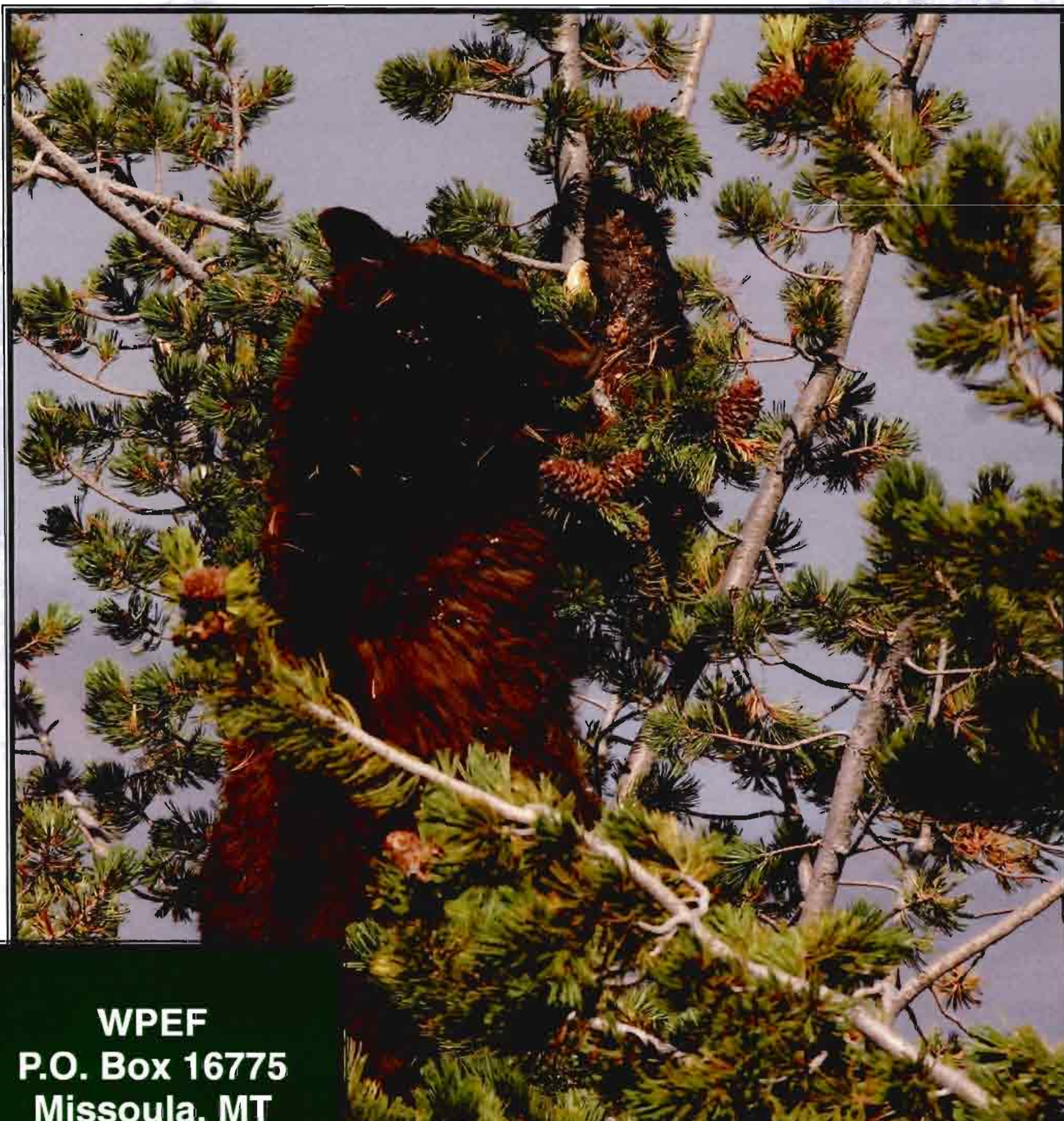
Issue No. 12: Spring/Summer 2007

Nutcracker Notes

Whitebark Pine Ecosystem Foundation



Black bear harvesting whitebark pine cones, Yellowstone National Park. Robert J. Weselmann photo [www.robertweselmann.com]

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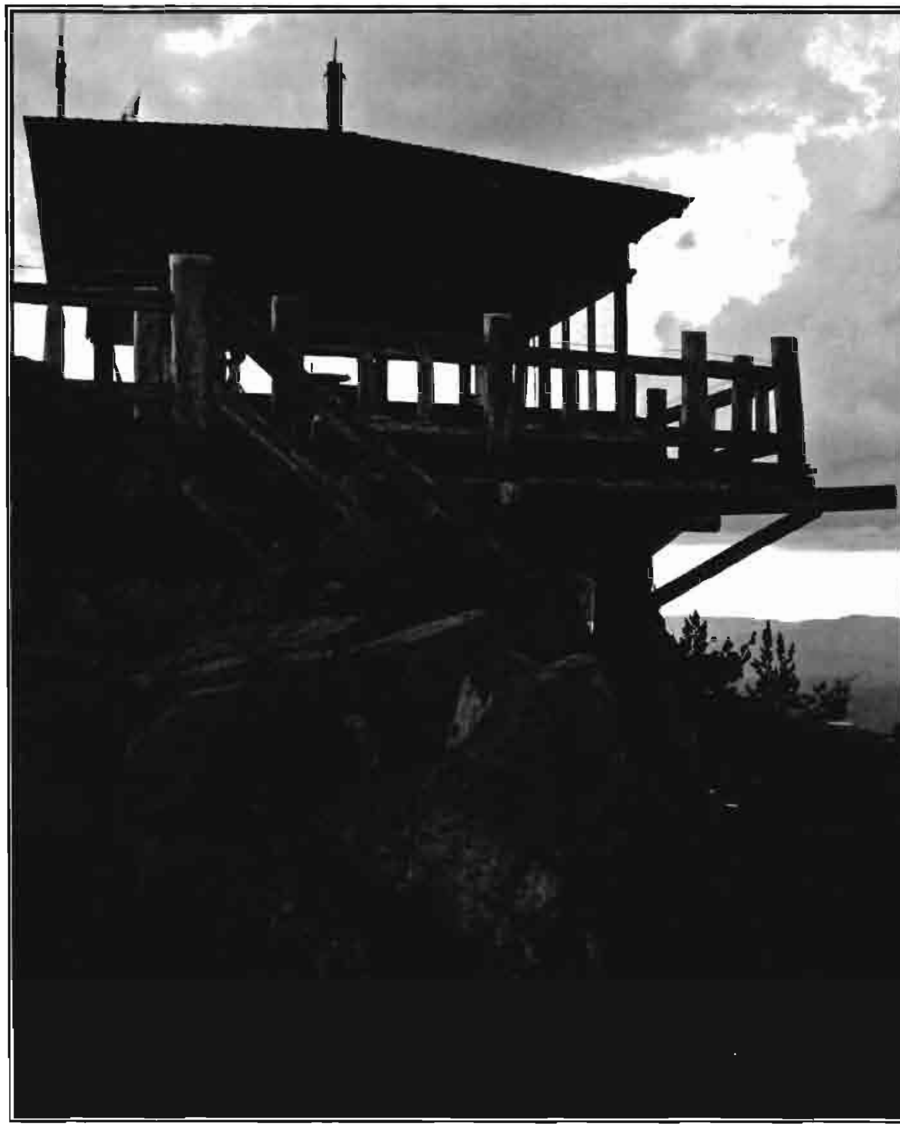

Watchman Lookout and whitebark pine. Rob Mutch photo [www.robmutch.com]

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Diana F. Tomback

Grizzly bear delisting and federal funding for whitebark pine

This has been an eventful year for whitebark pine. With the publication of the draft Grizzly Bear Delisting Rule by U.S. Fish and Wildlife in 2006, whitebark pine was pulled front and center into the ensuing controversy--"to delist or not to delist." There were numerous news reports evaluating the fate of the major grizzly bear foods in the coming decades, and especially the outlook for whitebark pine in the Greater Yellowstone Ecosystem (GYE). Whitebark pine seeds are an important pre-hibernation food for grizzlies. Although good cone crops occur only every few years, they have been correlated with female survival, cub productivity, and fewer adverse bear-human interactions. One especially well-written article by Charles Petit in the *New York Times*, "In the Rockies, Pines Die and Bears Feel It", discussed the threat of global warming and mountain pine beetles to whitebark pine, highlighting the work of Jesse Logan, a recently retired US Forest Service researcher. Petit and I talked by phone last fall for this article: I was quoted in the article as a representative of the WPEF concerning the threat posed to whitebark pine by the combination of blister rust, the pine beetle outbreak, and global warming.

Although the Delisting Rule was recently finalized, the heart of the controversy remains the question of future carrying capacity for the grizzly bear as whitebark pine populations are diminished by beetles and the spread of blister rust. Currently, an average of 25% of whitebark pine trees in the GYE are infected with blister rust, and the pattern of progression over time will lead to higher infection levels, greater damage to trees already infected, increasing mortality, and, consequently, diminished seed production, even as the mountain pine beetle kills tens of thousands of trees more each summer. Fish and Wildlife officials have addressed this scenario by stating that the foraging behavior of bears is highly opportunistic, and that they will find other foods to compensate for the diminishing whitebark pine populations. I defer to the experts as to availability of alternative foods for the grizzly bear, but I believe that the implementation of proactive whitebark pine restoration would help mitigate the uncertain future of food sources for the grizzly: If a new generation of blister rust-resistant whitebark pine were planted as the older trees succumbed to rust and beetles, there would be a more secure future for the bear.

Given the clear and growing need for whitebark pine restoration, it is unfortunate that the $800,000 whitebark pine restoration funding earmark in the Forest Service budget faded into the sunset, as Congress failed to pass a 2007 federal budget. When the federal budget went into Continuing Resolution, basically all earmarks not in the President's budget disappeared. I would like to pay tribute to Senator Conrad Burns for his strong support of whitebark pine restoration, and his invaluable help in bringing the funding request forward. I also wish to thank the current Montana Congressional Delegation, Senator Baucus, Senator Tester, and Representative Rehberg, and their staffers, for their support of whitebark pine restoration as well.

Funding for whitebark pine protection and restoration

Forest Health Protection (FHP), U.S. Forest Service, announced the availability of funds this past fall to protect high value whitebark pine against mountain pine beetles. This program was primarily aimed at trees identified as genetically-resistant or potentially resistant to white pine blister rust. It is our hope that these funds will be available again this coming fall. It is critical that all National Forests that are experiencing mountain pine beetle outbreaks request funding in a timely fashion to protect their "plus trees" the following summer.

In addition, FHP, Washington Office, provided $200,000 in competitive grant funding to Regions 1 and 4 for whitebark pine restoration. A Technical Committee was formed last fall by John Schwandt, FHP, Region 1, with broad representation, to draft guidelines for the competition; the committee also developed evaluation criteria and met late winter and again in spring to rank pre-proposals and proposals. Despite the very short time frame, more than 50 proposals requesting over a million dollars were received, showing the tremendous need for restoration. Of these proposals, 21 projects were recommended for funding representing a broad range of objectives that include silvicultural treatments, cone collecting, seedling planting, rust screening, monitoring burns for regeneration, and nursery projects to enhance seedling survival. These restoration projects will be initiated this field season.

The WPEF is currently fund-raising to match a grant from The National Arbor Day Foundation to make restoration funding available next year on a competitive basis. Regardless of outside funding sources, the WPEF will also contribute to this restoration partnership from its rather modest coffers. I urge all members to help us raise the ante by making a donation to our Restoration Fund.

WPEF board business

I would like to welcome, literally "on board", Ron Mastrogiuseppe. Ron was nominated and elected by the Board of Directors to replace Cyndi Smith when Cyndi became Associate Director last fall. Ron is a founding member of the Crater Lake Institute, which works in partnership with Crater Lake National Park. He lives in Oregon and has been an active member of the WPEF for several years and served as an inspirational force behind last summer's Pacific Coast whitebark pine symposium.

With respect to elections, this issue of *Nutcracker Notes* represents a milestone with our first-ever ballot enclosed for general membership elections. We are now dutifully following our by-laws, which the membership approved last year. Note that the ballot includes a few proposed changes to these by-laws which I am certain will require some tweaking here and there on an on-going basis. Please vote!

