Issue No. 14: Spring/Summer 2008

Nutcracker Notes

Whitebark Pine Ecosystem Foundation

Mountain pine beetle-killed limber pine at treeline in Colorado (see Schoettle's article; photo by A. Schoettle)

Whitebark near its northern limits in B.C. (see Haeussler's article; photo by Sierra Curtis-McLane)

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Sixth Grader Writes in Behalf of Whitebark Pine

Whitebark Pine Ecosystem Foundation
***Nutcracker Notes*, Issue No. 14; Spring/Summer 2008**

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Separates Enclosed:
Bylaw ballot
Color Bookmark: *Whitebark Pine—species in peril*

Web Site: **www.whitebarkfound.org**

Web Site Contact Person: Robert Keane (address above)

Web Site Provider: Chuck Crouter

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 Tomback

Progress Milestones

As we cope with our routine work obligations, meet our deadlines, and put out the occasional "fire" (more than a figure of speech for many of you!), it is sometimes difficult to step back and see actual progress. This is particularly true when it comes to the conservation of whitebark and its five-needle white pine relatives. Sometimes we take the bad news to heart and wonder if it will end well. The bad news these days has been about the unprecedented geographic spread of mountain pine beetle outbreaks, the loss of whitebark pine and other high elevation white pines to pine beetles, and the potential impact of climate change on the future of whitebark pine. Other discouraging news is the budgetary outlook for our federal resource stewardship agencies including proposed budget cuts for the Forest Service. Administrators have been digging deep to fund various projects related to five-needle white pine conservation and restoration, recognizing the importance and urgency of this problem, and people heading these conservation projects have been pursuing every funding lead possible.

There is another side to this story, and the news indicates that we are definitely making progress in attracting attention to the precarious status of whitebark pine and its relatives. First of all, several Forest Service regions are developing restoration plans. Kelly Burns, pathologist with Forest Health Management in the Rocky Mountain Region is lead author of a March, 2008, Rocky Mountain Research Station publication *Options for the management of white pine blister rust in the Rocky Mountain Region* (RMRS-GTR-206) which describes the challenges and restoration options for limber, bristlecone, southwestern white, and whitebark pine. In fact, at the April 22 annual workshop of the Central Rockies White Pine Health Working Group, Anna Schoettle, RMRS, Ft. Collins, and second author of this GTR, reported on her work with Rich Sniezko and others on screening bristlecone pine and limber pine for genetic resistance to blister rust. The good news is that trees with resistance are present throughout the region; the bad news is that these trees must be protected immediately from the rapidly spreading mountain pine beetle outbreak.

A draft restoration plan for whitebark pine for the Pacific Northwest Region has been developed under the leadership of Carol Aubry, geneticist and director of the *Albicaulis* project.; and, Bob Keane of the Missoula Fires Sciences Laboratory, RMRS, and a member of the board of the WPEF, has collaborated with a number of individuals and generated a whitebark pine restoration plan for USFS Region 1, which should be in draft form by fall. Meanwhile, whitebark pine has just been designated a species at risk (Blue list) in British Columbia; it is being considered for similar status in Alberta; and has been listed as a Species of Concern in western Washington by the U. S. Fish and Wildlife Service. We have also had a second round of funding for whitebark pine restoration projects from the Forest Health Protection's Whitebark Pine Restoration Fund, which is coordinated by John Schwandt. I hope that these listings will pave the way for increased funding for whitebark restoration projects on both sides of the international border.

Kudos to the Education Committee

The cover of the last issue of Nutcracker Notes (Fall/Winter 2007) featured a spectacular painting of a high-elevation whitebark pine ecosystem by Larry Eifert, an accomplished nature artist living in Port Townsend, WA. The painting shows whitebark pine and its animal dependents. It was originally commissioned by the Crater Lake Institute, Oregon, as a mural. Through WPEF board member Ron Mastrogiuseppe, who is also a founding board member of the Crater Lake Institute, we had the opportunity to collaborate with Larry Eifert on an educational project for the WPEF. Jane Kapler Smith and Anna Sala, who comprise WPEF's Education Outreach Committee, worked with Larry to develop a beautiful bookmark, entitled *Whitebark pine—species in peril*, featuring part of the mural, and a succinct explanation of whitebark pine's ecological value and on-going decline. Jane penned the very effective message on the bookmark, one of which is enclosed with this issue of *Nutcracker Notes*. We have received 10,000 of these bookmarks and are distributing them to national parks and national forests in both the Pacific coast and Rocky Mountain distribution of whitebark pine for use as "give-aways" at visitor centers and bookstores. We hope that the bookmarks will raise awareness of the ecological importance of whitebark pine and garner public support for restoration. Kudos to Jane, Anna, and Larry for a job well done!

Annual Meeting and Restoration Funding

Our 2008 annual meeting will take place in the conference facilities at Grand Targhee Ski Resort on Saturday and Sunday, September 13 and 14. The organizers of this event are Liz Davy, Bridger-Teton National Forest and chair of the Greater Yellowstone Coordinating Committee's Whitebark Pine Group, and Dan Reinhart, Yellowstone National Park and WPEF Board of Directors. Our Sunday field trip will also be at the ski area, which has beautiful old whitebark pine heavily damaged by blister rust and advancing succes-

sion. We will have the opportunity to view on-site restoration efforts by the Caribou-Targhee National Forest. We have been promised a ride up the mountain on the chairlift, to be operated just for our field trip. Please see additional information about the meeting in this issue of *Nutcracker Notes*.

On another topic, at this time the WPEF has about $30,000 dedicated to whitebark pine restoration, of which $24,000 is a grant obtained from The National Arbor Day Foundation. We envision making these funds available for restoration projects in summer 2009. I plan to provide information on how these funds will be awarded in the next issue of *Nutcracker Notes*.

Housekeeping

Prior to our spring board meeting, the Board of Directors separated the position of Publications Editor from the Board of Directors (BOD) at the request of Steve Arno, who feels that allowing the BOD to appoint an editor is a more customary and flexible approach for filling this position. With this clarified in our by-laws, we had a vacancy on the BOD and called for nominations to fill the vacancy temporarily. Shawn McKinney, whitebark pine researcher and postdoctoral associate at the University of Montana, had been nominated and was unanimously elected at the board meeting to fill this vacancy. This board seat will come up for election next year. We welcome Shawn and his fresh perspective to the BOD!

Michael Murray, ecologist at Crater Lake National Park, Oregon, who was elected to the BOD in 2007, recently announced that he was taking a new position. Mike will become our second Canadian board member as he moves into a forest pathologist position for British Columbia Ministry of Forests and Range in Nelson, B.C. We wish Mike much success in his new job and look forward to his continuing participation on the board. And, as summer is rapidly approaching I wish all of our WPEF members a productive, successful, and safe field season. ■

Election News

Cyndi Smith, WPEF Associate Director

Over the last few months the WPEF solicited nominations for a number of positions, including a 7th general member of the Board of Directors. The following were elected by acclamation:

Associate Director:	Cyndi Smith
Treasurer:	Ward McCaughey
Board Member:	Carl Fiedler
Board Member:	Ron Mastroguiseppe
Board Member:	Shawn McKinney

We thank all of the candidates for running. We especially thank Steve Shelly, who has served many years as Treasurer for the Foundation, and who is helping until January 2009 as we transition to the new Treasurer. ■

WPEF Annual Meeting & Field Trip
Grand Targhee Resort, September 13-14, 2008

Mark your calendar for September 13 and 14 (Saturday and Sunday), and please join us for WPEF's Annual Science and Management Conference and Field Trip. These events are being held at the beautiful Grand Targhee Resort on the west side of the Teton Range near Driggs, Idaho, and they are co-hosted by the Greater Yellowstone Coordinating Committee's Whitebark Pine Group. The day-long conference on September 13th will be held at Grand Targhee's Teewinot Conference Room. Presentations will feature the latest scientific findings about whitebark pine ecosystems and discussion of ongoing projects aimed at restoring whitebark pine.

September 14th features a moderate hike into the extensive whitebark pine communities surrounding the resort. Grand Targhee's staff biologist Andy Steele will provide an overview of area features, and USFS silviculturist Melissa Jenkins will discuss whitebark restoration activities.

Check www.whitebarkfound.org in June for detailed information about the meeting, and contacts and prices for local accommodations. Coordinator Liz Davy, who lives in Driggs, Idaho, has volunteered to field questions from potential speakers, and people who want information about accommodations, etc. Liz can be reached at edavy@fs.fed.us or at 307 739 5562 (office). ■

WPEF Membership Report

Bryan Donner

As of April 1, 2008, the WPEF has 141 members, the largest enrollment we have ever had in spring. This is helpful when WPEF applies for grants to aid in our mission, since a significant membership base attests to the credibility of our organization. Now is a good time to recruit a friend or colleague as their new member would be in effect though 2009.

Membership from individuals and organizations in Canada continues to increase. We currently have fourteen Canadian members including two new members that joined at the lifetime Grizzly level.

WPEF's dues increase that went into effect last year did not measurably affected membership numbers. We feel this attests to the dedication our members have to the restoration of whitebark pine ecosystems.

