Issue No. 32: Spring 2017

nutcracker notes

JOURNAL OF THE WHITEBARK PINE ECOSYSTEM FOUNDATION

A report on a report: Whitebark Pine on Bureau of Land Management Lands in the Western United States

Note the ca. 1930 beetle killed snag (center), the ca. 2000 beetle killed snags left, and the live surviving whitebark pines. Taken on Challis Field Office, BLM lands.

By Dana L. Perkins

When most people think of BLM administered lands in the western US, the upland vegetation types that generally come to mind are sagebrush steppe, and mountain mahogany, juniper, aspen and Douglas-fir woodlands. Whitebark pine? Well, there is a little. And quite a bit more of it's cousin, limber pine. Until recently just how much, where, and what condition these five-needle pines were in was limited to the local knowledge of BLM resource specialists, who might have an eye for it.

In 2009, the Idaho BLM forestry lead, Mike DeArmond, and I wrote a whitepaper to identify the need to gather information

BLM continued on page 4

OUR MISSION

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

WHITEBARK PINE
ECOSYSTEM FOUNDATION

WHITEBARK PINE
ECOSYSTEM FOUNDATION

Inside *Nutcracker Notes*

FOUNDATION NEWS

ARTICLES

WHITEBARK PINE FOREVER
Restoration Fund Campaign

How can you help? Donate now to fund restoration projects such as:

- Plant whitebark pine seedlings
- Collect whitebark pine cones for future seedlings
- Grow blister rust resistant trees in whitebark pine seed orchards
- Protect high value whitebark pine trees from bark beetle attacks
- Remove other trees from growing whitebark pine

Go to our website whitebarkfound.org and donate NOW to Whitebark Pine Forever.

Director's Message - Bob Means Memorial Project, National Restoration Plan, & Housekeeping

Diana F. Tomback

This issue of Nutcracker Notes is dedicated to our friend and colleague, Bob Means, who passed away suddenly on May 27, 2015. With Bob's passing, the Bureau of Land Management (BLM) lost a strong and effective voice in support of five-needle white pines, and we at the WPEF lost a committed and supportive member. Bob joined the BLM Wyoming office in 2001 as the Wyoming state forester; and, as he learned about the diversity of communities on BLM lands in his state, he became an advocate for the previously underappreciated but precipitously declining limber and whitebark pine communities.

He had a scholar's interest in the ecology of lower elevation limber pine woodlands (e.g., Means, R. E., 2011, Proceedings of the High Five Symposium, RMRS-P-63, pp.29-36). Bob pointed out that these woodlands were highly under-studied, and he identified a set of important research questions to improve our understanding of their development and dynamics.

Bob was also active in the Colorado-Wyoming Chapter of the Society of American Foresters, and kept the plight of five-needle white pines on their radar screen. More recently, he worked with Dana Perkins and Alexia Cochrane to develop the BLM restoration strategy for whitebark pine, Conservation and Management of Whitebark Pine Ecosystems on Bureau of Land Management Lands in the Western United States, published in August 2016. (See article, this issue, by Dana Perkins, lead author of the strategy).

A number of people generously contributed to the WPEF Bob Means Memorial Fund. Over the last year, we have been working with the BLM to identify an appropriate restoration project to fund in Bob's name. We are pleased to announce that the WPEF is partnering with the BLM to support the Whiskey Basin Daylight Thinning Project for whitebark pine, led by Jim Gates (see article, this issue). Whiskey Basin is on the east slope of the Wind River Range, south of Dubois, WY. This is special country where both lower elevation limber pine and high elevation whitebark pine form extensive communities, but both pines over the last 20 years have experienced major losses from mountain pine beetles and blister rust. This region also represents the southeastern-most limits to the distribution of whitebark pine in the Rocky Mountains. Our thanks to Jim Gates for helping make this project happen.

We will follow the Whiskey Basin Daylight Thinning Project and showcase photos in a future issue. Our sincere thanks to those of you who contributed to this fund and for all involved in making this happen.

National Whitebark Pine Restoration Plan

In the weeks to come, we anticipate an official announcement of some very important news. Last August, the WPEF and American Forests offered a proposal to the U.S. Forest Service leadership to collaboratively develop a "National Restoration Plan" for whitebark pine, working logistically with the U.S. Forest Service but extending the effort across all federal agencies that have whitebark pine on their lands. We have been working out the details of this plan over the last six months. At the end of March, the agreement with the Washington Office was finalized and signed. By the next issue of Nutcracker Notes, we will be deep into the execution of this plan, with more information to share.

Housekeeping

At the end of October, 2017, I step down as Acting Director, and assume my new board role as Outreach and Policy Coordinator. Cyndi Smith, currently Associate Director, has graciously agreed to become Acting Director as we search for a candidate for the Director position. As Outreach and Policy Coordinator, I will be the lead for WPEF's work on the National Restoration Plan.

Please join us September 21-23, 2017, for the annual WPEF Whitebark Pine Science and Management Workshop in Jasper National Park, Alberta, which will be held jointly with WPEF-Canada. This is an opportunity to visit whitebark pine in an extraordinary setting—some of the most stunning mountain landscapes in the world--and to hear about challenges and efforts in the management whitebark pine, which is an endangered species under the Canada Species at Risk Act, in this northern region of whitebark pine's range.

Randy Moody

DIRECTOR'S MESSAGE

www.whitebarkpine.ca

Whitebark pine recovery work continues to move forward in Canada and it seems as though we have some momentum building as the number of players and types of projects has been steadily increasing. Of note are projects to support seedling availability, initiating seed orchards, and improving the current state of whitebark pine mapping in BC.

A constant barrier to widespread recovery related seedling planting has been the availability of seedlings in Canada. Until now, it was always the responsibility of the proponent to collect their own seed and produce their own seedlings for planting work; often resulting in long timelines and an obstacle to groups participating in planting based recovery work. To remedy this situation, the Whitebark Pine Ecosystem Foundation is paying to produce 5,000 + seedlings to be available on a cost recovery basis to interested parties. If the response is positive, it is likely that the foundation will continue with this initiative to increase the availability of seedlings and in-turn increase the number of seedlings planted on the landbase.

In mid-winter, Board Members Michael Murray (BCMFLNRO) and Adrian Leslie led an initiative to collect scion material from parent trees displaying promising levels of rust resistance. This scion material was grafted to root stock at Kalamalka Nursery as the first foray into the development of whitebark pine based seed orchards in Canada. Although the scion material was only from putatively resistant parents (not confirmed resistant); a need to develop scion collection and grafting expertise was identified thus this project was created.

In BC, a need to improve data standards and related mapping products was identified. To resolve this, the province hired a consultant to collate all whitebark pine data ranging from individual tree points to landscape scale polygons. The data set was standardized using the BC Conservation Data Centre's protocols to ensure all data meets provincial standards.

Perhaps the most exciting development regarding work in Canada is the upcoming Annual Science Meeting being held in Jasper National Park in Sept 2017. It is likely that the above-mentioned activities will be presented at the meeting to provide and excellent opportunity to learn more about what is occurring with whitebark pine in Canada.

Election News: What's Happening on the Board of Directors

By Cyndi Smith, Associate Director & Chair of Nominations Committee

The Board of Directors (BOD) continues to work hard on behalf of the Foundation's members and whitebark pine. We hold two in-person board meetings each year, one in conjunction with the annual fall science meeting and field trip, and the other one in the spring in Missoula. In addition, we have added two conference call meetings in between, to keep the momentum going. I think these have been very helpful.

After the fall board meeting in Whitefish, general board member Melissa Early resigned to devote her time to further education on the East Coast. As she intends to move back west, Melissa will continue as a member of the Education and Ski Area Partnership committees.

Meanwhile, Scott Smith was voted onto the BOD as an interim general board member to fill the vacancy. Scott hails from the Portland area, and is a recently retired physician with an interest in ecology and conservation.. Scott is now Chair of the Education Committee and has some great ideas for rejuvenating their work. He is also a member of the Development Committee.

BLM Report continued from front

on whitebark and limber pine distribution, stand structure, and condition.

Whitebark pine hadn't been listed as a candidate species yet, but the petition to list it under the Endangered Species act had been submitted by the Natural Resource Defense Council. With the forward looking leadership of the BLM Washington Office Forestry Program, support from the Idaho, Montana and Wyoming forestry leads, (Mike DeArmond, Robin Boyce and Joe Adamski, Bill Hensley and, Bob Means) and the Oregon BLM sivicluture and tree improvement programs we were fortunate to start an effort to assess our whitebark and limber pine systems and initiate restoration efforts where needed.

From 2010 to 2015, I was the "Five-Needle Pine Coordinator" for Idaho, Montana, and Wyoming BLM. During this period we conducted forest inventories, identified candidate plus-trees, made seed collections, researched verbenone effectiveness to deter mountain pine beetle attacks and conducted thinning treatments. In 2016 we published a BLM Technical Reference, "Conservation and Management of Whitebark Pine Ecosystems on Bureau of Land Management Lands in the Western United States" (CMWP) (Perkins et al. 2016).

https://www.blm.gov/style/medialib/blm/wo/blm_library/tech_refs.Par.97770.File.dat/TR_6711-01.pdf. I hoped the document would encourage further work on not just whitebark, but also limber pine, and provide a road map for BLM resource specialists.

