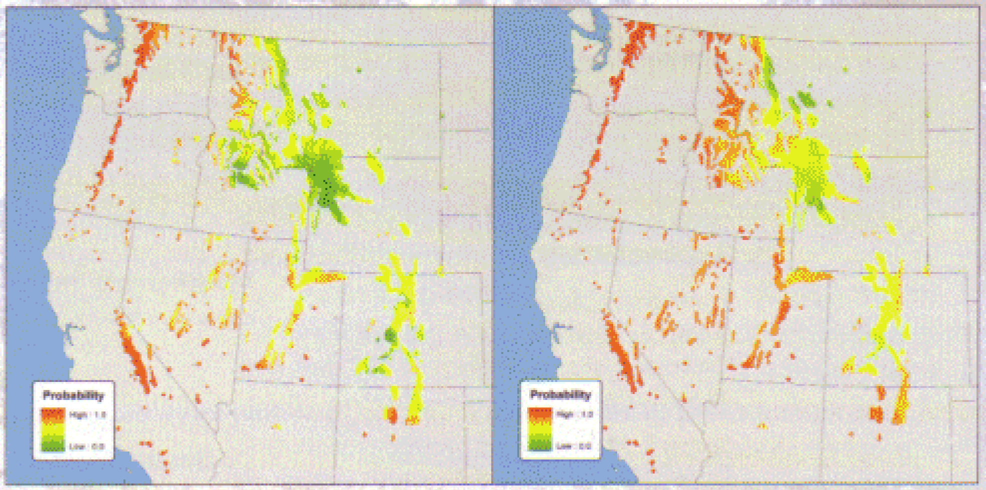
Issue No. 15: Autumn/Winter 2008

Nutcracker Notes

Whitebark Pine Ecosystem Foundation

WPEF Field trip, September 2008, Grand Targhee Ski Area (photo by S. Arno.)



Predicted probability of mountain pine beetle cold temperature survival during A) 1961-1990; B) 2011–2031 (Fig. 1 in Bentz article).

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Whitebark Pine Ecosystem Foundation
***Nutcracker Notes*, Issue No. 15; Fall/Winter 2008**

CONTENTS **PAGE**

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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

Time for rethinking restoration strategies?

This summer, in conjunction with research, my students and I had a first-hand look at whitebark pine in four national parks, Grand Teton, Yellowstone, Glacier, and Waterton Lakes. In Yellowstone and Grand Teton national parks, we found high incidence of recent mortality from mountain pine beetles and new faders in most areas; my students also found new beetle attacks on trees in late August. We also found blister rust infection levels to be moderately high in Grand Teton National Park, but more sporadic in Yellowstone. In Glacier and Waterton Lakes national parks, most living whitebark pines are infected with blister rust, with evidence of recent mortality from rust as well. These observations are in line with recent assessments from a variety of sources.

The time has come to revisit our whitebark pine restoration strategies. Our focus has been on blister rust, an invasive fungal pathogen, and planting seedlings from parent trees with genetic resistance to blister rust, and also the use of fire and thinning projects to reduce competition and encourage regeneration in late successional communities. Blister rust spread and intensification clearly remain a threat throughout the range of whitebark pine, and currently account for serious population declines in the northwestern U.S. and southwestern Canada. However, mountain pine beetle outbreaks are killing whitebark pine much more rapidly than blister rust or successional replacement in the Greater Yellowstone Area and in Idaho, and the outbreaks are spreading to other regions.

This issue is complex: mountain pine beetles are native. Small-scale outbreaks have provided openings for tree regeneration. Large-scale outbreaks across the West, which occurred during periods of higher temperatures and drought in the 20th century, created a mosaic of successional stages. But, some researchers believe that anthropogenically-driven global warming has fueled this current outbreak, and that the outbreak will continue over the coming years until whitebark pine is greatly depleted.

What is the outlook for whitebark pine and other five-needle white pines? Can we devise restoration strategies that incorporate the impacts of continued mountain pine beetle outbreaks? Are widespread losses of whitebark pine to mountain pine beetles a good rationale for planting whitebark pine? How will the unrelenting spread of blister rust affect future regeneration? Will beetles kill a new generation of whitebark pine trees as they reach cone-bearing size?

Given the areal extent of their whitebark pine communities, the Greater Yellowstone and much of the northern Rocky Mountains of the U.S. comprise the center of abundance for whitebark pine. Losses in these regions are widespread and increasing, and clearly whitebark pine is becoming a much smaller ecological component . What will be the ecological consequences?

Meetings and workshops

This past August, the Livingston, MT, office of the Natural Resource Defense Council, headed by Louisa Willcox, organized a media workshop at Headwaters Conference Center, Dubois, WY, to discuss the impacts of climate change on the Greater Yellowstone Ecosystem. Several other scientists and I made presentations--the presenters including Steve Running, pine beetle experts Jesse Logan and Diana Six, and NRDC climate change policy expert David Hawkins. Bruce Gordon, president of the non-profit organization EcoFlight, flew media representatives and scientists over whitebark pine stands at Union Pass and Togwotee Pass, Wind River Range, to show the widespread mortality from mountain pine beetle. Meredith and Tory Taylor, and Robert Hoskins, outfitters in Dubois, packed in and set up camp at Union Pass, providing base support while we explored the condition of whitebark pine in the vicinity for two days. We discovered massive whitebark pines, at least a thousand years of age, hit this year by mountain pine beetles. Given that these pines had survived numerous past beetle outbreaks, including those of the 1930s and 1970s, this was a disheartening find.

In September, a number of WPEF members including me, attended the conference marking the 20th anniversary of the Yellowstone fires, in Jackson Hole. One sobering pronouncement from the conference, articulated by several speakers—both fire managers and scientists—was that the scale and severity of the 1988 fires were a harbinger of things to come, given climatic trends.

2008 and 2009 Annual meetings

In mid-September our 8th Annual WPEF Members' Meeting was held at Grand Targhee Resort, Alta, Wyoming, in conjunction with the fall meeting of the Greater Yellowstone Coordinating Committee Whitebark Pine Subcommittee. Liz Davy, Bridger-Teton National Forest, and WPEF Board Member Dan Reinhart, Yellowstone National Park, were organizers and hosts for this highly successful event. The scientific program covered a number of whitebark pine-related issues from the Greater Yellowstone Area and elsewhere; our thanks to the speakers. The late summer weather was clear and sunny--perfect for our field trip to whitebark pine at the highest point of the ski area, accessible by hiking up the service road or by chairlift. Field trip leaders were Andy Steele, Matt Germino, and Melissa Jenkins. Thanks to all who attended, to the field trip leaders, and especially to Liz and Dan for organizing the meeting.

Please mark your calendars! Our 2009 Annual Members' Meeting will be Thursday and Friday, September 10 and 11 in Nelson, British Columbia, about 3 hours north of Spokane. WPEF Board Member, Michael Murray, who now works for British Columbia Ministry of Forests, has volunteered to organize this meeting. Details will be posted on our website next spring.

Upcoming 2009 WPEF election

This coming year, the terms of office will expire for our WPEF Membership Coordinator and three board members. We are always looking for new individuals and fresh views to help shape our goals and mission for the coming years and help bring our projects to fruition. Please consider nominating an interested colleague or asking to be nominated by other members. Remember that attendance at board meetings is extremely critical for the success of our work.

RFP Whitebark Pine Restoration Funding

The third annual Request for Proposals for Whitebark Pine Restoration was recently announced by John Schwandt, USDA Forest Service Forest Service, Forest Health Protection. This year, the Whitebark Pine Ecosystem Foundation and The National Arbor Day Foundation, together are providing $30,000 to FHP for Whitebark Pine Restoration, which brings the total available funds to $180,000. John Schwandt hopes for additional funding to become available over the next few months (see article in this issue). The money contributed by the WPEF comes from our restoration fund and from member donations. It is our philosophy to use any funds over and above what we require for overhead and on-going projects for the purpose of whitebark pine restoration.

