Issue No. 18: Spring / Summer 2010

Nutcracker Notes

Whitebark Pine Ecosystem Foundation

New alternate host for blister rust

Pedicularis racemosa in former whitebark pine stand, Great Burn area west of Missoula. Photo by S. Arno

Naturally-infected *P. racemosa* plant at Mt. Hood with multiple telial lesions of *C. ribicola*. Photographer: R. L. Mulvey

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Whitebark Pine Ecosystem Foundation

***Nutcracker Notes,* Issue No. 18; Spring/Summer 2010**

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Our Mission: The Whitebark Pine Ecosystem Foundation (WPEF) is a science-based nonprofit organization dedicated to counteracting the decline of whitebark pine and enhancing knowledge of its ecosystems.

Membership Information and an application is found at <www.whitebarkfound.org>

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Director's Message

Diana F. Tomback

Home Stretch to "High Five"

For all of us involved in the ecology, management, or restoration of whitebark pine and its high elevation relatives, the upcoming "High Five Symposium: The Future of High Elevation Five- Needle White Pines in Western North America" will be a major, if not a watershed event. This symposium, to be held 28 to 30 June 2010 on the University of Montana campus, is the first time that six ecologically important high elevation pines considered "at risk" are the main topics of plenary talks, special, and contributed paper sessions. Conceived and planned by the WPEF for nearly two years, with the organizational support of Continuing Education at the University of Montana, this symposium brings together experts in research and restoration strategies, as well as land managers who are involved in restoration projects. A proceedings will be compiled and published by the USDA Forest Service Rocky Mountain Research Station.

The "High Five" species are whitebark, limber, foxtail, southwestern white, and Great Basin and Rocky Mountain bristlecone pines. All six pines are susceptible to white pine blister rust, and all but Great Basin bristlecone have populations succumbing to this pathogen. These pines may also host outbreaks of mountain pine beetle, and several have experienced high mortality during recent mountain pine beetle outbreaks. Some of these pines are also declining as a result of fire suppression and advancing succession, and all are likely to require shifts in their elevational distribution to survive a warming climate.

Acknowledged experts have agreed to present our plenary talks, leading off with Robert Mangold, Director of Forest Health Protection (FHP) for the US Forest Service, Washington Office Dr. Mangold was responsible for initiating the Whitebark Pine Restoration Fund—a program that has been ably managed by John Schwandt. Other plenary speakers include Drs. Sally Aitken and Andrew Bower on conservation genetics, Dr. Brian Geils on *Cronartium ribicola*, Drs. Richard Sniezko and Mary Frances Mahalovich on blister rust resistance in pines, Dr. Barbara Bentz on mountain pine beetles, Dr. Elizabeth Campbell on disturbance ecology, and Drs. Robert Keane and Anna Schoettle on restoration and management. Two of the three meeting days will be dedicated to presentations, with several plenary talks each morning and concurrent sessions in late morning and afternoon.

On the last day of the meeting, Wednesday, June 30, we have scheduled a daylong field trip to Snowbowl Ski Area for all attendees to view a series of whitebark pine restoration projects developed by Robert Keane and his colleagues at the USDA Forest Service Missoula Fire Sciences Laboratory. Two additional all day field trips are scheduled for Thursday, July 1: Steve Arno will lead a hike to Lewis and Clark Pass, northeast of Lincoln, Montana, to view a windswept forest with both limber and whitebark pine. The other field trip, led by Clint Carlson, is to Blackleaf Wildlife Management Area, west of Bynum and north of Choteau, Montana, to view a stand of limber pine highly damaged by blister rust. For more information about the High Five symposium, please go to www.umt.edu/CE/CPS/highfive/.

Advice and support concerning plenary speakers and other organizational aspects of High Five have been provided by the High Five Steering Committee, composed of members from different agencies and NGOs across the range of the High Five pines. Through the generosity of our sponsors, we have been able to keep the cost of registration reasonably low and provide travel scholarships for speakers. Sponsoring agencies and non-profits include USDA Forest Service, Region 1; National Park Service, Rocky Mountains Cooperative Ecosystems Study Unit (NPS-RMCESU); National Park Service, Greater Yellowstone Network; University of Montana, College of Forestry and Conservation; the Natural Resources Defense Council (NRDC), Livingston; the Crater Lake Natural History Association; and the Crater Lake Institute.

Please note that the WPEF Annual Members' Meeting, usually held in September, will take place this year in conjunction with the High Five symposium. All members and observers are invited to attend and to use this opportunity to provide WPEF with advice concerning our organization and its mission.

WPEF Going International

Two years ago, the Board of Directors was approached by Randy Moody, an environmental consultant and whitebark pine researcher from British Columbia, who expressed interest in forming a Canadian chapter of the WPEF. The primary objective was to provide an organization to help increase funding opportunities and secure grants for research and restoration of whitebark pine communities in western Canada. Randy had been an active participant in WPEF workshops and meetings for a number of years, and recently organized a small group of like-minded Canadians to take the first steps in creating a Canadian WPEF.

This past fall, 2009, Randy registered the name Whitebark Pine Ecosystem Foundation of Canada under The Society Act in British Columbia. For the past year, Randy and I worked on a set of guiding principles to understand how the two organizations would interact in terms of administration, financial matters, and respective obligations. Recently, Cyndi Smith, Associate Director of the WPEF and a Canadian, developed a Review Draft memorandum of understanding (MOU) between the two organizations, with the following stated purpose:

> "to establish a collaborative working relationship between WPEF and WPEF-Canada to jointly build capacity and remove barriers to the conservation of whitebark pine ecosystems across the international border by supporting restoration, education, management, and research projects that enhance knowledge and stewardship of these valuable ecosystems. To define the roles and responsibilities of each organisation in this relationship"

Several key aspects of the relationship between WPEF and WPEF-Canada, as outlined in the draft MOU are as follows: Membership is essentially in both organizations, with dues paid to the WPEF. *Nutcracker Notes* and the WPEF website will also have news and membership content from the WPEF-Canada. However, as required by Canadian law, WPEF-Canada will have a separate Board of Directors and Director. Fund-raising and other financial details will remain separate between the two organizations, unless specific joint ventures are initiated. The WPEF will return a portion of the joint membership dues to WPEF-Canada each year.

It is our hope to have WPEF-Canada finalized shortly.

Update on ESA Petition for Whitebark Pine

As we reported previously, the Natural Resources Defense Council (NRDC) submitted a petition in December, 2008, to list whitebark pine under the Endangered Species Act to the U.S. Fish and Wildlife Service (USFWS). A year later, the 90-day finding, the first level of review, was not yet announced, prompting the NRDC to send an intent to sue notice to the Denver regional office of the USFWS. Last fall, I was told by a staff member from the USFWS field office in Wyoming responsible for the petition review that a draft report was due at the Denver office by February 2010 and the 90-day finding would be announced in the Federal Register by July 2010.

In response to the notice of intent to sue sent by the NRDC, the Regional Director of the USFWS sent a letter to the NRDC. The letter explained that budget and workload priorities for Fiscal Year 2009 had already been set when the petition was received; the regional workload included challenging cases, for example, findings for greater sage-grouse, Wyoming pocket gopher, lynx critical habitat, Rocky Mountain fisher, black-tailed prairie dog, and American pika. Furthermore, the letter explained that the decision on whitebark pine was challenging because of "the species' widespread range, and overlapping potential threats of climate, insects, and disease." The 90-day finding is expected to be completed within the current (2010) fiscal year.

