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nutcracker notes

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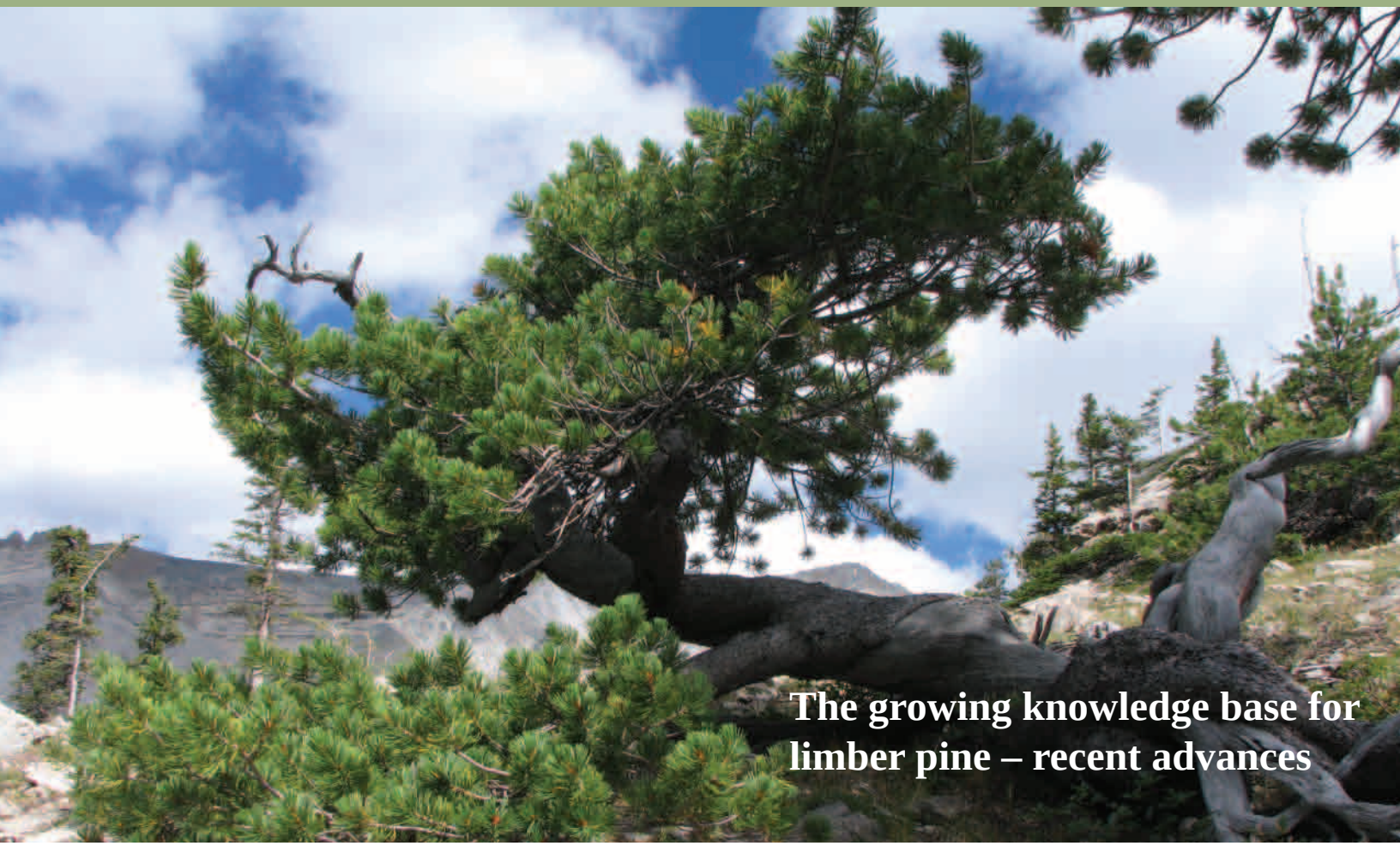

The growing knowledge base for limber pine – recent advances

By Anna W. Schoettle
USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO

Progress is being made to build the science foundation for effective limber pine management. The power of repeated monitoring assessments now provides valuable condition trends for limber pine (Smith et al. 2013, Cleaver et al. 2015). In Canada, the proportion of dead limber pine increased from 2003-2004 and 2009 and WPBR infection increased from 33% to 43% putting some populations at risk for extirpation (Smith et al. 2013). In northern Colorado, Wyoming, and southeastern Montana 73% of the stands have been invaded by white pine blister rust (WPBR) with an average disease incidence of 26%; in re-measured plots that is an increase in incidence of 6% over 8–9 years (Cleaver et al. 2015). WPBR has not yet been found on limber pine in California or Oregon although other white pines are infected in those states; Utah is WPBR-free on the pines yet *C.*

LIMBER 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

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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 - A LAST REPORT

Diana F. Tomback

Our work to preserve whitebark pine is based on deep appreciation for this one particular tree that we call a keystone and foundation species. The meaning transcends whitebark pine ecology: the tree is symbolic of the interconnections among all organisms, including us.