A New Beginning

It is not just whitebark pine. Wildlife and ecological communities are threatened by fragmentation, development, water wars, pollution, and introduced pests and disease. Furthermore, nearly 50% of the U.S. Forest Service budget been used to fight fire in fire-adapted landscapes over the last few years, and fire policy needs to be revisited. It is my hope that the incoming presidential administration will rise to these challenges by devising realistic, science-based policies and management plans, seeking broad-based input from scientists and resource managers, and allocating sufficient resources to get the job done. ■

Plan for WPEF's Annual Conference in scenic Nelson, B.C. September 10-11 (Thurs.-Fri.), 2009

Located only about 3 hours north of Spokane and Coeur d'Alene, Nelson is a cultural center in the lake and mountain country of southeastern British Columbia (see photos on our back cover). With a population of about 10,000, Nelson has been called the number one small arts community in Canada. Downtown boasts a vibrant assortment of street musicians, unique shops, and restored century-old "heritage" buildings. Located on an arm of Kootenay Lake, Nelson is surrounded by the spectacular Selkirk Mountains, which support whitebark pine, alpine larch, grizzly bears, mountain caribou, and alpine glaciers.

Canadian scientists and provincial governments of B.C. and Alberta have recognized that their native whitebark pine communities are at risk from depredations by blister rust and outbreaks of mountain pine beetles. Join us in Nelson next September to learn more about the status and conservation of whitebark pine in Canada, as well as to hear updates on conservation efforts in the U.S., at the 9th annual WPEF Science Conference (September 10th). Then travel with us into whitebark pine communities in the Selkirks on our September 11th field trip.

A block of rooms is available at Baker Street Inn (www.bwbakerstreetinn.com) with a special conference rate of $85/$95 (single/double). Recently the U.S. dollar has regained a favorable exchange rate vs. the Canadian dollar; but visitors from the U.S. will need to have a passport or passport card for returning to the U.S. starting in June 2009.

Details on the conference will be posted on our web site (www.whitebarkfound.org) by early 2009, or contact WPEF's conference coordinator in Nelson at Michael.murray@gov.bc.ca. ■

Clark's Nutcracker:
A New On-line Literature Review

Nancy E. McMurray,
Missoula Fire Sciences Laboratory

A comprehensive review of literature on the Clark's nutcracker (*Nucifraga columbiana*) was published in early November in the Fire Effects Information System (http://www.fs.fed.us/database/feis/index.html). This synthesis, written by Nancy (Nanka) McMurray and containing nearly 200 citations, describes the general ecology of the Clark's nutcracker and also focuses on the bird's relationship to fire.

Some highlights:

Clark's nutcracker inhabits montane coniferous forests from the Canadian Rockies to northern Mexico. Since the bird specializes in consuming conifer seeds, many aspects of its life history revolve around the need to harvest, cache, and retrieve seeds of its preferred food species. The Clark's nutcracker is probably best known for its role as the only effective initial dispersal agent of whitebark pine (*Pinus albicaulis*) seeds, but nutcrackers also consume and cache the seeds of other large, wingless seeded pines including limber pine (*Pinus flexilis*), southwestern white pine (*Pinus strobiformis*), Colorado pinyon (*Pinus edulis*), and singleleaf pinyon (*Pinus monophylla*). These five species are considered "nutcracker pines" because they depend, to varying degrees, on the Clark's nutcracker for seed dispersal. Clark's nutcrackers also harvest and store the seeds of wind-dispersed (winged seeded) conifers that grow near their preferred pines. Use of wind-dispersed species requires more time and energy than use of the preferred pines because nutcrackers remove each seed wing before consuming or caching the seeds of these species. At high elevations, Clark's nutcrackers sometimes use the small, winged seeds of Rocky Mountain bristlecone pine (*Pinus aristata*) and perhaps Great Basin bristlecone pine (*Pinus longaeva*) and foxtail pine (*Pinus balfouriana*).

The tree species preferred by Clark's nutcrackers are masting species characterized by "boom and bust" seed production cycles. To buffer the effects of such an erratic food source, the birds possess a flexible foraging ecology. Individuals range extensively throughout mountain habitats during the fall, exploiting an array of conifer species. They often use the seed crop from different tree species sequentially. For example, in the Northern Rockies, Clark's nutcrackers typically harvest and cache the seeds of whichever preferred pine ripens first–whitebark and/or limber pine. Then they move on to the seeds of later-ripening, wind-dispersed species that occur at lower elevations—ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*).

Clark's nutcrackers are highly dependent on habitat shaped by fire, especially in the Northern Rocky Mountains and the Cascade Range. Fire initially creates caching habitat by opening up tree canopies, reducing vegetation on the forest floor, and increasing visibility of objects that help the birds relocate caches. The caching habits of the Clark's nutcracker help the shade-intolerant nutcracker pines dominate burned areas. As post-fire seedlings reach reproductive maturity, burns eventually become foraging habitat for Clark's nutcrackers, with the preferred pines serving as a food source for decades to centuries. Where shade-tolerant species gradually become dominant, production of preferred seed declines, as does nutcracker foraging. Another fire can help maintain nutcracker pines on the landscape by once again creating caching habitat, and the cycle continues…or at least it used to.

This cycle has been disrupted by the introduction of white pine blister rust (*Cronartium ribicola*), successful fire exclusion, mountain pine beetle epidemics, and possibly climate change. As a result, Clark's nutcracker habitat is declining. How does blister rust affect Clark's nutcracker seed harvesting? Will Clark's nutcrackers use caching habitat produced by prescribed burns? Do some nutcrackers cache differently than others within the same local population? For some answers, read the review of this fascinating bird online at (http://www.fs.fed.us/database/feis/animals/bird/nuco/all.html).

Clark's Nutcracker isn't the only species from whitebark pine and related ecosystems reviewed in FEIS. Here are others, along with the year the review was published. Go online for more information: www.fs.fed.us/database/feis.

Scientific name	Common name	Year
Pinus albicaulis	whitebark pine	2002
Pinus aristata	Rocky Mountain bristlecone pine	2004
Pinus balfouriana	foxtail pine	2004
Pinus cembroides	Mexican pinyon	1994
Pinus edulis	Colorado pinyon	2002
Pinus flexilis	limber pine	2001
Pinus jeffreyi	Jeffrey pine	2007
Pinus longaeva	Great Basin bristlecone pine	2004
Pinus monophylla	singleleaf pinyon	2001
Pinus ponderosa var. arizonica	Arizona pine	2002
Pinus ponderosa var. ponderosa	Pacific ponderosa pine	1992
Pinus ponderosa var. scopulorum	interior ponderosa pine	2003
Pinus quadrifolia	Parry pinyon	1993
Pinus strobiformis	southwestern white pine	1993
Pseudotsuga menziesii var. glauca	Rocky Mountain Douglas-fir	2002
Pseudotsuga menziesii var. menziesii	coast Douglas-fir	1991
Tamiasciurus hudsonicus	red squirrel	1995
Ursus americanus	American black bear	2008
Ursus arctos ssp. horribilis	grizzly bear	1991

■

Whitebark Pine Posters and Puzzles for Holiday Gifts

Crater Lake Institute is selling beautiful posters and 500-piece puzzles of Larry Eifert's whitebark pine scenes at cost for a limited time. The "Rocky Mountain" whitebark pine scene featuring a grizzly bear and other wildlife was pictured on the cover of *Nutcracker Notes, issue 13* (fall/winter 2007) and the Crater Lake whitebark pine scene featuring Wizard Island (see it at www.larryeifert.com/blog/2007/12/whitebark-pines-wizard-island.html) are both available as large posters (at $5 each) and puzzles (at $10) plus shipping costs. Order from Crater Lake Institute, PO Box 2, Crater Lake, OR 97604 or by phoning Ron at 541-810-3942. Please provide a UPS/FedEx shipping address. ■

Whitebark Pine Restoration Program: An Update

John Schwandt, jschwandt@fs.fed.us

The whitebark pine restoration program is entering its third year of providing seed money for restoration projects. Projects must be one year in duration and proposals are evaluated by an interdisciplinary team on scope, objectives, cost efficiency, technical merit, level of matching funds and sunk costs.

In 2008, we received 62 proposals requesting over $2,000,000. Proposals came from USFS regions 1, 2, 4, and 6, six national parks, three Forest Service research stations, and eight universities. Twenty-six proposals were recommended for funding (see table on page 18) and $398,000 in Forest Health Protection funds were leveraged to a total of more than $830,000 by other matching funds.