Whitebark Pine Conservation in 2010

Every field season is critical for furthering our knowledge of whitebark pine biology, ecology, and management needs, and for implementing restoration efforts. I wish all our members a productive and successful 2010 field season; and, I hope to see many of you at High Five. ■

"High-Five" Symposium:
The Future of High-Elevation Five-Needle White Pines in Western North America

The Whitebark Pine Ecosystem Foundation, in conjunction with USDA Forest Service, Region One, National Parks Service – Greater Yellowstone Network, and National Parks Service-Rocky Mountain Cooperative Ecosystem Studies Unit would like to invite you to attend an international symposium on high elevation five needle pines on June 28-30, in Missoula Montana, USA.

High‐elevation five‐needle pines are rapidly declining throughout North America. A comprehensive symposium will be held June 28‐30, 2010, to present current research and management on whitebark, limber, foxtail, southwestern white, Rocky Mountain bristlecone, and Great basin bristlecone pines. It is comprised of two sessions of plenary papers, three sets of four concurrent sessions, and a field trip day. Managers, researchers, students, administrators, and all others interested in high‐elevation ecosystems are invited to attend. Information on the symposium can be obtained at www.umt.edu/ce/cps/highfive/.

LODGING: Room blocks have been reserved at the hotels listed below. Please reference the "High‐Five Symposium" when calling to make your reservation. A percentage of each room block will be available at the 2010 Federal rate. For complete details please visit our home page at: www.umt.edu/ce/cps/

Holiday Inn Downtown at the Park
Phone: (406) 721-8550 or (888) 465-4329 or (888) 465-4329 or (800) 222-8733

Holiday Inn Express Missoula - Riverside
Phone: (406) 549-7600

Doubletree Hotel Missoula/Edgewater
Phone: (406) 728-3100
Jesse Hall – The University of Montana
UM On - Campus Housing

REFRESHMENTS & MEALS: Refreshments and light snacks will be provided during breaks in the late mornings and afternoons on Monday and Tuesday. There will be an Evening Social and Poster Session with light hors d'oeuvres and a cash bar on Monday evening from 7:00 to 9:00 p.m. We invite you to attend and network with the peakers and other symposium participants. A buffet lunch will be provided on Monday, and lunch is on our own Tuesday. Sack lunches will be provided for the Wednesday field day.

DRIVING DIRECTIONS & PARKING: Parking permits will be provided free of charge at the registration desk. The provided permits allow for parking in the **GREEN highlighted areas (see UM Campus Parking Map** for details). Please do not park in "Reserved", "Hourly", "Quick Stop 20 Minute" or "Handicapped" parking areas. For directions to the University and further information, please visit: UM Interactive Map.

POSTERS AND PRESENTATIONS: Please check - in your poster or display when you register on the morning of June 28th. There will be space to set up posters and table top displays; if you need additional accommodations (e.g., extra table, electrical outlet, etc.,) please notify Deb Graham (debbra.graham@umontana.edu) or Lori Reed (lori.reed@umontana.edu) prior to the symposium. Those giving Oral Presentations must provide their presentations to the moderator at least 30 minutes prior to the start of their assigned session. Please bring your presentation on a flash drive, memory stick, CD, or DVD. Please refer to the conference program for presentation schedule and assigned times. If you have any questions or need further assistance, please contact **Deb Graham, 406-243-4623, debbra.graham@umontana.edu or Lori Reed, 406-243-4681, lori.reed@umontana.edu.**

The Deadline for cancellation is April 30, 2010. After April 30, a 15% fee will be accessed for processing and you will be refunded the balance of the registration. ***Please notify us immediately of substitutions or last-minute cancellations.*** ■

"High-Five" Symposium:
Featured Presentations

1. Overview for high elevation five-needle white pines: taxonomy, distribution, ecology, seed dispersal, keystone/foundation roles, wildlife, use by Native Americans, threats, decline, climate change, and conservation status.

2. Conservation genetics of pines: taxonomic flux, population genetic structures, common garden studies, geographical variation, gene conservation strategies, planning for climate change.

3. *Cronartium ribicola* (blister rust): origin, life cycle, alternate hosts, historical introduction and spread, geographic distribution, epidemiology, genetic diversity, projected effects of climate change

4. Genetic resistance to blister rust: resistance mechanisms in high elevation white pines, genetics of resistance, target resistance screening methods, goals for operational deployment, results to date, effects of climate change and rust adaptation

5. Mountain pine beetle: historical outbreaks, life cycle, complex interactions, preferred hosts, beetle-rust interactions, efficacy of protective treatments, current population levels and trends, outlook with climate change

6. Disturbance ecology: what we know about fire and other disturbance regimes for each "high five" pine, successional dynamics, effects of fire exclusion, fire history, fire effects, dendrochronology, effects of mountain pine beetles, and climate change

7. Restoration tools and strategies: fire, thinning, planting (genetic resistance), mycorrhizal inoculation, protection against mountain pine beetles, reactive restoration strategies, proactive restoration strategies, restoration options in wilderness, restoration valuation and cost, conflicts with other management mandates, and planning for climate change. Knowledge needs. ■

Field Trips at the "High Five" Symposium

Symposium Field Trip (June 30, 2010)

An all-day field trip to whitebark pine restoration site at Snowbowl Ski Area is included as part of symposium registration. Lunch is provided. Study coordinator Robert Keane will show us treatment units and field questions. Treatments include (1) a burn without fuel augmentation, (2) burn with fuel augmentation, (3) commercial harvest with slashing and burning, and (4) a control. The tour visits several different stations each having a different presentation on whitebark pine ecology and management. See the symposium web site for details of this field trip and advice on outdoor clothing recommended for this high-mountain site.

Optional Guided Field Trips (July 1)

1. **Continental Divide Trip.** Steve Arno will lead this moderately strenuous day hike to Lewis and Clark Pass and Green Mountain along the Continental Divide northeast of Lincoln, MT, where participants will visit groves of both limber and whitebark pines and other features (see details on the symposium web site).
2. **Rocky Mountain Front.** Clint Carlson will lead an automobile/short walk visit to foothill stands of limber pine north of Choteau, MT. The trip is through rich wildlife habitat, including grizzly bears, so bear spray is a must! (again, web site has details)

Optional Self-Guided Field Trips

Information including maps are available at the Registration Desk for three different day-hikes to extensive whitebark pine stands in the Bitterroot Range south of Missoula. Ask for Field Trip Coordinator Bryan Donner and obtain further information on the symposium web site. ■

WPEF Membership—How We're Doing

Bryan Donner

The WPEF had 148 members as of March 1, 2010, a new "record" high. A recent surge of new Canadian members has increased our totals. The WPEF board is very encouraged that membership continues to increase when many environmental non-profit organizations are losing members.

A significant and growing membership attests to our credibility when we apply for grants to aid our mission. Please consider recruiting a friend or colleague today. Also please consider upgrading your membership and/or encouraging your employer to join as an institutional member.