This is likely my last message as Director of the Whitebark Pine Ecosystem Foundation. But I agreed to assume the position of Acting Director for up to 12 months as the Board of Directors searches for a Director who can fully advocate, without conflict of interest, for whitebark pine. I also transition to the new position of Policy and Outreach Coordinator in the WPEF, which allows me to be the liaison with various external constituencies, including NGOs and federal and other government partners. As a reminder, all positions on our Board of Directors are voluntary and not paid.

I was elected by the board as the founding director of the Whitebark Pine Ecosystem Foundation in 2001. When the WPEF board completed by-laws about ten years ago, term limits were instituted. Since then, I have served the maximum allowable three terms, each term three years in length.

Over the years, I have had the satisfaction in seeing a number of individuals and groups, government agencies and non-profit organizations, take up the cause for whitebark pine conservation and restoration. During the last 16 years, the WPEF membership has grown to represent all states and provinces across the range of whitebark pine, and we have a sister organization WPEF-Canada, with like-minded dedicated individuals. I have seen increasing commitment among agency employees—US Forest Service, National Park Service, and Bureau of Land Management—as they come to value whitebark pine through their experiences in resource management and fieldwork. Many of these folks literally go the extra mile to locate plus trees, place verbenone patches, and advocate for, plan, and implement restoration projects.

My 16 years as Director has truly been a labor of love but also a reflection of the urgency I feel as populations of whitebark pine rapidly decline in many parts of its range.

My 16 years as Director has truly been a labor of love but also a reflection of the urgency I feel as populations of whitebark pine rapidly decline in many parts of its range. This past July, this was abruptly hit home. I had returned with my doctoral student (and former WPEF intern) Libby Pansing to core a sample of trees within a long-term study area Divide Mountain (AKA Triple Divide Peak) near the western boundary of the Blackfeet Reservation, which is shared with the eastern boundary of Glacier National Park, MT. This iconic mountain, spiritually significant to the Blackfeet, is known geographically as a hydrological apex, where water flowing down three different slope aspects (west, northeast, and south) journeys to the Pacific, Arctic, and Atlantic oceans. Libby and I had not visited Divide Mountain in three years, and we were stunned to see the increase in blister rust. Ninety percent of the whitebark pine trees we cored that day, which were selected by random points, had blister rust, many with stem cankers. In September, I came back with John Gilham, forester with the Blackfeet Reservation, to show him the extent of infection, and we are now discussing a more detailed survey and future restoration plan.

During my tenure, and thanks to our dedicated and inspired board members, the WPEF has made steady progress with respect to advocating for whitebark pine, raising awareness of its on-going decline, and communicating science and best practices. The list of our accomplishments is posted on the WPEF website at http://whitebarkfound.org/?page_id=1672. Our most recent accomplishment was

TOMBACK continued on page 31

Randy Moody

DIRECTOR'S MESSAGE

Whitebark Pine Ecosystem Foundation Of Canada

www.whitebarkpine.ca

In 2016, whitebark pine recovery progress in Canada has made some great leaps largely due to continued actions of Foundation members and direct work from the foundation itself. This work essentially encompasses all scales from seedling to ecosystem to policy and partnerships.

At the seedling level, the good news here is that more quality seedlings than ever are being produced, by an array of nurseries and by an increased number of clients. I recently stopped in at the Skimikin Nursery near Salmon Arm to inspect my own seedlings, only to observe seedlings being produced for 3 other clients as well, including BC Timber Sales. If BC Timber sales is beginning to plant whitebark pine, this is likely to resolve many regulatory obstacles and pave the way for other forestry companies to include whitebark pine planting in their silviculture plans.

From an ecosystem perspective, it appears more and more individuals and companies are considering whitebark pine management from the ecosystem scale and its role in the management of other species.

