box. A slate of candidates will be published on a ballot in the spring-summer issue of *Nutcracker Notes* with the vote by the General Membership due on August 1, 2007. You are encouraged to nominate people for these offices by following the guidelines to appear in the next issue of *Nutcracker Notes*.

Dutton Fire, Crater Lake National Park - see Murray's article

Index to Nutcracker Notes, 1993-2005. Years 1993-2000 refer to the electronic newsletter. Beginning in 2001 *Nutcracker Notes* has been a biannual magazine. This is just a small portion of the index printed as a sample. The complete index is available at our web site (www.whitebarkfound.org), under publications. All back issues are on file at the University of Montana's Mansfield Library in Missoula.

Beetle-killed whitebark pine on Bonners Ferry Ranger District
-see Behrens article.

A 500+ year old whitebark pine among alpine larch atop Carlton Ridge - see Arno article.
S. Arno photo

Pedicularis and *Castillega*, the alternate/alternate hosts for rust
-see Zambino article.