The BOD is looking into the cost of acquiring the capability to accept credit card payment for dues, donations, and purchases of WPEF books, logo caps, shirts, etc. If the BOD deems this option to be affordable, members would in the future be able to join and renew with greater convenience.

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. Questions, comments, or suggestions about membership in our foundation can be directed to the foundation's Membership and Outreach Coordinator, Bryan Donner, at (406) 758-3508 or reindeer@centurytel.net Please put "WPEF" or "Whitebark" in the subject line of your e-mail. ■

High Mountain Pine Symposium June 28-30, 2010, Missoula, MT

Mark your calendar for two years from now. A major symposium on high-elevation five-needled pines in western North America will take place June 28-30, 2010 (Monday-Wednesday) on the University of Montana campus in Missoula. The Whitebark Pine Ecosystem Foundation has initiated this effort and is inviting individuals, governmental and non-governmental organizations to join in planning and co-sponsorship. More information will follow in the next issue of Nutcracker Notes. ■

Whitebark Pine on Blue List in British Columbia

Cyndi Smith, WPEF

In October 2007, the B.C. Conservation Data Centre added whitebark pine to its Blue List. The reason given was that although the species currently occurs in relatively high numbers over a fairly large range in the province, major declines of 75-90% are expected "due to a severe negative long-term trend expected from mountain pine beetle infections, the white pine blister rust epidemics, climatic warming trends, and successional replacement."

The Blue list includes communities, species, or subspecies that are considered to be of special concern because of characteristics that make them particularly sensitive to human activities or natural events.

The "Conservation Status Report for *Pinus albicaulis*" can be accessed on-line at http://a100.gov.bc.ca/pub/eswp. Search for whitebark pine by its scientific or English name, then "reports" where you can find various other references as well. ■

What's Hot in Whitebark Pine Publications?

Bob Keane, Missoula Fire Sciences Laboratory, RMRS

This past year produced a cornucopia of interesting reading for the whitebark pine enthusiast. The first two publications are proceedings from two conferences that contain a wide variety of fascinating papers on whitebark pine and blister rust:

Goheen, E. M., and R. A. Sniezko, tech. coords. 2007. Proceedings of the conference whitebark pine: a Pacific Coast perspective. Ashland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, 2006 August 27-31; Ashland, OR. R6-NR-FHP-2007-01. 175 pages.

Guyon, J. 2006. Proceedings of the 53rd Western International Forest Disease Work Conference. Pages 197 p *in*. Ogden, UT: U.S. Department of Agriculture, Forest Service, Forest Health Protection, Ogden Field Office, 2005 August 26-29; Jackson, WY.

The Goheen and Sniezko (2007) proceedings contains over 27 papers on a wide variety of whitebark pine subjects including current conditions, blister rust, bark beetles, planting issues, inventory, and climate change. The Guyon (2006) proceedings deal mostly with blister rust issues.

Several new publications on blister rust may be of interest. Burns et al. (2007) and Burns et al. (2008) present a comprehensive plan for blister rust management in the Rocky Mountains, while proactive intervention for high elevation pines is discussed in the Schoettle and Sniezko (2007) paper. Van Arsdel et al. (2006) suggests a new hazard rating for blister rust. The extent and impacts of blister rust and possible restoration techniques are covered in Schwandt et al. (2006). Smith et al. (2008) present a quantitative assessment of blister rust in whitebark pine in the Rocky Mountains of Canada and northern Montana. Two new papers by Resler and Tomback (2008) and Tomback and Resler (2008) document the incidence of blister rust in alpine and krummholz communities. Last, there are three exciting papers on the interaction of blister rust with other ecosystem processes. Six and Adams (2007) discuss the interaction of blister rust severity and mountain pine beetle on selection of possible hosts. McKinney and Tomback (2007) detail the interactions between blister rust and whitebark pine seed dispersal dynamics, while a thesis by Bockino (2008) describes the complex interactions between rust, the host species, and mountain pine beetle in Yellowstone National Park.

Several excellent reference documents have been written concerning whitebark pine artificial regeneration and genetics. First, the Scott and McCaughey (2006) planting guidelines are available. Murray (2007) and Davies and Murray (2006) present some new techniques for cone collecting. Whitebark pine seed production is detailed in Owens et al. (2008) for Idaho and Nevada and in Haroldson and Podruzny (2007) for Yellowstone and southwest Montana. Seed maturity and structures are presented in Tillman-Sutela et al. (2007). Bower and Aitken (2008) present seed transfer guidelines for whitebark pine and Bower and Aitken (2007)

 present genetic dynamics for the same species.

Whitebark and limber pine ecology is well documented in a number of other publications. Ectomycorrhizal relationships in treeline whitebark pine is documented in Mohatt et al. (2008), while bark beetle Holocene histories are documented by Brunelle et al. (2008) for upper subalpine forests of Idaho and Montana. Only two publications concerning fire ecology became available. Barrett (2008) presents a fire history for the Montana's Mission Mountains while Murray (2008) documents new findings in fire dynamics for the Cascades. Schrag et al. (2007) present current and future conditions for whitebark pine in the Greater Yellowstone Ecosystem using a species envelop modeling approach. A great general whitebark pine ecology article was written by Smith (2007). Adaptive evolution is the subject of three papers by Adam Siepielski: Sieplieski and Benkman (2007a) deals with convergent selection patterns between whitebark and limber pine, Sieplieski and Benkman (2007c) discuss squirrel-nutcracker interactions on pine evolution, and Sieplieski and Benkman (2007b) present the importance of environmental variation in evolution. Baumeister and Callaway (2006) discuss the role of facilitation in limber pine succession. And last, Keane et al. (2007) show whitebark pine can respond to the removal of competing subalpine fir by increasing diameter growth. I hope you will find some of these publications will be useful and interesting, as well as HOT.

Barrett, S. W. 2008. Role of fire in the Mission Mountains northwestern Montana - fire regimes and fire regime condition class. Report.

Baumeister, D., and R. M. Callaway. 2006. Facilitation by *Pinus flexilis* during succession: a hierarchy of mechanisms benefits other plant species. Ecology 87:1816-1830.

Bockino, N. K. 2008. Interactions of white pine blister rust, host species, and mountain pine beetle in whitebark pine ecosystems in the Greater Yellowstone. M.S. Thesis. Univeristy of Wyoming, Laramie, WY.

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

Bower, A. D., and S. N. Aitken. 2008. Ecological genetics and seed transfer guidelines for Pinus albicaulis (Pinaceae). American Journal of Botany 95:66-76.

Brunelle, A., G. E. Rehfeldt, B. Bentz, and A. S. Munson. 2008. Holocene records of Dendroctonus bark beetles in high elevation pine forests of Idaho and Montana, USA. Forest Ecology and Management 255:836-846.

Burns, K. S., A. Achoettle, W. R. Jacobi, and M. F. Mahalovich. 2007. White pine blister rust in the Rocky Mountain Region and options for management. Report R2-07-04, U.S. Department of Agriculture, Forest Service, Rocky Mountain Region Renewable Resources, Golden, CO.

Burns, K. S., A. W. Schoettle, W. R. Jacobi, and M. F. Mahalovich. 2008. Options for the management of white pine blister rust in the Rocky Mountain Region. Report RMRS-GTR-206, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Davies, M. A., and M. Murray. 2006. Tree tong puts whitebark pine cones within reach. Report U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center, Missoula, MT.

Haroldson, M., and S. Podruzny. 2007. Whitebark pine cone production. Pages 2 p *in*. U.S. Geological Service, Northern Rocky Mountain Science Center, Interagency Grizzly Bear Study Team, Bozeman, MT.

Keane, R. E., K. L. Gray, and L. J. Dickinson. 2007. Whitebark pine diameter growth response to removal of competition. Research Note RMRS-RN-32, U.S. Department of Agriculture, Forest Service, Intermountain Region, Ogden, UT:.

McKinney, S. T., and D. F. Tomback. 2007. The influence of white pine blister rust on seed dispersal in whitebark pine. Canadian Journal of Forest Research 37:1044-1057.

Mohatt, K., C. L. Cripps, and M. Lavin. 2008. Ectomycorrhizal fungi of whitebark pine (a tree in peril) revealed by sporocarps and molecular analysis of mycorrhizae from treeline forests in the Greater Yellowstone Ecosystem. Botany 86:14-15.

Murray, M. P. 2007. Cone collecting techniques for whitebark pine. Western Journal of Applied Forestry 22:153-155.

Murray, M. P. 2008. Fires in the high Cascades: new findings for managing whitebark pine. Fire Management Today 68:26-29.

Owens, J. N., T. Kittirat, and M. F. Mahalovich. 2008. Whitebark pine (Pinus albicaulis Englem.) seed production in natural stands. Forest Ecology and Management 255:803-809.

Resler, L. M., and D. F. Tomback. 2008. Blister rust prevalence in Krummholz whitebark pine: implications for treeline dynamics, Northern Rocky Mountains, Montana, U.S.A. Arctic, Antarctic, and Alpine Research 40:161-170.

Schoettle, A. W., and R. A. Sniezko. 2007. Proactive intervention to sustain high-elevation pine ecosystems threatened by white pine blister rust. Journal of Forest Restoration 12:327-336.

Schrag, A. M., A. G. Bunn, and L. J. Graumlich. 2007. Influence of bioclimatic variables on tree-line conifer distribution in the Greater Yellowstone Ecosystem: implications for species of conservation concern. Journal of Biogeography 35:698-710.