The 2009 restoration program is underway (see accompanying RFP announcement) and will include contributions from the Whitebark Pine Ecosystem Foundation and the Arbor Day Foundation. ■ →Continued on page 18

Pinus flexilis: *a*, cone scale and seeds.

Editor's Note: Although this RFP announcement's closing date is past, coordinator John Schwandt may be able to entertain additional proposals if additional funding appears. John's contact information is listed below.

REQUEST FOR WHITEBARK PINE RESTORATION PROJECT PRE-PROPOSALS FY 2009

RELEASE DATE: October 24, 2008

CLOSING DATE: Pre-Proposals must be e-mailed to the address below no later than COB **November 19, 2008**

CONTACT PERSON: John Schwandt, Program Coordinator
USDA Forest Service Forest Health Protection
(208) 765-7415
Email:
jschwandt@fs.fed.us

INTRODUCTION

Whitebark pine has disappeared from areas within parts of its historic range, and many of the remaining populations are threatened by white pine blister rust, mountain pine beetle, and competing vegetation. The whitebark pine restoration program is entering it's third year of providing seed money for restoration projects throughout the whitebark pine range.

Although the exact amount of funding available may not be known until final Congressional action, we expect that at least $180,000 will be allocated from a combination of Forest Health Protection (FHP), the Whitebark Pine Ecosystem Foundation (WBEF) and National Arbor Day Foundation. Funds will be allocated on a competitive basis, as described in the attached document, and will need to be spent or obligated prior to September 30, 2009.

State, non-governmental organizations, and universities as well as federal agencies may apply for funding but may need to meet specific cost share requirements (Contact the Program Coordinator if you have questions 208-765-7415).■

Temperature Influences Mountain Pine Beetle Outbreaks

Barbara J. Bentz, Rocky Mountain Research Station, Logan, UT

Mountain pine beetle (*Dendroctonus ponderosae*) is currently widespread in pine forests of western North America. Although *Dendroctonus* (most likely mountain pine beetle) has been a resident of high-elevation white pine (5-needle pine) forests for at least the past 8000 years (Brunelle et al. 2008), within the last century beetle activity has been most notable in low-elevation forests. Dendroecological and written evidence support the existence of region-wide mountain pine beetle activity in high-elevation white pine forests during the warm, dry period of the late 1920s and early 1930s (Perkins and Swetnam 1996, Furniss and Renkin 2003). Cooler periods within the last century reduced mountain pine beetle activity at high elevations (Amman 1973).

Although the connection between temperature and mountain pine beetle life-cycle timing is well recognized, little is known regarding the influence of temperature on population seasonality at high elevations. Observations suggest that phenological timing in high-elevation forests differs from that in low-elevation pine forests where synchronicity in life-stage timing and adult emergence, in addition to strict univoltinism (adult beetle emergence from trees one year after attack), are thought to be necessary for population success (Logan and Bentz 1999). If synchronicity is lacking in high-elevation pine forests, how is mountain pine beetle so successful?

Mountain pine beetle phenology was monitored over three years (2003-2005) in whitebark pine at three sites above 8200 feet (2500m) elevation in the Greater Yellowstone Ecosystem (GYE). At all sites, adult mountain pine beetle emerged from individual trees both one (univoltine) and two (semivoltine) years following attack, and the majority were semivoltine. There were no clear trends in the proportion of univoltinism among trees, and emergence timing was similar among sites. Temperature trends among the sites were also quite similar, although summer heat at a low-elevation lodgepole pine site was greater than at the high-elevation whitebark sites. Because substantial tree mortality was occurring at each of the high-elevation sites, these data suggest that strict univoltine seasonality, as is often observed in low-elevation lodgepole pine sites, is not necessarily a requirement for mountain pine beetle population outbreaks in high-elevation forests. Increased proportion of a population that completes development in a single year, however, will further increase mountain pine beetle population growth rates at the high-elevation sites. Additionally, observations suggest that a number of age-classes of beetles (including re-emerging parents, and one- and two-year adults) are contributing to population success at the high-elevation sites.

Several models have been developed to describe mountain pine beetle response to temperature. These are driven by temperature and can be used to analyze historical trends in outbreak dynamics (Hicke et al. 2006) and also to make forecasts of population success in a changing climate. To further our understanding of the role of temperature in mountain pine beetle outbreak dynamics at high elevations, two models were run based on observed temperature records at one high elevation whitebark pine site near Togwotee Pass, WY located at about 9500 feet (2900m). Using data from the Historical Climatology Network and the observed temperatures, regression analyses was used to predict temperatures at the Togwotee site over the past century. These predicted temperatures were then used to drive a phenology model (Gilbert et al. 2004) and a cold tolerance model (Régnière and Bentz 2007) developed for mountain pine beetle. Model-predicted results suggest that during the warm and dry period of the early 1930s when dendroecological evidence indicates increased mountain pine beetle activity in high-elevation forests, temperature patterns were favorable for increased univoltinism.

How will temperature increase predicted for high elevations affect thermal suitability for mountain pine beetle success? Although both cold temperature-based mortality and seasonality will be affected, shown here are only predictions for cold temperature survival. Using the cold tolerance model and climate change predicted temperatures over the next century (based on the CGCM1 model developed by the Canadian Centre for Climate Modeling and Analysis), thermal suitability for mountain pine beetle cold temperature survival in high-elevation white pine forests is predicted to increase significantly, most notably in the Rocky Mountain region (Figure 1—see cover; full caption given below). Note that relative to the pre-warming period (1961-1990), predictions suggest a significant increase in thermal suitability over the next 30 years (2011-2030). The widespread mountain pine beetle-caused high-elevation white pine mortality seen today is perhaps a real-world validation of these predictions.

Temperature, as it affects developmental timing and cold temperature survival, appears to be a strong driver of mountain pine beetle population success and resultant tree mortality in both low- and high-elevation pine forests as evidenced by numerous outbreaks in many host tree species throughout the range of this insect. Does temperature trump all other factors in mountain pine beetle population success? Although it may seem that temperature is an over-riding driver in high-elevation forests, we currently do not have the required information to fully answer this question. There are many factors, in addition to temperature, that can influence mountain pine beetle population success in high-elevation forests including inherent tree defenses of the host species and the influence of drought on these defenses. The relative contribution of each factor, as well as interaction among factors, in mountain pine beetle outbreak dynamics in high-elevation forests is currently unclear and in need of further investigation. This knowledge would aid management to enhance the sustainability of high-elevation white pine forests.

Figure 1. (On cover) Model predicted probability of mountain pine beetle cold temperature survival during normals period A) 1961-1990, B) 2011–2031. The mountain pine beetle cold tolerance model (Régnière and Bentz 2007) was driven using temperature predictions from the CGCM1 climate change model within the BioSim framework (Régnière and St-Amant 2007). Shown are model predictions for high elevation white pine habitat in the western U.S. based on Little (1971).

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Beetle Impacts on Whitebark Pine: An Interview with the Experts

JL = Dr. Jesse Logan, USFS, Rocky Mountain Research Station, retired
DS = Dr. Diana Six, College of Forestry and Conservation, University of Montana, Missoula

Editor: (1) What do you see as the likely impact of climatic change on mountain pine beetle (MPB) activity in whitebark pine over the next few years?

JL: I'll restrict my remarks to the Greater Yellowstone Ecosystem (GYE), which I'm most familiar with. Gibson et al. (2008) state, "We anticipate beetle populations will remain high as long as weather conditions are conducive to beetle survival and/*or until most mature host trees have been killed*." They go on to report mortality rates exceeding 90% of trees over 5 inches DBH in some surveyed stands. My personal observations collaborate Gibson et al.: the only places in the GYE that I am familiar with that are not experiencing significant mountain pine beetle (MPB) mortality are the central core of the Wind River Mountains, northern Gallatin Range and the Beartooth Plateau. The key here is, "as long as weather conditions are conducive" - with continuing weather trends accompanying climate change, I anticipate that most (80% as a guess) of the cone-bearing whitebark pine trees in the GYE will be lost within the next 5-8 years.