I would like to thank Anna Sala, University of Montana, and Jane Kapler Smith, USFS Fires Sciences Laboratory, for their continuing efforts on behalf of our Education outreach initiatives. Anna and Jane are designing educational materials to help us get the word out on whitebark pine to the general public. Jane's work on a whitebark pine display at the Montana Natural History Center was featured in the Fall/Winter 2006 issue of *Nutcracker Notes*. The WPEF has donated $500 to the Center to help support the completion of the display, with the unveiling anticipated for September, 2007.

WPEF's Annual Members' Meeting will be in Lincoln, Montana, September 28, 2007 (see accompanying article). Please join us for a day of science and management papers on whitebark pine, followed by two local day hikes to unique whitebark pine/limber pine communities. Have a great field season!

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WPEF's Annual Meeting & Field Trips Lincoln, MT, September 28-30, 2007

Please mark your calendar and plan to join us at Lincoln, Montana, near the Continental Divide, for an interesting venue of presentations on research and management of whitebark pine ecosystems and two spectacular field trips into mixed limber pine-whitebark pine habitats. Lincoln is a small scenic town nestled among stately old ponderosa pines at the head of the Blackfoot River on Highway 200 between Missoula and Great Falls—each 80 miles away. Lincoln is situated 60 miles west of Helena, and is surrounded by the Lincoln Ranger District of the Helena National Forest.

Sept. 28: Ranger Amber Kamps is co-hosting our Whitebark Pine/Limber Pine Science and Management Conference scheduled to begin at 8:00 a.m. on Friday, September 28th, followed at 4:30 p.m. by the members' meeting chaired by WPEF Director Diana Tomback. The conference is being held in the Community Center, a large log building on the north side of Highway 200 in "downtown" Lincoln, just east of Lambkin's Restaurant. Presentations currently scheduled include those listed below. The agenda will be updated on our web site (www.whitebarkfound.org). Inquiries should be directed to Bob Keane (rkeane@fs.fed.us).

Science emphasis:

- Blister rust in krummholz (D. Tomback);
- Blister rust in the Greater Yellowstone area (D. Reinhart);
- Situations that shout "watch out" in whitebark pine restoration (R. Keane);
- Creation of a coarse scale blister rust infection map (D. Helmbrecht);
- A rapid system for rating blister rust (D. Six);
- Status of whitebark pine in Crater Lake N.P. (R. Mastrogiuseppe).

Management emphasis:

- Whitebark pine restoration in the Idaho Panhandle N. F. (A. Zack);
- Condition of whitebark pine in the Cascades (L. Kurth);
- Forest Health Protection funding for whitebark pine (J. Schwandt);
- Blister rust on the Medicine Bow N.F. (H. Kearns);
- Carlton Ridge Research Natural Area—a place to study whitebark pine (S. Arno);
- Equipment for protecting whitebark pine cones for harvesting (Davies);
- Educational tools and exhibits for telling the whitebark pine story (J. K. Smith).

Sept. 29: Our featured field trip departs at 8 a.m. Saturday, September 29th, from the Ranger Station, on Highway 200 one mile east of downtown Lincoln. A moderate trail hike (2 miles) brings us to 6400-foot Lewis and Clark Pass, an area that looks much the same as in 1806 when Meriwether Lewis's small party crossed the Continental Divide here on their return to the Great Plains, in impressive view to the east. The pass is a wind-funnel site populated by krummholz forms of limber pine, whitebark pine, and other species. From here, we hike 2 miles south along the Great Divide trail to the top of Green Mountain (7450 feet) where we view and hear an explanation of the large restoration burn conducted recently by the Lincoln R. D. We return to the Ranger Station in late afternoon.

Sept. 30: Our optional field trip up "Flexicaulis Ridge" in the Red Mountain Research Natural Area is suitable only for those experienced in hiking up a long, very steep slope without a trail. Good hiking boots are necessary and a walking pole comes in handy. If you are interested, contact hike leader Steve Arno by the afternoon of September 29th. This hike departs from the Ranger Station at 8 a.m. Sunday, September 30th. From the mouth of Red Creek at an elevation of 5600

3:30 back Lincoln

feet, north of Lincoln, it ascends directly up the steep slope through the 2003 Snow-Talon wildfire to 7300-foot Flexicaulis Ridge on the shoulder of 9300-foot Red Mountain. This ridge has an extensive mixture of mature and young whitebark and limber pines as well as wind-swept fell-field vegetation and awesome views. We will be back in Lincoln by mid-afternoon.

Accommodations: Lincoln's restaurants and cafés have a reputation for uniquely great food, and several motels are available at moderate rates. WPEF's website will have information on accommodations and driving directions. Also, see the community's web site (www.lincolnmontana.com) for information about the community, accommodations, and area attractions. We do hope you will join us!

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Dues Increase to Aid WPEF's Mission

Bryan Donner

At their March 1, 2007, meeting board members unanimously approved a modest increase in dues for annual membership effective in fall 2007—the first increase since WPEF was established in 2001. Members at the Whitebark Level will be assessed $35 annually, up from $25. Student Members will be assessed $20, up from $15. All other membership categories will remain unchanged at current levels—Nutcracker ($75); Institutional ($150), and Grizzly ($1000). For an explanation of the levels and sign-up information, see [www.whitebarkfound.org].

The new rates become effective September 1, 2007. New members joining before that date pay the current rates. Renewals of current members will be assessed at the new rates. Memberships are for a fiscal year, October 1st through the following September.

The reason for the increase was the board's concern that the two lowest dues categories minimally contribute to restoration efforts after six years of increased printing, mailing, and other operating expenses. The board wants to support more restoration efforts on the ground, and hopes increased income from these two categories will help. In addition, the board reviewed annual dues for comparable organizations and determined the WPEF's least expensive memberships were some of the lowest dues in the country.

We hope this increase will not create a hardship for maintaining membership in the foundation. If you have any questions or concerns, please contact Membership Coordinator Bryan Donner [reindeer@centurytel.net].

WHITEBARK PINE IN WESTERN CANADA: a workshop on current research and management issues

August 21 - 24, 2007
Whistler, BC

The last several decades have seen the decline in whitebark pine, a keystone species of high-elevation forest ecosystems in western North America. Introduced disease (white pine blister rust), and fire exclusion that has favoured its competitors, are important culprits.

Warming climates are also making whitebark pine more vulnerable to mountain pine beetle outbreaks. The current outbreak, which is more widespread than ever documented, has killed whitebark pine throughout its geographic range in Canada.

The cumulative and interacting effects of introduced disease, altered natural disturbance regimes, and climate change are precipitating a massive decline of whitebark pine that will have cascading ecosystem effects.

WORKSHOP GOALS

- Foster communication among those doing research and conservation work on whitebark pine in British Columbia and Alberta
- Maintain strong connections with the network of researchers and land managers in the US
- Discuss ways to consolidate/co-ordinate whitebark pine work

WORKSHOP FORMAT

The workshop will include invited speakers, volunteer presentations, a field trip, and panel discussion. Invited and volunteer presentations may address a broad array of topics, including: status reports, general ecology, ecosystem resilience, population structure and genetics, physiology and reproduction, blister rust, mountain pine beetle, wildlife interactions with whitebark pine, and conservation challenges associated with mitigating the decline of whitebark pine.

Presentations will be Wednesday, August 22, and the morning of Thursday, August 23 followed by a field trip that afternoon.

Friday,August 24, we will meet in the morning for additional presentations followed by a panel discussion.

CONFIRMED SPEAKER

Diana Tomback, Ph. D.,
Professor Biology, Colorado University, Denver CO and
Director, Whitebark Pine Ecosystem Foundation
http://www.whitebarkfound.org/index.html

CALL FOR PRESENTATIONS

This announcement is the first call for presentations of about 20 minutes long. To be included in the program please contact:

Elizabeth Campbell:
Elizabeth.M.Campbell@gov.bc.ca or 250.387.6712

Room will be provided for posters, to review during break periods.

Location

Whistler BC will be the location of the workshop. Visit the following websites to preview all that Whistler has to offer:

http://www.whistler-bc.com/
http://www.tourismwhistler.com/

Listel Whistler Hotel http://www.listelhotel.com.

is the venue for the meeting and they are offering a great rate of $89.00 Canadian, per room, per night, single occupancy, subject to taxes. They have also extended the special rate to the evenings of August 20 and 25.

Registration details, including on-line booking for Listel Whistler Hotel will be available soon.

We look forward to seeing you in Whistler.

For more information contact:

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What's Hot in Whitebark Pine Publications?

Bob Keane, USFS, Missoula Fire Sciences Lab

There were several new papers published in the last few years that people interested in whitebark pine may find appealing. First up, John Schwandt's report on whitebark pine is an excellent reference for restoring whitebark pine:

Schwandt, J. 2006. Whitebark pine in peril: a case for restoration. Northern Region Report R1-06-28, USDA Forest Service, Missoula Montana USA.

Next, a paper by a cast of thousands put together an excellent reference for the consequences of loss of whitebark pine from the high elevation ecosystem:

Ellison, A. M., M. S. Bank, B. D. Clinton, E. A. Colburn, K. Elliot, C. R. Ford, and 12 others. 2005. Loss of foundation species: consequences for the structure and dynamics of forested ecosystems. Front Ecol Environ **3**:479-486.

Two studies contrasted high elevation conifer growth (includes whitebark pine) in the last 100 years with the last 1000 years and found a unique signature of climate change in the latter part of the 20th century.

Bunn, A. G., L. J. Graumlich, and D. L. Urban. 2005. Trends in twentieth-century tree growth at high elevations in the Sierra Nevada and White Mountains, USA. The Holocene **15**:481-488.

Millar, C. I., R. D. Westfall, D. L. Delany, J. C. King, and L. J. Graumlich. 2004. Response of subalpine conifers in the Sierra Nevada, California, USA to 20th-century and decadal climate variability. Artic, Antartic, and Alpine Research **36**:181-200.

Another study of timberline whitebark pine found that the species is very important for establishing other conifers at the alpine ecotone:

Maher, E., L., M. J. Germino, and N. J. Hasselquist. 2005. Interactive effects of tree and herb cover on survivorship, physiology, and microclimate of conifer seedlings at the alpine tree-line ecotone. Canadain Journal of Forest Research **35**:567-574.

Several recent publications have been released on blister rust in high elevation conifers and these are of direct use to management:

Kearns, H. S. J. 2005. White pine blister rust in the central Rocky Mountains: modeling current status and potential impacts. PhD Dissertation. Colorado State University, Fort Collins, Colorado.423 pages.

Vogler, D., and A. Delfino-mix. 2006. Genetic resistance to blister rust in limber pine. (I can't figure out the reference for this but can send a copy)

Kearns, H. S. J., and K. S. Burns. 2005. Distribution, incidence, and severity of white pine blister rust on the Medicine Bow National Forest. Biological Evaluation R2-06-01, USDA Forest Service, Golden, Colorado.

Howell, B., K. S. Burns, and H. S. J. Kearns. 2006. Biological evaluation of a model for predicting presence of white pine blister rust in Colorado based on climatic variables and susceptible white pine species distribution. Biological Evaluation R2-06-04, USDA Forest Service, Lakewood, Colorado.

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.

Here's the paper that documents the finding of new alternate hosts for the blister rust:

MacDonald, G. I., B. A. Richardson, P. J. Zambino, N. B. Kloppenstein, and M. S. Kim. 2006. *Pedicularis* and *Castilleja* are natural hosts of *Cronatium ribicola* in North America: a first report. Forest Pathology **36**:73-82.

Three reports have recently been published describing whitebark pine in Region 6 of the Forest Service (Pacific Northwest) and presenting methods for surveys and cone collections:

Ward, K., R. Shoal, and C. Aubry. 2006. Whitebark pine in Washington and Oregon: a synthesis of current studies and historical data. Report Feb 2006, USDA Forest Service Pacific Northwest Region, Portland, Oregon.

Shoal, R., and C. Aubry. 2006. Core data attributes for whitebark pine surveys. Report March 2006, USDA Forest Service Pacific Northwest Region, Portland, Oregon.

Ward, K., R. Shoal, and C. Aubry. 2006. Whitebark pine cone collection manual. Report March 2006, USDA Forest Service Pacific Northwest Region, Portland, Oregon.