The board established different categories of membership to recognize different levels of support. The category with the largest number of members is the Whitebark level ($35 annual dues) with 106. The Nutcracker level ($75) has 25 members, the Institutional members ($150) come in at 6, there are 7 student members ($25), and 4 members are at the Grizzly level ($1000).

The Whitebark level was meant to be the standard membership category. The $35 annual dues rate covers the costs of the Foundation (administrative work and publication and mailing of Nutcracker Notes) as well as provide some funds towards restoration and educational efforts. The Nutcracker level allows members to be recognized for maintaining a greater amount of restoration and educational support. The Institutional level allows for a business or agency to help support the foundation and allows the circulation of Nutcracker Notes throughout the organization's staff. The Grizzly level is a one-time membership fee for the lifetime of the member and shows the greatest amount of dedication to the restoration of whitebark pine ecosystems. The Student level was established to allow for participation by those currently enrolled in college.

Membership is comprised of individuals and organizations from all across North America. States with the most members are Montana (57), Idaho (21), Oregon (12), Washington (10), and Wyoming (7). Canadians number 25, primarily split between British Columbia and Alberta. Some of our members reside in states or provinces outside the range of whitebark pine, including Colorado, Michigan, New Mexico, New York, Ohio, Quebec, Wisconsin, the Yukon Territory, and Washington, DC.

New members at the Nutcracker, Institutional, and Grizzly levels have in the past been provided a copy of the Foundation's book *Whitebark Pine Communities, Ecology and Restoration* by Tomback, Arno and Keane. The Foundation's and publisher's (Island Press) stocks of this book are now exhausted, so we will no longer be available to offer the book. (Although "out of print" from time to time a few used copies are listed on www.Amazon.com.)

The foundation's web site at www.whitebarkfound.org has a complete discussion of the different membership levels and forms for initial membership and renewal. Joining or renewing by using *PayPal* at the web site is a recent improvement. Questions, comments, or suggestions about membership can be directed to Membership and Outreach Coordinator, Bryan Donner, at (406) 758-3508 or donnermt@yahoo.com. Please put "WPEF" or "Whitebark" in the subject line of your e-mail. ■

Election News

Cyndi Smith, WPEF Associate Director

By the time you read this hopefully you will have already voted in the WPEF elections via the mail-in ballot card. If not, *tsk, tsk*, because we've made it about as easy as possible!

The Board of Directors discussed a few options to improve participation in the election process, as only 15% of our members voted in 2009, down from our high of 36% participation in our first elections in 2007. The options considered were: 1) on-line voting through a commercial service, 2) sending out and receiving ballots by e-mail, and regular mail for those without e-mail, and 3) mailing out a pre-stamped and pre-addressed ballot card. The first option was too expensive, and there was concern about the second option regarding difficulties with changing e-mail addresses and those members that do not have an e-mail address. So, we landed on the third option, to mail out the ballot cards. As of early April, we have already received a large percentage of mail-in ballot cards, so it appears this approach is working. We'll announce the results soon on our web site---www.whitebarkfound.org. ■

Whitebark Pine Management Guide Available

Management Guide to Ecosystem Restoration Treatments: Whitebark Pine Forests of the Northern Rocky Mountains, U.S.A.
General Technical Report RMRS-GTR-232, by Robert Keane and Russell Parsons.

This 180 page report is available from Publications Distribution at the Rocky Mountain Research Station, Fort Collins, CO, by phoning 970-498-1392 or online at www.fs.fed.us/rm/pubs/rmrs_gtr232.html.

The publication summarizes data collected at whitebark pine treatment sites for three periods: pre-treatment; one year post-treatment; and five years post-treatment. Study results are organized so that managers can identify possible effects of treatment at their own site by matching it to the most similar treatment unit in the publication based on vegetation, fire regime, and geographical location. This guide is based on studies initiated in 1993 to investigate effects of various restoration treatments on tree mortaility, regeneration, and vegetation response on five geographically dispersed sites.

A related report scheduled to appear soon in the journal *Ecological Restoration* presents results of the studies across major treatment types instead of by treatment units. ■

Interview with Shawn McKinney

(Shawn is a WPEF board member, stationed at Yosemite N. P.)

Editor: How and when did you become interested in whitebark pine?

McKinney: I first learned about whitebark pine and became aware of its challenging situation in 2001 as a first-year graduate student working with Diana Tomback. We were exploring possible topics for my master's research, and I distinctly recall the moment when I realized the whitebark pine 'problem' contained many areas of research I was interested in; a conservation issue, potential for applied aspects of basic research, genetic and evolutionary components, amazing interspecific relationships, and fantastic field locations. I was hooked then and have been ever since.

Editor: You have conducted several studies of whitebark pine ecosystems; please describe them briefly.

McKinney: For the majority of my research I have taken a community-oriented approach to studying whitebark pine forest dynamics in a range of habitats and conditions altered to various degrees by white pine blister rust. Although all of the research took place in the Rocky Mountains, I attempted to sample from as broad a range of conditions as possible. My field sites were located in northwestern Montana (Glacier National Park and Flathead National Forest), the Bitterroot Mountains in Idaho and west-central Montana, and the Greater Yellowstone Ecosystem. I have been specifically interested in understanding how habitat context (including influences from rust, bark beetles, or fire) shapes the strength of interactions between whitebark pine and Clark's nutcracker, and whitebark pine and the red squirrel, and ultimately how prospects for natural regeneration vary under different scenarios. Of course nutcrackers are critical because of their seed caching behavior, but red squirrels are also important because they can harvest significant amounts of whitebark pine cone crops and directly influence whether nutcrackers will remain in a forest to disperse seeds. We carried out a range of studies to address these issues including detailed observations of animal activity throughout the day within small forest stands, and running wildlife transects through forests where we measured forest structure and composition.

Included in all of the studies were multi-year counts of cone production within trees and forest stands. So a subset of this work has identified how rust infection affects cone production and directly constrains the ability of forests to naturally regenerate.

Editor: What has surprised you most about whitebark and the other high-elevation five-needle pines since moving to the Sierra Nevada.

McKinney: Tree size, elevation, and diversity. The first thing that struck me when I hit the high country of the Sierra Nevada was the tremendous size of the trees. I recall encountering the largest western white pines I had ever seen and they were growing above 9,000 ft. I know western white is not considered one of the 'high five', but a trip to the southern Sierra would tell you differently. I was also impressed in quite a visceral way by the occurrence of extensive, mature forests at very high elevations. For example, last summer I lugged myself up to a pure stand of very large foxtail pines growing well above 10,000 feet in Sequoia National Park. These trees achieve great age growing under conditions and have proven important for climate and fire reconstructions. Lastly, the diversity of the five needle pines is impressive. You can climb into the southern high Sierra Nevada and see whitebark, foxtail, limber, and western white pines.

Editor: How does the occurrence of whitebark in the Sierra differ from what you were used to in the N. Rockies?