DS: I predict that mountain pine beetle activity will continue to increase in whitebark pine. The tree appears have little resistance to the insect, and so, as long as warm temperatures allow the beetle to survive in the subalpine, the beetle will continue to kill trees. From observations made over the last two summers, I expect populations of this insect to continue to increase rapidly. Outbreaks in whitebark pine currently are moving at rates much faster than we typically observe in lodgepole pine. I expect that to continue. In addition, we are seeing considerable mortality in small diameter trees (6 cm diameter and up) at sites with moderate-to-high beetle pressure. We don't know, at this point, whether the beetle can actually complete development in these smaller trees, but regardless, the loss of these trees has serious implications in the time-frame of recovery of these stands after an outbreak.

Editor: (2) As a result (of your answer to #1), what longer-term future do you view as likely for whitebark in your region?

JL: Unfortunately, I don't see the prognosis as good in either the short or long term. Critical aspects of whitebark pine ecology--asymmetry in the mutualistic relationship with Clark's nutcracker, contiguous distribution with lodgepole to provide a reservoir of MPB populations, predisposition of blister-rust infected trees to subsequent MPB attack, and direct effects of climate change on plant community distribution--lead to long term fragility. I could see, particularly considering the antagonistic impacts of blister rust, whitebark pine becoming functionally lost in the GYE. The situation might be analogous to the chestnut forests of Appalachia. Chestnut is not genetically extinct, but the great chestnut forests are gone.

DS: I don't think the future for whitebark pine is very bright. As long as we have warm temperatures in the high elevations, the beetle will be able to access whitebark pine. Unlike outbreaks in the past which occurred in response to pulses of unusually high temperatures, warm temperatures are now chronic, meaning the beetle is now a permanent denizen of the subalpine ecosystem, and no longer just a periodic visitor. This tree appears to have very low resistance to the beetle and a more rapid stress response to drought which means the beetle will have very different dynamics in this tree than it does in lodgepole pine. This is likely to have some serious implications in whether, after outbreaks remove mature trees, replacement trees in a stand can survive long enough to reach a cone-bearing age.

Editor: (3) What management implications do you envision, or what management activities or treatments might be helpful for whitebark pine communities?

JL: So far as immediate management responses, unfortunately, I don't think there is much that can be done. In my opinion, the die is cast; we are going to lose whitebark over much of the GYE. On the other hand, the overarching strategy for conservation of whitebark pine in the GYE is to follow Aldo Leopold's admonition not to discard the parts. The idea is to maintain whitebark pine on the landscape so that when (if) we successfully address the issue of global warming that results in a future stable climate, the pieces will remain on the landscape for selection to work on; hopefully, resulting in a new dynamically stable community structure. In order to implement this strategy we first need a full, consistent, and supportable assessment of MPB activity and impact across the *entire* GYE. Comprehensive monitoring is the first priority: how can we address a problem without knowing its full extent? Secondly, we can use existing models and develop new ones that help focus management responses to areas more resilient to climate warming, like the core Wind River Range and Beartooth Plateau. This is particularly important for long-term strategies like blister rust-resistant plantation. Third, there remain critical research questions, driven by the fact that almost all our knowledge of MPB biology/ecology comes from lodgepole pine. The most important of these is host resistance. A consistent observation is that whitebark pine is *almost* completely lacking in defensive response for both the primary and induced resin capacities; however, the capacity for an induced response does exist in the population, albeit at low gene frequencies. Research could result in identification of resistant trees for subsequent collection of seed source, much like current blister rust resistant efforts.

DS: Before implementing management, we need to understand the physiology of the tree much better. We know little about the defensive systems of the tree or its physiological responses to environmental change. Only by understanding these factors will we be able to even begin to develop management that has any chance of working. For example, if the tree has low innate defenses or defenses are reduced due to environmental change (changing temperature and precipitation patterns), thinning is not likely to provide much in the way of improved resistance to attack. Given the little money available for restoration in whitebark pine, we need to do the basic groundwork to determine what is most likely to work before spending the big bucks to implement treatments. This brings me to the three biggest challenges I think we face in managing the beetle in whitebark pine – cost, inaccessibility, and underlying conditions. Obviously, managing the beetle in a way that maintains the tree in a functional role on the landscape, even if we knew how to do it, would be extremely expensive and the funds just don't exist. The tree also grows in relatively inaccessible sites, increasing the difficulty of implementing management at a level that will be meaningful. The third, and most important, is the fact that all of this is driven by underlying factor of climate change. As long as it is warm in the subalpine, the underlying conditions for mountain pine beetle outbreaks will exist. Until, and if, warming trends are reversed, this will not change. Even if people begin to work fast and hard at reversing this problem, it will take many decades for effects to occur, and that is likely too long for this tree in many portions of its range. ■

OPINION

Global Climate Change: Does Whitebark Pine Have a Future?

Diana F. Tomback, WPEF Director

In our book chapter, "The compelling case for management intervention," (D.F. Tomback, S. F. Arno, and R. E. Keane, 2001, in *Whitebark Pine Communities: Ecology and Restoration*, Island Press), we point out that "Whitebark pine could be a twenty-first-century environmental symbol—a sort of ecological 'poster child'—for the combined consequences of altered fire regimes and the introduction of exotics to western North America." Furthermore, we point out that whitebark pine "... is also symbolic in the larger sense—for the awareness that 'preservation' alone is not the answer to saving biodiversity," considering that the majority of whitebark pine is already "protected" in national parks and roadless areas on national forests. This statement has proven prophetic: Whitebark pine has now become symbolic for another human-influenced environmental perturbation, global warming.

This phenomenon is impacting whitebark pine ecosystems in two ways: The on-going, massive losses of whitebark pine to mountain pine beetle in the Greater Yellowstone Area and adjacent regions are attributed to warming trends in regional temperatures, which are favorable to pine beetle activity and survival. These losses are rapidly reducing the functional role of whitebark pine in high elevation communities, altering ecosystem services and species interactions. There are few other ecosystems in North America that are showing the effects of climate change trends as rapidly and as severely as whitebark pine ecosystems!

Global warming is also predicted to drive distributional changes in whitebark pine, according to bioclimatic modeling in several recent papers. For example, Warwell et al. (2007) and Schrag et al. (2008) model upward shifts in elevational distribution for whitebark pine, resulting in major range contraction in the United States. Hamann and Wang (2006) and McKenny et al. (2007) model northward range shifts of whitebark pine and other five-needle white pines as well.

Blister rust, mountain pine beetles, successional replacement, and now climate change, all eventually leading to a major loss of whitebark pine communities--should we even bother to manage and restore whitebark pine? This is a question that has come up several times at recent meetings and workshops. The answer is a definite yes for the following reasons: 1) The bioclimatic models are based on the general distribution of whitebark pine in latitude and longitude. Far more whitebark pine may remain than has been projected but in restricted locations both topographically and climatically, such as on cold, harsh sites, and on north slopes. 2) We need healthy whitebark pine at high elevations and at northern latitudes (and everywhere else) to produce seeds in order to respond to range shifts or to be dispersed into climatically suitable local sites. In other words, we require healthy trees to produce seeds for dispersal by Clark's nutcracker, or even for planting by managers. Eventually, the healthy, seed-bearing trees will include individuals that were planted by resource managers as blister-rust resistant seedlings, or perhaps to mitigate the impact of whitebark pine mortality from mountain pine beetle.

If anything, the predicted effects of climate change should compel us to develop new and cost-effective strategic management plans for whitebark pine. Our work now, and the management plans and funding priorities we develop, will determine whether whitebark pine has a future.

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Whitebark Pine Bioclimate Model

Marcus V. Warwell, Gerald E. Rehfeldt
and Nicholas L. Crookston,

Rocky Mountain Research Station,
Forestry Sciences Laboratory, Moscow, Idaho

Climate is a principal factor that controls the distribution of species (Woodward 1987). We developed a whitebark pine bioclimatic model that accurately predicts the presence and absence of whitebark pine using only climatic predictors. The fit and validation for the model was excellent. It used 9 climatic variables and had an overall error of classification of 2.5%. The climatic variables used represented simple interactions of temperature and precipitation, which have been shown to be important to plant processes. Among the 9 variables, the 3 most important were degree-days (number of days) with a mean temperature > 5 °C, temperature of the warmest month, and Julian calendar date when degree-days > 5 °C reaches 100. When run independently, these 3 variables classified the species' occurrence with an overall error of only 4.9%.