Here is a general interest article that was recently published on whitebark pine:

Siepielski, A. M. 2006. What's a tree to do? Interactions between nutcrackers, squirrels, and bird-dispersed pines. Castilleja **25**:12-13.

The following article is an oldie but a goodie: a general description of whitebark and limber pine that is mostly wrong but worth reading:

Rockwell, F. I. 1911. The white pines of Montana and Idaho: their distribution, quality, and uses. Forest Quarterly **9**:219-231.

Here are two papers recently published by Bower on the genetics of whitebark pine:

Bower, A. D., and S. N. Aitken. 2007. Mating system and inbreeding depression in whitebark pine (*Pinus albicaulis* Engelm.). Tree Genetics and Genomes **11**:123-126.

Bower, A. D., and S. N. Aitken. 2006. Geographical and seasonal variation of cold hardiness in whitebark pine. Canadian Journal of Forest Research **36**:1842-1850.

These two articles slipped through the cracks so I thought I would list them now:

Pinol, J., and A. Sala. 2000. Ecological implications of xylem cavitation for several Pinaceae in the Pacific Northern USA. Functional Ecology **14**:538-545.

Trent, A., T. Kuhn, and K. Burr. 2005. Improved whitebark pine seed scarifier. Reforestation Tech Tips 0524-2331-MTDC, USDA Forest Service Technology and Development Program, Missoula, Montana.

This last article emphasizes the importance of whitebark pine to grizzly bears:

Schwartz, C. C., M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen. 2006. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the greater Yellowstone Ecosystem. Wildlife Monographs **161**:1-55.

Whitebark Trails: Watchman Lookout

Ron Mastrogiuseppe, Director,
Crater Lake Institute
http://www.craterlakeinstitute.com

[Editor's Note: This is the first installment of a series on favorite trails into whitebark pine habitats. Readers are invited to submit a write-up describing a favorite hike that features whitebark pine.].

If you would like to enjoy an eagle's view of the Crater Lake landscape, consider the Watchman Lookout Trail, only 1.6-miles with an elevation gain of 400 ft to the 8,025 foot summit. The hike begins along a section of the old 1916-17 Crater Lake Rim Road, which is now a walking path lying just above the existing Rim Drive on the west side of Crater Lake, opposite Wizard Island. This walk is so short, you may wish to hike the four miles from Rim Village along the gentle old rim drive to the trailhead. Deep snowpack accumulates along these routes, however, and often remains in scattered drifts into mid-July.

The historic lookout is described by the park historian: "The location for the Watchman lookout station was chosen . . . [because of its] commanding view of the western half of the park. . . completed in early 1932, it has served a dual purpose as lookout and trail museum. The flat-roofed first floor, walled by massive stones, houses a museum room for fire prevention data with an eight-foot plate-glass window overlooking the lake and also contained restrooms and a storage area--a somewhat unique arrangement for the first floor of a fire lookout and necessary primarily because of its accessibility to the public. The steel-framed second story, resting on only a portion of the irregularly-shaped first floor, is a four-sided, plate-glass-enclosed observation room. The roof of the observation room and the catwalk around it are of logs, enabling the tower to blend in remarkably well with the peak. After Mr. J.D. Coffman, Fire Control Expert, inspected the building he stated that he believed it to be the best fire lookout building in the United States."

The name, The Watchman, dates to 1886 when the U.S. Geological Survey was measuring the depth of Crater Lake and a surveyor (watchman) atop the peak plotted the sounding boat's location on the lake surface. The Watchman Trail is often littered with unopened whitebark pine cone and especially cone fragments as it meanders through a whitebark pine woodland to the summit. Whitebark pine graces many prime lake view points along the caldera rim, and provides the visitor with the opportunity to witness Clark's Nutcrackers harvesting seeds in the trees or retrieving old seed caches on the ground. Blue grouse are also seen in early morning or in the evening.

The trail head welcomes visitors with colonies of the showy western pasque flower amid magenta flowered penstemon. This area also features lupine and phlox among the scattered clumps and clusters of mountain hemlocks and whitebark pines. In addition to spectacular views of Crater Lake and Wizard Island, panoramic views of forested mountains spread far and wide. Dense fog often fills some of the deep valleys visible to the west. Immediately, below the lookout to the west the forest canopy is broken by pumice fields dotted with tree atolls featuring ancient snags of whitebark pines now enveloped by mountain hemlocks or subalpine firs that became established under the isolated pines.

During the summer and early autumn of 2006, the largest prescribed natural fire to burn in Crater Lake N.P. history was underway, and its burn pattern can be viewed from the lookout. Called the Bybee Creek Fire Complex, it was permitted to burn approximately 2930 acres under monitoring until cold, wet weather suppressed it. The fire was contained below Rim Drive, but under more critical fire weather (with high winds and low humidity) might have threatened the historic lookout with its wood shingled roof, and also might have spotted (from air-borne embers) to Wizard Island. This fire event has expanded open pumice fields and dry meadows and provided a diversity of habitats for studies of future conifer regeneration especially for seed caches of whitebark pine. The Watchman Trail is a great location to contemplate both spectacular sunsets and a rising moon amidst the beauty of the volcanic landscape that arose from total devastation when Mt. Mazama exploded 7700 years ago.

One of my first memories of this place was spending nights in the lookout and being awakened during the dawn as large flocks of Clark's Nutcrackers were busily opening whitebark pine cones. The sight and sounds are indelible even though this experience happened 44 years ago!

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An Interview with Dan Reinhart: Resource Management Coordinator, Yellowstone N.P., and WPEF Board Member

Editor: What first sparked your interest in whitebark pine?

Reinhart: In 1984 I was as a biological technician working on food habits and habitat use for the Interagency Grizzly Bear Study Team in the Greater Yellowstone Area (GYA). I initiated a study conducting annual linear transects of red squirrel sign (i.e., sightings, vocalizations, middens, etc.) and bear activity. It became apparent that bears sought out whitebark pine seeds from red squirrel cone caches. Thus, both whitebark pine and red squirrels seemed to be important to the welfare of grizzly bears, clearly suggesting interesting relationships that warranted further investigation.

Editor: When did you and your colleagues recognize that blister rust might become a threat in the Yellowstone ecosystem?

Reinhart: When I first worked with whitebark pine in the mid-1980s, I was confident that the overall health of whitebark pine in the GYA was in great shape. I was aware of white pine blister rust, since a few buildings in Yellowstone National Park remain from the old blister rust control days in the 1940s and 1950s. For a long time I believed the prevailing wisdom that the climate in the GYA was not conducive to extensive blister rust infestation. However, our program initiated in 2004 to systematically monitor whitebark pine health has found an overall rust infection rate of 25 percent, clearly an increase from 1990s and earlier surveys.

Editor: Suddenly it appears that mountain pine beetle epidemics exacerbated by global warming may pose a devastating threat to whitebark pine in the GYA. What is your take on this?

Reinhart: Recent mountain pine beetle outbreaks in whitebark pine in the GYA are certainly a cause for concern. A coordinated series of aerial detection flights in the GYA in 2005 by Forest Health Protection concluded that 171,200 acres or approximately 16 percent of whitebark pine dominated stands had some level of recent beetle -caused mortality. Entire stands and drainages of dead whitebark pine trees appear in some areas. Assessing the long-term threat is complex, however. Mountain pine beetle is a native organism that may be part of a natural disturbance regime for native pine species. The recent series of drought years has certainly led to this recent endemic, of not only mountain pine beetle in whitebark pine, but for other conifer species showing major hits of insect-caused mortality. History tells us that we had a major epidemic of mountain pine beetle in whitebark pine in the 1930s, so there is precedent for viewing today's outbreak as a natural disturbance. What troubles me the most is the tandem hit on whitebark pine from mountain pine beetles and the introduced white pine blister rust. Also, what if human-aided global warming contributes to continuing conditions that favor beetle attacks.

Editor: What do you think the future holds for whitebark pine in the GYA?

Reinhart: Throughout its range, I am concerned about the future of whitebark pine. In the Yellowstone ecosystem, while I remain concerned, I also have a few reasons to be cautiously optimistic:

(1) Although blister rust is present throughout whitebark pine in the GYA, it appears so far at lower levels as stem cankers with smaller, more terminal limbs affected. We have not seen very much rust-caused mortality and the number of cankers per tree remain relatively low. I do realize that given the nature of blister rust, it will continue to grow and worsen over time. But I also think that we have an opportunity to work toward restoration efforts before it gets to be a major problem.

(2) We have recently lost a significant amount of whitebark pine due to pine beetle attacks. While there may very well be cause for concern due to recent climate change, I also hope that this infestation will cycle through and diminish. In truth, I remain more concerned about a non-native and more incipient pathogen such as blister rust. An important GYA effort is to work toward protecting potentially rust resistant trees from beetle attacks.

(3) Kate Kendall has made the point that due to white pine blister rust, whitebark pine may not necessarily disappear but can become "functionally extinct." Tree tops are damaged even in surviving whitebarks and cone production plummets so that cones no longer provide important forage for wildlife, nor is their successfully regeneration. Fortunately, whitebark pine currently remains an important component of the Yellowstone ecosystem. Because of that, we have a temporal window to take advantage of the natural ecological processes to help managers in our restoration initiatives.

(4) One of my most important reasons for my optimism is the interagency collaboration that managers in the GYA have demonstrated toward whitebark pine management. There has been a whitebark pine subcommittee as part of the Greater Yellowstone Coordinating Committee for over a decade. Each year, managers meet to discuss collaborative strategies to monitor, and move toward restoration strategies of whitebark pine. The GYA was one of the first whitebark pine seed zones to complete identification and cone collection for the Plus Tree Program to propagate seedlings and develop rust resistant tree stock. Recently, the GYA whitebark pine subcommittee collaborated in putting forth funding initiatives for whitebark pine restoration projects. We are committed to work together to understand the threats to whitebark pine, the ecological consequences of doing nothing, and to develop collaborative strategies to move forward in maintaining and restoring this critical element of the Yellowstone ecosystem.

Disturbance Interactions: Mountain Pine Beetle & Blister Rust in Whitebark Pine

Nancy Bockino – Master's Candidate
(nbockino@uwyo.edu) and
Daniel B. Tinker (academic advisor)
University of Wyoming, Department of Botany
Expected Defense Date: December 2007

Introduction

Whitebark pine (*Pinus albicaulis* Englem.) is a keystone species of many high elevation ecosystems in the Greater Yellowstone Ecosystem (GYE) and directly influence watershed quality by regulating snow accumulation and retention, facilitating regeneration after a disturbance, and stabilizing soil and rock on steep, harsh sites.

Historically, the principle source of cyclic tree mortality in whitebark pine ecosystems was the mountain pine beetle (MPB; *Dendroctonus ponderosae* Hopk.). Periodic epidemics of bark beetles result in widespread tree mortality and are an important component of stand dynamics. The current beetle activity in the Greater Yellowstone is at epidemic levels, driven by high densities of both susceptible host trees and beetles.

In contrast to the MPB, blister rust (*Cronartium ribicola* Fisch.) is an exotic pathogen and a continuous source of disturbance, rather than cyclic. Paramount to the influence of this fungus is a severe reduction in whitebark pine recruitment due to the loss of cone production and extensive damage to seedlings and saplings. Blister rust is continuing to spread throughout the GYE , and due to its perpetual presence, is considered the most damaging agent to whitebark pine.

Because the current decline of whitebark is unprecedented, my master's research seeks to quantify the interactions between blister rust and the MPB. It is not known how the following variables influence this species' susceptibility to the MPB: 1) presence of an alternate host, specifically lodgepole pine (*Pinus contorta* var. *latifolia*); 2) severity of white pine blister rust; or 3) variable whitebark pine density due to diffusion by non-alternate host species. An enhanced understanding of these questions could support successful preservation strategies for this critical and charismatic high elevation conifer.

Research Project

During the summer of 2006, I collected data from four study sites in the GYE with the help of two dedicated field assistants Michael Straw and Ryan Simms. Four sites were selected based on the presence of MPB and biophysical characteristics through the use of Forest Health Protection aerial surveys, personal field reconnaissance, and cooperation with National Forest and Park Service personnel.