At the fall meeting in Whitefish, Canfor representatives were present and they are looking for ways to manage whitebark pine ecosystems by improving guidelines for reserve areas, retention, and silviculture; a much more wholistic view of whitebark pine management.

Further to the ecosystem scale, I had the good fortune of spending time with a hunting guide in the Chilcotin Region of BC, he saw whitebark pine as not only an important ecosystem for Grizzly Bear but also for Mule Deer. He felt that the open forests offered the right level of forage and cover, which may be lost with successional replacement.

We must continue working to ensure this level of work is applied across the Canadian range and for a sustained duration to guarantee species recovery.

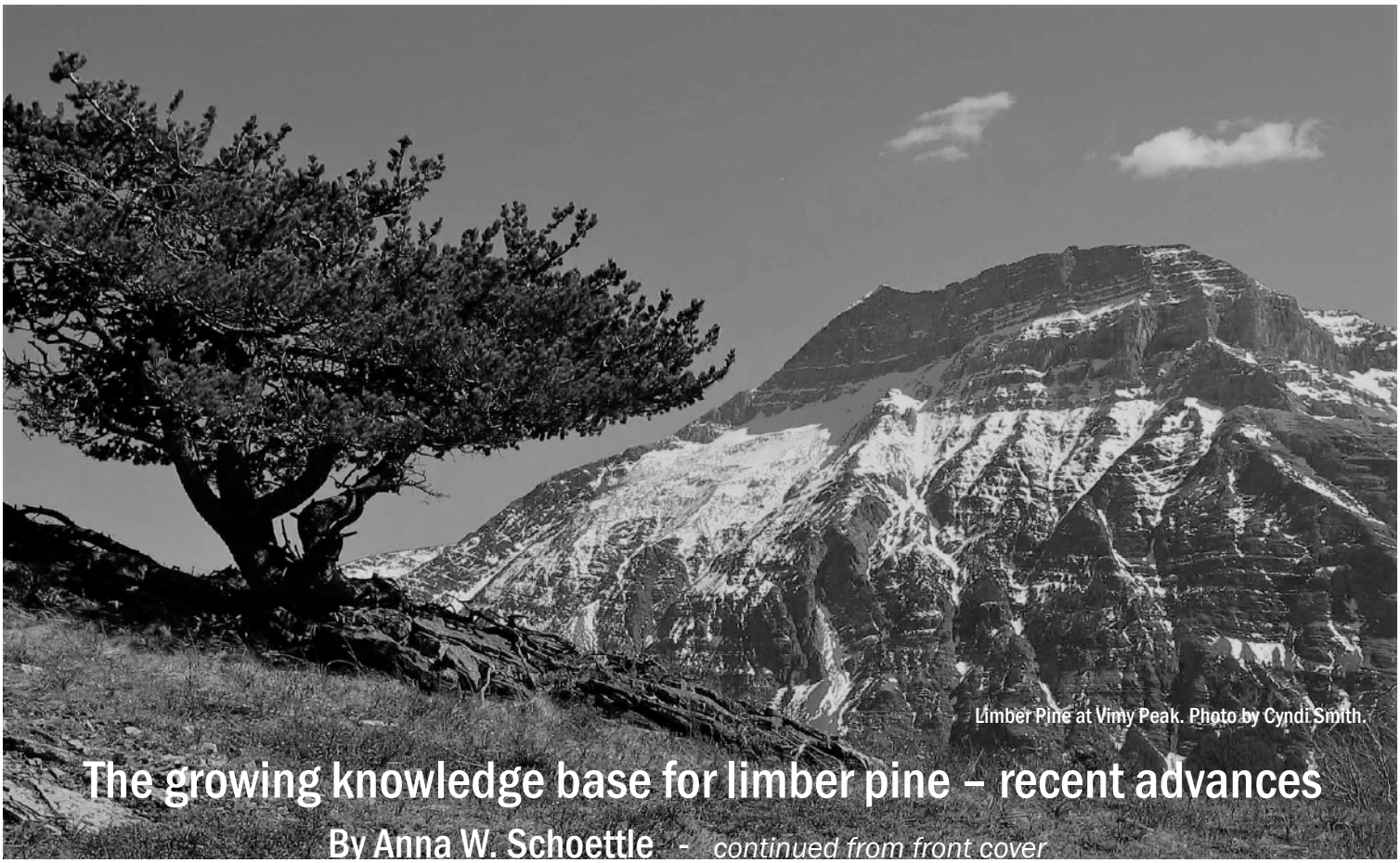
In fact, he had an expression that for a good mule deer hunt you need: "shaley soils, whitebark pine, and blue skies." Perhaps this is an attribute we need to consider when trying to convince authorities of the importance of whitebark pine forests.