Our methodology for building and testing the model followed Rehfeldt *et al.* 2006. This approach is currently unique in its scope, power, and precision. Briefly, we compiled a presence-absence dataset for whitebark pine that consisted of more than 119,000 plot locations largely from USDA Forest Inventory and Analysis. Of these plots, 2738 contained whitebark pine. We estimated the climate for each of these locations using the Spline Climate Model for the Western United States (Rehfeldt 2006). This procedure produced a large data set listing whitebark pine's presence and absence and corresponding climate variables. We then sampled this data set and applied the sampled data to a statistical procedure called Random Forests classification tree analysis (see Breiman 2001). The procedure assessed the relationship between the presence and absence of the species with corresponding climate variables. In doing this, decision trees were built that ranked the relative importance of each climate variable for predicting whitebark pine's occurrence. These decision trees are the bioclimate model. By inputting climate variables for any given location, the model predicts whether whitebark pine would occur there.

This bioclimate model can be used for a range of applications which include predicting species occurrence, building range maps and identifying locations currently climatically suited for whitebark establishment. It can be integrated with adaptive models to define climate based seed zones or seed transfer guidelines. The model can also be used in conjunction with climate change scenarios to identify populations threatened by rapid climate change, and predict future geographic locations climatically suited for whitebark pine.

For example, we used the bioclimate model to map whitebark pine's contemporary distribution and predict its response to a climate change. To do this we again followed procedures detailed in Rehfeldt *et al.* 2006. Briefly, we ran climate estimates on a 1 km grid for the western U.S. through the whitebark pine bioclimate model. The output was projected in geographic space and superimposed over geographic maps using Geographic Information Systems software. The result was more accurate than whitebark pine's published range map (Fig 1a). To map where the species' contemporary climate niche would occur under climate change, the above process was followed using predicted future climate. Climate predictions for decades beginning in 2030, 2060, and 2090 were produced using the Hadley and Canadian general climate models (GCMs) running the IS92a emissions scenario. This scenario assumes a "business-as-usual" emission of greenhouse gases (see IPCC, 1992). Results indicate a rapid and large scale decline in the total area predicted to be suitable for whitebark pine (Fig 1). For the decade beginning in 2030, whitebark pine's climatic niche space is projected to decline 70% while moving upward in altitude by 333m on average. By the end of the century, whitebark pine's climatic niche is projected to diminish to an area equivalent to less than 3% of its current distribution.

These projections provide resource professionals with a means of anticipating whitebark pine's response to climate change. Users should be aware, however, that substantial variability in climatic change predictions should encourage inputting multiple climate change scenarios into the model (see Hannah 2006).

In addition, this analysis uses a correlative approach that relates climate to the occurrence of whitebark pine. It assumes that other abiotic factors like soils and biotic factors such as insects and diseases, which may define a portion of the species' current range are limited or will remain constant in future scenarios. However, these range defining factors may be significant and may shift independently in response to climate change. As a consequence, the climate that describes where whitebark pine occurs today may or may not describe where it will occur under future climate change. Interpretation of results from this type of analysis should also take into consideration species' genetic structure, physiology, and life history.

The current predicted distribution of whitebark, as well as, its predicted response to the CGC A2 emissions scenario, is available on line at http://forest.moscowfsl.wsu.edu/climate. The site also has additional projections scenarios for whitebark pine as well as current and future projections for other western forest trees. All results are available at a resolution of 1 square kilometer. Please note that the site is currently in "review" mode and is subject to revision.

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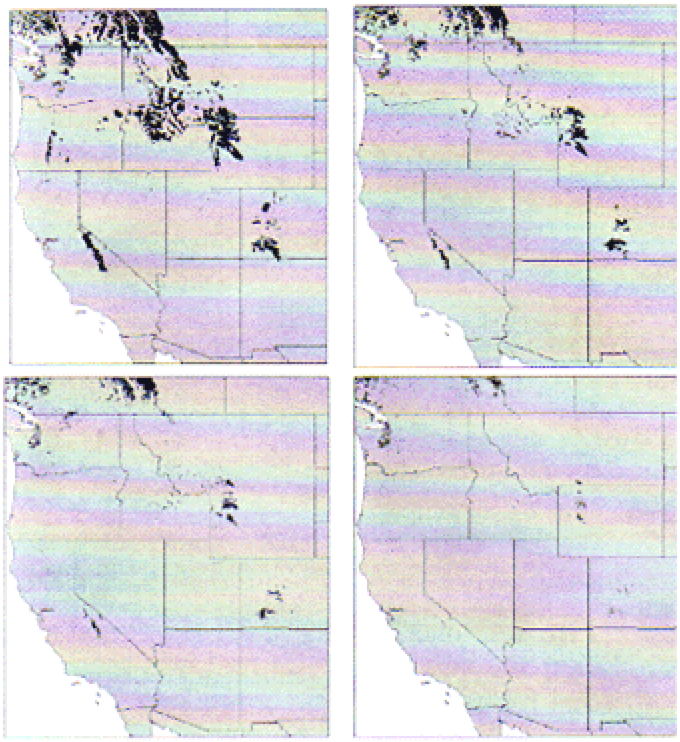

Fig. 1. Modeled bioclimate profile of whitebark pine *(Pinus albicaulis)* for the present (a) and predicted climate for decades beginning in 2030 (b), 2060 (c), and 2090 (d) under IS92a emissions (climate change) scenario. Black indicates areas where climate is predicted to be suitable for whitebark pine. ■

Monitoring Whitebark Pine In the Greater Yellowstone Area: An Update

Erin Shanahan, Greater Yellowstone Inventory & Monitoring Network;
Daniel Reinhart, NPS, Yellowstone National Park

Whitebark pine is an important component of the Greater Yellowstone ecosystem, and conservation of this species depends on collaboration of all public land management units in the area, which includes six national forests and two national parks. The Greater Yellowstone Whitebark Pine Monitoring Working Group (GYWPG) was established in 2004 with representatives from the U.S. Forest Service, National Park Service, U.S. Geological Survey, and Montana State University in an effort to integrate common interests, goals and resources into one unified monitoring program for the Greater Yellowstone Area. From 2004 to 2007, the working group established 150 permanent whitebark pine monitoring transects throughout the Greater Yellowstone Area (GYA), as shown in Figure 1.

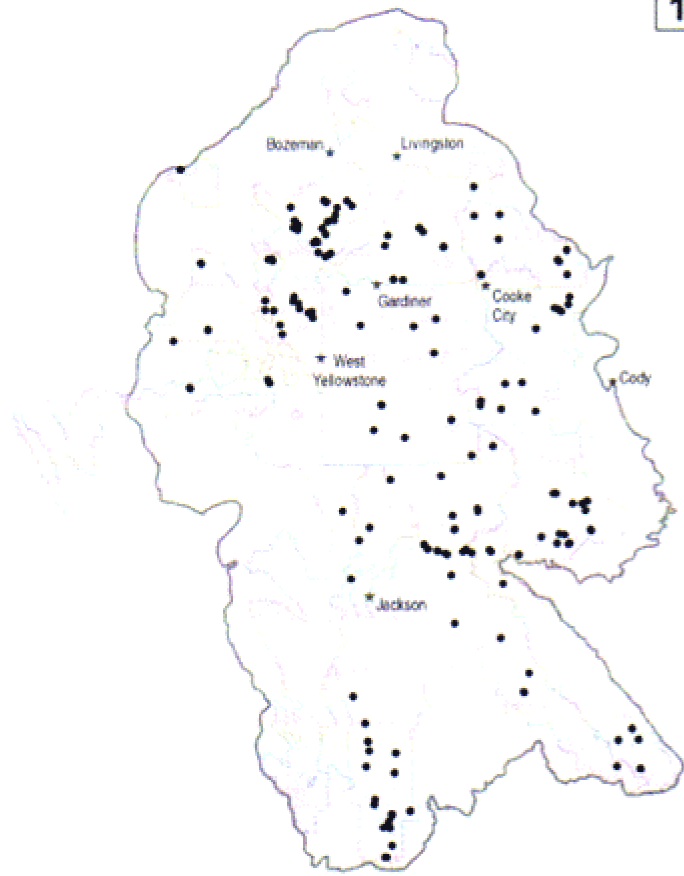

Fig.1. Distribution of permanently marked whitebark pine transects throughout the GYA.