Schwandt, J. W., J. LKliejunas, B. Lockman, and J. Muir. 2006. White pines and bister rust in western North America: spread, impacts and restoration. Pages 65-68 *in* J. Guyon, comp., editor. Proceedings of the 53rd Western International Forest Disease Work Conference. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region, 2005 August 26-29; Jackson, WY.

Scott, G. L., and W. W. McCaughey. 2006. Whitebark pine guidelines for planting prescriptions. Pages 84-90 *in* L. E. Riley, R. K. Dumroese, and T. D. Landis, tech. coords., editors. National proceedings: Forest and Conservation Nursery Associations--2005. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Sieplieski, A. M., and C. W. Benkman. 2007a. Convergent patterns in the selection mosaic for two North American bird-dispersed pines. Ecological Monographs 77:203-220.

Sieplieski, A. M., and C. W. Benkman. 2007b. Extreme environmental variation sharpens selection that drives the evolution of a mutualism. Proceedings of the Royal Society B 274:1799-1805.

Sieplieski, A. M., and C. W. Benkman. 2007c. Selection by a predispersal seed predator constrains the evolution of avian seed dispersal in pines. Functional Ecology 21:611-618.

Six, D. L., and J. Adams. 2007. White pine blister rust severity and selection of individual whitebark pine by the mountain pine beetle (Coleoptera: Curculionidae, Scolytinae). Journal of Entomological Science 42:345-353.

Smith, C. M., B. Wilson, S. Rasheed, R. C. Walker, T. Carolin, and B. Shepherd. 2008. Canadian Journal of Forestry Research 38:982-995.

Smith, J. K. 2007. Tough trees at timberline. Montana Naturalist Winter:1.

Tillman-Sutela, E., A. Kauppi, K. Karppinen, and D. F. Tomback. 2007. Variant maturity in seed structures of Pinus albicaulis (Engelm.) and Pinus sibirica (Du Tour): key to a soil seed bank, unusual among conifers? Trees:12 p.

Tomback, D. F., and L. M. Resler. 2008. Invasive pathogens at alpine treeline: consequences for treeline dynamics. Physical Geography 28:397-418.

Van Arsdel, E. P., B. W. Geils, and P. J. Zambino. 2006. Epidemiology for hazard rating of white pine blister rust. Pages 49-61 *in* J. Guyon, comp., editor. Proceedings of the 53rd Western International Forest Disease Work Conference. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region, 2005 August 26-29; Jackson, WY. ■

Editor's Note: This report was transmitted to us by WPEF board member Dan Reinhart, who helped Laura obtain information for it as a class project. It is reprinted with permission from Laura's mother, Wendy Brown.

The Bears, The Beetles, The Blister Rust, And The Bark

Laura Brown, Sixth Grade
Yellowstone Park School
Yellowstone National Park, Wyoming

I chose the topic of the whitebark pine trees because every year my family goes to a camp in Colorado. Every time we go there, there are more and more dead trees because of certain causes. So I decided to do my speech on the whitebark pine trees because they are having the same problems in Yellowstone National Park as the trees in Colorado. A lot of animals depend on the whitebark pine trees, but a lot of the trees are dying. Let me tell you about some of those animals and what is happening to the whitebark pine trees.

First, the whitebark pine trees are a "keystone species" because a lot of animals depend on them to stay healthy. The whitebark pine trees are not trees that spread their seeds by wind, but by birds. They get help from the Clark's nutcracker which is a bird that we often see in Yellowstone. The Clark's nutcracker bird gets the cones from the trees and stores them underground for the winter. Then the seeds grow into more and more trees. The trees are adapted to harsh environments like cold winds that other trees wouldn't survive in.

Secondly, animals depend upon the whitebark pine trees, but the problem is that a lot of the trees are dying. The first reason is because of the mountain pine beetle; these beetles are native bugs to Yellowstone and didn't come from somewhere else like Africa. The beetles get into the trees and eat them which cause them to die. If the beetles girdle the trees (which means to go around the whole tree and eat it) then the tree dies for sure. The mountain pine beetles look like this picture.

Another reason that the whitebark pine trees are dying is because of the whitepine blister rust which is a disease that is caused by a type of a fungus which leaves spores that make the tree look bumpy.

Third, the animals feast on the nuts that are inside the cones. They do not eat the actual cones. Some of the animals that eat the nuts are the grizzly bears, the black bears, the Clark's nutcracker, and different types of squirrels. The squirrels get the nuts and store them in what is called a "midden" for winter. The bears get the nuts by either going into the squirrel's middens or they can climb the trees to get the nuts. It's mostly the black bear that climbs the trees. The nuts

from the cones are stuffed full of nutrition. The nuts help the bears and other animals with giving birth to healthy babies. The nuts are one of the animal's favorite foods to eat.

Fourth, this year had a good crop of whitebark pine nuts in Yellowstone, so there were a lot of grizzly bear cubs in Yellowstone because the mother bears were so fat and healthy. There were fifty grizzly bears that gave birth in Yellowstone this year and eighteen of those bears had a litter of three cubs! What helped the bears are the nuts from the whitebark pine trees. The beetles and other threats to the trees are bad and the only way we can get rid of some of those threats are by forest fires that renew the forest or if we have colder winters so the beetles die.

Fifth, today in Yellowstone most of the trees are doing pretty well but experts are concerned. I talked to Mr. Dan Reinhart, who is a Resource Management Specialist and knows a lot about the whitebark pine trees. He says that the "the future is uncertain" for this type of tree. I hope that blister rust and beetles will both die out. I am concerned that the bears might not survive through the winter because they might not have had enough food. Or they might not have been healthy.

In conclusion, if you would like to learn more about this problem with the whitebark pine trees you can go to the internet, or books, or you can go to Dan Reinhart who studies the whitebark pine trees in Yellowstone. ■

Citizen Scientists Monitor Whitebark Pine

Louisa Willcox, Natural Resources Defense Council, Livingston, MT; llwillcox@aol.com

The Whitebark Pine Citizen Scientists Project is a loosely organized group of citizens who are concerned about the future of the Greater Yellowstone Ecosystem (GYE), and are interested in documenting the health of its whitebark pine forests.

"Citizen science" is a term used to describe a project in which a network of volunteers, many of whom may have no formal scientific training, perform research-related tasks such as field observations. Citizen scientists involved in this initiative document mountain pine beetle activity and infestation in whitebark pine in the GYE. The project also involves Google Group, which provides a forum for the exchange of observations, ideas, and concerns regarding whitebark pine.

The initiative was started by Dr. Jesse Logan, retired head of the Forest Service Western Bark Beetle Research Unit; Louisa Willcox, Senior Wildlife Advocate of the Natural Resources Defense Council, and Wally MacFarlane, a GIS specialist of GEO/Graphics Inc. in Logan, Utah. Bruce Gordon, a pilot and President of Ecoflight, is also engaged in documenting whitebark pine health through aerial overflights. The effort grew out of their concern about the mounting beetle epidemic in whitebark pine and the potentially devastating consequences of its loss. It also responded to the expression of concern from NRDC members and others asking the question: "why are so many whitebark pine turning red?"

The Citizen Scientists project currently includes horsepackers, backpackers, climbers, and outfitters such as the National Outdoor Leadership School, which had a number of students last fall assessing whitebark pine damage in Wyoming's Wind River Mountains. Our goal is to expand this network over the next few years, with the hope of obtaining a more complete picture of what is happening to whitebark pine in the GYE.

The information collected by citizen scientists is critically important because of the mounting threats from mountain pine beetle (MPB) to whitebark pine in the GYE. And with 26 million acres, the GYE is a big place. In addition, management agencies such as the U.S. Forest Service are strapped for the resources necessary to develop a comprehensive picture of whitebark pine health.

With increasing temperatures, the range of MPB is expanding into previously inhospitable habitats. The result is an alarming intensification of MPB activity in whitebark pine forests. High-elevation whitebark pine ecosystems are particularly vulnerable to MPB outbreaks because they have not co-evolved in the same manner as lower-elevation forest ecosystems. With respect to mountain pine beetle and whitebark pine, nothing like what we see occurring today has been observed in recorded history or exists in the disturbance legacy of this long-lived species. If warming continues unabated, whitebark pine could become functionally extinct within the next 7 to 10 years in the GYE, according to modeling done by Dr. Jesse Logan.

The ecological implications of the loss of whitebark pine are profound and widespread, as whitebark pine is the foundation species for alpine ecosystems of the northern U.S. Rocky Mountains. The ecological benefits provided by whitebark pine ecosystems are far reaching, ranging from maintaining healthy watersheds to providing critical wildlife habitat. And, whitebark pine serves the particularly important function of regulating the spring runoff of the mountain snowpack and the supply of water for the region's world-class fisheries, as well as downstream agriculture and communities. In addition, whitebark pine is an engine driving the health of the Yellowstone grizzly bear population. The loss of whitebark pine seeds will likely be catastrophic to the future of the Yellowstone grizzlies. Dramatic loss of this food would result in substantially reduced carrying capacity for bears in the GYE, and increased bear/human conflicts and resulting bear mortality. The information on whitebark pine provided by citizen scientists will shed important light on the health of this key grizzly food.