At three of the four sites, two stand types were identified based on overstory conifer species composition. These different stand types assist in the determination of the roles tree density and a "diffusion-effect" by non-host species (*Abies lasiocarpa* Hook. and *Picea engelmanni* Parry.) play in the susceptibility of an individual whitebark pine to selection by the MPB within this sites. Blister rust was present on all three sites and in both stand types. The fourth study site, Sylvan Pass, is dissimilar from the above three sites because blister rust is absent, and whitebark and lodgepole pine are growing is association as codominant canopy species. This site was examined to determine the role of host species in selection by the MPB.

At each stand, 24 temporary angle point sampling plots, using a metric basal area factor of 2.0, were systematically established to collect both tree and plot level data. Tree data collected included species, diameter at 1.3 meters, live or dead status, cone presence or absence, average number and size of pitch tubes, crown needle color, and blister rust severity (Six & Newcomb 2005). Plot data included location, elevation, slope, aspect, and topographic position.

Data analysis incorporates several statistical techniques. Non-parametric chi-square analyses were utilized to test the statistical significance of the differences in frequency of a given characteristic (such as tree diameter and blister rust severity) for bivariate tabular data (SAS Institute, 2006). Selection ratios provide a probability of use for a specified host characteristic, and are calculated by determining the frequency of occurrence of MPB in habitat A compared to the frequency in habitat B (Manly et al. 1993). In this case, dissimilar MPB habitats are defined by individual whitebark pine host characteristics. For example, selection by MPB for whitebark pine with heavy blister rust was compared to the selection of trees with light blister rust. Selection ratio analyses complimented the chi-square analyses by accounting for stand density, species composition, epidemic intensity, and temporal sequence of attack. Logistic regression was used to describe a dichotomous discrete response (selection by MPB or not) as a function of tree and stand variables (Minitab Release 14.1, 2007).

Preliminary Findings

The overall condition of the whitebark stands sampled in this study provides a perspective on the severity of the disturbances currently impacting whitebark pine in the GYE. Roughly one half of the whitebark pine sampled in this study are dead, 70% have been attacked by MPB, and 85% have at least one blister rust symptom.

Our data provide evidence that at Sylvan Pass the MPBoutbreak began in the whitebark pine, which were preferentially selected over lodgepole pine throughout the progression of the epidemic.

In addition, beetle activity was greater in trees with greater blister rust severity. Therefore, we conclude that host tree species and blister rust severity influence individual tree selection by MPB.

Acknowledgments

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References

Manly, B. F. J., McDonald, L. L. & Thomas, D. L. 1993. Resource selection by animals. London: Chapman & Hall.

Minitab, 2007. State College, Pennsylvania. Version 14.1.

SAS Institute, 2006. Cary North Carolina, Version. 9.3.1.

Six, D.L. & Newcomb, M. 2005. A rapid rating system for rating white pine blister rust incidence, severity, and within-tree distribution in whitebark pine. Northwest Science, 79(2&3):189-195.

Ecological genetics of whitebark pine

Andrew Bower

Conservation and restoration efforts are needed to reverse the declines in whitebark pine due to blister rust, pine beetle, and the effects of fire suppression. However, until now, almost nothing has been known about the genetics of quantitative traits of whitebark pine to help direct these efforts. Differences in these traits are more likely than differences in molecular markers to reflect the effects of natural selection and will determine how well adapted a population is to its local environment. Therefore this information is crucial for any type of management program because its success is likely to be influenced by the degree to which planted seedlings are adapted to the local environment. For my Ph.D. thesis research at the University of British Columbia, I utilized a near range-wide seed collection to address these questions for a suite of quantitative traits, and a used a genetic marker analysis to investigate the mating system of whitebark pine and the effects of inbreeding and white pine blister rust on genetic diversity.

A common garden experiment was used to assess rangewide genetic diversity and geographic differentiation of quantitative traits, and to determine the climatic variables driving local adaptation. Seedlings grown from seed from 48 provenances (individual locations) that covered much of the range of the species (Fig. 1) were grown for two years in raised beds on the University of British Columbia campus in Vancouver, B.C. The seedlings were grown in two soil temperature treatments (ambient and cooled), and measured for height increment, biomass, root:shoot ratio, date of needle flush, fall and spring cold injury, and survival. Significant variation among provenances was detected for all traits except spring cold injury. Interestingly, means for both height growth increment and survival were higher in the cold treatment than in the ambient treatment. The environment on the UBC campus, where the common garden experiment was grown, was considerably warmer than whitebark pine's native habitat. Although this warmer soil would enhance growth for most tree species, for whitebark pine, since it is adapted to cold, harsh environments, the warmer soil temperature was more stressful, even with the soil kept moist.

Geographic differentiation (calculated as Q_{ST}) was weak (0.07-0.14) for growth traits (height increment and biomass) and moderate (0.36-0.47) for cold adaptation related traits (date of needle flush and fall cold injury). For all traits Q_{ST} was greater than previously published estimates based on molecular markers (F_{ST}), indicative of local adaptation. Cold adaptation traits were strongly correlated with winter temperature (mean temperature of the coldest month) of source locations, while growth traits were correlated with the length of the growing season. A multivariate analysis was used to determine the rate of change in the quantitative traits relative to a climatic variable . This rate of change was then compared with the trait values separating genetically different populations in order to determine guidelines for seed movement in whitebark pine management and restoration. Based on these results, it was determined that seed can be moved within areas differing by approximately 1.2°C, which is equivalent to 3 degrees in latitude, with minimal risk of maladaptation.

The predicted increases in temperature will push whitebark pine beyond the geographic limits to which is locally adapted and will likely result in a dramatic reduction in suitable habitat, potentially decreasing genetic diversity. It is likely that with global warming, whitebark pine will shift both northward and higher in elevation, tracking the niche in which it can survive and be competitive. Restricting movement of seed to the south may provide a buffer against future climate warming. Therefore, movement of whitebark pine seed should be restricted to 3° to the north and 1° or less to the south, in order to minimize maladaptation in current and future environments. Ideally, restoration activities should attempts to utilize seed from within the local provenance or the nearest provenance possible.

Mating system and inbreeding depression in quantitative traits was determined using genetic markers (isozymes) in conjunction with the seedling common garden experiment. Marker analysis of seeds tissues of families in three distinct geographic regions (Oregon, Montana, and southern British Columbia) was used to estimate parental and offspring inbreeding coefficients. Quantitative trait family means of seedlings from the same families growing in the common garden experiment were regressed on the estimated inbreeding coefficient to determine the presence and magnitude of inbreeding depression. Regional estimates of inbreeding ranged from 7 to 27%, with a mean over all regions of 14%. This is slightly higher than most wind-pollinated conifers, which typically have inbreeding rates less than 10% (Ledig 1998). Family mean inbreeding coefficients indicated predominant outcrossing, however, some individuals experienced substantial inbreeding. Biomass in the ambient temperature treatment for the southern B.C. region was the only trait significantly related to inbreeding coefficient. The mean inbreeding coefficient for this region was 25%, and based on this relationship, mean predicted biomass would be reduced by 19.6% in this region if inbred individuals are not removed by selection.

Isozyme analysis of bud tissues was used to investigate the associations of inbreeding and blister rust infection with genetic diversity. The isozyme analysis was used to determine genetic diversity (measured by observed heterozygosity: H_o) and inbreeding (measured by the fixation index F_{is}) for three age cohorts (seedling, young, and mature), sampled from 14 sites located in British Columbia, Oregon, Idaho, and Montana. Comparison of genetic diversity parameters among cohorts within a site was used to assess the extent and persistence of inbreeding with age, while comparisons of parameters among sites within a cohort were used to assess the impact of the disease on genetic diversity. Significant evidence of inbreeding (F_{is}>0) was found in all age cohorts. When sites were stratified by level of blister rust infection (low, moderate, and high), differences in F_{is} and H_o among cohorts were only significant when level of infection was low. A significant negative association was found between level of blister rust infection and H_o in the mature cohort. This suggests that when differential selection due to blister rust is weak, more heterozygous (less inbred) individuals may be favored. However, more homozygous (more inbred) individuals may have higher fitness under higher blister rust levels. The relationship between H_o and level of blister rust infection suggests that the apparent higher fitness of more homozygous individuals when challenged by blister rust may be due to recessive genes for resistance being expressed under inbreeding.

These results and others are described in greater detail several publications, two of which are already in press (Bower and Aitken 2006 and 2007) and three more are forthcoming. I would like to thank my supervisor, Dr. Sally Aitken, for her support and guidance throughout this project. Funding for this study came from the British Columbia Forestry Investment Account through the Forest Genetics Council of B.C. to the Centre for Forest Gene Conservation.

References:

Bower, A.D. and S.N. Aitken. 2006. Geographic and seasonal variation in cold hardiness of whitebark pine. Can. J. For. Res. 36:1842-1850.

Bower, A.D. and S.N. Aitken. 2007. Mating system and inbreeding depression in whitebark pine (*Pinus albicaulis* Engelm.). Tree Genetics and Genomes. DOI: 10.1007/s11295-007-0082-4.

Ledig, F. T. 1998. Genetic variation in *Pinus*. Pages 251-280 *in* D. M. Richardson, editor. Ecology and biogeography of *Pinus*. Cambridge University Press, Cambridge.

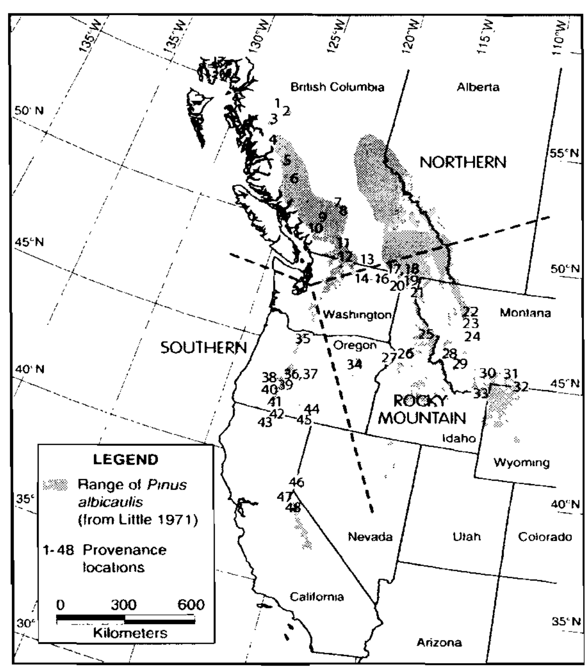

Figure 1. Distribution of whitebark pine and locations of provenances tested in common garden experiment. Dashed lines separate the Southern, Rocky Mountain and Northern regions.

Climate-related changes in the vulnerability of whitebark pine to mountain pine beetle outbreaks in British Columbia

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INTRODUCTION

Populations of mountain pine beetle are currently at epidemic levels in British Columbia (BC) and approximately 9.2 million hectares of pine forest have been killed by the beetle to date (British Columbia Ministry of Forests & Range, 2006). Warming climates seem to be expanding the northern limits of mountain pine beetle's range in BC (Carroll et al. 2004; 2006), and are probably creating more suitable habitat for the establishment and persistence of beetle populations at higher elevations. This means that high-elevation whitebark pine forests may be more vulnerable to beetle outbreaks than ever before. Whitebark pine is already declining due to white pine blister rust infections and forest management activities that favour more competitive tree species. The added pressure of more widespread mountain pine beetle outbreaks is likely to exacerbate the decline of whitebark pine. Decline of this keystone species will have substantial effects on large-scale ecological processes like vegetation succession and pose a threat to animals like the Clark's nutcracker and the grizzly bear, which rely on it's high-fat seed for food.

The objective of this work was to use existing models describing climate effects on beetle establishment and persistence to assess how the suitability of mountain pine beetle habitats has: i) changed throughout the range of whitebark pine from 1931 to 2000 and ii) how it is projected to change several decades into the future.