The CMWP is organized in three sections: 1) a review of the ecology of

whitebark pine 2) threats and disturbances and 3) conservation actions-guidelines for planning, implementing, and evaluating conservation activities.

It was adapted and modified from three other important strategies:

- A Range-Wide Restoration Strategy for Whitebark Pine (Pinus albicaulis) (Keane et al. 2012)
- Whitebark Pine Strategy for the Greater Yellowstone Area (Greater Yellowstone Coordinating Committee - Whitebark Pine Subcommittee 2011)
- Whitebark Pine Restoration Strategy for the Pacific Northwest Region 2009–2013 (Aubry et al. 2008).

Whitebark pine on BLM-administered lands occurs primarily in Idaho, Montana, Wyoming, and to a lesser extent in California, Nevada, Oregon, and Washington. Only 1-2% of the species entire range occurs on BLM. This is a small but important portion, because the BLM's whitebark pine populations border the major core areas (usually on USFS and NPS lands), and also exist on isolated, range margins of the species. Populations are often different than those on USFS and NPS lands because they include communities of trees, shrubs and understory vegetation at the lower elevation range of whitebark pine. As geographically distinct mountain islands, they serve as valuable seed sources for distant populations. Individual trees at lower tree line, and at high-elevation sagebrush-whitebark pine ecotones (~8,000–9,000 ft., 2,440–2,750 m) on all federal ownerships may be especially drought resistant, and provide potential sources of genetic diversity in an uncertain and changing climate.

From 2011-2015 we conducted forest inventories (standard stand exams) on 1,800 acres of whitebark pine, mixed whitebark and limber pine, and limber pine stands. Mortality ranged from 15% to 52% from the recent (ca. 2000s) mountain pine beetle epidemic, and blister rust levels ranged from 0% to 43% for stand-level averages. Nearly 50 whitebark pines were identified as candidate plus-trees and cone collections and rust-screenings are ongoing.

Increment cores from random samples on inventory plots show establishment dates reaching back to the 1200s. The isolated individuals and small populations on BLM-administered lands may represent the best-adapted trees for survival in the BLM's characteristically dry and lower-elevation habitats. These trees are important genetic resources for future changing climates and landscapes.

None of our efforts could have happened without the commitment of the BLM and USFS foresters, entomologists, researchers, resource specialists and managers who shuffled priorities and made time for me and my questions.

Aubry, C., Goheen, D., Shoal, R., Ohlson, T., Lorenz, T., Bower, A., Mehmel, C., Sniezko, R.A., 2008. Whitebark pine restoration strategy for the Pacific Northwest 2009-2013. In. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, Portland, OR, p. 212.

Greater Yellowstone Coordinating Committee Whitebark Pine Subcommittee, 2011. Whitebark pine strategy for the Greater Yellowstone Area. In. USDA Forest Service and USDI National Park Service, West Yellowstone, Montana, USA, p. 41.

Keane, R.E., Tomback, D.F., Aubry, C.A., Bower, A.D., Campbell, E.M., Cripps, C.L., Jenkins, M.B., Mahalovich, M.F., Manning, M., McKinney, S.T., Murray, M.P., Perkins, D.L., Reinhart, D.P., Ryan, C., Schoettle, A.W., Smith, C.M., 2012. A range-wide restoration strategy for whitebark pine forests. In. USDA Forest Service Rocky Mountain Research Station, Fort Collins, Colorado, p. 108.

Perkins, D.L., R.E. Means, and A.C. Cochrane. 2016. Conservation and Management of Whitebark Pine Ecosystems on Bureau of Land Management Lands in the Western United States. Technical Reference 6711-1. Bureau of Land Management, Denver, Colorado.

Skeleton by Ben Wilson

Notable Accomplishments in the Montana-Dakotas BLM Region

By Mike Albritton

Foresters and fuels specialists with the Bureau of Land Management (BLM) Montana/Dakotas started working in five needle pine (5NP) management in 2010. This work has been concentrated in four Field Offices: Missoula (MiFO), Dillon (DFO), Butte (BFO), and Lewistown (LFO).

All whitebark pine work has been guided by the BLM's Conservation and Management of Whitebark Pine Ecosystems. Authored by Dana Perkins, Bob Means, and Alexia Cochrane, this technical reference provides national direction on the management and conservation of whitebark pine on BLM lands.

Over the last seven years, notable accomplishments include:

Partnerships

DFO's forester Emily Guiberson is an active member of the Greater Yellowstone Coordinating Committee (GYCC) Whitebark Pine Subcommittee, and currently serves as the Co/Vice chair of the subcommittee.

DFO has partnered with United State Forest Service (USFS) Rocky Mountain Research Station in Missoula, MT to conduct research on competition and treatments in whitebark pine stands. The research area is located at lower elevations near the transitional zone between sagebrush steppe and forest where whitebark pine trees are currently competing with sage brush and Douglas-fir trees. The project will look at different treatment types to remove competition (burn only, cut/mow only, cut/mow/burn) and their applicability to management decisions, as well as the short/long term response from the leave trees once the competition has been removed. Additionally, the entire area will be monitored for natural regeneration to determine what level of disturbance is enough to attract the Clark's Nutcracker to cache seeds within the treatments.

MiFO represents the BLM on the Crown of the Continent High Five Working

Dillon Field Offcie - Windy Pass Planting

Dillon Field Offcie - Windy Pass Planting

Group. This unique organization includes the United States Federal and Canadian land management agencies, states, tribes, local conservation organizations, and private landowners. This group recently developed a charter to promote whitebark pine conservation and is in the process of developing a strategy to maintain whitebark pine on this landscape.

The MiFO has partnered with the Confederated Salish and Kootenai Tribes (CSKT) independent of the Crown of the Continent High Five Working Group, to share resources and information regarding whitebark pine cone collection and propagation. In 2016, through an MOU, MiFO climbers, caged and collected cones from trees identified by CSKT foresters. A seed sharing program has been discussed as a potential future action.

Treatments

In 2012, the Pony Fire burned a whitebark pine stand in the Windy Pass area of the Tobacco Root Mountains with almost 100% mortality. DFO used their seed bank to begin restoration of this stand and while working jointly with the USFS, GYCC, and American Forest Foundation, they planted ~7,500 whitebark pine seedlings over the course of 3 years. A 3rd year survival survey showed a 97% survival rate.

Verbenone application for protection against mountain pine beetle has been done yearly in MiFO and DFO in areas with high value trees.

MiFO is currently implementing a mechanical and prescribed fire project to reduce competing conifers in a mixed conifer whitebark pine stand near Philipsburg, MT.

Monitoring

Last summer the DFO hosted training with the National Park Service (NPS) to instruct BLM foresters in Montana and Wyoming on the current protocol developed by the Greater Yellowstone Whitebark Pine Monitoring Working Group for establishing long term whitebark pine monitoring plots and rapid assessment plots. MiFO installed four long term monitoring plots, and most offices plan on establishing plots during the 2017 field season.

Missoula Field Offcie - Verbenone Application

Climbing/Caging

The BLM currently has eight certified tree climbers, and also uses USFS and NPS crews to cage and collect cones. 11 plus trees have been identified and seed has been submitted to the USFS Coeur D'Alene nursery for genetic testing for white pine blister rust resistance. The Montana BLM currently has over 25 pounds of whitebark pine seed in storage

for future restoration efforts.

This summer the LFO plans to collect cones for resistance testing on West Butte and East Butte in the Sweet Grass Hills if there is a good cone crop.
Inventory:

In 2014, MiFO completed a Field Office wide inventory and mapping project. The inventory turned up areas of both whitebark and limber pine that were previously unrecorded, including one plus tree.

The DFO has inventoried most accessible stands

The LFO has completed whitebark inventory in the Sweet Grass Hills and is in the process of inventorying 5,000 acres along the Rocky Mountain Front. Early results from the Rocky Mountain Front inventory effort reveals mainly limber pine on these BLM lands. Whitebark pine was positively identified in the Sweet Grass Hills.

BFO started inventorying five needle pines last summer. 290 acres were inventoried, and 35 individual whitebark pine trees were found. The BFO is planning to inventory 300 acres this summer in areas that have a higher likelihood of having stands of whitebark pine. During the inventory, BFO found a site near Rogers Pass that has ponderosa, whitebark, lodgepole, and limber pine on it.

BLM foresters and fuels specialists are committed and passionate about the whitebark pine work that is going on in the BLM Montana/Dakotas.

Dillon Field Offcie - Cone Caging

Dillon field Office - Axolotl Lakes WSA Field Inventory

Dillon Field Office - Monitoring Training

Drought tolerance and strong edaphic signals provide a better understanding of whitebark pine's response to climate change

By Mary F. Mahalovich and Mark J. Kimsey

Mahalovich: USDA Forest Service, Northern, Rocky Mountain, Southwestern, and Intermountain Regions, Forestry Sciences Lab, 1221 S. Main St., Moscow, ID 83843-1134, USA, mmahalovich@fs.fed.us , (208) 883-2350.

Kimsey: Intermountain Forest Tree Nutrition Cooperative, University of Idaho, P.O. Box 441133, University of Idaho, Moscow, ID, 83844-1133, USA mkimsey@uidaho.edu .