The work of the citizen science initiative is in-

tended to complement monitoring efforts of agencies and others. For example, by collecting field observations, the citizen scientists could bolster the ground-truth for satellite imaging analysis and computer simulations of risk to whitebark pine.

We also hope that citizen scientists will become a valuable part of an ongoing dialogue aimed at fostering the best possible monitoring and conservation work for whitebark pine in the GYE. ■

Tracking the Home Range of the Clark's Nutcracker

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

Whitebark pine is an obligate mutualist of Clark's nutcracker and it requires nutcrackers to disperse its seeds. Despite the importance of nutcrackers for forest regeneration in whitebark pine communities, we lack basic information on space use by them. In general an understanding of space use by animals is central to the management and conservation of species. Studies of space use provide information on (1) the amount of land required to provide home ranges for a population; (2) the attributes of habitats that are required for survival and reproduction of a species; and (3) the abundance and distribution of individuals in different habitats. Radio telemetry is a powerful tool for obtaining space use data because it enables researchers to remotely monitor free-ranging animals as they go about their normal movements and activities; telemetry studies provide basic but critical information on the natural history strategies of animals.

Beginning in 2005 we undertook a study of nutcracker space use in Washington State. Our study area was located on the eastern slopes of the Cascade Range and is just east of Mount Rainier. Our study objectives were to (1) estimate home range size, (2) measure habitat use, (3) identify areas in home ranges used for critical behaviors such as foraging, breeding and seed harvesting, (4) model cache site selection, and (5) test four survey techniques for accuracy for drafting a range-wide nutcracker monitoring protocol. Our study objectives required us to radio tag and monitor the behaviors of free-ranging Clark's nutcrackers. In the first three years of the study we captured and radio-tagged 31 nutcrackers. We plan to capture and radio-tag an additional 25 nutcrackers in 2008.

Our radio transmitter batteries lasted 14 months and we have obtained a wealth of data on our nutcrackers: over the course of three years of telemetry we have 4491 point relocations and over 17,000 minutes of behaviors observations on our radio-tagged nutcrackers. Overall we have observed many fascinating phenomena.

The Nature of Migration in Clark's Nutcracker

Previously there have been two hypotheses regarding the nature of migration in nutcrackers. Steve Vander Wall postulated that nutcracker populations are composed of two life-history types: non-migratory residents who remain on a stable, year-round home range and more nomadic individuals that migrate long distances (Vander Wall et al. 1981). The alternative hypothesis proposed that altitudinal migration (migration from high elevations in summer and autumn to low elevations in the winter months), rather than latitudinal migration, was common in nutcrackers (Tomback 1978, 1998).

Results from our study show that latitudinal migration is a common occurrence in populations of nutcrackers in Washington State. We radio-tagged 21 migrant nutcrackers that were attracted to large cone crops in ponderosa pine in the winter of 2006-2007. These migrant nutcrackers formed large flocks that moved throughout high-elevation whitebark pine and mid-elevation ponderosa pine forests. They migrated back to their summer ranges in late spring of 2007. We conducted aerial telemetry flights over the state of Washington searching for our migrant nutcrackers during the summer. Two of these individuals were relocated and we monitored their movements in autumn of 2007 and winter 2008. The ranged over hundreds of square kilometers in autumn as they foraged on and cached whitebark pine seeds.

Over the course of our study we have also radio-tagged eight non-migratory, resident Clark's nutcrackers. Our resident nutcrackers have behaved very differently from migrant nutcrackers. Rather than forming large flocks in fall and winter, our resident nutcrackers tend to move in pairs or in small groups of 3-5 individuals year-round. Also, rather than wandering over hundreds of square miles in autumn, our resident nutcrackers have shown very strong fidelity to one home range. Residents have remained within a defined home range year-round and all activities, with the exception of seed harvesting, have occurred within this home range. Home ranges have been located in a breadth of habitat types: burned ponderosa pine forest, mixed Douglas-fir/ponderosa pine, mixed subalpine-fir/whitebark pine, and climax whitebark pine stands. The home ranges of our residents are very large for birds of comparable size; for example in Washington average size of home ranges for the Steller's jay is reported as 60 ha, compared to the 318 ha home ranges of Clark's nutcracker, although both species weight about 130 g.

Seed Caching Observations

Our extensive behavior observations of radio-tagged nutcrackers have led to some amazing insights into the seed-harvest and caching decisions of nutcrackers. We were fascinated by the slight idiosyncrasies between individuals and each individual radio-

tagged nutcracker responded uniquely to seed availability in each year. For example, one female resident nutcracker never transported whitebark pine seeds more than 1.8 km. In the same year, however, a male nutcracker routinely transported whitebark pine seeds 29.3 km from harvest trees to cache sites. On average, whitebark pine seeds were transported 10.6 km, ponderosa pine seeds 6.3 km, and Douglas-fir seeds 2.4 km. Despite these differences, resident nutcrackers were all alike in that while they foraged widely and on a landscape scale when harvesting seeds from trees, they placed all of their seed caches within their year-round home range.

We observed differences in the species of tree that individual residents harvested seeds from. Of eight nutcrackers monitored in autumn, all have been observed harvesting ponderosa pine seed but only six also harvested whitebark pine seed and only three harvested Douglas-fir seed.

We also observed differences in the caching behaviors of resident versus migrant nutcrackers. Only resident nutcrackers transported seeds long distances. This is because residents transported seeds long distances for the purpose of placing seeds centrally and within their home range. Moreover, resident nutcrackers commonly selected concealed locations for caching. Conversely, we observed migrant nutcrackers transporting seeds only short distances (less than 2 km) and they cached seeds only in communal caching grounds. These differences may reflect differences in spring seed retrieval behaviors by residents versus migrants. In our study, we observed that residents remained within one central home range year-round and year-round they foraged on seeds retrieved from memory of their personal caches. Conversely, we never observed migrants retrieving seeds from caches by using their memories; rather, we observed migrants foraging in communal caching grounds in spring and summer, where they pulled whitebark pine seedlings from the ground as the seedlings emerged. Rather than retrieving these seed stores from memory, the migrant nutcrackers used visual cues to locate seed caches that were germinating.

On a microsite scale, we observed that nutcrackers inhabiting different forest types may have different cache-site preferences. Nutcrackers with home ranges in high-elevation study areas near the Cascade Crest placed 70% of their caches above ground in the foliage and bark of trees. Nearly all of the remaining caches were placed on steep south- or west-facing cliffs or slopes within the mid-elevation ponderosa pine zone. These study areas were covered in snow from November through June and therefore caches sites were selected that would be accessible in the winter and spring months. Conversely, nutcrackers inhabiting a dry, low-elevation ponderosa pine stand 25 km to the east of this area placed only 36% of their caches in above-ground sites. Winter snowfall in this low elevation area was sporadic and therefore most of the ground was snow-free for the majority of the winter. Overall, it appears that the individual nutcrackers responded to unique microclimatic conditions in their locality and they selected sites for seed storage accordingly. While multiple burns were present within the study area, we did not observe a preference by residents or migrants for caching seeds in burns.

Spring Breeding Season Observations

Although our original study objectives did not include studying breeding productivity, we incidentally found and monitored several nutcracker nests in our study area. Four of our radio-tagged nutcrackers attempted to breed and we have also monitored an additional eight nests from non-tagged nutcrackers to examine productivity and causes of nest failure. We stationed digital video recorders at some of these nests to monitor feeding rates and predation attempts. Of nests of radio-tagged nutcrackers, nest predation by common ravens accounted for nest failure at one monitored nest and northern goshawks were responsible for failure at a second nest. The other two radio-tagged nutcrackers were successful in raising young from the nest.

This study is ongoing and we expect to learn more about movements of the elusive and critically-important Clark's nutcracker.

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Trapping Clark's Nutcrackers and Locating Nests

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Whitebark pine is entirely dependent upon Clark's nutcracker for dispersal of its large and wingless seeds. This important behavior initiates in late summer and continues into the fall, depending upon the size of the cone crop. Interestingly however, nutcrackers utilize whitebark pine communities for about 25-40% of any given year. What the birds forage on and how they move about the landscape for the remainder of the year is poorly understood in the U.S. northern Rocky Mountains.

Professor Charles Janson (Division of Biological Sciences, University of Montana), research assis-

tant John Fothergill (College of Forestry and Conservation, UM), and I began research in fall 2007, in part to address this missing piece of nutcracker natural history. Our study objectives are 1) to identify how nutcrackers meet their energy needs throughout the year, by documenting seasonal variation in food source types, where they obtain food, and what forest types they use; 2) to determine whether nutcrackers use multiple spatial levels in seed-cache site selection and recovery; and 3) to understand how spatial and temporal knowledge are integrated and used in nutcracker foraging decisions. The purpose of this article is to describe our field methods and progress to date.