At the policy level, the BC Government at last seems to be working on developing policy regarding species at risk as they have embarked on a public campaign to get public engagement on how to best manage species at risk. Feedback needs to be in by November 30th, so please participate if possible.

Partnerships. Several good partnerships have been developed in 2016 with both the Crown Managers Partnership and American Forests. The CMP has resulted in many Canadian members stepping up to play active committee roles. If you are interested in further involvement, check their website at crownmanagers.org.

This was our first year partnering with American Forests, they supported a planting project near Lillooet, which resulted in 2,250 seedlings planted with 25 volunteers in attendance; this was a phenomenal turnout as the town of Lillooet is only about 2,000 people. It is hoped that we can continue this relationship with American Forests and initiate even larger events in the future.

Now, the above work deals with a few hives of activity, but we must continue working to ensure this level of work is applied across the Canadian range and for a sustained duration to guarantee species recovery. Hopefully by the Jasper meeting in 2017 we can report on even more successes.



Limber Pine at Vimy Peak. Photo by Cyndi Smith.

The growing knowledge base for limber pine – recent advances

By Anna W. Schoettle - *continued from front cover*

C. ribicola has been identified on *Ribes* within the state (Vogler et al. 2016). Mountain pine beetle has caused high mortality on 75% of limber pine plots during the recent epidemic in the US Rocky Mountains (Cleaver et al. 2015). In less than 15 years, limber pine is expected to experience a 40% reduction in basal area in the US and mortality of close to two-thirds of the mature limber pine is expected over the next 100 years in Canada. Limber pine is a species of conservation and management concern in some areas of the US, is listed as endangered in Alberta, and it is being considered for national listing as such under the Species at Risk Act nationally in Canada.

There is some good news for limber pine – earlier reports of the presence of genetic resistance to WPBR in limber pine with bulk seed lots have been confirmed to be family traits, and inferred to be hereditary, using artificial inoculation testing at Dorena Genetic Resource Center (OR). Limber pine is the fourth white pine species to have a major gene (called "Cr4" in limber pine) conferring complete (or qualitative) resistance to WPBR (Schoettle et al 2014).

Confirmed:
Limber pine is fourth white pine to have major gene conferring complete resistance to WP blister rust.

Proactive resistance screening of seedling families, each from individual tree seed collections from limber pine stands not yet invaded by WPBR in the southern Rockies, reveal unusually high frequencies of complete resistance of up to 30% in some populations in northern Colorado (Schoettle et al 2014; Schoettle, Sniezko, et al. in prep).

Testing limber pine sources from outside of the southern Rockies revealed one family from Alberta (5 families tested) with a similar complete resistance trait (Sniezko et al 2016), yet complete resistance has not been detected in British Columbia (5 families tested), Oregon (3 families tested), and Montana (30 families tested) (Sniezko et al 2016; Schoettle, Sniezko, et al. in prep;).

A range-wide study to estimate the occurrence and frequency of complete resistance and growth trait variation in limber pine is underway (Schoettle, Sniezko, Burns et al., in progress), made possible by funding from the Western Wildland Environmental Threat Assessment Center (WWETAC) and the donation of seed collections from Alberta, BLM, NPS, and USFS. Seedling families from NM, CO, WY, MT, ID, UT, NV, CA, and AB are

Figure 1. Overview of the Alberta limber pine planting site for the International Limber Pine Provenance Study (ILPPS) initiated this fall (2016). A planted limber pine seedling is shown in the insert.
Photo credits: Jodie Krakowski.

included. Limited testing for quantitative resistance (also known as partial resistance) suggests its presence at low frequency in limber pine; more trials are underway. The Southern Rockies Rust Resistance Trial (SRRRT) outside of Laramie, WY and a planting at the USFS Region 5 Happy Camp facility (CA) are ongoing to verify resistance expression in limber pine under field conditions and exposure to different rust genotypes.

A genetic marker for the Cr4 resistance allele is under development to accelerate detection of resistant trees (Liu et al 2016). A marker will enable assessment of trees of all ages, unlike the current progeny test methodology that restricts inference of resistance status only to seed-bearing trees; this capability will be especially important for the continued timely estimation of the frequency of this resistance in populations heavily impacted by MPB with few remaining mature trees.