METHODS

Using empirical relationships of the direct and indirect influences of climate on mountain pine beetle (Safranyik et al., 1975) in combination with a spatially explicit, climate-driven simulation tool [BioSIM (Régnière et al., 1996)], Carroll et al. (2004) produced landscape-wide projections of climatically suitable beetle habitat. Six variables describe climatic thresholds for beetle survival, development, and dispersal as well as host susceptibility, in 64 ha grid cells covering British Columbia: i) presence of 833 degree days above 5.5°C ii) presence of minimum winter temperatures greater than -40°C; iii) presence of August temperatures ≥ 18 °C; iv) presence of greater than average April-June precipitation; v) variability in growing season precipitation; and vi) an index of aridity (Carroll et al. 2006). The climate suitability indices produced from these variables were calculated for each grid cell and assigned to one of five climate suitability classes (CSC) indicating very low, low, moderate, high and extreme risk of a beetle outbreak. Historical weather records were used to project climate suitability from 1931-2000, and a climate change scenario assuming a doubling of atmospheric CO_2 by 2100 (Flato et al., 2001) was used to project climate suitability from 2001 to 2070. The projections were mapped (based on 30-year climate normals) in ten-year increments from 1931-60 to 2041-70 (Fig. 1). These projections were used to assess changes in the distribution of suitable beetle habitat within the range of whitebark pine through time, and formed the basis for assessing the potential impacts of climate change.

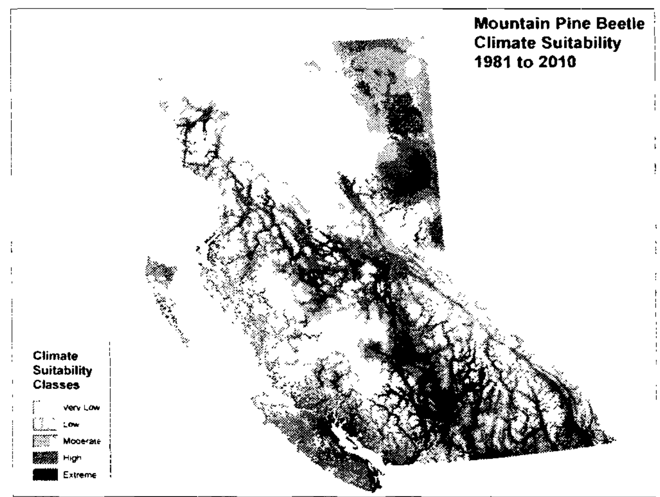

Fig. 1. An example of a landscape-wide projection of climatically suitability habitat for for mountain pine beetle between 1981 and 2010 in British Columbia.

Arc/Info GIS was used to query the BC provincial forest inventory database for all stands containing whitebark pine. The resulting map describing geographic range of whitebark pine in BC was intersected with each of the 12 maps projecting climate suitability. The intersection of these files produced a database that classified the entire range of whitebark pine according to past and future risk of beetle outbreak. The percentage of whitebark pine's range covered by each of these climate suitability classes in each time step was summarized from this database.

RESULTS

We found substantial temporal changes in the risk of mountain pine beetle outbreaks in high-elevation whitebark pine ecosystems (Figure 2). Warming climates are and will continue to increase the risk of mountain pine beetle outbreaks throughout the geographic range of whitebark pine in British Columbia. The greatest changes occur in the percentage of whitebark pine's range at low, high, and extreme risk to beetle outbreaks. The area of whitebark pine's range at very low risk to beetle outbreaks was projected to decrease by about one third from 1981 to 2010, and then again by another third by 2070 (Fig. 1). Even more significant was the shift in the percentage of whitebark pine's range at high and extreme risk to beetle outbreaks. The percentage of whitebark pine's range at high risk to beetle outbreaks was projected to double between 1981and 2010, and then double again between 2001 to 2070 (Fig. 2). Projected changes in the percentage of whitebark pine's range at low to moderate risk to beetle outbreaks was less dramatic.

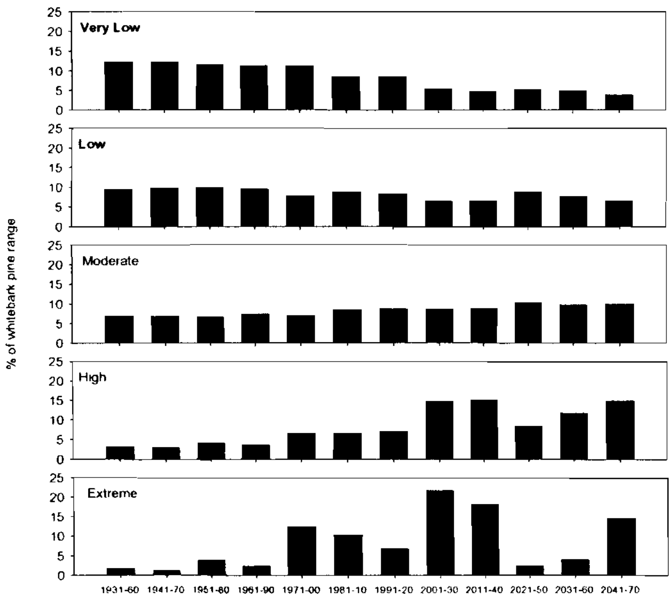

Figure 2. Temporal changes in the percentage of whitebark pine`s geographic range at very low, low, moderate, high and extreme risk to beetle outbreaks.

PRELIMINARY RESULTS FROM CONTINUING WORK

Expansion of beetle outbreaks throughout the range of whitebark pine – We have summarized documentary archives of beetle infestations on whitebark pine. Field data indicate scattered infestations from 1928 to 1946. Annual aerial surveys of insect and disease conditions, which have occurred in British Columbia since 1959, show localized infestations in whitebark pine forests almost every year from 1973 to present. More widespread beetle outbreaks occurred in whitebark pine forests from the mid-1970s to the mid-1980s and the current outbreak began in 1999. As of 2006, mountain pine beetle has infested ~10% of whitebark pine's geographic range. This is already more than triple the extent of the last outbreak in whitebark pine ecosystems and outbreaks are now occurring in the northernmost limits of whitebark pine's range in BC. To assess the apparent shift in the climatic suitability of whitebark pine forests since 1960, we are currently overlaying aerial survey data with climate suitability projections for 1941-1971. We expect to find that infestations have become more abundant with time in whitebark pine forests previously considered very low to moderately suitable for the beetle.

Field studies - During the summer of 2006, we visited 8 whitebark pine forests where model projections indicated high to severe risk of beetle outbreaks. All stands had beetle infestations. While beetle outbreaks have been present in some stands for about 6 years and has already killed many mature whitebark pines, others infestations occurred last year and trees were beginning to die this year. We collected increment cores from long dead whitebark pine (when they occurred) and other species to determine the timing of previous beetle outbreaks. Tree ages, abundance by diameter class and species, and regeneration information collected in the field will be used to describe past and potential future successional trajectories in response to beetle disturbances. On at least 10 whitebark pine per stand, we also assessed beetle attack densities, brood success, and voltinism. Preliminary results suggest that attack densities were greatest in the hottest and driest parts of whitebark pine's range and that beetle brood success was greater and development faster on the southern sides of whitebark pine trees. The presence of brood in all stages of development (L1 to L4, and pupae) at a single point in time suggest semi-voltine life-cycles in most stands.

Acknowledgements

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References

British Columbia Ministry of Forests and Range. 2006. Summary of Forest Health Conditions in British Columbia. BC. Min. For. Rge. Victoria, British Columbia.

Carroll, A.L., Taylor S.W., Régnière, J., Safranyik, L. 2004. Effects of climate change on range expansion by the mountain pine beetle in British Columbia. Pp. 223-232 *In* T.L. Shore, J.E. Brooks, and J.E. Stone, Editors. Mountain pine beetle symposium: Challenges and solutions, October 30-31, 2003. Kelowna, British Columbia, Canada. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, British Columbia, Information Report BC-X-399. 298 p.

Carroll, A.L., Regnière, J., Logan, J.A., Taylor, S.W., Bentz, B. J., Powell, J.A. 2006. Impacts of climate change on range expansion by the mountain pine beetle. Mountain Pine Beetle Initiative Working Paper 2006-14. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre. Victoria, British Columbia. 20 p.

Flato, G.M., Boer, G.J. Lee, W., McFarlane, N. Ramsden, D., Reader, M., Weaver, A. 2000. The Canadian Centre for Climate Modelling and Analysis global coupled model and its climate. Climate Dynamics 16: 451-467.

Régnière, J., Cooke, B., Bergeron, B. 1995. BioSIM : A computer-based decision support tool for seasonal planning of pest management activities. User`s manual. Canadian Forest Service Information Report LAU-X-116.

Safranyik, L., Shrimpton, D.M., Whitney, H.S. 1975. An interpretation of the interaction between lodgepole pine, the mountain pine beetle and its associated blue stain fungi in western Canada. Pp. 406-428 *In* D.M. Baumgartner, Editor. Mangement of lodgepole pine ecosystems. Washington State University Cooperative Extension Service, Pullman, WA.

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Blister Rust Infection Rates on Whitebark Pine in Washington's National Parks

Laurie Kurth, USFS, Missoula Fire Sciences Lab

Mount Rainier (MORA), North Cascades (NOCA), and Olympic (OLYM) national parks in Washington State support populations of whitebark pine (*Pinus albicaulis*). In all three parks, whitebark pine is just at or above forest line at high elevations in relatively open stands with subalpine fir (*Abies lasiocarpa*) and Engleman spruce (*Picea englemanii*). In Olympic National Park, whitebark pine is limited to three populations east of Mount Olympus, and trees are often found in a clumped formation where individuals are difficult to distinguish. In the Cascade Mountains, whitebark pines are generally distinct individuals. They occupy the eastern portion of North Cascades National Park. At Mount Rainier National Park, whitebark pine is found primarily in the drier northeast portion of the park; however, there is one disjunct population in the park's southwest corner.

Original population surveys of whitebark pine were completed in the twentieth century with some blister rust information noted. Recently the parks completed additional blister rust surveys and collected cones and needles to test for rust resistance with the potential for active restoration. Surveys of three stands were completed in Olympic National Park using transects that varied in length. Circular 0.4 ha plots were randomly located in populations at Mount Rainier and North Cascades National Parks. Populations at Mount Rainier were selected randomly while those at North Cascades were selected based on accessibility. All trees greater than 1 inch in diameter were measured and all saplings less than 1 inch diameter were tallied. The health of whitebark pine trees was noted including blister rust cankers, flagging, and dead needles.

Overall, thirty-two stands were surveyed with more than 2000 trees, 1200 saplings, and 260 tree clumps included. Trees were distributed across size classes with smaller trees having the greatest representation.

Blister rust infection rates varied by stand and by tree size classes. At Olympic National Park, 32, 28, and 4 percent of tree clumps were infected in the three stands. The four percent infection rate was much lower than average for western Washington. However, field observations by Steve Arno (pers. comm.) suggest that rust damage to whitebark pine at Olympic was already extensive in 1964 and thereafter resulted in heavy mortality; thus the populations we measured might be viewed as remnants that perhaps exhibit higher-than-average rust resistance. In Mount Rainier and North Cascades, blister rust was present in 97% of all stands examined. Twenty-two percent of the trees were infected with blister rust; thirty percent of the trees were dead while forty-eight percent of the trees showed no signs of blister rust. Trees at North Cascades NP had higher incidence of blister rust infection and a larger percentage of the larger trees were dead (figure 1).

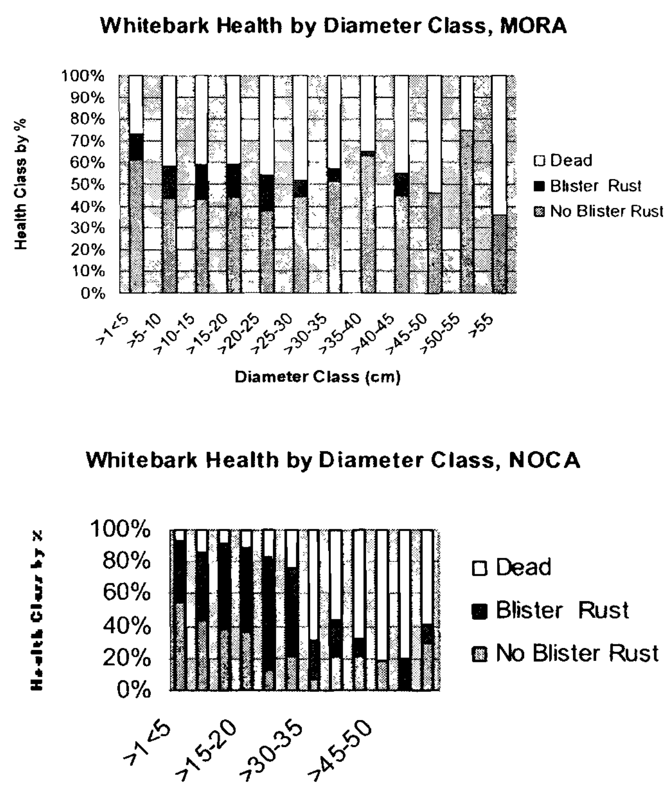

Figure 1. Health of whitebark pine in North Cascades and Mount Rainier National Parks

Statistical analysis of infection and mortality rates showed that infection rates increase to the east and increase somewhat with elevation while mortality decreases with elevation. Latitude had little effect on mortality or infection and there was no statistical difference between the two parks; however, overall mortality was slightly lower at North Cascades NP.