McKinney: The most profound difference between whitebark pine in the Sierra Nevada and the Northern Rockies is the health of the forests. I was excited to work in forests where there are no obvious signs of blister rust or pine beetle; healthy trees with copious cones as far as the eye can see and nutcrackers doing their thing all over the place. I found this experience to be motivating and good for the soul. It is also interesting to note that red squirrels do not occur in the Sierra Nevada. So as far as my prior research experience is concerned, Sierra Nevada forests were quite distinct in their structure and how they functioned at the community level. There are Douglas's squirrels here however, and I am looking forward to getting into the field this summer to see how, if at all, they influence the fate of whitebark pine seeds. Another big difference between the two regions is the existence of extensive nearly-pure stands of whitebark pine in the Sierra Nevada. Perhaps this is due in some part to the difference in health conditions, but it seems that whitebark pine is a forest dominant for a more extensive region than in the Northern Rockies. For example, it is estimated that forests comprised mostly of whitebark pine occupy 37,000 hectares in Sequoia, Kings Canyon, and Yosemite National Parks alone. ■

New Alternate Hosts for Blister Rust

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White pine blister rust (WPBR), the disease caused by the fungus *Cronartium ribicola*, has caused widespread mortality in whitebark and other five-needled pines in North America. *Ribes* spp. (currant and gooseberry shrubs) are well-known as the alternate hosts that allow WPBR to complete its complex lifecycle. For my Master's project at Oregon State University (OSU), I set out to determine if non-*Ribes* hosts were also naturally infected by *C. ribicola* at detectable levels in whitebark pine ecosystems of the Oregon and Washington Cascade Range.

C. ribicola has a lifecycle composed of five distinct spore stages. Two of these are completed on pine hosts, creating perennial cankers on the branches and boles of susceptible pines that can lead to branch or whole tree mortality when the vascular tissue is girdled. The other three spore stages are completed on the foliage of another type of plant called an alternate, or telial, host, usually understood to be *Ribes* plants. Despite national *Ribes* eradication efforts that were in place from the 1920s through the 1960s, WPBR continued to spread throughout the distribution of five-needled pines in North America, and its range is still expanding in the southwestern United States. *Ribes* eradication did not successfully prevent disease spread, and many attribute the failed eradication effort to the resilient nature and widespread distribution of *Ribes*, the extreme distances over which some aerially dispersed spore stages are able to travel, and incomplete or inaccurate information about the biology of the pathogen.

In 2004, researchers at the Rocky Mountain Research Station (USDA Forest Service) verified *C. ribicola* infection on new alternate host plants from the genera *Castilleja* (paintbrush) and *Pedicularis* (lousewort) in a whitebark pine stand in northern Idaho (McDonald et al. 2006, For. Path., 36, 73-82). The species of rust on these hosts was verified using biochemical diagnostic methods, because another *Cronartium* species that is native to North America is also able to utilize *Castilleja* and *Pedicularis* as hosts and cannot be morphologically distinguished from *C. ribicola*. In many countries in Asia, where *C. ribicola* is present and believed to be native, *Castilleja, Pedicularis* and *Ribes* are all known to serve as alternate hosts for the fungus. Now that this phenomenon has been confirmed in North America, researchers are investigating these hosts to gain an understanding of their importance to WPBR-epidemiology. The role of *Castilleja* and *Pedicularis* as hosts in whitebark pine ecosystems, and other ecosystems containing susceptible five-needled pines, is of particular interest, as infection has been observed in high-elevation stands in which *Ribes* are extremely scarce or absent. Several species of *Castilleja* and *Pedicularis* are prevalent in high-elevation ecosystems, and frequently grow in association with susceptible pines.

For my Master's research, I established observational study plots in whitebark pine ecosystems at Mt. Rainier, Mt. Adams, Mt. Hood, Mt. Bachelor, Tumalo Mtn. and Crater Lake, where species of interest were growing within 25 meters of infected pines. These plots were monitored multiple times per season to carefully check *Castilleja* and *Pedicularis* species for signs of infection, and to track disease progression on pine and alternate host plants. In addition, I experimentally inoculated eight species of *Castilleja* and *Pedicularis* in the field at Mt. Rainier and Crater Lake to assess their susceptibility using aeciospore inoculum from locally-infected pines. Lastly, I propagated four species of *Castilleja* native to whitebark pine ecosystems at Mt. Rainier and Crater Lake and inoculated them with *C. ribicola* aeciospores in growth chamber experiments.

Natural infection was most abundant on *Pedicularis racemosa*, and 84 infected plants of this species were discovered at Mt. Rainier, Mt. Adams and Mt. Hood over the course of the study (Fig 1 on front cover). Natural infection of *Castilleja* was discovered much less frequently, with five infected plants of three *Castilleja* species detected at Mt. Hood and Crater Lake. *Ribes* were found to be infected at Mt. Rainier, Mt. Hood and Crater Lake, and *Ribes erythrocarpum* at Crater Lake appeared to be the most important alternate host plant at this location. *Ribes* were uncommon at Mt. Rainier and Mt. Hood, and infection of *P. racemosa* may be a key source of inoculum at these sites. Field inoculation success was low, perhaps due to environmental conditions at the time of inoculation, but allowed for the susceptibility of additional *Castilleja* and *Pedicularis* species to be verified. Genetic sequencing methods were used to confirm the rust species identity on field specimens as *C. ribicola*. All species of *Castilleja* inoculated in the growth chamber were shown to be susceptible to *C. ribicola*, and infection was observed on 167 of 270 plants (62%).

Preliminary results suggest that *P. racemosa* is a potentially significant alternate host in some whitebark pine ecosystems, and this may also be the case in stands containing other species of susceptible five-needled pines. Although infection was common and widespread on this host at some locations (e.g. Mt. Hood), careful and thorough inspection was required to locate infected leaves. Infection of this species was rare on some sites (e.g. Mt. Adams), even where *Pedicularis* plants were growing directly beneath sporulating cankers, and suitable environmental conditions seem to be a key determinant of whether or not disease occurs. *C. ribicola* is an obligate parasite, unable to survive on dead host tissue; therefore, the survival of live host foliage late into the growing season is essential for *C. ribicola* to complete its lifecycle on alternate host plants. The senescence of most *Castilleja* and some *Pedicularis* species earlier in the growing season appears to affect their capacity to become infected. Some species had a tendency to lose most live foliage by the time infection was detected on other susceptible hosts.

Fig 1 Naturally-infected *P. racemosa* plant at Mt. Hood with multiple telial lesions of *C. ribicola*. Photographer: R. L. Mulvey. (see front cover)

Continued monitoring of these species over space and time will allow researchers to assess their relative importance to the WPBR disease cycle. There has been a paradigm shift since the *Ribes* eradication efforts of the 20th century, and it is now understood that, like whitebark pine, *Castilleja*, *Pedicularis* and *Ribes* species play important ecological roles in their native ecosystems. Knowledge of these hosts should be incorporated into Rust Hazard Assessments and used to prioritize sites for whitebark pine restoration. The evaluation of *Castilleja* and *Pedicularis* as hosts for *C. ribicola* in North America is a new area of research, and it is essential that we augment our current understanding in order to improve management of whitebark pine and the communities that it supports.