Substantial strides have been made in identifying blister rust resistant seed sources in the US Northern Rockies. Since 1999, approximately 160,000 seedlings from over 1,100 plus trees have been challenged with blister rust to aid in the selection for rust resistance. Top performing seed sources have been identified for cone collections to meet immediate planting needs.

Over 6,900 acres of rust resistant whitebark pine have been planted across Idaho, Montana and Wyoming; however, genetic gains in rust resistance are only part of our restoration effort.

Whitebark pine also faces an uncertain future with climate change. Temperatures in this region are expected to increase and precipitation is projected to be more variable, with less precipitation available in the form of snowpack (NRAP in press).

Thus, other adaptive traits are necessary to better address whitebark pine's response to climate change. As trees migrate north and upslope, they are expected to experience an adaptational lag in their new environment. An important physiological trait to address this lack-of-fit is cold hardiness, a trait controlled by temperature and photoperiod. A third trait of interest with more direct connections to climate change is drought tolerance. As we select for rust resistance in a non-native pathogen, which incidentally has been shaping whitebark pine for less than two generations, it is critical to understand the genetic relationships and correlated response among these traits.

This note highlights our recent findings of drought tolerance and previously unknown edaphic variation in whitebark pine. It is adapted from an interdisciplinary study characterizing the natural abundance and spatial variation in carbon, nitrogen and sulfur stable

isotopes (Mahalovich et al. 2016). Carbon isotopes are routinely used as a measure of fitness to determine water-use efficiency (O'Leary 1981, Farquhar et al. 1989). Because of the relationships among carbon isotope, carbon isotope discrimination and hydraulic parameters in trees (Marshall and Zhang 1994, Martínez-Vilalta et al. 2004, Marshall et al. 2007), carbon isotope discrimination can be a useful and cost-effective measure of drought tolerance.

Adjusted carbon-isotope discrimination indicates whitebark pine has moderate drought tolerance in contrast to other tree species (Table 1). And among seed zones, the Greater Yellowstone area has the highest level of drought tolerance.

To better match genetic resources to sites projected to support whitebark pine in the future, it is important to similarly identify key drivers contributing to spatial heterogeneity in drought tolerance. Utilizing a backwards-stepwise approach and hybrid regression (Bowen et al., 2009, Bowen 2010), our selected model for drought tolerance includes elevation, Ca-Sedimentary and sedimentary soil parent materials, number of frost-free days, summer mean temperature from June to August, and mean annual precipitation.

Drought tolerance in this portion of the species' range increases from the northwest to southeast (Fig. 1 located on page 26). This broad-scale variation and moderate resolution model further supports whitebark pine as having a generalist adaptive strategy. While we expected a strong edaphic signal for the sulfur isotope, we were surprised to find one for carbon. Only recently have plant studies begun to recognize other elemental source pools beyond atmospheric carbon.

Edaphic variation may also provide a better understanding of current and projected range limits. Present-day whitebark pine is thought to be limited by competition with other conifers at lower elevations and lower temperatures at higher elevations (Keane et al., 2012).

The edaphic signals in our study may provide additional insight into the current species distribution and subsequent limits imposed on species range shifts to the south and east, as whitebark pine is predominantly found on inceptisols, limber pine on endisols and western white pine on andisols. Known edaphic variation has direct implications for management prescriptions involving species selection and seedling deployment strategies.

Climate models have identified future climate space for tree species; however, most have not applied filters for suitable substrate. Site prescriptions exchanging species with compatible climate space but unsuitable substrates may lead to dire consequences (lower survival, poor growth, and inability to fight of insects and disease).

Knowledge of regional patterns in adaptive traits are key to prioritizing areas for monitoring and managing landscapes, particularly when resources are limited. An isoscape of drought tolerance is well-suited as a quantitative measure of adaptive capacity to better inform species distribution models and vulnerability assessments (Nicotra et al., 2015). Spatially explicit maps alone (Fig. 1), or in combination with other maps and filters, are useful tools for identifying refugia, or those areas where species

continued on page 25

Species	**$\Delta^{13}C$ (‰)**
Abies grandis	19.75
Abies lasiocarpa	18.52
Larix occidentalis	20.95
Picea engelmannii	18.15
Pinus albicaulis	18.77[1/]
Pinus contorta	18.94
Pinus monticola	18.58
Pinus ponderosa	18.65
Pseudotsuga menziesii	18.42
Thuja plicata	16.67
Tsuga heterophylla	19.44

1/ Δ13Clipids extracted pine nut tissue = 13.38 (‰).

Table 1. Carbon-isotope discrimination (Δ 13C, parts per thousand [‰]) among trees species in the US Northern Rockies, based on lipid-extracted needle tissue (modified after Marshall and Zhang 1994). Pinus albicaulis tissue type adjusted after Mahalovich et al. (Fig A1, 2016).

Whitebark pine (*Pinus albicaulis*) transcriptome and genetic diversity investigated by a genomics approach

By Jun-Jun Liu and Richard A. Sniezko

Understanding the adaptive genetic variation in a species will give us more information to help manage a species in the face of biotic and abiotic threats. The genomic resources being developed in conifers are offering new tools to help us understand the genetic variation within a species.

In a recent paper published in PLoS ONE (Liu et al. 2016), we reported on the DNA sequencing of the whitebark pine needle transcriptome and application of these sequence data to investigate genetic diversity among whitebark pine populations. Due to current difficulties in sequencing the complete very large genome of pines (up to 30 giga base pairs in five-needle pines), we chose to sequence the protein-coding regions of all expressed genes in needle tissues by mRNA deep sequencing (RNA-seq).

The whitebark pine needle transcriptome showed an enormous complexity and a total of 97.5K protein-coding transcripts were de novo assembled. The reference transcriptome was deposited in GenBank and is available to the public, providing a genomic resource to facilitate future investigations on gene functions and the genotypic variations that may contribute to whitebark pine's adaptive fitness to high elevation habitats.

> The genomic resources being developed in conifers are offering new tools to help us understand the genetic variation within a species.

The potential functions of all proteins documented were explored by bioinformatics analysis. We identified those candidate genes in whitebark pine with putative functions involved in resistance to mountain pine beetle (MPB), white pine blister rust (WPBR)

fungus, *Cronartium ribicola*, or other pathogens.

The whitebark pine transcriptome contained 6.8K and 1.6K transcripts encoding defence-responsive proteins and resistance-homologous proteins, respectively. Since these whitebark pine proteins shared significant similarities to those proteins with verified functions in other plants, they may expected to be DNA targets that could be invaluable for development of genomics-based selection tools.

The number of genes in a conifer genome has not yet been accurately calculated. The number of putative proteins predicted in the whitebark pine transcriptome here probably far exceeded the number of all genes residing in its genome. Multiple protein isoforms were encoded and expressed by the same gene, indicating diversification of gene sequences and functions.

Furthermore, in this work we provided a detailed view on nucleotide variations of the transcriptome. About 100K DNA variant sites were detected in 11 seed families collected in British Columbia (BC), Canada; the majority of them (91% of the total) were single nucleotide polymorphisms (SNPs). Over 22K SNPs were non-synonymous SNPs (ns-SNPs) with distribution in 8K unigenes, averaging close to three amino acid changes per protein. The exciting discovery was that these ns-SNPs may be functional DNA markers because ns-SNPs result in amino acid changes or nonsense mutations in the protein isoforms encoded by the corresponding