Blister rust is well established in whitebark pine communities in the Pacific Northwest. While all stands exhibited infection, there is some apparent resistance as well. But blister rust is not the only potential threat. Lack of fire and global climate change may lead to competition from other species. Long-term monitoring established for the three national parks will be critical to determine the outlook for the species. Active restoration is also being considered. In Mount Rainier National Park several hundred seedlings were planted in 2006 in an old campground that has been undergoing restoration since its abandonment in 1972. The project is taking advantage of excess seedlings grown in resistance trials, but the results from this project will help determine the potential for additional restoration programs.

Acknowledgments

I would like to acknowledge collaboration in this study by Regina Rochefort at NOCA, Steve Acker at OLYM, and Mignonne Bivin at NOCA.

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Post-fire Regeneration Requirements of Whitebark Pine

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Relatively few studies have addressed the natural regeneration trends of whitebark pine. Although it is well established that fire plays an important role in the establishment and maintenance of many whitebark pine stands, we know relatively little about the early seral pathways following fire leading to whitebark pine stand development. Studies addressing ecological requirements for whitebark pine regeneration have reported conflicting results. Several studies have cited a nutcracker caching preference for warm aspect slopes (Vander Wall and Balda 1977, Tomback 1978). In Yellowstone, regeneration density following fire was greatest on moist sites, but dry sites had higher rates of seedling survival (Tomback et al. 2001). Increasing our knowledge of these early seral pathways is imperative if we are to make informed decisions regarding the application of prescribed fire in restoring this species.

Methods

Study Areas

In 2004 – 2005 seventeen fire stands ranging in age from two to fifty-four years post-stand replacing fire were sampled for whitebark pine regeneration in the Canadian Rocky Mountain National Parks and the North Cascades Provincial Parks. Sampling sites included a range of ecological conditions including both warm and cool aspects, and moisture regimes ranging from from xeric to mesic

In each stand, twenty plots were systematically established from a random starting point. Plots were established at 25 m intervals in a sampling grid of 4 plots x 5 plots. Basic plot design was adapted from those described in the Whitebark Pine Conservation Plan for the Canadian Rocky Mountain National Parks (Wilson and Stuart-Smith 2002). Two plot types and sizes were established at each location; a 5.64 m radius ecological/stand structure plot and an 11.28 m radius whitebark pine inventory plot, both using the same plot centre.

Ecological and Stand Structure Sampling

Ecological data collected in each plot included: slope, aspect, elevation, latitude, longitude, meso-slope position, ground cover variables and moisture regime. Soil moisture regime was determined for each site based on indicator species cover, soil characteristics, and meso-slope position. Ground cover variables included bedrock, rock, bryophytes, mineral soil, organic soil, and decaying wood.

Whitebark pine variables recorded in each plot included tree height, blister rust infection status, tree age, and distance to seed source. The age of whitebark pine regeneration was determined primarily by counting terminal bud scars and annual branch whorls; however, annual rings on increment cores, or destructive sampling techniques were also originally used.

The role of growing season length on each site was assessed by comparing recruitment with monthly insolation levels; and comparing years of recruitment with pacific decadal oscillation (PDO) values over time. Isolation levels were determined using Solar Analyst (Fu and Rich 2000) on a Digital Elevation Model (DEM) on the National Park sites. PDO values were obtained from the Climate Impacts Group at the University of Washington.

Ecological variables were analyzed using multiple regression. The dependent variable of stems/ha/year was compared with the independent variables of slope, transformed aspect, elevation, and ground cover variables. Growing season length variables of Insolation and winter PDO values were each compared with recruitment densities using Spearman's Rank Correlation test.

Results

Ecological factors

Whitebark recruitment patterns were variable between sites. Distance to seed source limited recruitment on several sites, and the presence of lodgepole pine regeneration often resulted in no whitebark pine recruitment or restricted whitebark pine regeneration to a suppressed layer. Ecologically, recruitment showed a negative relationship with steep rocky sites and warm aspects, as indicated by the recruitment model of whitebark pine, sqrt(stems/ha/year) = 3.225 – 0.0004*slope*rock – 1.124*aspect (R^2 = 0.87; P = 0.005),

Growing Season Length--Insolation

Recruitment rate was generally not related to monthly insolation values over the growing season, except for August (R^2 = 0.6, P = 0.02) and September (R^2 = 0.91, P = 0.01) insolation values. Recruitment showed a negative relationship with insolation values in all months.

PDO

The majority of the increases in whitebark pine recruitment occurred during the positive PDO phase. At the site level, correlations between whitebark pine recruitment and the PDO Index were significant only at the Arnica Lake site (Spearman's rho = 0.38; $P < 0.05$). However, when viewed by phase (not yearly winter index), recruitment on several older burns that have been present for both extended positive and negative phases showed close relationships with PDO.

Discussion and Conclusions

The greater recruitment observed on cooler aspects is notable in that Clark's nutcrackers are known for caching seeds on warm sites that facilitate seed recovery over winter. It is probable that greater moisture levels and potentially better seed stratification conditions on these sites resulted in higher recruitment. Nutcracker caching usually targets a narrow, high stress, zone of the whitebark's fundamental niche, however, when caching occurs on less stressful sites within the niche; seed germination and seedling growth are likely maximized.

The negative relationship between recruitment and insolation values over the growing season may support that insolation damage to seedlings or related drought factors are important to seedling survival. Of particular note is the insolation pattern observed on the north aspect Arnica Lake site, which had the greatest recruitment rate of all sites. Insolation values at this site were among the lowest in the winter, spring and fall, but were equal to the values observed on nearby south aspect sites during the early to mid-summer. This swing in solar inputs may provide the benefit of a growing season that is sufficient in length to support the establishment of whitebark pine, but sufficiently truncated to maintain adequate spring soil moisture conditions for seed germination and limit sun related drought and insolation damage later in the growing season.

Recruitment was episodic both at an annual and decadal scale. Annual variations are likely explained by cone masting events. However, the decadal scale changes showed a close association with PDO winter values. Periods of positive PDO are associated with lower snowpack resulting in an earlier spring and a longer growing season (Selkowitz et al. 2002). On moist sites, shallow snowpack associated with positive PDO Index values have been shown to result in greater growing season length and increased growth of mountain hemlock (Peterson and Peterson 2001) and subalpine fir (Peterson et al. 2002). The greater influence of PDO on recruitment at the Arnica Lake site is likely explained by the cool aspect of this site which may frequently be limited by snow cover and associated length of growing season; however, during years of positive PDO the extended growing season permits very high recruitment on the site as other factors such as moisture are not limiting.

It appears that achieving high levels of whitebark pine recruitment may require a fine balance between seed source variables, adequate soil moisture, and length of growing season. Sites that adequately meet all three requirements may be further limited by large scale climate fluctuations; in fact, it is probable that those sites which best meet the moisture needs of whitebark pine due to aspect related factors may be most affected by PDO phases, potentially limiting recruitment on a decadal scale. Restoration programs should consider sites as described here, as those coupling adequate soil moisture with long growing seasons may simply be lacking seed inputs as seed sources decline and nutcrackers select sites better suited to cache recovery.

Literature Cited

Fu, P. and P.M. Rich. 2000. The Solar Analyst user manual. Helios Environmental Modeling Institute.

Peterson, D.W. and D.L. Peterson. 2001. Mountain hemlock growth responds to climate variability at annual and decadal time scales. Ecology. 82: 3300-3345.

Peterson, D.W., D.L. Peterson, and G.J. Ettl. 2002. Growth responses of subalpine fir to climatic variability in the Pacific Northwest. Canadian Journal of Forest Research. 32: 1503-1517.

Selkowitz, D.J., D.B. Fagre, B.A. Reardon. 2002. Interannual variations in snowpack in the Crown of the Continent Ecosystem. Hydrological Processes. 16(18): 3651-3665.

Tomback, D.F. 1978. Foraging strategies of Clark's nutcracker. Living Bird 16:123-161.

Vander Wall, S.B. and R.P. Balda. 1977. Coadaptations of the Clark's nutcracker and the pinion pine for efficient seed harvest and dispersal. Ecological Monographs. 47: 89-111.

Wilson, B.C. and G.J. Stuart-Smith. 2002. Whitebark pine conservation for the Canadian Rocky Mountain National Parks. Draft Report. *Prepared for*: Parks Canada, Radium Hot Springs, B.C.

Tomback, D.F.; Anderies, A.J.; Carsey, K.S.; Powell, M.L.; and Mellmann-Brown, S. 2001. Delayed seed germination in whitebark pine and regeneration patterns following the Yellowstone fires. Ecology. 82(9): 2587-2600.

Black Bears Feed on Whitebark Pine in the Cascade Range

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At least one recent observation confirms that black bears eat whitebark pine seeds in the Cascade Range. Black bears are noted as consumers of these seeds in the Northern Rocky Mountains (Kendall and Arno 1990). The bears climb trees to reach the cones (see cover photos).

This past summer, while collecting cones on Pelican Butte on the Winema National Forest near Klamath Lake, Oregon, a cluster of bear scat was found. It consisted entirely of whitebark pine seed shells. (A color photo of similar bear scat appears on back cover of *Nutcracker Notes*, No. 3:2002). The scat was collected and later tested for species identification using standard analysis of the 16S rRNA, mtDNA gene. The results strongly indicate a black bear.

An observation in Washington State provides evidence that black bears are also consuming whitebark pine seeds in the northern Cascades. In mid-September, 2005, a Forest Service crew collecting whitebark pine cones on the Wenatchee National Forest north of Lake Chelan found evidence that a bear had recently climbed a cone-bearing whitebark pine tree. Claw marks in the tree's bark indicated that the bear had climbed about twenty feet up into the tree, and an apparent bear scat near the base of the tree was made up mostly of whitebark pine seed shells.

These may be the first formal documentations of black bear use of whitebark pine seeds in the Cascades. With grizzly bears no longer roaming most of Cascades, black bears are now the largest-known mammals that consumer whitebark pine seeds.

Environmental education efforts can benefit from this knowledge. In addition to the many other ecological services provided by whitebark pine, its importance to black bears in the Cascades is a topic worthy of further investigation.

Kendall, K. C. and S. F. Arno. 1990. Whitebark pine—an important but endangered wildlife resource. USDA Forest Service, Intermountain Research Sta., Gen. Tech. Rep. INT-270: 264-273. Ogden, UT.

Project Proposal - Genetic Markers to Investigate the Origin and Maintenance of Island Populations of whitebark Pine

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The discovery of a small relict population of whitebark pine on Mt. Ashland in the Eastern Siskiyous raises questions about the origin and maintenance of such relicts. There are a number of other small, "island" populations of whitebark pine in this region including those on Mt. McLoughlin and in the Marble Mountains. The use of genetic markers can provide insight into extinction colonization dynamics, particularly when these markers have different patterns of inheritance. In conifers an unusual pattern of inheritance exists - mitochondrial DNA is inherited through the cytoplasm of the female (seed) parent, while chloroplast DNA is inherited from the male (pollen) parent. For virtually all other plants, both mitochondrial DNA and chloroplast DNA are inherited through the maternal parent. Because of the difference in inheritance of these two types of genes, patterns of gene flow from seed and pollen can be investigated separately. This is of particular importance for species like whitebark pine, with wind-dispersed pollen and bird-dispersed seeds.