For more information on this study, please refer to my MS Thesis (Mulvey, R.L., 2010), available online through the OSU library. ■

Assisting Whitebark Pine's Migration

Sierra C. McLane
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University of British Columbia

In a 2008 issue (No. 15) of Nutcracker Notes, Marcus Warwell, Gerry Rehfeldt and Nicholas Crookston demonstrated that whitebark pine's climatic niche – the area within which climatic conditions are suitable for the species – is predicted to all but vanish from the current U.S. portion of the species range by the end of the 21st century due to climate change (Warwell et al. 2007). The prediction for Canada, created by Tongli Wang using the species distribution modeling technique of Hamann and Wang (2006), is only slightly less dire, with three quarters of whitebark pine's current range slated to become climatically unsuitable by 2085.

These predictions are troubling for a species already facing severe losses due to white pine blister rust, mountain pine beetle and changing fire regimes. However, there is a major difference between the two predictions that could affect whitebark pine's long-term survival prospects: whereas in the U.S., whitebark loses habitable ground without gaining a climatic foothold elsewhere, in Canada, a large quadrant of British Columbia (B.C.) north of the current northwestern range margin is predicted to be climatically suitable for whitebark pine at present, and to remain so through the end of the 21st century. Why does whitebark pine not inhabit this quadrant of its purported fundamental niche? I approached this question experimentally, by testing how well the species establishes and grows north of its current range. My hypothesis is that if whitebark recruits and grows when planted in climatically-suitable areas north of its range, then the model may be correct and dispersal may be a more significant barrier to range expansion than climate.

However, my experiment begs a thornier question: what if whitebark pine cannot migrate fast enough to keep up with its northward-bound climatic niche? Can we save the species by translocating it to new habitable locations north of the current range? Called "assisted migration," this proposed technique has garnered mixed reviews from ecologists and ethicists, with opinions ranging from no, assisted migration further manipulates natural systems that humans have already meddled with to excess, to yes, we can soften the ecological blow of climate change by assisting some species without unduly harming others.

Whitebark pine has characteristics that make it ideal for informing the issue of assisted migration. It has negligible invasion potential because of high habitat specificity and slow reproductive maturity. Also, it is being considered for endangered status in the U.S. and Canada, making it a realistic candidate for conservation-based assisted migration should the need arise.

By testing whether whitebark pine can germinate and survive north of its current range, I hope to (a) deduce how seed viability characteristics and planting site conditions affect whitebark pine germination, survival and growth, (b) evaluate the effectiveness of Hamann and Wang's (2006) species distribution model in predicting suitable habitats for whitebark pine and recommend refinements, and (c) contribute to the creation of assisted migration guidelines.

Methods

I established trials in eight locations: two within the current species range and six north of the northwestern range margin (Figure 1). Within each trial location, two sites 50 to 500 m apart were selected with the intention of mimicking conditions experienced by whitebark pine within its current ecological niche. Sites were established above continuous treeline and 100 to 200 m below the highest tree islands on south-facing, 5 to 20 ° slopes with coarse, well-drained soils. Cones from seven populations representing a wide geographic gradient within the northwestern portion of the species range were collected in 2007 (Figure 1). Half of the seeds were planted raw in the sites in September 2007 (n = 8,960), while the other half were treated (x-rayed to identify empty seeds, stratified to break seed dormancy, and nicked to promote germination) and planted in June 2008 (n = 6,992). Two Maxim iButton temperature sensors were installed per site at the time of planting.

Seedling and microsite data were collected and temperature sensor data downloaded in August 2008 and July 2009. Germination, survival, health, height, and needle development data were recorded for every seedling while slope, convexity, soil type and depth and vegetation height were recorded for the 10 cm-radius microsite around every seed cache. Normal (1970 – 2000) climate data for each site were downloaded using ClimateWNA (www.genetics.forestry.ubc.ca/cfcg/ClimateWNA/ClimateWNA.html). The effects of seed treatment, seed development characteristics, climate and microsite on germination, survival and growth, were determined using generalized linear models.

Results and discussion

Seeds have germinated and are growing (slowly) at all of the trial locations! Three factors are responsible for the majority of the differences in germination, survival and growth: 1) seed treatment, 2) snowmelt timing, and 3) seed weight and viability. By August 2008, 27.5% of the treated seeds and 0.5% of the untreated seeds had germinated. By July 2009 these numbers climbed to 29.9% of the treated and 6.3% of the untreated seeds (Figure 2). I attribute the majority of the treatment effect to stratification, as numerous seeds cracked during the induced cold dormancy, rendering nicking of lesser importance. Following the Yellowstone National Park fires of 1988, Tomback et al. (2001) found that natural whitebark pine regeneration in burned areas was greatest two years, and continued for at least four years, following probable seed-caching events. If the same trend holds in my experiment, the untreated seeds that germinated in 2009 will constitute the majority of the untreated seeds that germinate in total, but germination could continue beyond 2011. While treated seeds may also continue germinating in subsequent years, relatively fewer are expected do so, since the treatment regime appears to have effectively induced a same-year germination response for most seeds.

All quantitative traits were positively associated with earlier snowmelt dates, which correlate strongly with higher numbers of growing-season degree days and warmer summer temperatures. Counter to this trend, the two Atlin sites – the only sites that did not develop a persistent snowpack during the 2008 – 2009 winter – had excellent germination of treated seed in 2008, but very little germination of untreated seeds and near-zero treated-seed survival in 2009. These data indicate that whitebark pine seedlings are both reliant on the insulating properties of snow and limited by snowpacks that shorten the growing season. As the climate warms, whitebark pine may be able to grow at higher elevations if snowpacks dissipate earlier, but not if snow accumulation is excessively reduced.

Seeds with heavier initial weights and better x-ray-determined viability were more likely to germinate and survive, signifying that most of the quantifiable differences among populations to date are maternal, rather than genetic effects. This is not surprising for a species with such resource-rich seeds.

It is too early in the lives of the translocated whitebark pines to evaluate the accuracy of climate-based habitability predictions. However, incorporating snow accumulation and duration data into species distribution models for whitebark and other snow-affected species will likely improve model fit. This will entail accounting for slope and aspect, as well as satellite-based snow cover data (available for the northern hemisphere at nsidc.org/data/nsidc-0447.html). It is also too early to recommend assisting whitebark pine's northward migration. My trial, which is permitted through 2037, is a small contribution to the efforts many scientists are applying to the issue. By the time drastic measures might be needed for whitebark pine, a comprehensive assisted migration decision-making framework will hopefully be in place to guide our actions.

Acknowledgements
I am grateful to Sally Aitken for supervising this dissertation research, the B.C. Ministry of Forests and Range for permitting the trials, and many others without whose assistance this project would have remained merely an idea. Funding was provided by the Forest Investment Account through the B.C. Forest Genetics Council to the Centre for Forest Conservation Genetics, as well as by University of British Columbia Graduate Scholarships.

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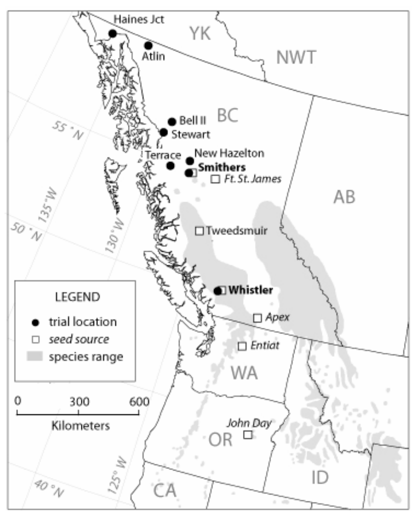

Figure 1: Trial locations and provenances relative to the current whitebark pine (*Pinus albicaulis*) species range. Of the eight sites, two are within the current species range and three are north of the species range in areas broadly predicted to be habitable under both present (1971-2000 normal) and 2055 climate regimes.