Current research suggests that each of the four Cr resistance alleles appear unique to their respective five-needle pine species (e.g. sugar, western white, southwestern white, and limber pine), and mapping the Cr alleles can further assess their uniqueness and provide insights into functional genes associated or closely linked with the resistance alleles (Liu et al. 2016).

A genetic marker for the Cr4 resistance allele is under development to accelerate detection of resistant trees.

The high frequency of complete resistance in limber pine in the Southern Rockies and the health status of these ecosystems at the WPBR infection front warranted the development of the conservation strategy for the Greater Rocky Mountain National Park area (target area includes northern Colorado and southern Wyoming) (Schoettle et al., in press).

In situ and ex situ conservation, increasing the population size and frequency of durable WPBR resistance early in the invasion, managing the existing resistance, and monitoring the pines and rust is emphasized.

Characterization of the sensitivity of limber pine to climate factors is critical for appropriate pairing of plant material to locations for proactive and restoration plantings, especially in a changing climate. Sustained moisture stress is increasing and contributing to increased mortality of limber pine along the Colorado Front Range, Great Basin, and southwest. These patterns are in the absence of WPBR yet there is also evidence that selection for resistance to WPBR may have lasting impacts to growth, stress tolerances, and competitive performance, even for those limber pine trees with resistance that survive WPBR infection (Vogan and Schoettle 2014 and 2016). The interactions of pathogen exposure, genetic diversity, and planting environment will be further complicated by a changing climate and other escalating stressors.

International Provenance Study

The International Limber Pine Provenance Study (ILPPS), installed this fall (2016), will provide further assessment of population differentiation and plasticity throughout the Rocky Mountains (Schoettle, Angert, et al, in process). This study is a collaboration of the USDA Forest Service, University of British Columbia, Colorado State Forest Service, Alberta Ministry of Agriculture and Forestry, Colorado State University, and others.

Common garden plantings of limber pine seed sources were established in two contrasting environments, one near the northernmost (central Alberta) and the other near the southernmost (Colorado) species range extent in the Rocky Mountains, to assess adaptive trait variation, plasticity, and climate interactions (Figure 1).
The study includes 143 limber pine seedling families from seed trees from 32 sources throughout the US-Canadian Rocky Mountains.

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WPEF

SAVE THE DATE: SEP 21-22, 2017
2017 Whitebark Pine Ecosystem Foundation Science & Management Conference

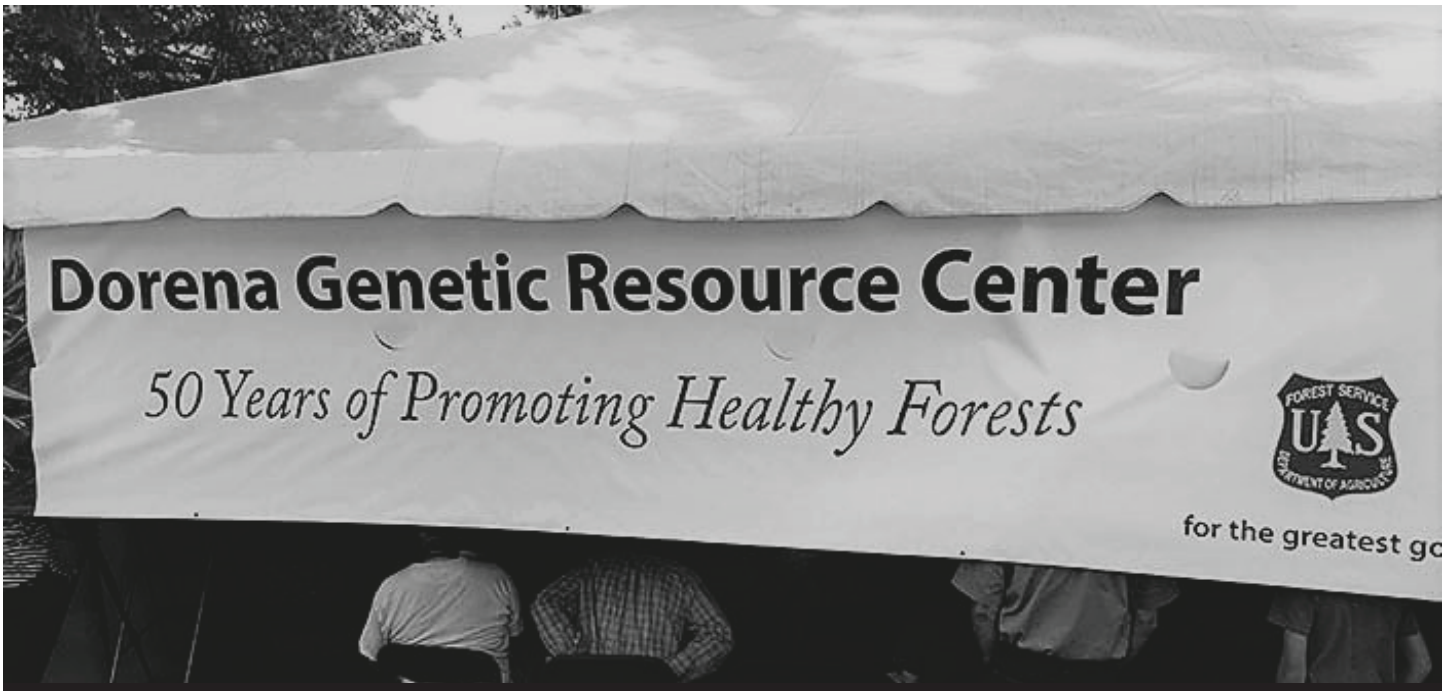
By Brenda Shepherd, *2017 Science Conference Committee*