The transects were established across a broad range of whitebark pine habitats to keep track of the health of whitebark pine relative to levels of white pine blister rust and mountain pine beetle. Our sampling methods are similar to protocols for range-wide monitoring of whitebark pine established by the Whitebark Pine Ecosystem Foundation (www.whitebarkfound.org). Details of our sampling design and field methodology can be found in GYWPMWG (2005, 2006, and 2007). Transects and individual trees within each transect were permanently marked in order to estimate changes in infection and survival rates over an extended period. Once the final sample panel was completed in 2007, the monitoring group determined that to best detect change in whitebark pine health, transects would be revisited every 4 years.

Each transect was randomly assigned to one of four panels with each panel consisting of approximately 44 transects--a number of transects that could be visited in one season by one field crew. However, due to increased mountain pine beetle mortality in whitebark pine and because a beetle attack can kill a given tree in one to two years, the monitoring group became concerned that the 4 year revisit interval would be insufficient to document mortality. Thus, a second field crew was employed to conduct annual monitoring of mountain pine beetle activity. With this design, two of the four panels are surveyed by field crews every year. For example, in 2008, Panel 1 was sampled for blister rust infection and mountain pine beetle and Panel 3 was surveyed only for mountain pine beetle. For the 2009 season, Panel 2 will be surveyed for blister rust and mountain pine beetle and Panel 4 will be surveyed only for mountain pine beetle. With this rotating schedule, each transect will be visited every 2 years for either blister rust/mountain pine beetle or mountain pine beetle only (GYWPMWG 2008).

Table 1. Summary of the overall blister rust infection rates by year. This data has been collected from a total of 4,774 live whitebark pine trees.

Year	2004	2005	2006	2007
Location	Within PCA	Outside PCA	Full Study Area	Full Study Area
# Stands	45	55	36	15
# Transects	51	76	40	15
Proportion of Trees Infected	0.71	0.86	0.87	0.80
Estimated Proportion of Trees Infected	0.17 ± (0.06 se)	0.27 ± (0.04 se)	0.25 ± (0.03 se)	0.20 ± (0.03)

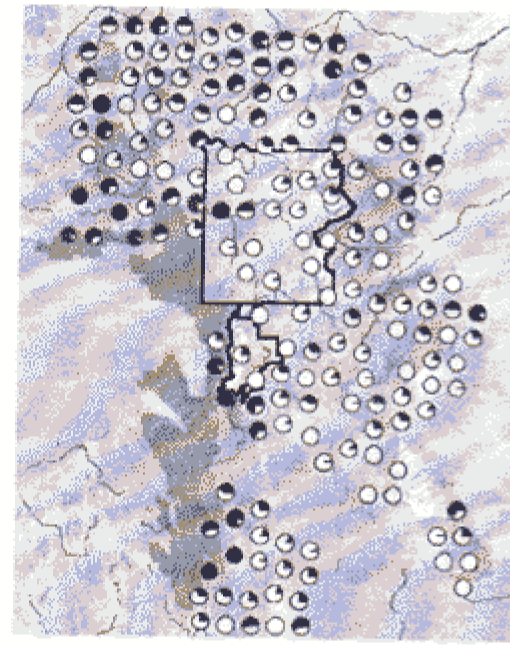

Fig. 2. Ratio (in dark gray) of trees at each monitoring site in which blister rust was recorded from 2004 through 2007. Pie charts are distributed for readability and may not be placed on the actual survey location.

Our estimates suggest that the proportion of live whitebark pine trees infected with blister rust is 0.20 (±0.037) in the GYE. This is the first overall estimate of blister rust calculated for the entire GYA based on a probabilistic sample design. Approximately 86% of the blister rust cankers detected were on branches, as opposed to the main bole of the tree. Bole cankers are generally more lethal than branch cankers. During the transect establishment period (2004-2007), the presence or absence of mountain pine beetle was recorded for the 4,774 individual trees; 99 or 2% showed some sign of mountain pine beetle activity. Preliminary analysis of data from 33 transects established in 2004 and resurveyed in 2007 found that 29 (approx. 4%) of the 744 permanently marked trees had died over a 3-year period; only 9 of these dead trees had observable signs of mountain pine beetle.

Our monitoring effort concentrates on the health and status of whitebark pine in the Greater Yellowstone Area. We consider the proportion of transects that show the presence of blister rust as an indication of how widespread blister rust is. Our data indicated that blister rust is widespread throughout the GYA (80% of all transects had some level of infection). We consider the proportion of trees infected and the number and location (branch or bole) of cankers as indicators of the severity of blister rust infections. By these measures, the severity of infections was less alarming than the spatial extent, with an estimated 20% of the trees in the GYA estimated as having some level of infection. These estimates apply only to the current status of whitebark pine; change in blister rust infection and rates of mortality will be derived from repeated sampling of the 176 permanent transects over time.

Our overall estimate of blister rust infections is likely conservative. Our criteria of having aecia or at least three of the other indicators (rodent chewing, flagging, oozing sap, roughened bark or swelling) present to confirm infection, may result in the rejection of questionable cankers. We are continuing to evaluate the efficacy of these criteria. Our data also suggests that observer variability may be quite important. This result has broad implications for all monitoring efforts of whitebark pine where observer differences are not considered. For monitoring efforts to be reliable, differences in infection rates observed over time should not be confounded with observer differences.

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Whitebark Pine Restoration Strategy for the Pacific Northwest

Carol Aubry (Olympic National Forest, Olympia, WA), Don Goheen, Robin Shoal, Therese Ohlson, Teresa Lorenz, Andrew Bower, Connie Mehmel, and Richard Sniezko (all authors are U.S. Forest Service employees, at various locations)

The goal of the restoration strategy for Pacific Northwest Region of the U.S. Forest Service is to summarize existing information regarding the biology, ecology, and genetics of whitebark pine (*Pinus albicaulis* Engelm.), describe threats to the species, and identify a management approach. This document represents the culmination of a four-year effort that began in 2005. We employed an ecoregion-based approach used by The Nature Conservancy and the World Wildlife Fund that includes three components:

- Select a portfolio of sites for conservation and restoration.
- Set long- and short-term conservation goals.
- Prioritize actions to meet conservation goals.

National forest personnel compiled information on the extent and condition of whitebark pine habitat. We divided the region into nine subregions based on seed zones which were divided into conservation areas and in turn into smaller management units. The reviewers then compiled information on the condition of the habitat, and described the access for each management unit including:

- Blister rust infection levels;
- Fire history;
- Mountain pine beetle level of activity and extent of mortality;
- Presence of mature cone-bearing trees;
- Evidence of seedling establishment;
- Cone-collection history;
- Availability of seed for planting;
- Where confirmed blister rust resistant trees exist;
- What, if any, inventory, planting, or thinning had been done;
- Condition of adjacent lodgepole pine habitat; and
- Opportunities for planting, thinning, and pruning.

Frequently, the reviewers commented that the extent and condition of whitebark pine was unknown.

Forest personnel used their professional judgment to assign proposed actions to management units by considering the complex interactions among fire, mountain pine beetle activity, blister rust severity, the size of the area, stand age, competition from other conifer species, and reproductive capability of the whitebark pine. It also involved looking at the logistics of getting to an area and the existence of any special management designations (such as designated wilderness or research natural areas) and potential benefit versus cost.

One or more of the following proposed actions were assigned to each management unit:

1. **Safeguard habitat**—Conserve/safeguard from fire (both wild and prescribed). This action was only assigned to designated wilderness areas which do not require restoration at this time.
2. **Collect cones**.
3. **Restore**—Plant seed or seedlings, thin for conifer release, and/or prune. Included in this category are units that have burned or have high mortality due to mountain pine beetle infestation. If a stand represents a unique ecological or aesthetic resource (say, at a popular ski area or campground), then pruning branches with blister rust cankers might be a good tool to retain live trees on the landscape, increase the stand's cone-bearing and regenerative potential, and provide ongoing recruitment of young trees as material for natural selection for blister rust resistance. Pruning may also be beneficial to protect individual high-value trees, such as blister rust resistant candidate trees and trees that are important local seed sources.
4. **Survey – condition**.
5. **Survey – seed trees**.
6. **No action**—Consider a combination of several factors that would indicate this unit is a low priority compared to the others in the conservation area. For example, units with poor access, marginal habitat, and no need for planting or thinning.