I propose to develop sequence-based genetic markers that can be used to investigate the population genetics of whitebark pine, with a focus on the smaller, more isolated populations. Although whitebark pine can form extensive forests with large populations in the Sierra Nevada and the Northern Rocky Mountains, there is a broad zone stretching from the Klamath-Siskiyou Mountains to the mountains of Northern Nevada in which most populations of whitebark pine are small and isolated.

To date there is very little sequence information for whitebark pine in the GenBank database, and most of this is for conserved genes that have been used for higher level plant phylogenetic analysis – not for population studies within the species. The most extensive study on whitebark pine is that of Richardson et al. (2002) who sampled widely throughout the species range using both mitochondrial and chloroplast genes. Their study found evidence of both postglacial range expansions from distinct refugia and extensive movement of seeds by Clark's nutcracker. However, their range-wide sampling necessitated the use of only a handful of samples from each region and precludes detailed study of specific populations.

I have a set of samples collected for a previous study which used molecular techniques to confirm the identification of the juvenile trees at Mt. Ashland as whitebark pine. These samples already have had their DNA extracted and are stored frozen and ready for molecular analyses and sequencing in the lab I have also already purchased two sets of chloroplast primers and three sets of mitochondrial primers, and have performed some preliminary PCR tests with successful amplification, and two students in my Molecular Biology class are proceeding on the initial tests of more primer sets.

During the summer of 2007 I plan to expand the existing collections by obtaining samples from scattered populations in the intermountain region. These will include the Warner Mountains in Oregon and California, and the Pine Forest, Jarbidge, and Ruby/East Humboldt Mountains in northern Nevada. I plan to sequence the two chloroplast genes and three mitochondrial genes for a small number of samples and then to expand the effort to search for both interpopulation and intrapopulation variability among the sampled populations. The development of population markers is of course hit-and-miss, though many different primer sets have been published which can be used for this type of screening. My initial choice of markers has been guided by previous results that have identified variability in whitebark pine or related species (Mitton et al. 2000, Richardson et al. 2002). A further goal is to identify markers in which alleles can be distinguished by the lower cost RFLP method rather than direct sequencing, which may enable the screening of larger population sizes in this and future studies. The immediate goal is to identify variable markers that can be used to set the stage for a larger population genetic study of these island populations.

References

Mitton, J.B., B.R. Kreiser, and R.G. Latta. 2000. Glacial refugia of limber pine (*Pinus flexilis* James) inferred from the population structure of mitochondrial DNA. Molecular Ecology 9:91-97.

Richardson, B.A., S.J. Brunsfeld, and N.B. Klopfenstein. 2002. DNA from birddispersed seed and wind0disseminated pollen provides insights into plostglacial colonization and population gnetic structure of whitebark pine (*Pinus albicaulis*). Molecular Ecology 11:215-227.

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How many whitebark pine trees are there? A sampling design for estimating their density

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I am sure it has happened to all of us studying the dynamics of forests with whitebark pine. In the office you generate the coordinates of a random location of where to set up a sample plot. You trek to that stand and then bushwhack to the random point. Upon arriving you realize that only one whitebark pine will fall in the plot along with 50 subalpine firs. This plot will not tell you much about the population dynamics of whitebark pine. What do you do?

This scenario describes the upper subalpine forest in the Canadian Rockies well. Whitebark pine is sparse relative to other species and patchy due to nutcracker caching or the availability of microsites such as dry, rocky outcrops. In addition, the density of whitebark pine varies greatly between stands. For example, we estimated that the density of whitebark pine ranged from 60 to 800 trees/ha using fixed radius plots in 18 stands in Waterton Lakes National Park, Alberta. What sampling design will allow you to estimate the density of a species that is relatively rare and spatially clumped within a stand and highly variable between stands?

Clumpiness, high variance and rarity, pose challenges to obtaining an accurate estimate of the density of whitebark pine. Accurate estimates are important for estimating the incidence of rust infection or the amount of regeneration in a population of whitebark pine across a landscape. The commonly used sampling design of fixed-area plots (also called quadrats), if of an adequate size and sampling intensity, can deal fairly well with non-random spatial patterns (Pielou 1977). However, with fixed-area plots it is often hard to get enough samples from populations that are highly variable and/or sparse in density. In order to sample enough trees to produce size or age-class distributions representative of stand dynamics, researchers often vary the radius or width of plots according to the density of trees in a stand. These decisions are typically made in the field and can be subject to bias or end up being inefficient. For example, the high variance within a stand can mean that a plot radius which worked at one location may generate unmanageable numbers of samples in another, more dense location in the same stand. Furthermore, you often end up with many samples of subalpine fir (*Abies lasciocarpa*) or Engelmann spruce (*Picea engelmanni*) and relatively few samples of whitebark pine – i.e., little information on the scarcer species.

In contrast to fixed-area plots, plotless or distance sampling guarantees a certain sample size of whitebark pine independent of stand density. There are many methods that fall into the category of distance sampling, some of the better known ones are the distance to the nearest neighbour and the point-centered quarter methods (see review in Engeman et al. 1994). All distance sampling are based on the concept of an area per plant – i.e., the reciprocal of density. The square root of this area provides an indication of the spacing between plants. It follows that measuring the actual spacing between plants in the field can lead to an accurate estimate of the area per plant and thus density. If the forest is dense, the distance from a random point to a tree will likely be small, if the forest is sparse, the distance will be larger (Pollard 1971).

Although distance sampling has been criticized for producing biased estimates of densities when populations do not have a random spatial pattern (Pielou

1977), simulation tests suggest methods which include distances to the second, third and fourth closest individuals from a random point perform well when spatial patterns are clumped (Engeman et al. 1994). Below, we will describe one distance sampling method we are using to sample whitebark pine stand dynamics in the Canadian Rockies.

The n-tree distance method measures the distance from a random point to the nth closest trees to estimate the density of trees, λ, (Lessard et al. 2002, Lynch and Wittwer 2003):

$$\lambda = \frac{1}{m}\left(\frac{n-1}{n}\right)\sum_{j=1}^{m}\frac{n}{A_j}$$

$$A_j = \pi(R^2_{nj} / 10000)$$

where m is the number of random points, R_{nj} is the distance in metres to nth tree on point j and n is the nth closest tree to the random point, and A_j is the area of the "plot" represented by the distance (plot radius) to the nth tree. The variance of the estimate is:

$$Var(\bar{\lambda}) = \frac{n}{m(m-1)} * \sum_{j=1}^{m} (\lambda_i - \bar{\lambda})^2$$

Some researchers have used distance sampling methods to improve estimates in fixed-area plots. For example, Lynch and Wittwer (2003) aged the trees sampled with a 2-tree distance method and used these to estimate the age of all trees sampled in fixed-area plots in the same location using a weighted ratio estimate per size class. We refer interested readers to the work done by Lynch and Wittwer (2003).

There are certain limitations to distance sampling methods. The largest is the sampling effort required to estimate the density of many types of objects. For example, if you wanted to estimate the density of regeneration versus mature trees of three species, distances have to be measured to each type of tree (with a n-tree method measuring to the four closest trees that would result in 3 species * two age classes * 4 distances each = 24 distances at each point). The usefulness of distance sampling methods also depends on your objectives. For example, these methods are not good for measuring change over time; monitoring of whitebark pine stands usually use fixed-area plots or belt transects.

In our research we are interested in understanding the dynamics of subalpine forests containing whitebark pine. We are using the n-tree distance sampling to obtain better estimates of the density of live and dead mature whitebark pines. We are also coring these trees to estimate the density in various age classes. In order to sample the dynamics of other species and whitebark pines of smaller sizes, we are sampling nested fixed-area plots of three different radii. Small trees are sampled in the smallest radii (3.99m) plot and large trees are sampled in the largest radii (8 or 12m) plot. The fixed-area plots and the 4n sampling occur at each of six randomly located points in a stand. It takes a crew of three two days to sample a stand. Our goal is to gain enough information to cover the variability in a stand while being able to visit many stands on a larger landscape.

Whitebark pine is not an easy species to sample. Given the variable nature of whitebark pine density across its range, we hope that other researchers will find elements of our sampling design useful.

References

Engeman, R. M., R. T. Sugihara, L. F. Pank, and W. E. Dusenberry. 1994. A comparison of plotless density estimators using Monte Carlo simulations. Ecology **75**:1769-1779.

Pielou, E. C. 1977. Mathematical Ecology. John Wiley and Sons, New York.

Lessard, V. C., T. D. Drummer, and D. D. Reed. 2002. Precision of density estimates from fixed-radius plots compared to N-tree distance sampling. Forest Science **48**:1-6.

Lynch, T. B., and R. F. Wittwer. 2003. n-Tree distance sampling for per-tree estimates with application to unequal-size cluster sampling of increment core data. Canadian Journal of Forest Research **33**:1189-1195.

Pollard, J. H. 1971. On distance estimators of density in randomly distributed forests. Biometrics **27**:991-1002.

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Fire History in Whitebark Pine in the Greater Yellowstone Area: Study Results and Implications

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In 2003 I initiated a study of historical fire regimes and stand dynamics in whitebark pine communities in the Greater Yellowstone Ecosystem (GYE). Under the guidance of Dr. Bill Romme at Colorado State University, I compared the physical structure (basal area, density, species composition) and stand-age structure of seven whitebark pine stands located throughout the GYE. I also compared the historical fire regimes in these whitebark pine stands given their different locations and landscape contexts, and quantified surface and ladder fuels to evaluate potential fire behavior. Although previous investigators have found both stand-replacing and mixed severity fire regimes in many parts of whitebark pine's range, very little historical fire data specific to whitebark pine exists for the GYE.

Study sites were dominated by whitebark pine, although subalpine fir, Engelmann spruce, and lodgepole pine were common in several stands. A total of seven stands were sampled for this study, representing some of the natural variability of whitebark pine communities in the GYE. Study locations included:

- **Beartooth Lake [BTL]**, Beartooth Mountains, Shoshone N.F., WY
- **Avalanche Peak [AVA]**, Absaroka Range, Yellowstone National Park, WY
- **Wind River Lake [WRL]**, Absaroka Range, Shoshone N.F.,WY
- **Union Pass [UNP]**, northern Wind River Range, Shoshone N.F., WY
- **Blue Ridge [BLU],** southern Wind River Range, Shoshone N.F., WY
- **Sawtell Peak [SAW],** Centennial Mountains, Caribou-Targhee N.F., ID
- **Golden Trout Lakes [GTL]**, Gallatin Range, Gallatin N.F., MT

Results of this research indicate that stand structure and amount and configuration of fuels varied considerably between study sites, although fuels were generally sparse in all stands where they were measured. Age analysis for the sampled stands revealed a wide range of variation in stand age structure. In terms of historical fire occurrence, three of the seven whitebark pine stands sampled (WRL, SAW, GTL) contained basal scars possibly indicative of low- or mixed-severity fire events. Other sites sampled did not contain scars or any other evidence indicative of fire disturbance.

Results of this study thus suggest that whitebark pine dynamics in the GYE have been shaped, in part, by fires of various frequencies and intensities as well as by many environmental conditions and agents of disturbance. The role of fire in these high-elevation sites is complex, and the importance of the spatial and temporal variability of the historic fires that helped shape present-day communities should not be minimized or marginalized. Some communities in the GYE are the result of large stand-replacing events; while others appear to have been maintained by infrequent low-intensity surface fires. The results of this study provide no evidence that 20th century fire suppression has caused a significant decline in fire frequency or caused abnormal stand development in any of the seven whitebark pine stands sampled.

Relatively rare, stand-replacing fire events probably are the primary driver of regeneration and succession in many whitebark pine stands throughout the GYE. In other areas of the GYE, whitebark pine may burn in small, patchy, low- or mixed-severity fires. To burn under such a regime, whitebark pine forests require a stand structure with sufficient surface fuels to sustain the spread of low-intensity fire. This necessary structure may be transitory in the successional development of whitebark pine communities, though more research is needed to test this hypothesis. Most of the mature whiebark pine communities sampled in this study currently lack sufficient fuels for the extensive spread of understory fires, and would likely burn only under severe weather conditions where crown fire spreads from forests at lower elevations. This type of fire behavior would be indicative of a stand-replacing fire regime operating at extremely long intervals (centuries).