Do you want to learn directly from the leaders in the field about what works for five needle pine restoration? Want to share your whitebark and limber pine discoveries and create the connections that help get great projects off the ground?

Come to the WPEF 2017 Science and Management Conference in Jasper National Park on September 21st and 22nd and celebrate Canada's 150th Birthday in one of our most breathtaking places. A committee of folks including Jodie Krakowski, Michael Murray, Brad Jones, Randy Moody and Rob Sissons are organizing a great event. The indoor presentations on Thursday will be held in the town of Jasper at the heart of the national park. A fun whitebark-pine themed gathering on Saturday night is in the works. There will be a field trip on Friday to the spectacular Mount Edith Cavell hiking area and whitebark stand.

The trip will focus on field-based techniques for stand assessment, tips on identifying rust resistant candidate trees and outreach/education demonstrations. You can also make history that day by helping to plant the first batch of putatively rust resistant whitebark pine seedlings in the park! For those returning through Banff and Calgary on Saturday, fire specialists will host a field trip to a Limber Pine stand along the Icefields Parkway in northern Banff National Park where they will discuss and demonstrate Parks Canada's fire management practices that support 5-needle pine recovery and visit an example of recent mechanical cuttings to reduce stand-level competition.

Keep checking to the WPEF website for accommodation links and conference updates starting in December. ***We hope to see you there!***



U.S. Forest Service's Dorena Genetic Resource Center Celebrates 50th Anniversary

By Richard A. Sniezko , Dorena Genetic Resource Center

On August 25, 2016, the U.S. Forest Service's Dorena Genetic Resource Center (DGRC) (Cottage Grove, Oregon) hosted a celebration to commemorate its 50 years as a regional service center for Pacific Northwest forest genetics.

The celebration was attended by over 110 people from a wide array of agencies and partnerships. The event acknowledged the USFS employees and cooperators that have forged successes in genetic resistance breeding, conservation education, and many other successful associated programs. The event also highlighted the vision for future work to promote forest health on all forested lands including urban forests.

The Center was established in 1966 as the headquarters for the regional White Pine Blister Rust Resistance Program

'Save the Trees, Save the Forests' was a subtheme that reflects the contribution the U.S. Forest Service's programs, including those at Dorena are making to keep several of our species as viable components of forest ecosystems.

The Center was established in 1966 as the headquarters for the regional White Pine Blister Rust Resistance Program where specialists worked to develop trees with resistance to white pine blister rust. At that time, the name was the Dorena Project and Jerry Barnes was project manager. In 1975, the name was changed to Dorena Tree Improvement Center to better reflect the program's work.

In January 2003, the name of the center was changed to the Dorena Genetic Resource Center, reflecting the center's enlarged focus on forest health.

DGRC houses disease-resistance breeding programs for 5-needled pines and Port-Orford-cedar (POC), a native plant development nursery program for restoration, and is the center for training and coordination of the National tree climbing program.

It is also part of the USFS regional genetic resources group and is involved in genetic variation studies, genetic conservation, and documenting impacts of a changing climate. The center is a regional unit, administered by the Umpqua National Forest, and located on BLM land.

The DGRC program is known

internationally as a world leader in development of populations of trees with genetic resistance to non-native diseases, and DGRC specialists are working with several western regions, Hawaii, Canada and Mexico on developing genetic resistance to various pathogens.