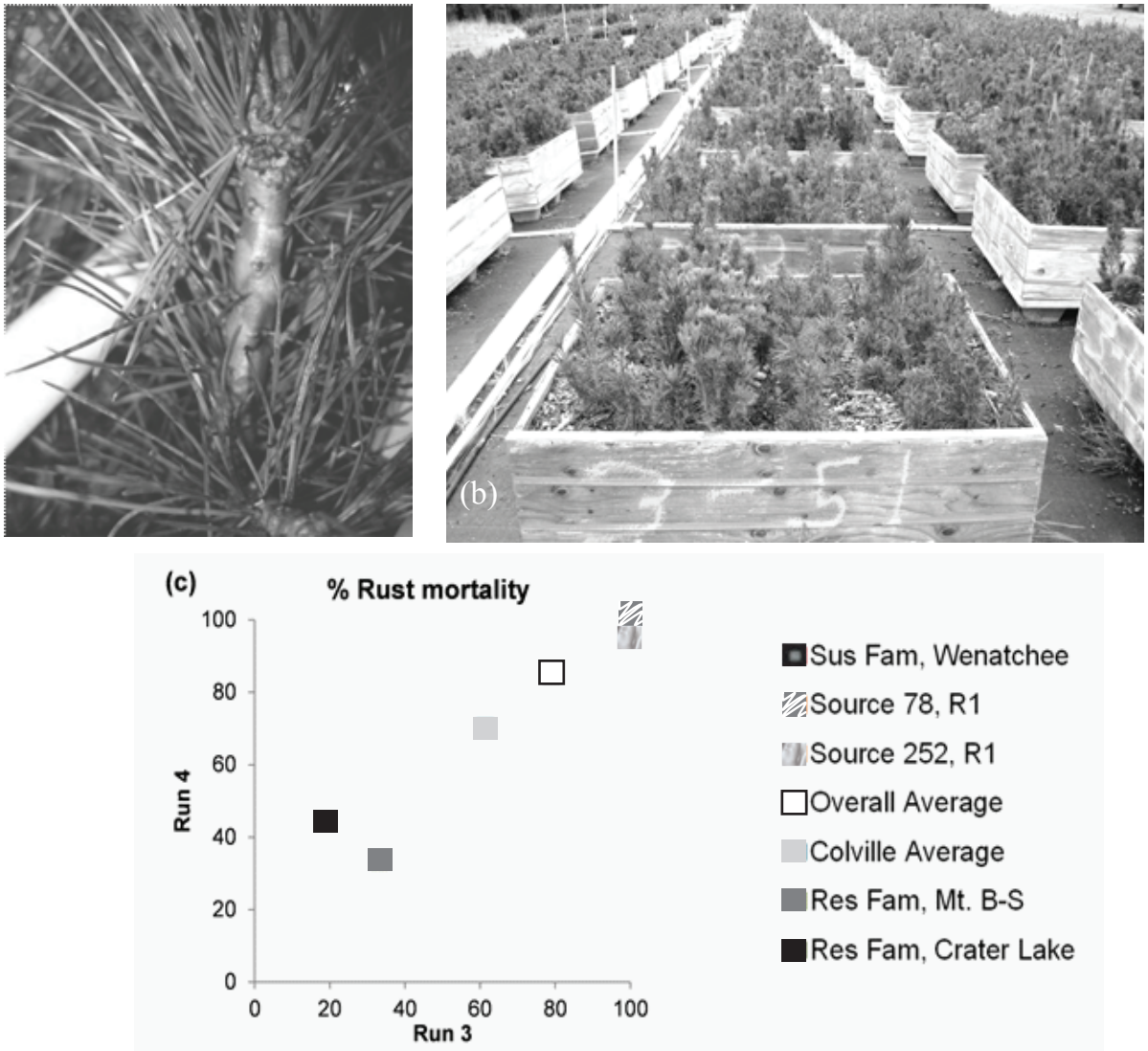


Figure 1. Whitebark pine (a) seedling with many cankers; (b) genetic resistance to white pine blister rust in whitebark pine. In this SY2007 trial, each family is planted in a 10-tree row plot. Large differences in survival 23 month after inoculation are evident; (c) large differences in mortality between some seedlots in the two SY2007 trials at Dorena Genetic Resource Center

genes. This diversity in the protein-coding regions also suggests alleles at each ns-SNP locus need to be genotyped in populations and analyzed by functional genomics studies to determine their roles in host resistance to MPB or WPBR.

We presented a case study in our paper to demonstrate application of these ns-SNP data in population genetics. We selected 216 ns-SNPs, each from one defence-related gene, for SNP genotyping by Sequenom technology. About 54% of selected ns-SNP loci were successfully genotyped, and 71 ns-SNP loci showed minor allele frequency (MAF) larger than 0.05. This result confirmed that the dataset of 22K ns-SNPs detected in transcriptome profiling are a powerful tool for any genome-wide association study in this endangered conifer.

Genomic resources are developing at a rapid pace in forest trees and will provide an invaluable tool in the future to help guide our management of forest resources.

We genotyped 371 seedlings of 124 open-pollinated seed families that originated from Canadian BC regions, and Oregon and Washington, U.S.A. These families encompassed eight seed zones (SZ-1 to SZ-8) in WA and OR, and two seed planning zones (SPZ) in BC, the West Kootenay (WK) and the East Kootenay (EK). The families had been tested for genetic resistance to white pine blister rust at the USDA Forest Service's Dorena Genetic Resource Center (DGRC), Cottage Grove, Oregon (Figure 1).

Based on genotypic data across 71 ns-SNP loci, the mean expected heterozygosity (He) of alleles was highest (0.40±0.02) in BC-EK and lowest (0.26±0.02) in SZ-1 (the Olympic National Forest in WA), with a mean He = 0.35 in western North American, a higher level than that found in an earlier study of the Inland West that utilized isozymatic loci, rather than SNPs.

The percentage of polymorphic loci (P) varied from 73.61% (SZ-1) to 97.22 % (SZ-3) with mean of 93.06 (±1.48) %. These results confirmed that the genetic diversity levels were high within seed zones, but at similar levels across eight seed zones in western North America.

As evaluated by AMOVA, 76% of the total genetic variation was detected within individuals. The remaining 24% of genetic variation was detected among seed families, which sub-partitioned 4% among the seed-(sub) zones and 2% among three sampled regions (BC, WA, and OR). We investigated the potential population structure using the Bayesian clustering approach in STRUCTURE, which revealed nine genetic subgroups (GG-1 to GG-9) in the collected seed families.

Multiple genetic subgroups were detected inside each seed zones except SZ-1 where only GG-2 was present. The most complex genetic compositions, which involved all nine genetic subgroups, were found in SZ-2_E, SZ-4, and SZ-7_3, and these regions may be candidate areas for selection of elite seed families with adaptation to pathogens/pests or other environmental stressors.

Relative to southern WA and OR, the genetic compositions were generally simpler in northern WA and BC regions, where 37% to 54% of samples were assigned to GG-4. The mixtures of genetic subgroups were present within breeding zones as they are currently established.

Resistance screening programs at DGRC identified several heritable traits related to disease resistance to WPBR, including large differences among families in canker-free seedlings and mortality from rust infection (Fig. 1).

We examined the association of genetic subgroups with relative disease severity recorded after WPBR infection. Genetic groups GG-2, GG-4, and GG-8 had the highest level of disease severity, while GG-1 and GG-9 showed the lowest mean level of relative disease severity.

The difference between the groups was significant (t-test $P < 0.05$, or $P < 0.01$). The other four subgroups GG-3, GG-5, GG-6, and GG-7 exhibited medium disease severity levels, not significantly different from the others.

Whitebark pine showed regional patterns for resistance to *Cronartium ribicola* and seed families with high levels of partial resistance were found in DGRC screening program over the past ten years (Figs. 1, 2).

All evidence indicates that there are genetic components affecting host resistance to pathogens/pests as well as the geographical distribution of this species. One main objective of the breeding and conservation program is to maintain high genetic diversity to allow

Figure 2. Large-scale white pine blister rust screening of 100's of whitebark pine families at Dorena Genetic Resource Center.

the species the best opportunity to evolve in the face of future abiotic and biotic challenges and climate change.

The genetic patterns we found for rust-resistant traits indicate that precise genomic selection from wild stands or seed families with predicted traits is probable in the future as the technology and research continue to develop.

Defence-responsive proteins and resistance-homologous proteins accounted for about 10% of the whitebark pine needle proteome. The current study is only a first case study at the beginning stage, and the genotyped SNP loci and seed families were still limited.

A more detailed view of gene variations inside a complete set of target genes will be needed to more fully realize the potential of understanding and mitigating susceptibility to diseases.

Identification of the disease resistance mechanisms at the gene level is complicated. Partial resistance is probably controlled by quantitative trait loci with multiple genes each contributing a small part to the disease resistance, and the molecular networks for plants to counter various stresses are far more divergent than we expected.

The dramatic differences of genetic resistance levels among seed families found at DGRC (Fig. 1) strongly suggests that a comparative genomics study between resistant and susceptible genotypes should help provide a detailed dissection of genetic variations influence diseased canker development.

Related information and knowledge from continuous endeavours is crucial for developing any diagnostic markers or pursuing a molecular breeding strategy.

A next step would be to undertake a genome-wide association study using more seed lots covering the entire geographical distribution of this species. Related information and knowledge from continuous endeavours is crucial for developing any diagnostic markers or pursuing a molecular breeding strategy.

Genomic resources are developing at a rapid pace in forest trees and will provide an invaluable tool in the future to help guide our management of forest resources.

Liu J-J, Sniezko RA, Murray M, Wang N, Chen H, Zamany A, Sturrock RN, Savin D, Kegley A. (2016) Genetic Diversity and Population Structure of Whitebark Pine (Pinus albicaulis Engelm.) in Western North America. PLoS ONE 11(12): e0167986. doi:10.1371/journal.pone.0167986.

The Bob Means Memorial Project – Whiskey Basin Daylight Thinning

By Jim Gates

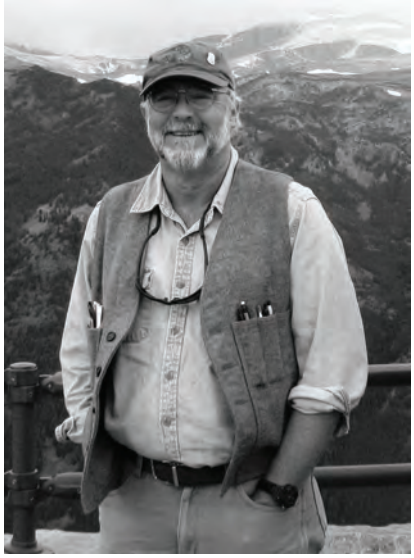
Folks in the whitebark pine community were stunned and saddened by the passing of Robert "Bob" Means on May 26, 2015. Bob started and led BLM Wyoming's whitebark pine conservation program, and was an enthusiastic supporter of five-needle pine conservation nationwide. His family suggested that, in lieu of flowers, donations be sent to the Whitebark Pine Ecosystem Foundation.

These generous donations will make possible a whitebark pine conservation project that will be completed as a memorial to Bob.