Because of changing land use practices, exurban development, climate change, insect and disease outbreaks, political pressures, as well as other factors, the fire regimes of the past are not precisely the regimes of the present, and in most places will not be the regimes of the future. But knowledge of a system's historical fire regime and stand dynamics in conjunction with site-specific data *can* help provide guidelines for management, and provide a benchmark for recognizing if ecosystems are functioning according to historic norms or not. This is especially true in many high-elevation forested systems where direct human impacts have been minimal.

Although the effect of past fire suppression is probably not a major concern for many whitebark pine forests in the GYE, the sustainability of whitebark pine communities is increasingly threatened by increasing mortality from mountain pine beetles and threats from the expansion of white pine blister rust. If these agents cause a reduction in whitebark pine seed crops, regeneration in the wake of fire may be hindered. Management of whitebark pine communities of the GYE must consider both the need for the long-term health and survival of these communities into the future as well as their value as a food source for many species, most obviously grizzly bears. Accomplishment of this goal will require management for a continuum of stand structures, ages, and species components.

SEE PAGE 23 FOR FIGURE 1

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Operational testing of whitebark pine for blister rust resistance: current trials and early results for Oregon and Washington seedling families

A. Kegley, R.A. Sniezko, and R. Danchok

The Pacific Northwest Region of the USDA Forest Service (Region 6) has begun testing seedling families of whitebark pine for resistance to white pine blister rust. These families are open-pollinated progeny of selections from throughout the range of whitebark pine (WBP) in Oregon and Washington. Screening of these families will provide baseline data on levels, frequencies and patterns of resistance.

Over 150 WBP families are now being tested at Dorena Genetic Resource Center (DGRC, Cottage Grove, OR). Several different trials have been inoculated in 2004, 2005, and 2006. Early results from the 2004 inoculation have been reported by Sniezko and others (in press). This note will present a few highlights of that trial.

In 2004 seedlings of 43 families from six National Forests in Region 6 as well as one bulked seedlot from the Shoshone National Forest, Wyoming were inoculated with two sources of white pine blister rust (Trial 1 and Trial 2). Seedlings have been evaluated for survival and the presence and number of disease symptoms. Thus far, data have been collected for two years post-inoculation.

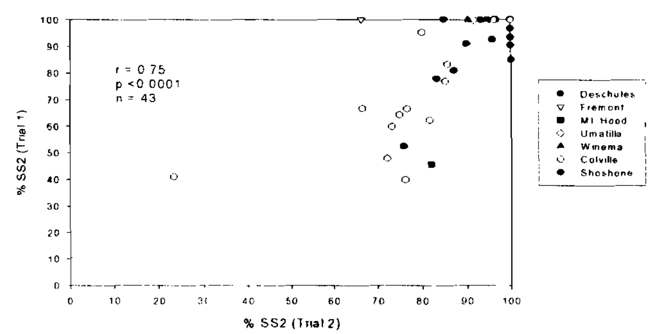
Artificial inoculation was very successful; 100% of the seedlings developed needle lesions ('spots'). The incidence of stem symptoms was also high for the two trials. Through the first two years after inoculation, 87.7 and 89.8% of the seedlings developed stem symptoms (% SS2) in the two trials, and families tended to perform similarly regardless of inoculum source (Figure 1). Note the lower incidence in % SS2 for the more northerly sources (Colville and Mt. Hood). The moderate to high frequency of families with low % SS2 in the 43 field selections is higher than that found in DGRC rust testing of open-pollinated progeny of field selections of two other white pine species, western white pine or sugar pine (Kegley and Sniezko 2004). However, the WBP seedlings averaged more stem symptoms per tree than the susceptible western white pine (WWP) control.

Survival through two years after inoculation averaged 25.6 and 24.4% for the two trials. Family means for survival ranged from 0 to 81.5% for Trial 1 and from 0 to 90% for Trial 2. Mortality in WBP proceeded more rapidly relative to the susceptible WWP control (which had 100% survival through 2 years after inoculation). Figure 2 (see back cover) shows some of the dramatic differences in survival of WBP observed in this trial. Survivors at this point include both seedlings that did not develop stem symptoms as well as those that did. The seedlings will be assessed for up to three more years, and it is likely that at least some of the seedlings with stem symptoms will die in the next year.

Other current WBP projects at DGRC include examining many more families for resistance, testing some of the highest surviving families for major gene resistance (not yet documented in WBP), examining the effect of inoculum density on resistance, and determining whether even younger seedlings can be used to rate families for resistance (which could reduce costs and shorten the time period for assessing resistance).

Short-term resistance screening of seedlings can be a valuable tool to efficiently evaluate many field selections. However, field trials will be essential to confirm that this resistance is also effective under field conditions and to monitor the durability of resistance for this species.

Figure 1. Family mean percentage seedlings with stem symptoms (% SS2) in Trial 1 vs. Trial 2 for seedlots from 7 National Forests



Acknowledgements

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References

Kegley, A.J.; Sniezko, R.A. 2004. Variation in blister rust resistance among 226 *Pinus monticola* and 217 *P. lambertiana* seedling families in the Pacific Northwest. In: Sniezko, R.A.; Samman, S.; Schlarbaum, S.E.; Kriebel, H.B., eds. Breeding and genetic resources of five-needle pines: genetics, breeding, and adaptability, Proceedings of the IUFRO 2.02.15 Working Party Conference. Proceedings RMRS-P-32. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 209-225.

Sniezko, R.A.; Kegley, A.; Danchok, R.; Long, S. 2007. Variation in resistance to white pine blister rust among 43 whitebark pine families from Oregon and Washington – early results and implications for conservation. *In* Proceedings of Whitebark pine: a Pacific Coast Perspective Workshop, August 27-31, 2006, Ashland, OR. In press.

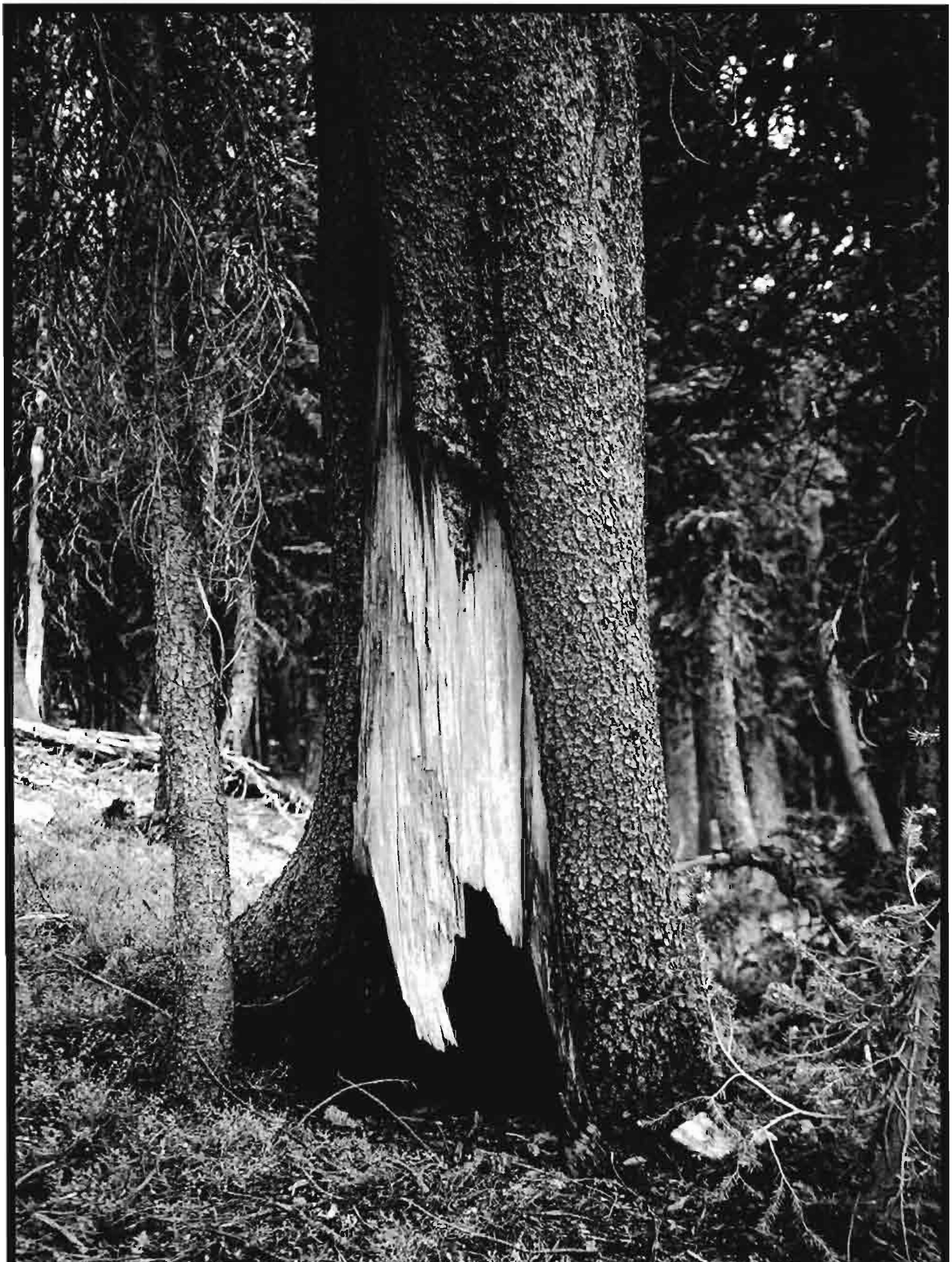
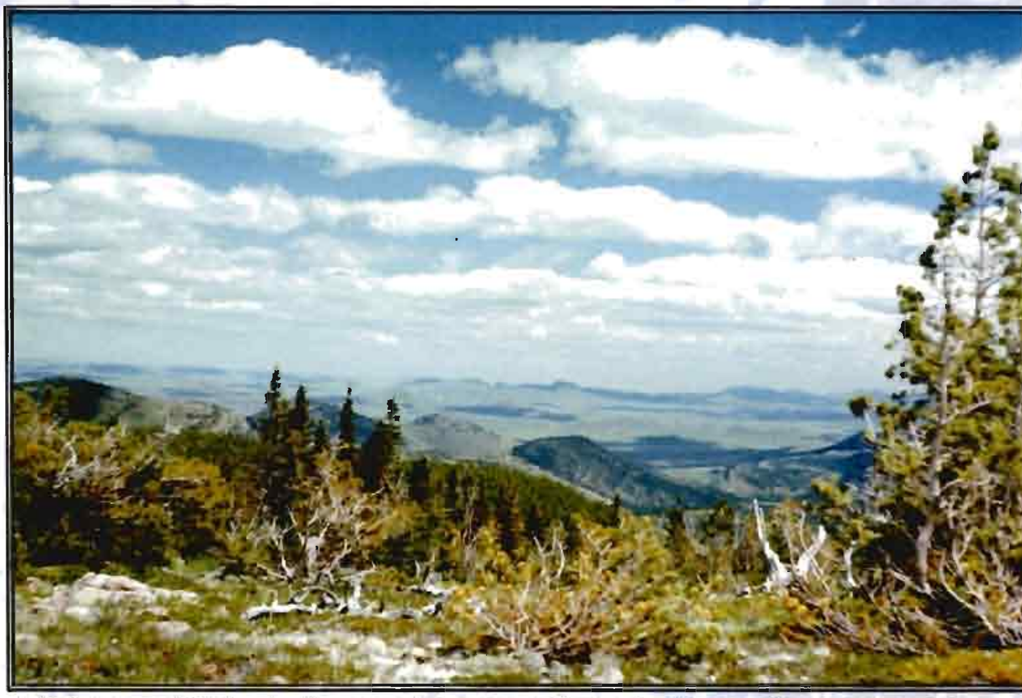


Figure 1. (from Walsh, pg. 21) Well-formed scar resulting from fires in about 1581 and 1751 at the Golden Trout Lakes study area. (Photo by author)



Location of WPEF's September 29, 2007, Field Trip. Stunted limber pine at Lewis and Clark Pass, and looking east toward the Great Plains. S. Arno photo

Figure 2. (from Kegley et al.) Mixed mortality among seedlings two years after rust inoculation. Tall seedling is from the Colville N.F. R. Sniezko photo

Black bear harvesting whitebark pine cones, Yellowstone National Park. Robert J. Weselmann photo [www.robertweselmann.com]