Currently, all eight species of white pines native to the western U.S. are in various stages of evaluation at DGRC for genetic resistance to blister rust. Once evaluations are completed, and seed is available from the resistant parents, restoration or reforestation efforts begin (Figure 1).

Summaries of some projects are available at http://www.fs.fed.us/psw/publications/documents/psw_gtr240/.

The 50th year celebration included a series of short-talks by USFS leaders from Washington DC, the Region 6 Regional Office and DGRC staff, as well as several cooperators (BLM, National Park Service, and Western Federal Lands Highway Administration) (Fig. 2).

Dr. Diana Tomback (Whitebark Pine Ecosystem Foundation) presented an overview on the high elevation white pine species and noted the important role DGRC plays with these species.

Currently, all eight species of white pines native to the western U.S. are in various stages of evaluation at DGRC for genetic resistance to blister rust.

A special guest and speaker at the event was Jerry Barnes, the first manager at DGRC when it was established in 1966 (Fig. 2). After a fantastic 'free' lunch, there were tours that featured the projects at DGRC and perhaps the world's largest inoculation 'fog' chamber (Figure 3).

There was also a demonstration of drone (UAV) and affiliated camera technology that is being prototyped for potential mass phenotyping of trees in the future.

DGRC works closely with both USFS Forest Health Protection and National Forest System groups. Partners and cooperators include federal, state, and tribal organizations, in the western U.S. and Canada, as well as universities, and private landowners and managers. The interagency cooperative work with BLM has been ongoing for 50 years!

The 50th celebration was a notable success. A blog on the event was posted by Mike Cloughesy, Director of Forestry, Oregon Forest Resources Institute at http://oregonforests.org/blog/fifty-years-breeding-disease-resistant-trees.

Figure 1. From resistance testing at DGRC to restoration planting in less than five years for whitebark pine, a vital species component in the high elevation ecosystems. (a) top ranked parent trees are identified in seedling inoculation trials (note the large differences in survival in the 10-tree family row plots in this example), and (b) seedling progeny from the top ranked parent trees at Crater Lake National Park was used for a restoration planting in this 2009 planting, which also serves as a genetic trial (Photos: R.Sniezko).

Figure 2. Gary Man (USFS Washington DC) and Jerry Barnes presenting talks at the DGRC 50th celebration. Richard Sniezko presenting Jerry Barnes an 'award' honoring his service in DGRC's early years

Photos: M.Oppliger & R.Sniezko

Celebrating 50 years at Dorena Genetic Resource Center

Figure 3. A tree climbing demonstration (left) featured one of the programs, while visitors to DGRC had a chance to get lost in the inoculation 'fog' chamber used for blister rust resistance testing (see top middle; and http://www.opb.org/television/programs/ofg/segment/crater-lake-dying-forest/ for some features of the blister rust inoculation program and the inoculation chamber 'in action'). An employee peruses a poster that provides some details of the early days of DGRC (right), another discusses pollen management (bottom left); and the crowd mingles in the area that talks were given (bottom middle).

Photos: M. Oppliger and R.Sniezko

Spatial prioritization of whitebark pine management under a changing climate

Authors: Kathryn Ireland, Andrew Hansen, Robert Keane, Kristen Legg, Robert Gump

Whitebark pine (*Pinus albicaulis*) faces many threats to its continued persistence. Within the past two decades, whitebark pine has declined due to recent mountain pine beetle (*Dendroctonus ponderosae*) outbreaks, spread of the invasive white pine blister rust disease, and fire exclusion policies that lead to increased competition with other conifer tree species (Keane et al. 2012). In addition, climate change is expected to decrease the area of future suitable habitat for whitebark pine in many ecosystems(Chang et al. 2014).

The Greater Yellowstone Ecosystem (GYE) includes 53% of the distribution of whitebark pine in the U.S. Whitebark stands in the region have been hit particularly hard, with over 82% of stands experiencing high mortality since 2000 (Macfarlane et al. 2010). Because of the ecosystem services it provides, loss of whitebark pine will have serious consequences for the functioning of large, intact landscapes.

In light of these threats, the Greater Yellowstone Coordinating Committee (GYCC), a federal interagency committee, has worked since 1999 to develop a strategy to protect and restore whitebark pine.

The Greater Yellowstone Ecosystem includes 53% of the distribution of whitebark pine in the U.S.