The Whitebark Pine Ecosystem Foundation, in coordination with BLM Wyoming and Wyoming Game & Fish Department, plan to use the donations to daylight thin whitebark pine saplings on BLM located in the upper reaches of the Whiskey Basin Wildlife Habitat Area, on the east slope of the Wind River Range, southeast of Dubois, Wyoming.

The project area is a 50 acre mixed conifer stand that regenerated following a wildfire in the 1990's. During summer 2017, Youth Conservation Corps from Utah State University will improve the health and vigor of sapling sized whitebark pine by removing competing subalpine fir and lodgepole pine within 15' of each whitebark pine.

I remember how Bob would often refer to himself as a "dirt forester." He made it a point to get out to the field as often as possible. This is a project that Bob would have liked because he knew making actual change on the ground really matters.



Bob Means

Aborted cones and accuracy in abscission scar counts

By Denyse Dawe, Vern Peters, Emmela Gondwe

Introduction

Compiling seed production histories for five-needle pines assists conservation efforts by identifying highly productive stands from which seeds can be gathered and stored for future restoration projects or genetic testing for white-pine blister rust resistance (Ward et al, 2006). Alternatively, seed production records can provide insight into observed episodes of increased regeneration within a stand's history. Detailed knowledge of seed production may also display reproductive patterns, thereby assisting with estimates of future seed production.

There are various examples in the literature of how these seed production records can be produced. Cone surveys identify cone densities for the current and subsequent year by counting both mature cones and immature conelets. To reveal trends in cone production, stands must be systematically resurveyed, a costly and time-consuming commitment.

Cone abscission scar counting, on the other hand, is a method which can produce between ten to twenty years of a tree's cone production history by using a small sample of healthy branches (Forcella, 1981). Estimates of a tree's cone production are produced by counting the oval shaped scars left after cones abscise from branches. Year of production can be differentiated through identification of terminal bud scars left between each year of growth. The abscission scars are then counted from the tip of the branch, showing the current year's production, back through time (Morgan and Bunting, 1992). An experienced researcher with a good sample of branches can theoretically create an estimate of historical cone production in a relatively short time. This method however is susceptible to error from misaligning years of production (Morgan and Bunting, 1992), damage obscuring abscission scars (Morgan and Bunting, 1992), or scars from cones aborted prior to maturation being included in the count (Redmond et al, 2012). Our objective was to identify whether abscission scars accurately reflect annual cone production and to identify methods that account for aborted cones, thereby improving annual cone production estimates.

Cone production assessment

To assess limber pine cone production in Alberta, undergraduate students at King's University conducted cone surveys within several stands in southern Alberta. Using binoculars, surveyors counted cones from multiple sides of each tree. Cone surveys were conducted in June of 2008 and 2009 to avoid the heaviest period of cone predation that occurs later in summer.

In the fall of 2009, branches were cut from a small subset of the surveyed trees. Within each sampled stand, five representative cone-bearing branches were taken from eight to ten trees. Branches were cut from the uppermost part of the tree and clipped to at least two feet in length so as to have at least a ten year history of abscission scars. Using a method similar to that of Forcella's 1981 study on pinyon pine,

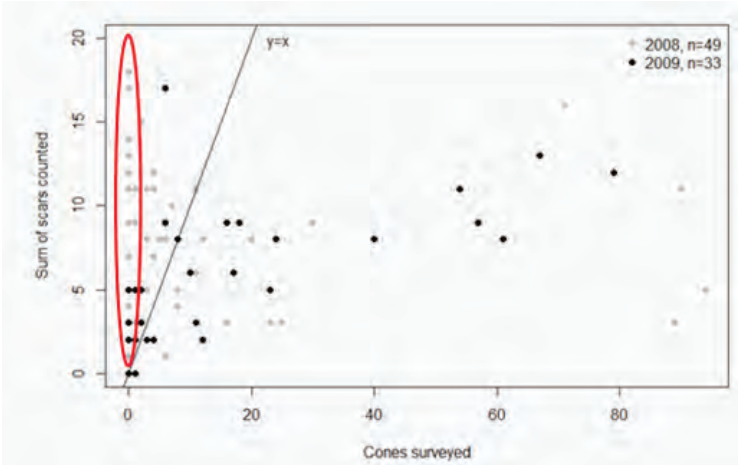


Figure 1: Cones surveyed compared to abscission scar counts for individual trees. A 1:1 line illustrates instances where abscission scars counts are similar to the number of cones surveyed. Circled data shows instances where abscission scars were found but no cones were observed.

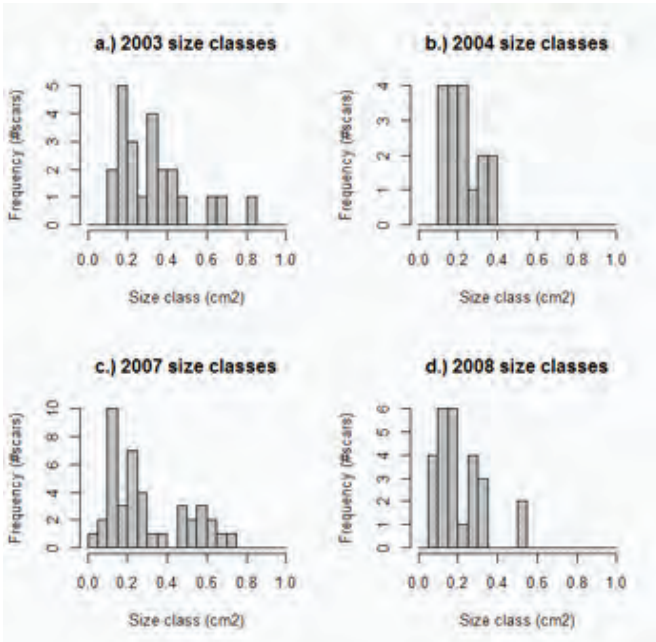


Figure 2: Abscission scar size classes for selected years, n= 15 branches total, from 4 sampled trees.

abscission scars were counted starting with the cone crop that had matured in 2009.

Comparison of cone surveys and scar counts

As a straightforward comparison of these two indices of cone production, we summed the abscission scars counted from the five branches sampled and compared this to the total number of cones that had been surveyed for each tree in the two years surveyed. Forty-nine trees from six sites were compared for 2008; thirty-three trees from four sites were compared for 2009. Although the sample size was small, we would expect abscission scar counts to be higher on average for trees with larger cone counts.

There does appear to be a slight upward trend in the 2009 data that suggests a relationship between higher abscission scar counts and trees in which greater cone production was observed (Fig. 1).

However, in a large proportion of the 2008 data, the number of abscission scars counted for five branches grossly exceeds the total number of cones that were observed for the tree (data to the left of the line, Fig. 1). Several of the largest abscission scar counts were obtained from trees where no cones were seen. Use of abscission scar data in such instances would lead to significant overestimation of cone production. Using our approach, underestimates in cone production are to be expected, as only a subsample of a tree's cone bearing branches are considered.

As mentioned, abscission scar counts are subject to error from inclusion of scars from aborted cones. Cone abortion rates are highly variable from year to year. In spruce, low cone production years have been found to have higher abortion rates (Coates et al, 1994) and in pines, cones abort unless a majority of ovules are pollinated (Owen, 2006). Although neither 2008 nor 2009 were remarkable cone production years (Peters 2012), 2008 may have experienced a far higher abortion rate. This variability in annual abortion rate signals that in order to reconstruct accurate cone production records, an additional step is needed to estimate the number of scars that originate from aborted instead of mature cones.

Aborted cone abscission scar sizes

Although not readily distinguishable, scars left from aborted cones are frequently smaller than those from mature cones (Forcella, 1981). We performed some preliminary research on aborted abscission scar sizes as one potential approach for distinguishing aborted cone scars from mature cone scars. Using a subsample of 15 branches collected from 4 trees in 2009, the length and width of cone scars was measured and multiplied to arrive at cumulative scar size which could be compared across scars.

A bimodal distribution of the data showing a peak between 0.15 0.25 cm2 was seen in some production years (Fig 2.). Only two obviously aborted cones remained attached in our sample and were also found to have abscission scars of less than 0.20 cm2. Our data suggests a threshold of 0.20 cm2 may be used as a conservative estimate for distinguishing an aborted versus a mature cone scar. The biomodality in scar size in Fig. 2 is likely further attributable to: 1) proportionately more

cones aborting in nonmast years (Coates, 1994) causing a skew towards small size classes in 2004 and 2008, and 2) greater pollination success in mast years (2003 and 2007).

The average scar size for each year thus fluctuates widely and may contribute to why the ability to distinguish scars from aborted versus mature cones is lost when plotting the data for all abscission scars over a longer time record (i.e. no bimodality; Fig. 3).

To determine if scar sizes changed significantly over time, we calculated the average abscission scar size per branch for each year and log transformed the values to meet assumptions of normality. A simple linear regression calculated on this data showed a significant increase in scar size with age (p=0.0002, R2=0.10).

This increase may be attributable to scars expanding with radial growth of a branch through time. If an obvious threshold size of abscission scars exists between aborted and mature cones, this data suggests a single value may not be applicable to the older portions of the branch. However, an adjustable correction factor could be obtained with further research.

Data presented here are preliminary and further study must be done to demonstrate the degree of error involved in abscission scar counting and the extent to which removing aborted cones could improve that accuracy.