Our research site is located on the Bitterroot National Forest and adjacent private land in western Montana. The first priority was to create areas that nutcrackers would reliably visit so that we could eventually trap them and fit them with radio transmitters and passive integrated transponders (PIT). In late fall and early winter, we installed six feeding platforms in different habitats that we thought nutcrackers would use (e.g., open mature ponderosa pine stand, burned forest, and younger mixed conifer forest). The platforms were 0.5 m x 0.5 m and were suspended from a nylon cord that was strung between two trees. We initially provisioned the feeders with ponderosa pine cones filled with either peanuts or pine nuts, and store-bought suet cakes. By mid-winter however, we learned that the local nutcracker population is particularly fond of beef suet straight from the processing plant. We therefore began using this food item as an attractant. We visited the feeders throughout the winter and played call-back tapes of various nutcracker vocalizations. Eventually we focused our efforts at the feeders frequented most by nutcrackers. Nutcrackers were also regular visitors to a suet-laden feeding platform at a nearby residence. This discovery was a stroke of luck that proved both edifying and instrumental to our plans moving forward.

We baited Havahart live traps with suet, wired the doors open, and placed them on the feeders so that the birds would become accustomed to them. After we observed nutcrackers routinely going in and out of the traps, we set them and began trapping. We have caught, attached backpack harnesses equipped with 3.9 g radio transmitters and 0.1 g PIT tags, and color-banded three nutcrackers to date. All three of the birds are residents and breeders.

We have located each bird's nest and followed their movements through April. One nest was found by following the radio signal of the tagged bird to an individual tree. Because we could not see the bird, we waited near the tree and eventually its mate flew in and replaced the bird at the nest. We found a second nest by following the radio signal into an area comprised of an open stand of ponderosa pine and quaking aspen, and adjacent to a riparian meadow. The tagged bird frequently moved throughout the stand, flew away and out of sight for 20-40 minutes, and then returned to the area. We closely inspected the larger pine trees and eventually located the nest by following the chirping sound of the bird's two large chicks. We found the third nest by observing a nutcracker fly up off the ground with nesting material and into a tree. After several flights we were able to pinpoint the location of the nest. We installed a feeding platform and trap 30 m away from the nest tree, baited it with suet, and trapped one of the nesting nutcrackers two days later.

One nest fledged two birds in mid-April, the second nest fledged two birds on May 1st, and the third is now on eggs in early May. All nests were built on east-southeast facing limbs, 6 to 8 m high in ponderosa pine trees growing in open stands on south-facing slopes. We will follow the movements of the three families throughout the spring, summer, and fall, and hopefully witness them ascend the mountains into the upper subalpine zone to perform their critical function in the whitebark pine life cycle.

One of the most important lessons learned thus far is the tremendous benefit one can gain by networking with and speaking to local residents. The support we have received from local property owners and businesses has been fantastic and our study would not be as far along without their help. We are especially grateful to Ira and Rose Mary Abney, and Jeane Lippert of Victor, MT for their generosity in allowing access to their property and for sharing their knowledge about the local nutcracker population. Many thanks also to Dave Lockman (Wildlife Biologist, Bitterroot National Forest) for help with gaining necessary permits and with logistics, and to Teresa Lorenz (Avian Ecologist, Okanogan-Wenatchee National Forest) for fielding questions about radio transmitters and the backpack harness design. ■

A Race Against Beetles: Conservation of Limber Pine

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The Rocky Mountain Research Station, Forest Health Management, Rocky Mountain National Park, Arapaho-Roosevelt National Forest, and the Medicine Bow NF are coordinating efforts to conserve limber pine along the Front Range of the southern Rockies. Mountain pine beetle (MPB) populations are increasing dramatically in the area and killing limber pines in their path. Last year alone, aerial survey recorded 38,000 acres of limber pine mortality in northern Colorado and southern Wyoming, a large increase over the 9,000 acres recorded in 2006. It is estimated that MPBs will infest nearly all the limber pine stands in this area within the next few years.

White pine blister rust (WPBR) also continues to spread and intensify in this area; incidence in some

stands is as high as 100 % while other stands have yet to be invaded (Kearns and Jacobi 2007). An on-going rust resistance screening study suggests that both rust-invaded and pristine stands in this area contain limber pines with resistance (Schoettle, Sniezko and Burns et al., in progress). Other non-tested trees within the populations may also have resistance and/or serve as pollen receptors for those trees with resistance. Our goal is to protect numerous trees in each population from MPB as they are needed for research and restoration aimed at mitigating impacts from WPBR into the future (Burns et al 2008; Schoettle and Sniezko 2007).

In a race against the beetles, efforts are currently underway to (1) protect mature limber pine trees in a range of geographic locations for *in situ* conservation of seed sources to support future natural regeneration and restoration projects and (2) collect seed for *ex situ* conservation of the genetic diversity of populations for future use. Two treatment options for controlling MPB are being used: insecticide application and synthetically produced verbenone pouches. Ground application of the insecticide carbaryl prior to beetle flight (before July 1) will be used wherever possible. In areas where spraying is not feasible or advisable, verbenone, the known anti-aggregation pheromone of MPB, will be used to protect limber pines. Access prior to beetle flight is difficult due to late lying snow for some sites; in such cases the trees will be treated with verbenone and later sprayed with insecticide when access becomes available.

The limber pine in Colorado and southern Wyoming are encompassed in one seed zone, though maximum elevation transfer of seed within the zone is recommended to be +/- 700 ft (~200m) (Mahalovich 2006). Cones will be collected from individual trees and in bulk population collections from each site treated for MPB control. Additional sites will be sampled where necessary to ensure acquisition of genotypes from the diversity of habitats and elevations occupied by limber pine.

The first test of the efficacy of verbenone to control MPB on limber pine under epidemic beetle populations will also begin this summer in northern Colorado. Verbenone has been used to protect whitebark pines from MPB attacks with moderate success in the USFS Northern Region (Kegley and Gibson 2004) but has not previously been tested on limber pine. The test with limber pine will be conducted in an area with high beetle pressure where non-treated and verbenone-treated trees will be monitored for beetle attack. Although it is not expected to be as reliable and effective as insecticides, verbenone may provide protection for limber pine in circumstances where the use of insecticides is not an option.

Depending on budgets, the trees will be treated yearly until the threat of MPB impacts decreases, or at least until adequate seed has been collected for *ex situ* conservation. All of the partners are contributing resources toward this effort in addition to some funding provided by the new USFS Forest Health Protection *Genetic Conservation of US Forest Trees Threatened by Invasive Insects and Pathogens* effort.

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Ectomycorrhizal Fungi with Whitebark Pine

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Like all pines, whitebark pine (*Pinus albicaulis*) requires ectomycorrhizal (ECM) fungi on roots for normal growth and survival (Read 1998) and are crucial to seedling establishment. Mycorrhizal fungi can enhance phosphorus and nitrogen uptake, increase drought tolerance, and provide protection from root pathogens and invertebrate grazers.

We wanted to assess ECM fungi crucial to whitebark pine before the significant decline of whitebark pine in areas of Waterton-Glacier International Peace Park (WGIPP) (Smith et al., 2008) becomes irreversible. Knowledge of the ECM fungi is potentially critical to the survival of this tree in peril.

Methods

The goal was to collect ECM fungi associated with whitebark pine at several ecosites in WGIPP with particular emphasis on accessible areas with significant seedling regeneration.

Sporocarps (mushrooms, truffles) of fungi known to be ECM were collected in whitebark pine communities and identified by their morphology. Sporocarps were tissue-cultured when possible but they were rare in WLNP and absent from GNP due to pre-

ceding drought conditions. Root samples were also taken, using minimally destructive techniques, then washed and assessed for ECM fungi. Mycorrhizae were sorted into morphotypes (fungal species) using a dissecting scope and identified by molecular analysis when necessary (see methods in Mohatt et al. 2008). Twenty-seven root samples consisting of hundreds of ectomycorrhizae were assessed.

Results and Discussion

A total of 20 species of ECM fungi with potential to associate with whitebark pine were recorded from WGIPP; at least 12 species of which were confirmed on roots of seedlings. These fall into two main ecological groups: those not restricted to a particular host (form mycorrhizae with pine, spruce and fir) and fungi host specific on some level (occurring with pines, 5-needle pines, or only stone pines). The non-host specific fungi include: *Cenococcum geophilum, Amphinema sp., Piloderma sp.* and *Tricholoma moseri.* All are also confirmed from the Greater Yellowstone Ecosystem (GYE) on whitebark pine (Cripps and Mohatt 2005). *Cenococcum geophilum* occurs on many hosts and has been shown to benefit trees in drought conditions. It was prolific on some seedlings, producing hundreds of mycorrhizae and covered whole root systems on two samples. Its abundance could be a result of recent drought conditions in WGIPP.

Of high interest was the discovery of a diversity of Suilloid fungi specific to 5-needle pines, including *Rhizopogon* and *Suillus* which were identified on roots. Some taxa are now in culture from WGIPP and GYE and have value for inoculation of nursery seedlings. *Rhizopogon* spores are distributed by mammals that consume the fruiting bodies, so the presence of these vectors is an important consideration for restoration. The importance of the discovery of Suilloid fungi in WGIPP whitebark pine forests cannot be over-stated because of their role in seedling establishment of pines. Some mycorrhizae were of large size (up to 2 cm across) and were prolific along larger roots (Fig. 1). It is not known how long spore banks of these species are maintained in the soil after whitebark pine mortality, and some are likely to be lost along with the pines.