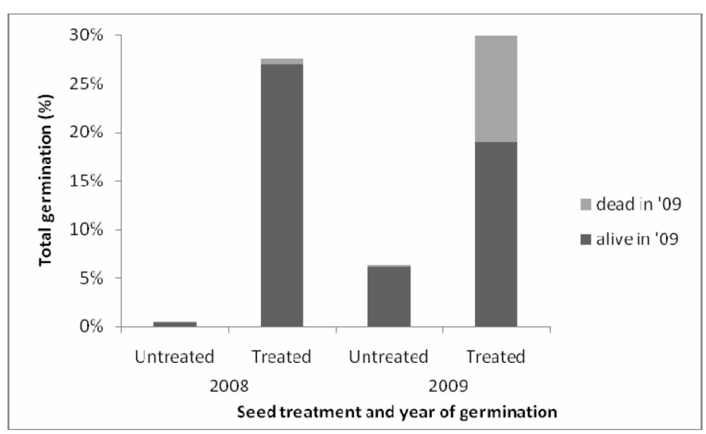

Figure 2: Germination and survival of whitebark pine seedlings by seed treatment and year.

Ecosystem Change at Whitebark Pine's Northern Limit

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This MSc research on whitebark pine (*Pinus albicaulis*) ecosystems continues the work of the Bulkley Valley Research Centre in northwestern British Columbia (Haeussler 2008). Here, whitebark pine is at the northern extent of its range in the Coastal mountains and is subject to mountain pine beetle (MPB) and white pine blister rust (WPBR). Stresses such as climate change and the effects of fire suppression may also contribute to whitebark pine decline in this region.

Haeussler et al (2009) focused on rare whitebark pine-dominated stands on coarse-textured, nutrient-poor sites. They re-visited sites surveyed by the BC Ministry of Forests (BC-MOF) from 1978-85 to determine how they have changed over time. They thought that a warmer, wetter climate combined with canopy disturbance from MPB and WPBR would increase resource availability such that whitebark pine ecosystems would shift compositionally to resemble common, mesic ecosystems. Preliminary results did not fully support this hypothesis. The climate was warmer after the 1970s, but precipitation was highly variable. There was no uniform shift in understory composition; however, there were interesting differences in understory response between two different whitebark pine ecosystems surveyed: 'Moderately dry/poor' versus 'Dry/poor' (Haeussler et al 2009).

We followed up this preliminary study testing two possible hypotheses: (1) was there a homogenization of forest communities over time through a shift in both types of whitebark pine ecosystems towards a mesic ecosystem composition? or (2) was there a threshold response whereby 'Dry/poor' ecosystems demonstrate resilience to change, while 'Moderately dry/poor' ecosystems are more vulnerable? In 2009 we undertook further re-sampling of old BC-MOF plots in both whitebark pine ecosystems, as well as surveying mesic, non-whitebark pine ecosystems as a reference. Here we present changes in forest structure over time.

Methods

We returned to sites surveyed in 1978-85 and followed the original BC-MOF survey methodology (Luttmerding et al. 1990). We were not always able to relocate the original plot markers so precise relocation was not always possible. However, we navigated as geographically close to the original plots as possible and ensured placement of our plot was in an area with as similar site characteristics as possible. In total in 2007-09 we surveyed 5 'Dry/poor', 4 'Moderately dry/poor' and 5 'Fresh/medium' sites collecting basic mensuration data using prism plots; in the 2007-09 surveys we also used 5.6 m radius plots. Diameter at breast height (DBH) was recorded for live and dead trees in both survey periods.

Results and Discussion

There was significant change in tree species composition and abundance over time. The observed change supports Hypothesis 1. A decrease in live whitebark pine stems has driven these forests to more closely resemble 'Fresh/medium' reference stands (Figure 1). Our results suggest that absolute disturbance intensity was similar in 'Moderately dry/poor' and 'Dry/poor' ecosystem types.

Disturbance in 'Dry/poor' ecosystems decreased the number of large *P. albicaulis*, changing this species from a J-shaped to a unimodal diameter distribution (Figure 1). The decline in smaller live *P. albicaulis* trees is worrying for the conservation of this species, particularly in dry, exposed stands, where it is expected to persist throughout old growth (Keane et al 1990). We did find that *P. albicaulis* seedlings continue to regenerate in the driest stands, suggesting these are the most suitable sites for whitebark pine persistence (Figure 2).

'Moderately dry/poor' ecosystems showed a similar loss of large whitebark pines as well as a decrease in large *A. lasiocarpa* accompanied by a sharp increase in small *T. mertensiana* (Figure 1). There were few small *P. albicaulis* trees in 2007-09; this, combined with the lack of *P. albicaulis* seedlings (Figure 2) suggests whitebark pine may not persist in these ecosystems. The lack of regeneration could be due to shading from the thickening canopy of hemlock and fir and also due to lack of seeds, as Clark's nutcrackers may be less likely to cache seeds in 'Moderately dry/poor' stands (Tomback et al 1990).

Our reference stands also changed over time, primarily through decreasing *A. lasiocarpa* in the canopy. This may have been due to balsam bark beetle (*Dryocoetes confusus*) disturbance, competition with more shade tolerant *A. amabilis* and *T. mertensiana*, or simply that there is a decline in density as stands age.

Disturbance and stand dynamics in whitebark pine ecosystems are complex. Whitebark pine continues to regenerate in 'Dry/poor' ecosystems; however, ongoing disturbance will further decrease its presence in the overstory and canopy recruitment in the future, resulting in a worsening outlook for this rare ecosystem.

Acknowledgements:
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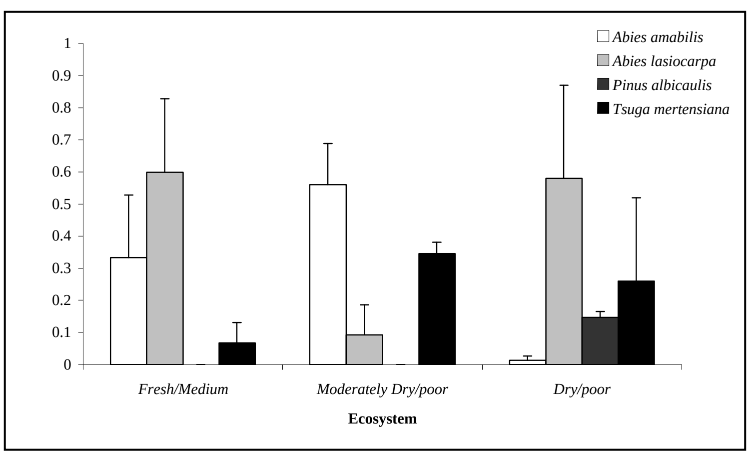

Figure 2 – The proportional number of seedlings/ha for each species by ecosystem type in the 2007/09 surveys