This assessment revealed a lack of information on whitebark pine distribution, stand conditions, and level of degradation of whitebark pine habitat from fire and mountain pine beetle. The high rate of blister rust infection and resulting mortality are also of great concern.

Recommendations include high priority for planting in management units located in potential grizzly bear habitat. Next priority was ascribed to management units outside designated wilderness areas that are relatively easy to access and include large areas of whitebark pine habitat. Due to lack of knowledge, whitebark pine surveys are recommended for 53 management units to verify habitat maps, stand conditions, and determine what, if any, restoration work is required. The highest priority units for surveys were selected based on combination of the following criteria:

- Grizzly bear recovery area,
- Outside designated wilderness areas,
- Accessibility, and
- Unit ranked among top 10 for planting.

The following is a list of actions to be accomplished over the next 5 years to reach the long-term goal of developing a network of viable populations of whitebark pine throughout the Pacific Northwest with an increase in the level of resistance to blister rust.

Actions

- Collect seed following a regional plan to meet gene conservation, rust resistance screening, and planting objectives.
- Survey all priority management units.
- Develop and implement a plan to plant priority management units.
- Continue rust screening program with emphasis on seed zones in grizzly bear recovery areas.
- Develop and implement a plan to treat mountain pine beetle in high risk units.
- Develop an approach for planting in designated wilderness areas that will allow the use of resistant plant material while maintaining wilderness character.
- Develop an approach to mitigate the predicted impacts of climate change.
- Develop monitoring plan(s) to track accomplishments, measure success of actions, provide information and feedback to improve procedures and outcomes of projects, and disseminate information.

Our project has also just completed a guide to management techniques:

Land Managers Guide to Whitebark Pine Restoration in the Pacific Northwest Region 2009–2013 September 2008

For copies of this and other whitebark pine publications produced by our project, please request an order form by sending an email to skeehfuss@fs.fed.us. ■

Telemetry Study with Clark's Nutcracker: An Update

Teresa Lorenz, Okanogan-Wenatchee N.F., Naches, WA

We have been studying home range size, habitat use, and seed caching behaviors of radio tagged Clark's Nutcrackers in the Washington Cascades and Olympic Mountains since 2005. Over the years we have captured and radio tracked 54 nutcrackers. Our primary objective is to come to a better understanding of how nutcrackers use the landscape year-round. In particular, we were interested in the seed transport and caching behaviors of nutcrackers. While caching is commonly observed, there is no previously published information on Clark's Nutcracker cache site selection and cache site preferences (*sensu* Johnson 1980).

Our 2008 field season was very successful. In spring 2008, we captured 20 adult nutcrackers at eight different trap sites. Seven trap sites were located on the east slopes of the Cascade Range, west of Yakima. One trap site was located in the Olympic Mountains, south of Sequim. The habitat and elevation of traps sites varied. In the Cascades we captured four adult nutcrackers at trap sites in ponderosa pine stands, eight adults in seral whitebark pine stands, and four adults in climax whitebark pine stands. In the Olympic Mountains we captured two adults in one seral whitebark pine stand.

During the summer of 2008, two of the nutcrackers captured in the Cascade Range migrated from the study area. We monitored the movements of the remaining 18 resident nutcrackers from April through November. Spring-summer home range size varied tremendously between individuals (mean of 1492 ha, standard deviation of 1669 ha). Despite the variation in home range size, all nutcrackers foraged on cached seeds in spring. As temperatures warmed in June and snow began to melt our nutcrackers changed their diet and subsisted nearly entirely on insects during the summer. Regardless of the forest composition of the trap site, all radio tagged nutcrackers moved between a range of elevations in summer to exploit insect outbreaks in many habitat types. In early summer, nutcrackers congregated in flocks in whitebark pine stands where insects were common in moist mountain meadows. As summer progressed and snow receded from the high elevation whitebark pine stands, nutcrackers congregated in mid-elevation, transitional forest types where they foraged in both forests and meadows, on spruce budworm larvae and grasshoppers.

In autumn 2008, whitebark pine did not produce cones in our study area. Although we were initially disappointed, we ended up gaining a wealth of information on how nutcrackers respond to whitebark pine cone failure. The two nutcrackers that were captured in the Olympic Mountains migrated from the Olympics in early August and were not detected again. Ponderosa pine produced a patchy but moderate cone crop in the Cascade Range. (Ponderosa pine forest is not found near the Olympics.) All of the nutcrackers captured in the Cascade Range began foraging on ponderosa pine seeds in early-August even though ponderosa pine seed typically does not ripen until September. It was interesting to observe that while the nutcrackers foraged in low elevations during the day, they returned to their high elevation home range for roosting every evening.

By mid-August, all of our nutcrackers were harvesting ponderosa pine seeds and transporting seeds long distances to their home ranges for caching. During this time, flocks composed of hundreds of nutcrackers were prevalent in the low elevation ponderosa pine stands. Every day, our radio tagged nutcrackers traveled multiple times between ponderosa pine stands (where they harvested seeds) and their respective home ranges (where they caches seeds). On average, this meant that nutcrackers transported ponderosa pine seeds approximately 13.3 km (standard deviation of 9.5 km). Nutcrackers with home ranges in whitebark pine stands that were far from the cone producing ponderosa pine stands were at a clear disadvantage and were forced to transport ponderosa pine seeds more than 30 km. The minimum ponderosa pine seed transport distance was 4.7 km. Nutcrackers with home ranges 10-30 km from ponderosa stands made only one or two seed transport flights daily, in autumn, whereas individuals with home ranges within ten kilometers of ponderosa pine stands made as many as six flights daily.

We observed 487 seed caching events by our radio tagged nutcrackers. Previous studies observing caching behavior of untagged nutcrackers have noted that the majority of seeds are placed very close to or directly underneath the harvest trees (Tomback 1978, Hutchins and Lanner 1982). We observed some radio tagged nutcrackers caching seeds in the ground underneath harvest trees. However, by late October, the ponderosa pine cones retained very few seeds since most seeds had been harvested and these (two) nutcrackers began retrieving seed caches that they had placed in the harvest stands and transporting the seeds to their home ranges. For radio tagged nutcrackers in our study, cache site selection on a landscape scale was made without regard to habitat availability, and was dependent only on the location of an individual's home range.

Once within the home range, nutcrackers placed their seed caches in a variety of habitat and microsite types, ranging from cliff faces, to open whitebark pine stands, and to closed canopy mid-elevation forests. They cached seeds below ground in the soil, above the soil surface in logs or rock piles, and above ground in the canopy of trees (such seeds were wedged into bark crevices and lichen clumps). Similar variation in cache site selection has been noted by Tomback (1978) and Hutchins and Lanner (1982). However we observed that despite such variation, nutcrackers in our study cached the majority of seeds above ground and in closed canopy forests. We observed that even birds that were caching on fairly open slopes and on cliffs would cache seeds within or near the edge of tree clumps. We suspect that this is because nutcrackers caching in open areas are more exposed and conspicuous and may be more susceptible to predation.

Overall, our results from 2008 demonstrate the importance of transitional habitat types and ponderosa pine forests in maintaining nutcracker populations in the Pacific Northwest. Radio telemetry has revealed that seed transport distances may be greater than previously thought. Moreover, cache site selection appears to be a complex process that nutcrackers make on multiple spatial scales. This study has provided a lot of interesting and new information on the behavioral ecology of Clark's Nutcracker. However, we feel that because of the large observed variation between individuals, additional studies are needed from other regions before far reaching conclusions can be made on nutcracker home range size, habitat use, and cache site selection.