Additional investigation into an abscission scar threshold size that includes measurements of scars known to have come from aborted cones may yet produce an accurate characterization of abscission scars. Although susceptible to error, the abscission scar method remains an important way to estimate historical cone production in areas where cone surveys have not been conducted.

Literature cited

Coates, D. K., S. Haeussler, S. Lindeburgh, R. Pojar, and A.J. Stock. 1994. Ecology and silviculture of interior spruce in British Columbia. FRDA Report 220. Forestry Canada, British Columbia Ministry of Forests, Victoria, British Columbia,Canada.

Forcella, F. 1981. Estimating pinyon cone production in New Mexico and western Oklahoma. The Journal of Wildlife Management. 45(2):553-557.

Morgan P., and S.C. Bunting. 1992. Using cone scars to estimate past cone crops of whitebark pine. Western Journal of Applied Forestry. 7:71-73.

Peters, V.S. 2012. Limber pine seed mutualisms: between the devil and the deep blue sea. Nutcracker Notes: 22:11–13.

Owens, J. N. 2006. The reproductive biology of lodgepole pine. Britsh Columbia: Forest Genetics Council of British Columbia.

Redmond, M., F. Forcella, and N. Barger. 2012. Declines in pinyon pine cone production associated with regional warming. Ecosphere. 3(12):120.

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

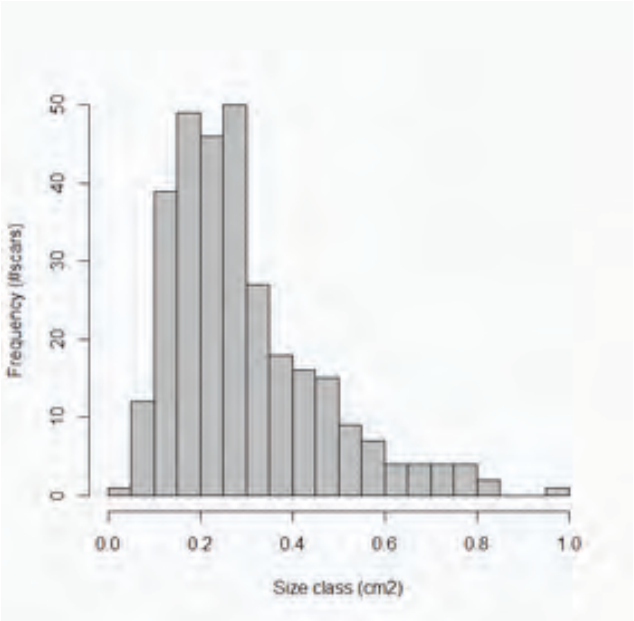


Figure 3: Abscission scar size classes for all years evaluated (1996-2008), n= 308 scars, 15 branches, 4 trees.

STUDENT RESEARCH GRANT

WPEF student research grant awarded for 2017:
Determine the level of hybridization and introgression of the hybrid pine stem rust *Cronartium x flexili* and to assess its level of fitness by Kiah Allen

A call for proposals for the annual WPEF student research grant was released in the Spring/Summer issue of Nutcracker Notes, and online. The proposals were reviewed by board members Bryan Donner and Cyndi Smith, and Nutcracker Notes editor Bob Keane. KIAH ALLEN, a MSc student in the Department of Forestry at University of British Columbia, was chosen as the grant recipient for 2017. Her supervisor is Dr. Richard Hamelin. Following is a description of Kiah's project:

Background and necessity of research

White pine blister rust, caused by *Cronartium ribicola*, was introduced from Europe and Asia in the 19th century and is responsible for one of the most devastating forest disease outbreaks worldwide. This pathogen attacks the stems and branches of five-needle (white) pines and alternates on currants and gooseberries (*Ribes* spp.). Comandra blister rust, caused by *C. comandra*, is a native rust that attacks two-needle pines (e.g., lodgepole and jack pines) and alternates on bastard toadflax (*Comandra spp.*).

The recent discovery of *Cronartium x flexili,* a hybrid between these two rusts, was surprising because they do not share hosts. These two rusts are considered among the most destructive rust pathogens in Canadian forests (Woods et al. 2000 Loo 2009). However, the impact of their hybridization is yet unknown.

Hybrid pathogens are known to jump hosts in unpredictable ways and can be subjected to episodic selection and speciation (Brasier et al. 2003). The hybrid rust has been found on the *C. ribicola* hosts limber pine (*Pinus flexilis*) and whitebark pine (*P. albicaulis*), but it is unknown if it also occurs on lodgepole pine (*P. contort*a) (Joly et al. 2006) or any of the known alternate (telial) hosts. The characteristics of the hybrid rust including occurrence, distribution, survivability, viability and host range are currently unknown (Joly et al. 2006).

Objective

My research objective is to determine the level of hybridization and introgression of the hybrid pine stem rust *Cronartium x flexili* and to assess its level of fitness. To address these aims I will test the hypothesis that *Cronartium x flexili* has an expanded host range compared to its parental species. I will sample and identify hybrid rusts using DNA SNPs profiles and perform inoculations of the hybrid rust spores on the hosts of the respective parent rusts.

Methods

Aeciospores will be collected from white pines, whitebark pines and lodgepole pines from sites where the presence of the hybrid rust is already known to occur, predominantly in British Columbia (Clason et al. 2014), but also the Rocky Mountains of Alberta (Waterton Lakes National Park, Kananaskis Country, Porcupine Hills) (Joly et al. 2006). The expected dates of data collection are from March through September 2017. The samples will be divided in two subsets to perform: 1) analysis of hybridization rate, direction and pattern; and 2) assessment of viability and host range. Half of the samples will be treated for DNA extraction and SNP genotyping using genotyping-by-sequencing.

The data will be used to calculate the rate of hybridization on the two pine hosts and determine if the hybridization is one-way or bi-directional. The second subsample will be used for inoculations and spore germination tests. The germination tests will serve to examine the viability of the hybrid spores. The spore morphology will be analyzed microscopically to identify intermediate spore types of the hybrids as well as parental species (Joly et al. 2006).

Spore germination efficiency will be measured and compared for pure parental species and the hybrids. In order to evaluate the fitness of the hybrid rust, I will measure infection efficiency and spore production, using aeciospores of both pure parental species and of *C. x flexilis* on all known telial hosts of the parental rusts. If aeciospores are viable and infectious onto the telial hosts, an inoculation of telia and basidiospores onto the respective aecial hosts (whitebark pine and lodgepole pine seedlings) will be conducted. The relative fitness of the parental rusts onto their hosts will be compared to the hybrid rust to evaluate its fitness. Expected date of writing completion is December 2018.

Impact and expected outcomes

The severity of the combined effects of *C. ribicola,* mountain pine beetle and

MEMBER NEWS

By Bryan Donner
WPEF Membership Coordinator

This edition of the annual report will begin with the numbers, but will then focus on the demographics of our wonderful members. At the time of this writing, our total membership is at 171, which is about where we have been at this time of year for the past three years. This plateau has been after a steady increase in the membership over the life of the Foundation.

I truly appreciate the positive feedback from folks after the recent dues increase. In fact, the $100 Nutcracker category increased in numbers substantially over last year to 42. Members from Canada also increased over the past year to a total of 37.

Where do the members of the Foundation come from? Pretty much all over. Twenty-four U.S. states and Canadian provinces/territories make up the home bases of our members. The state/province that leads the way is Montana with a staggering 55 members. The next closest entities are 19 from British Columbia, 16 from both Washington and Alberta, 15 from Oregon, and 14 from Idaho. To no one's surprise, the city with the most members is Missoula, with 21. In a distant second at 6 is Edmonton.

What lengths will people go to be members of the WPEF? The member whose listed address is the farthest from the range of whitebark pine hails from Hawaii at 2550 miles.

A tight competition on the mainland for second place put Springfield, VA in at 1678 miles. Following were Ithaca, NY at 1641 miles; Kingston, ON at 1612 miles; and Greensboro, NC at 1610. (For you analytical types, the distance for Hawaii was measured from the southern Sierra Mountains with the east coast cities measured from two different points in northwest Wyoming.) All readers of this article will agree it is strange there are no members from Maine.

Who are our members? We do not have complete information regarding the professional affiliations for our members, but for those who reported, the U.S. Federal Government is by far the largest component at 52%. Of those U.S. Federal members, 78% are affiliated with the USDA Forest Service.

People working or studying at colleges and universities make up 19% of the membership reporting an affiliation. Of course I need to include a pitch for recruiting new members.

Please do not be shy about asking your colleagues, associates, and even your relatives to join the WPEF! The Foundation's web site at

continued on page 22

Student Research continued

climate change have caused whitebark pine to be listed as endangered under the federal Species at Risk Act (SARA) (Clason et al. 2014). Findings from this study will determine the if the hybrid rust C. x flexilis is viable and has a modified host range or epidemiological behavior. Improving our understanding of hybridization between a native and non-native tree rust, such as C. x flexilis will help to address disease outbreaks in terms of conservation and to inform forest stewards of better disease management strategies.

References

Brasier, C.M., J. Delcan, D.E. Cooke, J.U. Thomas, and W.A. Man in't Veld. 2004. Phytophthora alni sp. nov. and its variants: designation of emerging heteroploid hybrid pathogens spreading on Alnus trees. Mycological Research 108(10):1172-84.