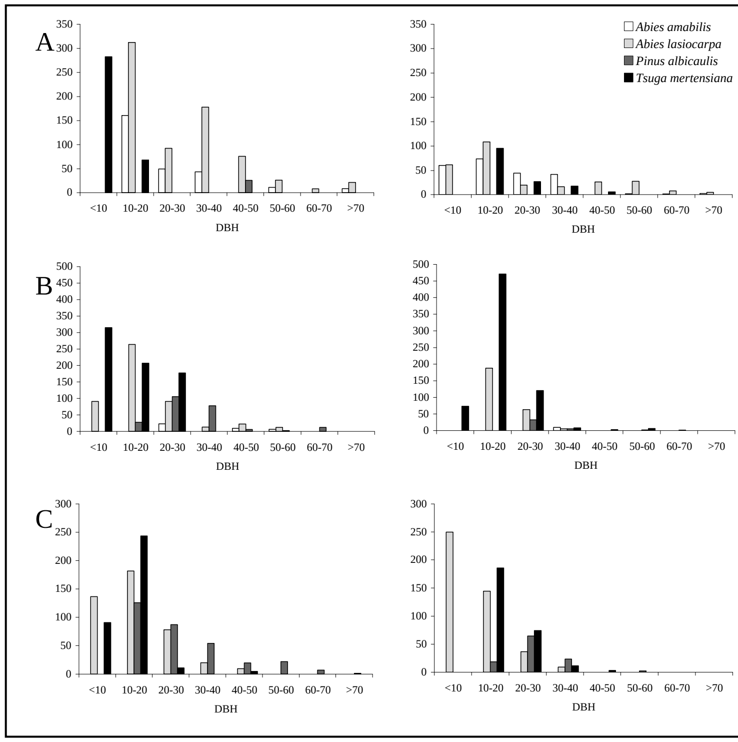

Figure 1 – The number of stems/ha by diameter at breast height (DBH) category for each species in the first survey period (left) and second survey period (right); A) 'Fresh/medium' reference stands; B) 'Moderately dry/poor' and C) 'Dry/poor' whitebark pine ecosystems.

Blister Rust, Fire Exclusion, and the Fate of Sugar Pine

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[Editor's Note:** Although not one of the "High Five" species, sugar pine is a magnificent white pine that is subject to similar threats**.]

Botanical explorers were awestruck by the sugar pine (*Pinus lambertiana)* (David Douglas called it the "most princely" of all pines). It is the tallest and largest pine, attaining heights of 50 to 60 m (165 to 200 feet) and diameters of 90 to 150 cm (35 to 60 inches). Its cones are impressive, reaching lengths of 25 to 50 cm (10 to 20 inches). Sugar pine is also prized for its high quality lumber.

Figure 1. Mature sugar pine at Sequoia National Park. Credit: NPS

Sugar pine inhabits the Oregon Cascades and spreads southward through the higher mountains of California. It is most abundant along the western slope of the Sierra Nevada in ponderosa pine and white fir mixed-conifer forests at elevations between 1200 and 2200 m (4000 and 7000 feet), but usually comprises less than 10 percent of the stand.

The exotic pathogen, white pine blister rust *(Cronartium ribicola)* continues to impact sugar pine. As an early successional tree, sugar pine historically benefited from frequent low-intensity fires. Fire exclusion has led to overcrowded stands and high accumulations of forest fuels, making sugar pine vulnerable to competition with shade-tolerant species, damage from insects, disease, and modern wildfires.

Although blister rust and fire exclusion are widely recognized threats, long-term demographic data documenting the effects of these stressors are rare. One recent study tracked sugar pine population trends from 2,168 individuals over 5–15 years at Sequoia and Yosemite National Parks (van Mantgem et al. 2004). Simple models of these sugar pine populations indicated that most unburned populations had slightly negative growth rates, implying slow population declines (Figure 2). Most populations appeared to be buffered against significant declines due to relatively high survivorship of large individuals. However, the increasing scarcity of smaller individuals, often due to blister rust-induced mortalities point to future problems. Deaths associated with blister rust and competition were common, indicating significant roles for both blister rust and fire exclusion in determining population trajectories.

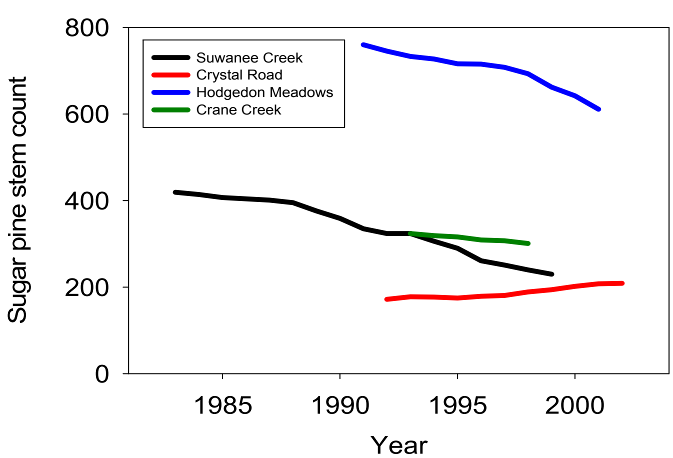

Figure 2. Sugar pine population trends at four sites in Sequoia and Yosemite National Parks. Redrawn from van Mantgem et al. (2004).

How might the reintroduction of fire influence the sugar pine population trends? There are anecdotal reports of high mortality of large sugar pine following prescribed fires (Muerle 2004). Data from 15 prescribed fires at Sequoia National Park showed the immediate effect of burning was the death of many small sugar pine, with the frequency of mortality returning to pre-fire levels within five years (van Mantgem et al. 2004). Trials are currently underway in Sequoia and Yosemite National Parks to assess post-fire survivorship when fuels (forest litter and duff) are raked away from the base of sugar pines prior to prescribed burning.

Other stressors beyond white pine blister rust and fire exclusion might be further affecting sugar pine. There is mounting evidence that forests in western North America are responding to climatically lengthening summer drought. Resulting forest responses have included increasing background mortality rates (van Mantgem and Stephenson 2007, van Mantgem et al. 2009), increasing frequency of die-backs of entire stands (Allen 2009), and perhaps greater susceptibility to insects and pathogens (Raffa et al. 2008). Climate model projections suggest all these phenomena will become more pronounced in coming years (IPCC 2007).

It is unclear how sugar pine will ultimately fare in response to these multiple threats. Current declines are relatively slow, allowing time to apply and refine management strategies to help improve resilience of sugar pine populations to environmental stress (Millar et al. 2007).