An unintentional result of this study was a comparison of the mycorrhizal status of seedlings in various microhabitats: seedlings on nurse logs hosted the highest diversity of ECM fungi, followed by those in an open understory, with a significantly lower diversity for those in beargrass (*Xerophyllum tenax*). Sample numbers were limited, but this trend is apparent, and may have functional significance (Fig. 2). Observation of healthy seedlings in beargrass suggests these species can co-exist, however, it was difficult to sample roots since the mats of grass rhizomes were several cm thick and needed to be sawed through. Mycorrhizae were either absent or could not be located on seedlings in beargrass.

In areas of WLNP with dense beargrass, numerous seedlings were located on nurse logs. These are assumed to be from bird-planted seeds since many were in clusters. These seedlings hosted numerous healthy-looking ECM rootlets situated within the decomposed wood.

Additional ecological roles of ECM fungi became apparent during the course of the investigation. Dense masses of mycorrhizae along roots aggregated the soil into large clumps which held moisture. Rhizomorphs of some fungi aggregated even gravel size particles. Mycelium was observed in close contact with granitic particles, and it is possible these fungi produce phosphatases to access inorganic phosphate in minerals. The large coralloid mycorrhizae (Fig. 1b) from mature roots in GNP have potential to host N-fixing bacteria, but this remains for discovery in these systems.

Management Considerations

Knowledge of the mycorrhizal fungi important to whitebark pine will eventually be valuable to the extensive efforts currently underway to restore whitebark pine communities using a combination of management strategies such as fire, silvicultural cutting, and the planting of rust-resistant nursery-grown seedlings (Keane and Arno 2001). Inoculation with native fungi may be necessary where they are missing. The cultivation of Suilloid fungi is important so that native species will be available for national parks where exotic fungi are unsuitable: commercial inocula with non-native fungi should not be applied to any whitebark pine. Systems are sensitive, and certain fungal species not only have particularly physiological and mechanical roles, but they are also part of the food chain and addition of alien fungi risks cascading ecological effects. Suilloid fungi have now been discovered in WGIPP as well as in GYE and could be of critical importance to the ecology of this tree in peril.

Perkins (1999) found that for whitebark pine neither seed germination nor survival differed among seeds planted with different understory neighbors, but in burned plots the average seedling dry mass was significantly lower in association with beargrass. Izlar (2007) recently noted beargrass to have a slight negative effect on planted whitebark pine seedlings. Therefore, if fire is the restoration strategy in these areas, the dynamics of beargrass recovery after fire should be taken into account in context with that of whitebark pine seedlings. Reduction of nurse logs is another consequence of fire that should be taken into account in areas slated for reforestation.

If areas are disturbed by fire or clear-cutting that remove the inoculum source, plantings should follow quickly while viable spore banks still exist in the soil. Monitoring can reveal if seedlings are at risk from lack of mycorrhizal colonization.

Color photographs of mycorrhizal types can be found at:
http://plantsciences.montana.edu/facultyorstaff/faculty/cripps/cripps.html

Acknowledgments

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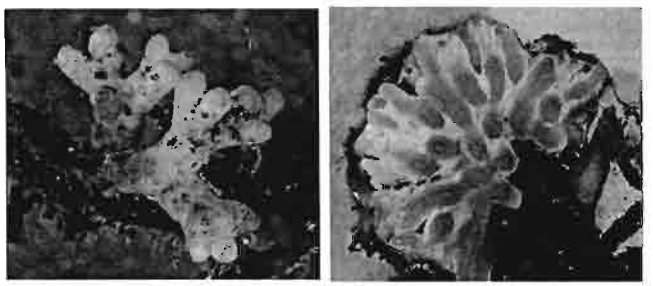

Fig 1a & 1b. Suilloid type mycorrhizae on whitebark pine.

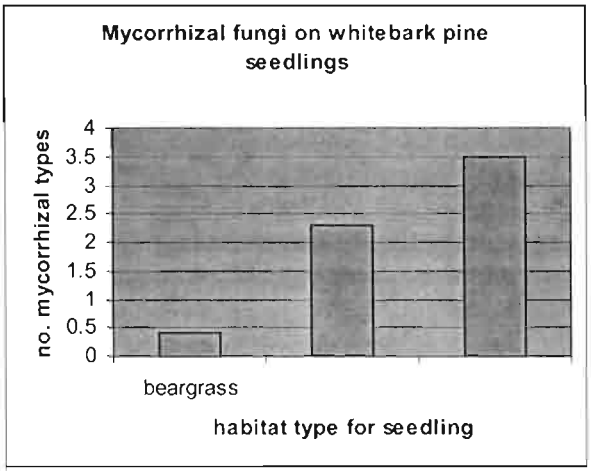

Fig. 2. Number of mycorrhizal types on whitebark pine seedlings situated in beargrass (n=7), under the canopy of mature whitebark pine forests with an open understory (n=11) and on nurse logs (n=4). Data for WLNP. ■

A Single-Season Whitebark Restoration Program

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In July of 2007, I received notice that funding had become available for some whitebark pine restoration in British Columbia's Manning Provincial Park, located in the Cascade Range along the province's southern border. Following a meeting with a BC Ministry of Environment representative, I went with some colleagues on a day hike through our previously identified restoration candidate areas to assess the best use of the funds. Our observations and initial restoration activities ran the gamut from good to bad and ugly.

The Good

Cones were in great supply in 2007--the largest mast crop in at least five years. Thus, we decided that a good use of funds would be for cone collection and implementing a seed planting program as recommended from previous whitebark work in the park. In two short days we caged 360 cones on 30 trees, which ultimately yielded 18,500 seeds, a very successful collection.

The Bad

I had previously visited the stand of whitebark pine from which we harvested cones two years earlier. Unfortunately, by 2007 mountain beetle damage had escalated. Recent mortality was evident as we drove up the road to the stand. Dead lodgepole pine gave way to dead whitebark pine; large gnarly veterans were now snags with orange needles. Mortality of mature whitebarks--including some that were potentially rust resistant--likely exceeded 80% for the stand when combined with blister rust impacts. Given this dire situation, we were fortunate that there was an abun-

dance of cones on the surviving trees.

The Ugly

We had caged cones and returned to collect them when it began to snow. Ugly. Even more ugly when one considers that we had a short-term contract that required all funding be used by March 31, 2008. Our intentions with this funding were to collect seed, dry it, apply a warm stratification, and plant it--all before the snow flew. However, the autumn snow came early and stayed, making seed planting a challenge. This emphasized to us that when coordinating funding surrounding a tree that grows in some of the harshest climates, alternatives should be considered in the event that weather takes a turn for the worst.

Playing Nutcracker

Why Nutcrackers Cache Where They Do

Following a four-week seed extraction and drying phase, we set off into the snow to plant as many seeds as we could. We decided to forego the warm stratification of the seeds as snow was accumulating, and we wanted to ensure some were planted this season. Seeds were planted in three restoration areas. The first consisted of gentle terrain and had accumulated about 30 cm of snow. The second and third areas were located on steeper south aspect slopes which, despite daytime temperature rarely above freezing, were completely free of snow (Figure 1). These snow-free areas allowed for easy seed planting. We also planted seeds under the snow on north slopes for experimental purposes, these slopes, however, were much more difficult to plant due to snow depths and frozen ground. Perhaps the nutcracker is on to something in preferring warm aspects for seed caching.

Figure 1. Differences in snow accumulations on warm and cool aspects.

Caching Seeds and Remembering Cache Locations

At each restoration site, seeds were cached in clusters of six at a depth of 3-5cm using a screwdriver to imitate the nutcracker's bill. Each cluster consisted of seeds from a common parent tree. To track the progress of the planting efforts, seeds were planted in fixed-radius plots and the location and parent tree information about each seed cache was recorded. Location information for each cache was mapped by permanently marking the plot centre and recording the bearing and distance to each cache from this centre point. In total, 10,500 seeds were cached with 8,000 cached in permanent monitoring plots. It is hoped that these caches can be monitored to track annual germination, mortality and possibly rust resistance over time.

Forgetting Cached Seeds and Planting a New Forest

In essence, this program was akin to a nutcracker caching and forgetting all of its seed caches. The question that remains is: will simply forgetting be enough? Successful germination in the field will be further dependent on low rodent scavenging, suitable environmental conditions and quality of the seed planted. By caging cones, we ensured the highest quality seed possible was planted given the time constraints. However, scavenging and environmental conditions were not addressed. Given that as of May 1st 2008 there were still several meters of snow covering most of the seeded areas, moisture availability should not be an issue for germinants, however growing season length may be too short for successful recruitment this year.

In the event that seed planting fails due to one or more causes, 8,000 seeds were retained for provenance and seedling production trials. Thankfully these were voluntary programs, which could make use of the excess seed we collected without impacting the limited budget. Seeds ear-marked for seedling production were stratified and planted with the first germinants emerging on April 30th (Figure 2) - a far earlier emergence than would be expected for seeds still under deep snow in the field.

Figure 2. Whitebark pine germinants in nursery.