Clason A., S.E. Macdonald, and S.E. Haeussler. 2014. Forest response to cumulative disturbance and stress: two decades of change in whitebark pine ecosystems of west-central British Columbia. Ecoscience 21(2):174-185.

Joly, D.L., D.W. Langor, and R.C. Hamelin. 2006. Molecular and morphological evidence for interspecific hybridization between Cronartium ribicola and C. comandrae on Pinus flexilis in southwestern Alberta. Plant Disease 90(12):1552.

Loo, J.A. 2009. Ecological impacts of non-indigenous invasive fungi as forest pathogens. Biological Invasions 11(1):81-96.

Woods, A.J., A. Nussbaum, and B. Golding. 2000. Predicted impacts of hard pine stem rusts on lodgepole pine dominated stands in central British Columbia. Canadian Journal of Forest Research 30(3):476-81.

Whitebark Pine Ecosystem Foundation 2017 Science and Management Meeting Jasper National Park

Submitted by the Conference Planning Committee

The Whitebark Pine Ecosystem Foundation's Science and Management Meeting is coming to Jasper National Park this September. Don't miss out!

Fall is one of the best times to see wildlife in Jasper. The elk will be bugling among the golden-yellow aspen and the whitebark pine cones will be ready to collect. The park is also home to caribou, moose, mountain goat, bighorn sheep, wolverine, grizzly bear, and wolves.

Join us in the town of Jasper in the heart of the national park for our science meeting and field trips on September 21st and 22nd, 2017 and celebrate Canada's 150th Birthday.

"Some mountain towns base their appeal on trying to be trendy. Jasper retains its timeless appeal by being unpretentious — an intimate community that originated as a railway town that just happens to be in the middle of some of the most gorgeous protected wilderness in the world".

Jasper, Venture Beyond
http://www.jasper.travel/

We are planning two field trips. The first will be a hike in a whitebark pine stand in the world-famous Angel Glacier / Cavell Meadows area in Jasper. We will stop at the Astoria trailhead for a 1.5 km (round-trip) hike into a mature whitebark pine stand.

This trail has very little elevation change and the hike will be easy. Our final destination will be a 1 to 1.5 km return hike on the easy Path of the Glacier Trail where a whitebark pine demonstration planting will be in progress, and the views are spectacular.

The second trip will visit a road-side limber pine fire site in northern Banff National Park. Outreach and education activities, planting, cone collection, prescribed fire will be key topics during the field trips.

Reminder to Reserve Accommodations in April!
Find important instructions about booking rooms BEFORE the end of April at the US and Canadian WPEF websites. Note that the meeting venue has been moved down the street to the Sawridge Inn and Conference Center in the town of Jasper (http://www.sawridge.com/our-hotels/jasper/). Stay tuned: conference registration will be available online in the near future.
http://www.whitebarkpine.ca/jasper-2017.html
http://whitebarkfound.org/annual-meetings/this-years--conference/2017-wpef-conference-accomodations/

Call for Silent Auction Items
The annual tradition continues! The Silent Auction will be held September 21st at the science meeting and during the cocktail party that follows.

Please consider donating an item in support of student research grants. For more information contact Joanne Vinnedge (joanne.vinnedge@gov.bc.ca) or Laura DeNitto (myfunnyfarm4@msn.com).

Call for Speakers
We will hear from a variety of speakers who have expertise in high elevation five-needle pines. Expect the latest research and operational findings!

If you'd like to give a presentation, please contact Jodie.Krakowski@gov.ab.ca or Michael.Murray@gov.bc.ca.

"Some mountain towns base their appeal on trying to be trendy. Jasper retains its timeless appeal by being unpretentious — an intimate community that originated as a railway town that just happens to be in the middle of some of the most gorgeous protected wilderness in the world".

Jasper, Venture Beyond
http://www.jasper.travel/

An Interview with Board Member Mike Giesey

1.Who are you and what are your interests?

I'm a recently retired forester and I'm really enjoying having time to do what I want. I'm married to my wonderful wife, Michelle.

I enjoy biking, skiing, fixing things, working in the woods, barbequing, exploring new places, camping, and working with and helping people.
I volunteer for a number of non-profit organizations in my community. I enjoy spending time with friends and appreciate a tasty IPA.

2.What piqued your interest in whitebark pine?

My interest in whitebark pine started with my work as a tree climber and silviculturist with the US Forest Service. I've had the opportunity to visit just about all 75 whitebark pine plus trees on the Kootenai NF and climbed many of them to collect cones, scion and pollen. Visiting stands of whitebark pine and witnessing the mortality from mountain pine beetle and whitepine blister rust that has occurred in the last 20 years or so is very alarming. I cannot help but be interested in working towards assuring this important tree survives present and future threats.

3.Why did you decide to be a board member?

The Whitebark Pine Ecosystem Foundation was created by, and is currently lead by "rock-stars" of the ecology world. The mission and goals of the foundation are appropriate for the challenges facing whitebark pine and all high-elevation 5-needle pines.

Additionally, I wanted to fill a void in my professional life since retiring. I'm honored to be a part of this excellent organization!

4.What is a book and movie that changed your life?

I can't think of any of these that changed my life!! However, I must admit I'm not much of a movie goer or a novel reader – more drawn to technical and instructional publications.

5.Pick one from the following pairs and feel free to elaborate: Dogs or cats? Football or baseball? Ranching or farming? Pickup or compact? Fiction or nonfiction? Introvert or extrovert? Beer or wine? And finally, whitebark pine or subalpine fir?

Hmmm. Lots of reasons for any of these choices – good and bad - except for the last one – obviously whitebark pine! So

I'll stir up some readers by choosing cats over dogs only because if you leave the house for an extended time, cats can make do on their own with no supervision needed (just an automatic feeder and big water dish). OK – for clarification, this is just for good cats…I'd take a dog over a bad cat, and now that I think of it most cats are bad…except mine!

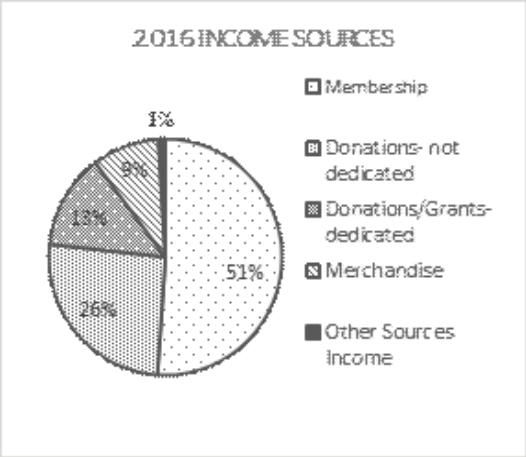
Member Report continued from page 20

www.whitebarkfound.org has a complete discussion of the different membership levels and includes forms for initial membership and renewal. Joining or renewing by using PayPal at the web site is a quick and convenient way to maintain your membership.
Questions, comments, or suggestions can be directed to me at (406) 296-7145 or bryan.donner@whitebarkfound.org. Please put "WPEF" in the subject line of your e-mail.

This is my last membership report before handing over these rewarding tasks to Michael Murray. It has been a tremendous pleasure and honor to work with and get to know you all over the past 16 years. We didn't always, in fact rarely, meet our membership objectives, but I feel we've made good progress over the years. I wish the Foundation luck in its endeavors in the coming years and will see you all at the annual meetings!

2016 Treasurer's Report

The 2016 year ended bright for WPEF with great strides in some of our highest priorities. The many hands that accomplish this work include Julee Shamhart, executive assistant, JoAnn Grant, contractor for the website and editor duties, and countless volunteer hours by board members and members-at-large for which we are very grateful.



Where our money comes from:

- Membership dues
- Member donations
- Contributions from organizations who support our cause
- WPEF merchandise sales
- Community fundraisers (e.g. pint nights)
- Silent auction donations at the annual meeting
- Donations at the annual meeting

Where our money has gone:

• Support the superb science-management symposium and membership meeting in Whitefish

• Certify the Whitefish Mtn. Ski Area as a whitebark pine friendly ski area

• Award the student research grant to examine the impact of climate change impacts in high elevation ecosystems through tree ring studies in the Beartooth Mountains

• Renewed formal partnership with the Forest Service for maintaining the restoration project website "One Project at a Time"

• Publish two editions of Nutcracker Notes

• Maintain the ever evolving WPEF website for education and member services

• Participate in community and research programs that help to conserve, restore and educate the public and government agencies about the plight of WBP ecosystems

• Pave the way for award of program funds for restoration projects and develop a partnership for develop a range wide 5-needle pine strategy for 2017 and beyond

Our 2016 yearend balance was $33,111 of which 32% ($10,892) is reserved for restoration activities as per the donor's request, and the balance ($22,219) for unspecified operating and program work. Review the table on the following page for details.

Expenses exceeded income this past year by $14,853; largely reflective of funding a part-time executive assistant for a full year, which was the first year we committed to this position. Her contribution has increased the Foundation's work capacity, which compliments the many volunteer hours continually dedicated.

In 2017, we are challenged to increase our income to fully cover the duties of the executive assistant and continue the work we are devoted to do.

Please direct budget questions to interim treasurer, Glenda Scott, glenda.scott@whitebarkfound.org, or any board member.