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Foxtail Pine in the Range of Light

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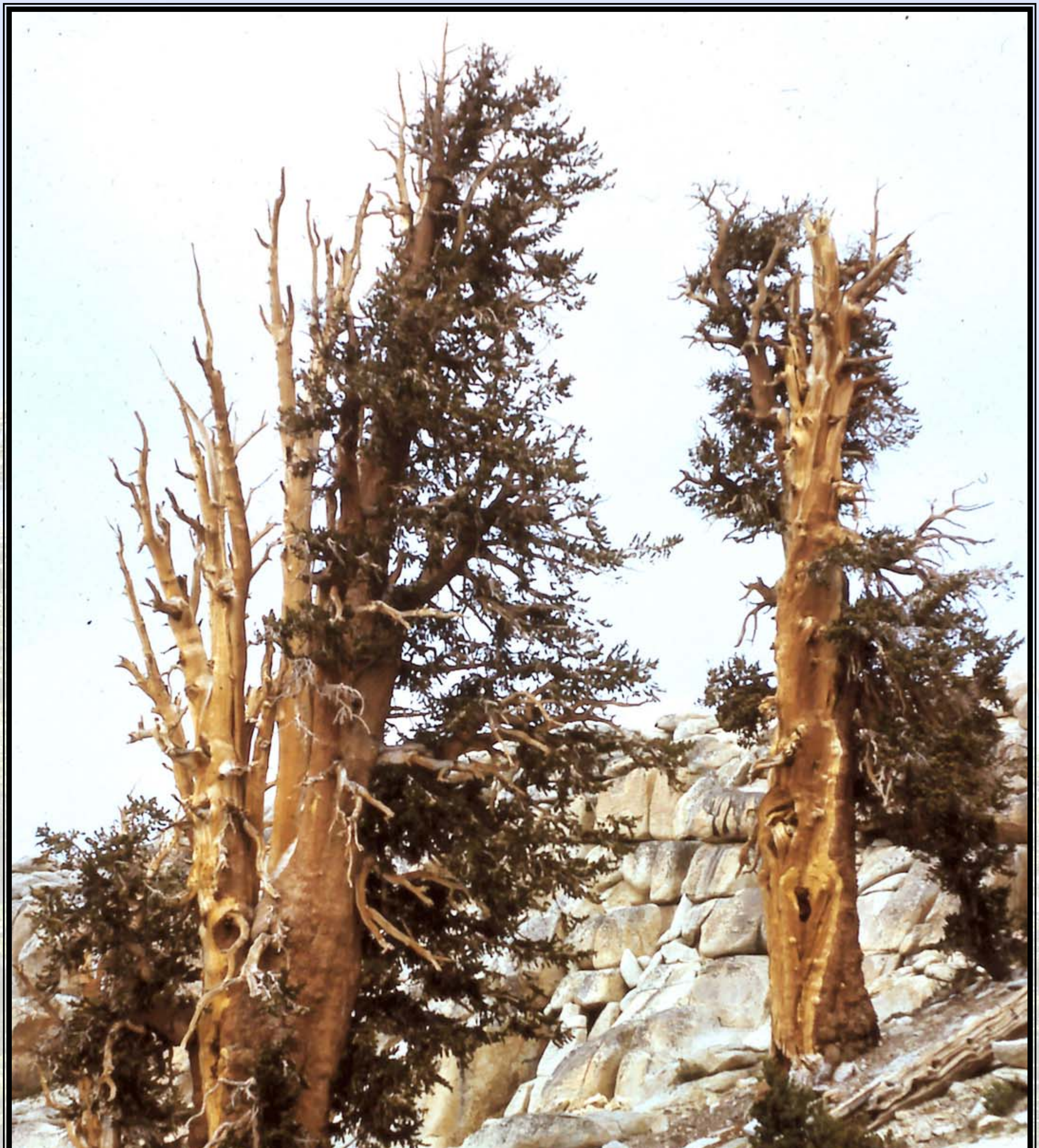
For many, the tree that epitomizes the Sierra Nevada is the giant sequoia, but for those who venture into the wilderness of the southern Sierra foxtail pine is the tree most emblematic of the high country of John Muir's "Range of Light". Foxtail pine (*Pinus balfouriana* Grev. & Balf.), a five-needle pine closely related to the bristlecone species of the Great Basin and Rocky Mountains, occurs in two distinct and widely separated populations in California, a southern subspecies found in the heart of the southern Sierra Nevada (subsp. *austrina*) and a northern subspecies (subsp. *balfouriana*) found in the Klamath Mountains and high coast ranges of northwestern California. Foxtail forests or woodlands are typically open with little understory but with scattered woody remnant material from long-dead trees.

Foxtails, like bristlecones, have needles that can persist for over 20 years resulting in branches with a bottlebrush appearance, hence the name "foxtail". The southern subspecies is a timberline species occupying harsh sites characterized by rocky, poorly developed soils at elevations from 9,000 to 12,000 ft. Climate in the area is distinctly Mediterranean characterized by cold wet winters and warm dry summers during which little or no rain falls. The heart of its distribution in the Sierra Nevada is centered in the upper Kern River Canyon and along the crest of the Great Western Divide that separates the Kern and Kaweah River drainages in Sequoia National Park. The Kings River drainage forms the northern limit of the subspecies in Kings Canyon National Park. Within its range foxtail co-occurs at its lower margin with red fir, western white pine, and lodgepole pine, while at tree line it can be associated with whitebark pine, which replaces it as a tree-line species to the north. Fire is uncommon or typically doesn't spread beyond one to a few trees at higher elevations because of sparse fuels but it may be an important factor governing the lower elevational boundary for the species because it is fire intolerant.

In a high elevation rugged mountain environment foxtail stands out because it maintains an upright posture with a well-developed crown, rarely developing a krummholz growth form or the squat growth form characteristic of old bristlecones. While trees can develop a strip-bark growth form it is not as common or as well-developed as in ancient bristlecone pines, some of the oldest of which are found just east of the Sierra Nevada in the White Mountains (Methuselah Walk and Patriarch's Grove in the Ancient Bristlecone Forest of Inyo National Forest). More typical is repeated dieback of portions of the crown, over many centuries, resulting in a distinctive "flagged" appearance. Another special characteristic of most foxtail forests is the ancient weathered dead wood, remnant logs and snags that can be several thousand years old. Of particular interest are the "ghost forests" of dead trees found above the current upper elevational limits of the species. These have been the subject of several recent studies and reveal changes in the forest border related to climate fluctuations over the last several millennia.

Foxtail pine is one of seven species worldwide reaching ages greater than 2,000 years (five of which occur in California). The oldest known individual, with a dendrochronologically dated age of 2,110 years in 1992, is located in Sequoia National Forest. Of even greater significance is the age of the highly resinous remnant wood found throughout extant foxtail stands and ghost forests, often exceeding the age of living trees by thousands of years. The wood often resembles sculptures formed by thousands of years of weathering by wind, snow, rain, and sun. Tree-ring chronologies from a number of sites have been constructed by crossdating living trees, and at some sites, successively older remnant logs (most with only a few hundred rings), with the oldest chronologies reaching nearly 4,000 years in length. These chronologies have been used to reconstruct seasonal climate and river flows from the region and as data for some worldwide temperature reconstructions.

Where can one go to see the species? While foxtail pine can be readily observed from a distance on many Sierran peaks, it requires at least a day of hiking to actually visit them up close. Some of the easier areas to visit the species include Timber Gap in the Mineral King area of Sequoia National Park on the west side of the Sierra Nevada (where one of the largest measured individuals is located), or on the east side of the range--Onion Valley or the Cottonwood Pass/Chicken Spring Lake areas in Inyo National Forest . ■



Foxtail pines on Alta Peak in 1963. Original and second trunk of tree at left are dead and a third, living "piggyback" trunk at right supports the foliage. Photo by S. Arno.