Continued on page 19

Continued from page 6

St	Location -- Agency/NF/RD	Title	Contact
Assessments			
MT	Glacier and Yellowstone NPs	Monitoring Seed Dispersal by Clark's nutcrackers in relation to whitebark pine health	Diana Tomback
MT	Absaroka Beartooth wilderness, Gallatin, Shoshone, Custer NFs	Determining whitebark pine regeneration following the 1988 Yellowstone fires	Marion Cherry
MT	Gallatin NF, Red Canyon, Hedgen Lake	Hebgen Lk Rx Burn Monitoring (Red Canyon)	Jodie Canfield
GYE	Greater Yellowstone Ecosystem	GYA WBKP Map & Risk Assessment	Jeff DiBenedetto
OR/Wa	Deschutes, Fremont-Winema, Malheur, Colville, Wenatchee, Okanogan NFs	WBP survey and monitoring - Eastern Or and Wa	Chris Jensen
Conserving Genetic Diversity			
MT	Lolo, Flathead, Bitterroot NF	Operational Cone Caging and Collection	John Errecart
Or/Wa	Dorena Genetic Resource Center	Establishment of prototype whitebark pine orchard/arboretum/clone bank and conservation of parent trees	Sally Long
GYE	Greater Yellowstone Ecosystem	GYA Operational Cone Caging and Collection	Melissa Jenkins
GYE	Greater Yellowstone Ecosystem	Operational Cone Caging and Collection	Cathey Hardin
Harnessing Natural Resistance			
WA	Colville, Okanogan, Wenatchee NF	Plus Tree and Operational Seed collection in Washington State	Carol Aubry
GYE	Grand Teton and Yellowstone NP, Beaverhead-Deerlodge & Shoshone NFs	Plus tree protection	Liz Davy
ID	Salmon-Challis NFs	Operational Cone Caging and Collection	Sharon Bradley
ID	BLM; Boise, Salmon-Challis NF's	Salmon River Area -BLM- WBP Genetic Restoration Program	Dana Perkins
Silvicultural Treatments			
ID	Boise NF, Cascade RD	Goldfork WBKP Restoration; Boise NF	David Marben
MT	Lolo NF, Plains RD	Whitebark pine planting - 2007 Montana Fires	john Errecart
MT	Lolo NF, Missoula RD	Restoring WBP - Snowbowl study site	John Waverek
ID	Idaho Panhandle NF's, Avery RD	Stateline WBP Release; different day-lighting treatments	Sidnee Dittman
ID	Clark Fork/ Lolo Pass	Blacklead/Beaver Ridge Restoration Planting Project	Mark Klinke
MT	Helena NF, Lincoln RD	WBP competition reduction	Jarel Kurtz
MT	Glacier NP and Flathead NF	WBP restoration; cone collections, planting, thinning, monitoring	Cathy Calloway
ID	NezPerce, Salmon River RD	Whitebark pine planting - Poe Cabin Fire	Meg Moynihan
Special Projects			
Wa	Missoula Fire Sciences Lab	Modeling Fire probability & WBP restoration in N. Cascade Mts	Laurie Kurth
GYE	Montana State University	Mycorrhizal inoculation of WBP seedlings with Native Fungi	Cathy Cripps
WA	Okanogan-Wanatchee NF	Monitoring Clark's nutcracker habitat use	Teresa Lorenz
Outreach and Educational Projects			
ID	Caribou-Targhee NF	Caribou-Targhee Whitebark Pine Restoration strategy	Melissa Jenkins
OR	Deschutes & Crater Lake NP	WBP Interpretative signs	Chris Jensen

Continued from page 17

Clark's Nutcracker in flight (photo by T. Lorenz)

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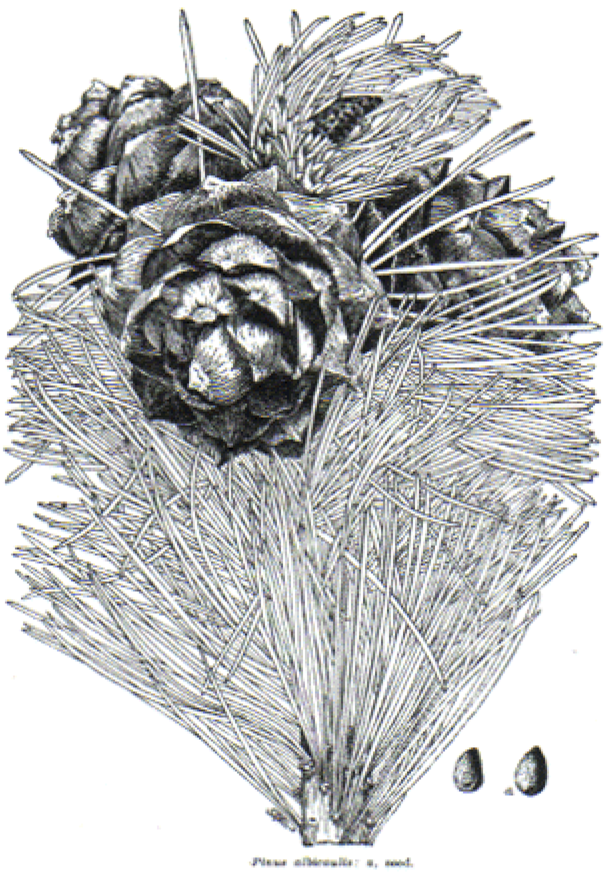
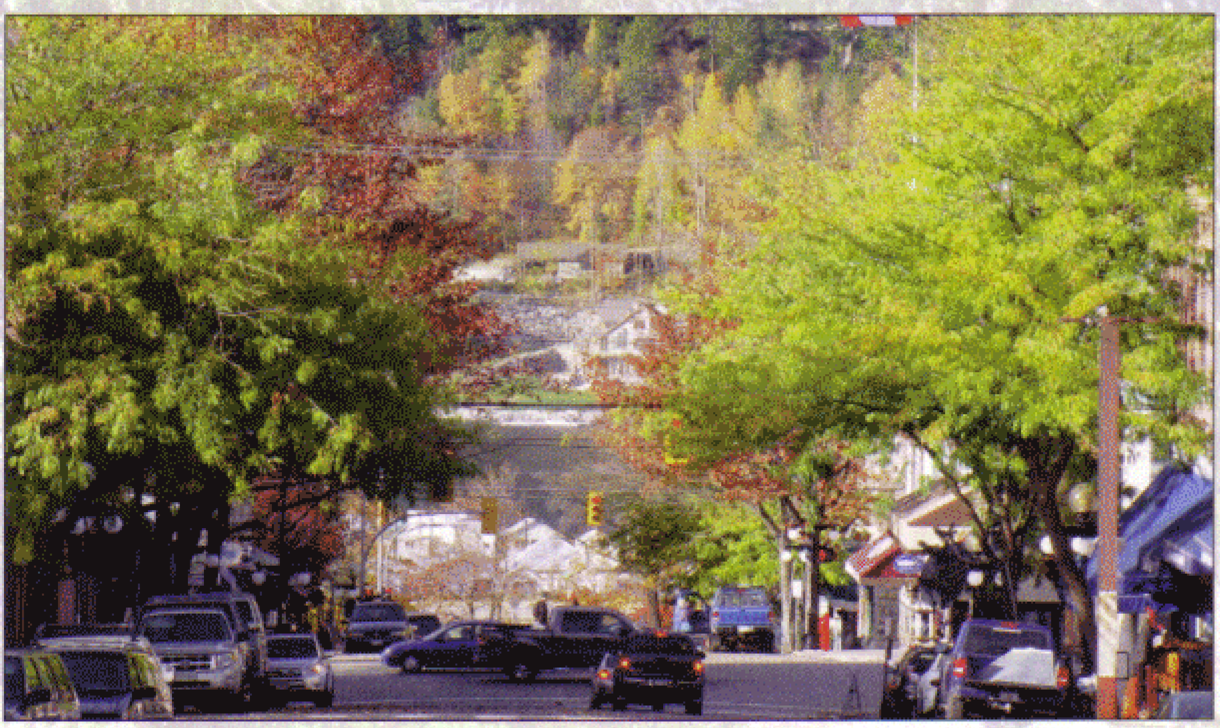


Pinus albicaulis: a, seed.

Nelson, B.C., Kootenay Lake, and Kokanee Peaks, site of WPEF's 2009 Conference.
(photos by Michael Murray)



Downtown
Nelson, B.C.