2015 yearend balance	**$ 47,964**
2016 yearend balance	**$ 33,111**
Dedicated to Restoration	$ 10,892
Unrestricted Funds	$ 22,219

INCOME	
Memberships	**$ 11,786**
Donations	**$ 5,432**
Individual Donations	$ 1,482
Annual meeting registration and refreshment donations	$ 2,855
Silent Auction	$ 1,095
Donations for restoration	**$ 2,998**
WBP Forever Donations	$ 498
Grant award - AKC Fund, Inc.	$ 2,500
Fundraisers	**$ 478**
Pint nite- Dancing Caddis/Wildlife Brewing, Victor ID	$ 478
Merchandise Sales	**$ 2,154**
Other	**$ 218**
TOTAL INCOME 2016	**$ 23,066**
EXPENSES	
Operating	**$ 19,088**
Operating supplies/subscriptions	$ 995
Postage-Mailing	$ 637
Professional Fees	$ 600
Bank Fees	$ 52
Director Travel	$ 3,851
Exec Asst Wages	$ 10,054
Taxes	$ 2,871
Exec Asst Travel	$ 28
Education/Outreach	**$ 6,458**
Nutcracker Notes	$ 3,470
Annual Meeting	$ 1,759
WPEF Website	$ 1,150
Exec Asst Wages	$ 63
Taxes	$ 16
Grant Writing	**$ 4,537**
Exec Asst Wages	$ 3,626
Taxes	$ 911
Merchandise	**$ 5,201**
Merchandise Purchase	$ 1,462
Exec Asst Wages	$ 3,002
Taxes	$ 737
Student Research Grant	**$ 1,000**
Ski Area Certification	**$ 1,492**
Supplies/design	$ 367
Travel	$ 300
Exec Asst Wages	$ 651
Taxes	$ 174
WBP Project Website	**$ 143**
Exec Asst Wages	$ 100
Taxes	$ 43
TOTAL EXPENSES 2016	**$ 37,919**

continued from page 10

retract when faced with environmental change. Intraspecific variation in drought tolerance, blister rust resistance and cold hardiness similarly provides an opportunity to select individuals better suited for optimal survival, vigor and cone production, while safeguarding a critical wildlife food.

We hope readers have gained an appreciation that we're more than just the 'plus tree' project or 'rust screening program'. One very unique aspect of our stable isotope study was the use of pine nuts rather than needle tissue to address our interdisciplinary objectives. Readers are encouraged to read the full manuscript to see how unique nitrogen and sulfur isotope signatures can be used as dietary markers to determine if a bear is consuming pine nuts.

Literature Cited

Bowen, G.J., West, J.B., Vaughn, B.H., Dawson, T.E., Ehleringer, J.R., Fogel, M.L., Hobson,K., Hoogewerfl, J., Kendall, C., Lai, C-T, Miller, C.C., Noone, D., Schwarcz, H., Still, C.J., 2009. Isoscapes to address large-scale earth science challenges. EOS, Transactions American Geophysical Union 90(13), 109-116.

Bowen, G.J., 2010. Statistical and geostatistical mapping of precipitation water isotope ratios. J.B. West, G.J. Bowen, T.E. Dawson, K.P. Tu (eds.). Isoscapes: Understanding Movement, Pattern, and Process on Earth Through Isotope Mapping, Springer Science+Business Media B.V., p. 139-160.

Farquhar, G.D., Ehleringer, J.R., Hubick, K.T., 1989. Carbon isotope discrimination and photosynthesis. Annual Review Plant Physiology 40, 503-537.

Keane, R.E., Tomback, D.F., Aubry, C.A., Bower, A.D., Campbell, E.M., Cripps, C.L., Jenkins, M.B., Mahalovich, M.F., Manning, M., McKinney, S.T., Murray, M.P., Perkins, D.L., Reinhart, D.P., Ryan, C., Schoettle, A.W., Smith, C.M., 2012. A range-wide restoration strategy for whitebark pine (Pinus albicaulis). Gen. Tech. Rep. RMRS-GTR-279. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 108 p.

Mahalovich, M. F., Kimsey, M. J., Fortin-Noreus, J. K., & Robbins, C. T. 2016. Isotopic heterogeneity in whitebark pine (Pinus albicaulis Engelm.) nuts across geographic, edaphic and climatic gradients in the Northern Rockies (USA). Forest Ecology and Management, 359, 174-189.

Marshall, J.D., Zhang, J., 1994. Carbon isotope discrimination and water-use efficiency in native plants of the north-central Rockies. Ecology, 75(7), 1887-1895.

Marshall, J.D., Brooks, J.R., Lajtha, K., 2007. Sources of variation in the stable isotopic composition of plants, 2nd ed. In: Stable isotopes in ecology and environmental science, K. Lajtha and R.H. Michener [eds.]. Blackwell Publishing, Malden, MA p. 22-60.

Martínez-Vilalta, J., Sala, A., Piñol, J., 2004. The hydraulic architecture of Pinaceae–a review. Plant Ecology 171(1-2), 3-13.

Northern Rockies Adaptation Partnership (NRAP). Climate change vulnerability and adaptation in the Northern Rocky Mountains. In press. Halofsky, J.E.; Peterson, D.L.; Dante-Wood, S.K.; Hoang, L.; Ho, J.J.; Joyce, L.A [eds]. Gen. Tech. Rep. RMRS-GTR-xxx. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Nicotra, A. B., Beever, E. A., Robertson, A. L., Hofmann, G. E., O'Leary, J., 2015. Assessing the components of adaptive capacity to improve conservation and management efforts under global change. Conservation Biology, Article first published online: 29 APR 2015.

O'Leary, M.H., 1981. Carbon isotope fractionation in plants. Phytochemistry 20(4), 553-567.

see Figure 1 on next page

Figure 1 from Mahalovich article

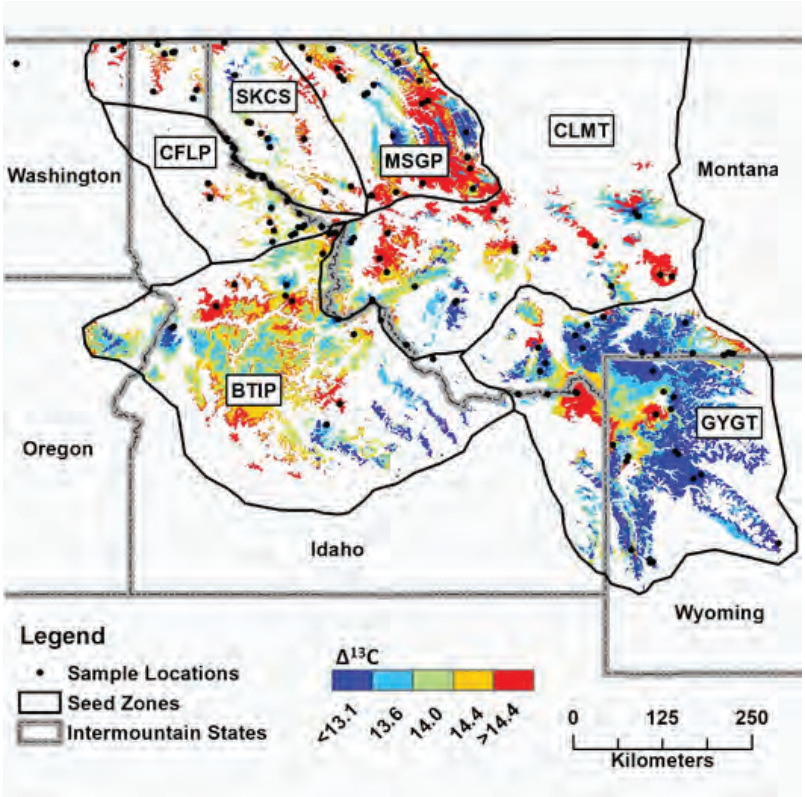


Figure 1. Increasing drought tolerance in whitebark pine nut tissue from the northwest to southeast, represented by carbon isotope discrimination (parts per thousand [‰]) (Δ13Clipid-extracted = 17.38 - .001*(Elevation) - 1.01*(Ca-Sedimentary) - 0.80*(Sedimentary) - 0.22*(summer mean temperature from June to August) + 0.01*(Number of frost-free days) - 0.001*(mean annual precipitation), R2=0.31, p < 0.01). Mapped seed zones include the Bitterroots-Idaho Plateau (BTIP), Central Montana (CLMT), Greater Yellowstone-Grand Teton (GYGT), Clark Fork-Lolo Pass (CFLP), Missions-Glacier Park (MSGP), and Selkirk-Cabinet (SKCS).

PO Box 17943
Missoula, MT 59808
www.whitebarkfound.org

WHITEBARK PINE
ECOSYSTEM FOUNDATION

WHITEBARK PINE FOREVER

Campaign to keep whitebark trees on the landscape

Donate now to our tree planting fundraising effort.

$5 to plant one tree
$1,200 to plant one acre
$6,000 to plant five acres
$12,000 to plant 10 acres

This year the Whitebark Pine Ecosystem Foundation continues our efforts to maintain whitebark pine trees on the landscape by planting blister rust-resistant seedlings, which can cost over $4 per seedling. Your contribution to this effort is very important. The more rust-resistant trees we plant, the longer we can assure whitebark pine will remain a viable species within its range.

DONATE NOW **- Visit the website www.whitebarkfound.org and donate to the restoration fund to plant an acre of rust resistant seedlings.**