This project was just the initiation of the seed collection and planting phase of a larger whitebark pine restoration initiative in Manning Park, which also includes habitat enhancement by prescribed burning. We hope

that seed collection and planting will be funded in future years, particularly in light of the dramatic loss of mature trees that no doubt diminishes the potential for natural regeneration. ■

Whitebark near its Northern Limits in Alberta

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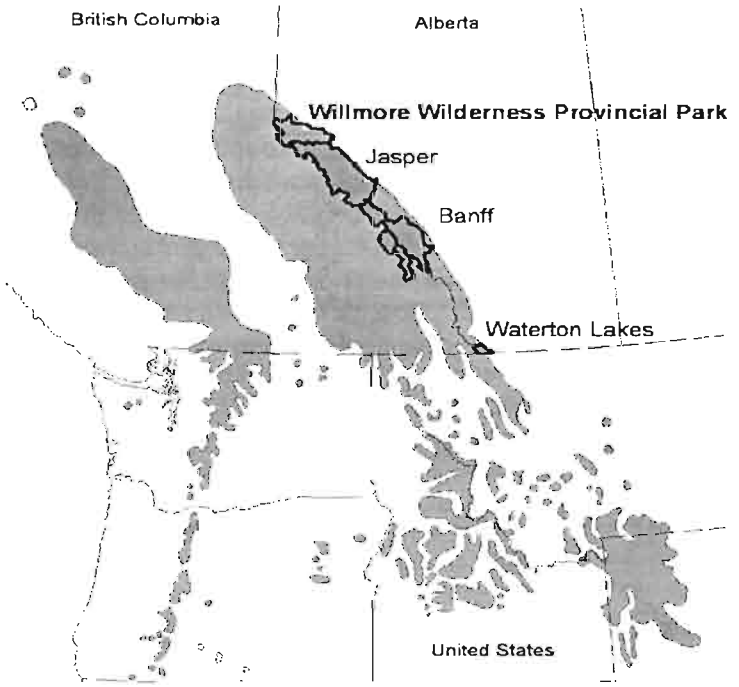
The Willmore Wilderness Provincial Park, immediately north of Jasper National Park in Alberta, has one of the most northerly populations of whitebark pine in the Rocky Mountains. In this remote and beautiful area Engelmann spruce (including hybrids with white spruce) and subalpine fir are the major high-elevation trees, whitebark pine is sparse and restricted to scattered locations in some valleys, and whitebark pine seedlings are found growing in the understory and even in fens.



Northern portion of whitebark pine's distribution showing Willmore Park.

The Parks Division of Alberta Tourism, Parks and Recreation has been working with the Forest Health Branch of Alberta Sustainable Resource Development (ASRD) to document the distribution of whitebark pine in Willmore Park. Most of the whitebark pine are located in mixed stands with spruce and subalpine fir but some are found mixed with lodgepole pine and at higher elevations whitebark may occur in almost pure groves. In 2008, rare vascular and non-vascular plants will also be assessed in these groves by Dr. J. Gould of Alberta Parks and Dr. R. Belland of the University of Alberta. The Parks Division and Forest Health Branch have also collaborated on assessing the health of whitebark pine, and nine permanent transects have been established and monitored to date (K. Ainsley and A. Benner, unpub data). These transects were established using protocols recommended by the Whitebark Pine Ecosystem Foundation. Additional transects will be established in 2008 to ensure a good representation of whitebark pine stands from different elevations, aspects and vegetation type. One large stand of whitebark pine was killed in a stand replacing fire in 2006, and we are hoping to get back in to the site to monitor the recovery.

Carmen Wong and Lori Daniels recently initiated work on stand dynamics. Carmen sampled two stands in the summer of 2007 for her Ph.D. These stands were chosen to complement 37other stands sampled across the Canadian Rockies. Whitebark pine made up 17% of the live stand density, averaging 160 trees/ha (Figure 1). Both stands had very old trees – whitebark pine dated back to 1518 in one stand and Engelmann spruce dated to 1634 in another (Table 1). However, 37% of whitebark pines in these stands were dead. Unlike in populations found in the southern part of its range in the Canadian Rockies, there were very low levels of white pine blister rust. We found only two trees with signs of inactive rust and unlike sites further south, none of the live trees had dead tops or squirrel feeding. Other survey work in Willmore Park also found low levels of active blister rust (average 3% of live trees had stem cankers, K. Ainsley and A. Benner unpublished data). Although mountain pine beetle is active in Willmore Park, we only found evidence of mountain pine beetle attack on one tree. It is likely that the main agent of mortality was stem rot causing stem breakage. Rot was evident in 30% of sampled live whitebark pine in one stand.

Preliminary results from these two stands also suggested that whitebark pine regeneration can be highly variable within and between stands: densities averaged 200 ± 283 and 2900 ± 872 (mean ± standard deviation) seedlings/ha, respectively. Out of the 80 seedlings surveyed, none had evidence of white pine blister rust and only two had dead tops from unknown causes. In both stands, whitebark pine seedlings were outnumbered by subalpine fir but the relative abundance of the two species varied - in one stand whitebark pine formed 40% of the seedlings but only 4% in the other (Figure 1).

Subalpine fir is often thought to be increasing in whitebark pine stands because fires have been excluded. The ages and growth of seedlings sampled did not support this. Subalpine fir "seedlings" ranged in age from 27 to 273 years with many older than the period of possible fire exclusion and older than most whitebark pine seedlings, which averaged 30 ± 8 and 66 ± 6 years in each stand. Many subalpine fir were highly

suppressed - one "seedling" was 84 cm tall, 1.8 cm in diameter and 184 years old. That is almost 100 rings per centimeter!

The other research projects on whitebark pine in Willmore Park involve mountain pine beetle, bears, cones and plants. Brooks Horne of Forest Health Branch of ASRD has been attempting protection against mountain pine beetle infestation with the anti-aggregation pheromone verbenone. This work has taken place in a small number of stands with a significant component of cone-bearing whitebark pine. Pouches were put on trees in one stand in 2006, two stands in 2007 and a third will be added in 2008. The total area protected will be about 17 ha. This program has been successful to date but the threat to whitebark and lodgepole pines within the area by mountain pine beetle will probably be substantial for several years. Alberta Parks is also co-sponsoring research on the phenology of mountain pine beetle in whitebark pine stands as well as documenting the other arthropods and investigating the effect white pine blister rust has on these organisms (E. Esch, University of Alberta, Dr. D. Langor, Canadian Forest Service and Dr. J. Spence, University of Alberta).

The ecological relationship between whitebark pine and grizzly bears in the northern Canadian Rockies is not clear. Current thought is that whitebark pine seeds do not form a significant component of the diet of bears (grizzly or black) in the northern Rocky Mountains of Alberta; however this has never been tested. Alberta Parks is initiating a project with the Grizzly Bear Program of the Foothills Model Forest to determine if whitebark pine seeds do form a significant part of the grizzly bear diet. Sites supporting whitebark pine will be targeted for the collection and content analysis of grizzly bear scat.

Leonard Barnhardt and co-workers in ASRD have collected cones from a stand in Willmore Park and seeds have been extracted and stored at the Alberta Tree Improvement and Seed Centre. Alberta Parks and ASRD are working on a forest gene conservation plan that addresses gaps and needs in tree gene conservation at a Natural Subregion and seed zone level. Seeds of whitebark and limber pines have been identified as high priority for collection and the two agencies will be working closely together to identify stands for protection and seed collection. Dr. Vern Peters from King's College, Edmonton will be examining the relationship between cone production, tree regeneration and radial growth of whitebark pine.

We are hoping to expand much of the work being done on whitebark pine in Willmore Park to other protected areas in the Canadian Rockies in Alberta and to limber pine throughout the province. Staff from several agencies (ASRD, Alberta Tourism, Parks and Recreation, Canadian Forest Service, Parks Canada, King's College) meet regularly to discuss research priorities and conservation strategies for whitebark and limber pine in Alberta. We are all working to help ensure that whitebark and limber pine remain on the landscape as part of the natural heritage of Alberta.

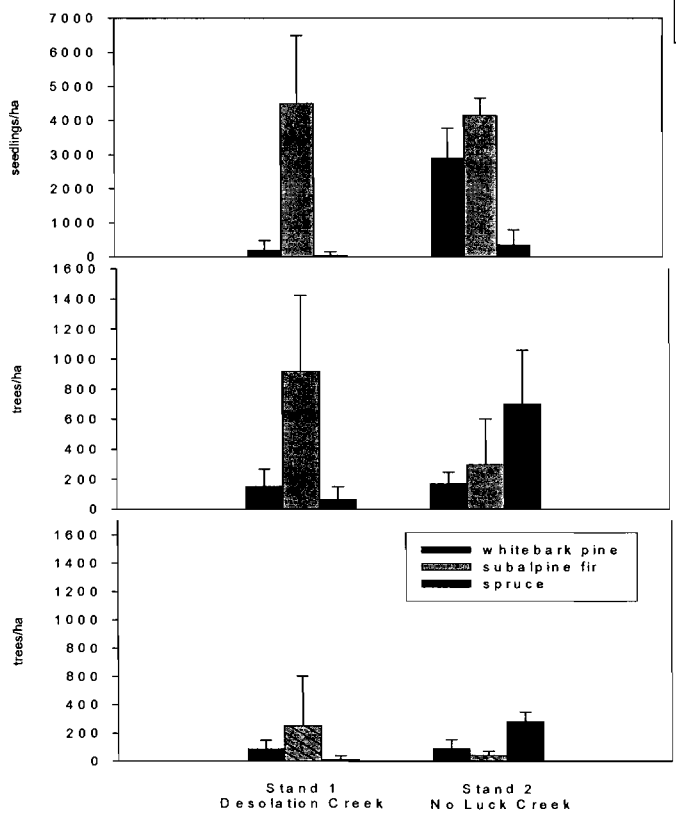


Figure 1. Density of seedlings, live and dead trees (top, mid and bottom plots) in two stands sampled in the Willmore Wilderness.

Species	Desolation Creek	No Luck Creek
Whitebark pine	1518 (1758) n=23	1690 (1800) n=14
Subalpine fir	1638 (1783) n=32	1728 (1807) n=10
Engelmann spruce	1520 (1753) n=8	1634 (1781) n=39

Table 1. Earliest (and average) dates of establishment for whitebark pine, Engelmann spruce and subalpine fir in two stands in Willmore Park. ■

Threatened Whitebark Ecosystems at their Northern Limits in B.C.

Sybille Haeussler, Bulkley Valley Research Centre and University of British Columbia, Smithers, B.C.

Whitebark pine reaches its northwestern range limits on the eastern slopes of the Coast Mountain Range, near my hometown of Smithers, British Columbia. The unusual scraggy-looking pines perched atop local rock outcrops and occasional sightings of Clark's Nutcrackers have long been a source of affection, pride and concern among local naturalists, foresters and biologists. But lately, concern has turned to alarm as the massive mountain pine beetle outbreak that has turned

 most of interior British Columbia into a sea of red and grey, has finally reached these remote mountain tops (Fig.1, on front cover).

Whitebark pine ecosystems in west central British Columbia face the same threats as elsewhere in their range: blister rust kills young trees, mountain pine beetle kills old trees, and creeping succession to shade-tolerant conifers occurs in the absence of wildfires. At their northern limits, these ecosystems may be particularly vulnerable because they are infrequent, viable seed production is uncertain, and the environment cannot support healthy flocks of Clark's Nutcrackers. The current pine beetle epidemic may tip these already weakened ecosystems over the edge.

In 2007 I undertook a joint research project with the Bulkley Valley Research Centre, a not-for-profit institute and the Forest Sciences Department of the University of British Columbia, with logistical support from BC Ministry of Forests and Range, Office of the Wet'suwet'en, Westland Resources and funding from the BC Forest Science Program. The research targeted isolated whitebark pine–dominated forest ecosystems that occur well below treeline (around 800-900 m elev.) on dry, gravelly soils. I hypothesized that these rare, lower elevation ecosystems would exhibit greater change than the more widespread rock outcrop ecosystems near timberline because forest succession would be more rapid and both the beetle and the rust would be more virulent in more benign environments.

These northern whitebark pine ecosystems have understories dominated by a white carpet of reindeer (*Cladina*) lichens with conspicuous circular patches of ericaceous shrubs (*Vaccinium membranaceum, Empetrum nigrum, Cassiope mertensiana, Menziesia ferruginea)* and mosses (*Pleurozium schreberi, Dicranum* spp.) extending outwards from tree bases (Fig.2). Apparently, lichen carpets are not a feature of more southerly whitebark pine ecosystems. For this reason, they may serve as useful indicators of the effects of climate change-related stress on forest ecosystems situated near the boreal/temperate zone transition.

We re-inventoried four old growth Whitebark Pine – Cladina lichen-dominated ecosystems located in mountains south of Smithers that were described during British Columbia's biogeoclimatic ecosystem classification program between 1978 and 1985. In fact, I did the vegetation work on two of these remote, helicopter-access plots during a summer job with the BC Forest Service nearly 30 years ago. One site near Burnie River experienced an undocumented mountain pine beetle outbreak in the 1980s or 1990s and was situated near an wildfire of unknown age. We conducted a detailed stand reconstruction and vegetation study in the Burnie old growth and wildfire areas to determine dates of these disturbance events and the successional processes that followed.

To our dismay, we discovered that all four old growth stands had been severely attacked by mountain pine beetle since 2004 and that very few mature whitebark pine trees remain alive. The dead trees were up to 500 years old, making them the oldest known trees in the region. The few mature pines in the Burnie stand that had survived the 1980/90s outbreak were attacked during the July 2007 beetle flight.

While flying over the area, it was evident that all lower elevation whitebark pine stands have now been attacked, whereas those at timberline have experienced only minor mortality. The beetle epidemic in west-central BC is now losing momentum as the low elevation lodgepole pine source habitat is essentially dead. With any luck, the timberline whitebark pine stands will not sustain local infestations and many of these trees will survive to help repopulate lower elevations.

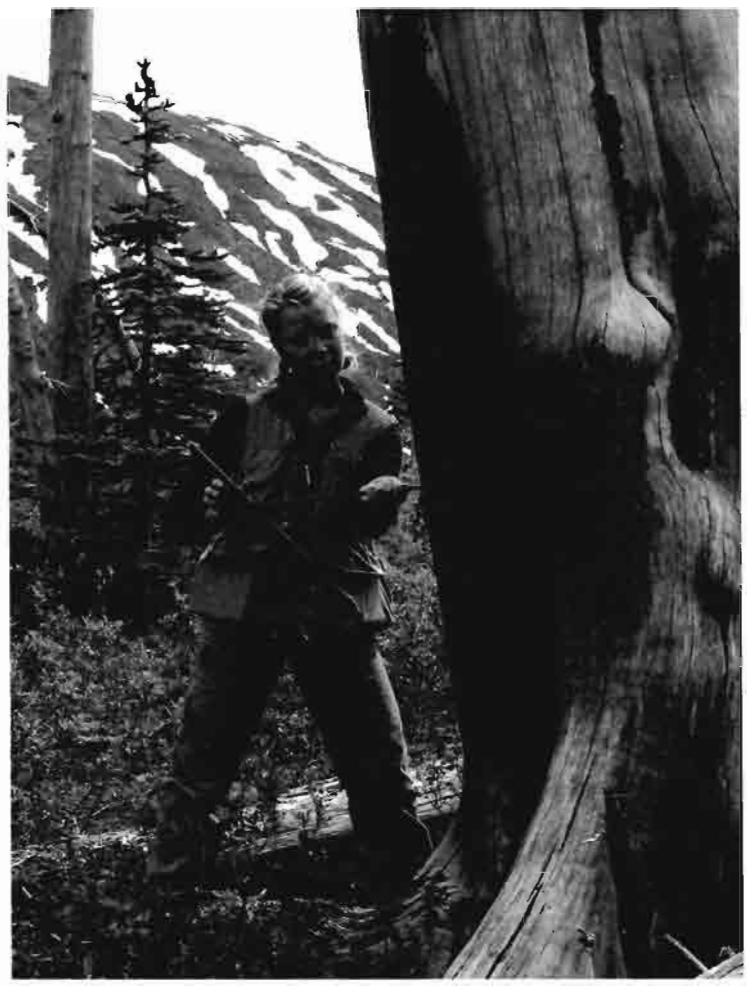
The now-dead old growth stands have abundant whitebark pine regeneration in a wide range of sizes and ages, but 72% of these smaller trees are visibly infected with white pine blister rust while 22% still appear healthy. A few of these understory trees seem likely to survive to reach the forest canopy, but it is hard to imagine future forest communities with impressive stands of large, old-growth whitebark pine.

One possible bright note in the otherwise bleak picture (one has to remain optimistic to be a whitebark pine researcher!) is that the hypothesized transformation of a reindeer lichen-dominated open pine woodland to a shaded mossy fir-hemlock forest is taking place much more slowly than expected. On the two driest old growth sites, the cover of reindeer lichens has almost doubled over the past 25-30 years, whereas the two more mesic sites have experienced a 1/3 decline in lichen cover. There was no evidence of an increase in Ericaceous shrubs. Furthermore, subalpine fir and mountain hemlock are taking over very gradually, if at all, because hemlock grows extremely slowly and spreads mainly by layering while subalpine fir is very vulnerable to disease on these ecosystems and has fared not much better than the pines.

On the Burnie wildfire (Fig. 3) we found many massive old whitebark pine snags and fallen logs, but only 10 rust-infected whitebark pine saplings scattered over 3.5 hectares. The 34-year old burn is slowly regenerating to lodgepole pine and subalpine fir, but remains very open and is a potential site for future restoration plantings.

We hope to find funding to conduct more in-depth soils and vegetation work as well as beginning some restoration work within these highly threatened ecosystems. Readers are invited to visit the Bulkley Valley Research Centre website (www.bvcentre.ca) where more detailed study results will be posted in May 2008. ■

Haeussler, Figure 2. Old-growth whitebark communities have white carpets of reindeer lichen with rings of moss and ericaceous shrubs around tree bases (photos by S. Haeussler)



Haeussler, Figure 3. Whitebark pine snag killed by the Burnie wildfire.

A radio-tagged Clark's nutcracker harvesting whitebark pine seeds in her home range near Rimrock Lake, WA (see T. Lorenz's article; N.T. Ernst photo)

Nutcracker retrieving seed caches in a ponderosa pine forest near Victor, MT (see S. McKinney's article; Charles Janson photo)

Nutcracker on nest in April near Victor, MT (McKinney article; Charles Janson photo)