However, little information on climate change impacts were available at the time they were developing their strategy. Recognizing this, the GYCC wrote into their plan the need to incorporate climate science and adapt their management as information became available.

We worked with the GYCC Whitebark Pine Subcommittee to develop a strategy for managing whitebark pine in the face of climate change. In recent years, various climate adaptation frameworks have been developed to help adapt management to climate change.

However, one difficulty of implementation is often determining exactly where on the ground management options might be most effective. Our goal was to map the locations where specific treatments might be most effective in maintaining whitebark pine populations into the

Table 1. Differences in the percentage of area where management activities would be permitted between the climate-informed and current management strategy were driven by land allocation constraints in the current management strategy. Reported percents are the percentage of the total land area of whitebark pine's distribution as mapped by the Greater Yellowstone Coordinating Committee's Whitebark Pine Subcommittee.

		Percent of Land Allocation Class Treated			
Land Allocation Class	Strategy	Planting	Thinning	Protection	Fire Planning
Multiple use forest	Climate-informed	20.7	0.7	29.5%	14.7%
	Current	26.5	31.1	31.1%	31.2%
NPS; non-wilderness	Climate-informed	0.0	0.1	1.3%	0.4%
	Current	0.1	0.1	0.1%	0.1%
Wilderness	Climate-informed	38.8	43.7	51.9%	25.9%
	Current	0.1	0.2	0.2%	66.8%
Non-federal	Climate-informed	1.5	1.4	10.9%	6.0%
	Current	0.0	0.0	0.0%	0.0%
Total WBP Climate suitable habitat:	Climate-informed	61.0	57.5	93.6%	47.0%
	Current	26.7	31.4	31.4%	98.2%

future. We also compared the area that would be treated under this "climate-informed" management strategy with the area that would treated under a strategy more representative of current management practices.

Methods

We mapped "zones" for the climate-informed and a current management strategy where different suites of management tools would be available.

We used available, spatial predictions of climatic impacts on whitebark pine and the threats to whitebark pine to map where treatments could be expected to be most effective under future climate change.

These tools include: planting blister-rust resistant whitebark pine seedlings, thinning to remove competing conifer species, wildland fire use planning to protect cone-bearing whitebark pine trees, and use of pesticides and pheromones to protect whitebark pine trees from mountain pine beetle attack.

Climate-informed Strategy

We used available, spatial predictions of climatic impacts on whitebark pine and the threats to whitebark pine to map where treatments could be expected to be most effective under future climate change.

Ideally, we would include predictions of future climate impacts on whitebark pine itself, its competitors, mountain pine beetles, blister rust, and fire.

However, mapped predictions of the impacts of climate change on mountain pine beetles, white pine blister rust, or fire severity are either unavailable at this time or do not cover the full distribution of whitebark pine in the GYE.

So, we based our prioritization of whitebark pine management on projections of the direct climate impacts on whitebark pine (Chang et al. 2014) and indirect effects through climate's effects on competing tree species (Piekielek et al. 2015). As spatial information on climate change impacts to the other threats to whitebark pine populations becomes available, it could be incorporated into our approach to improve prioritization of where to place treatments.

First, we used the historical and future projections of climate suitability for whitebark pine to map zones of core, deteriorating, and future whitebark pine habitat. Core zones were those areas that are currently suitable for whitebark and remain suitable in the future.

In these areas, the broad management goal is to maintain current populations

and promote regeneration and dispersal into new habitats. In the deteriorating zone, where the climatic conditions for whitebark pine are expected to decline, management is focused on trying to maintain populations for as long as possible to serve as future seed source.

As locations become newly suitable in future zones, encouraging establishment of new population through dispersal or more active management might be the management goal.

In general, a larger percentage of whitebark pine's current and potential future distribution is treated under the climate-informed strategy than in the current strategy

We then overlaid our climate zones for whitebark pine with similar projections of future climate suitability for all of whitebark pine's competitors. We discussed the different combinations of climate suitability zones (core, deteriorating, future) and potential future level of competition (low or high) from other species with the GYCC Whitebark Pine Subcommittee to determine which management activities should be prioritized within each management zone. The result is a map of management zones where different activities are prioritized to meet the goal of maintaining whitebark pine populations. This map became the manager's "toolbox" from which to select more specific treatments based on stand-level conditions.

Current Strategy

For the current strategy, we relied on differences in land allocation classes to determine where treatments would occur. The types of treatments that can be implemented in the current strategy are constrained by access, logistics, and management constraints among different jurisdictions.

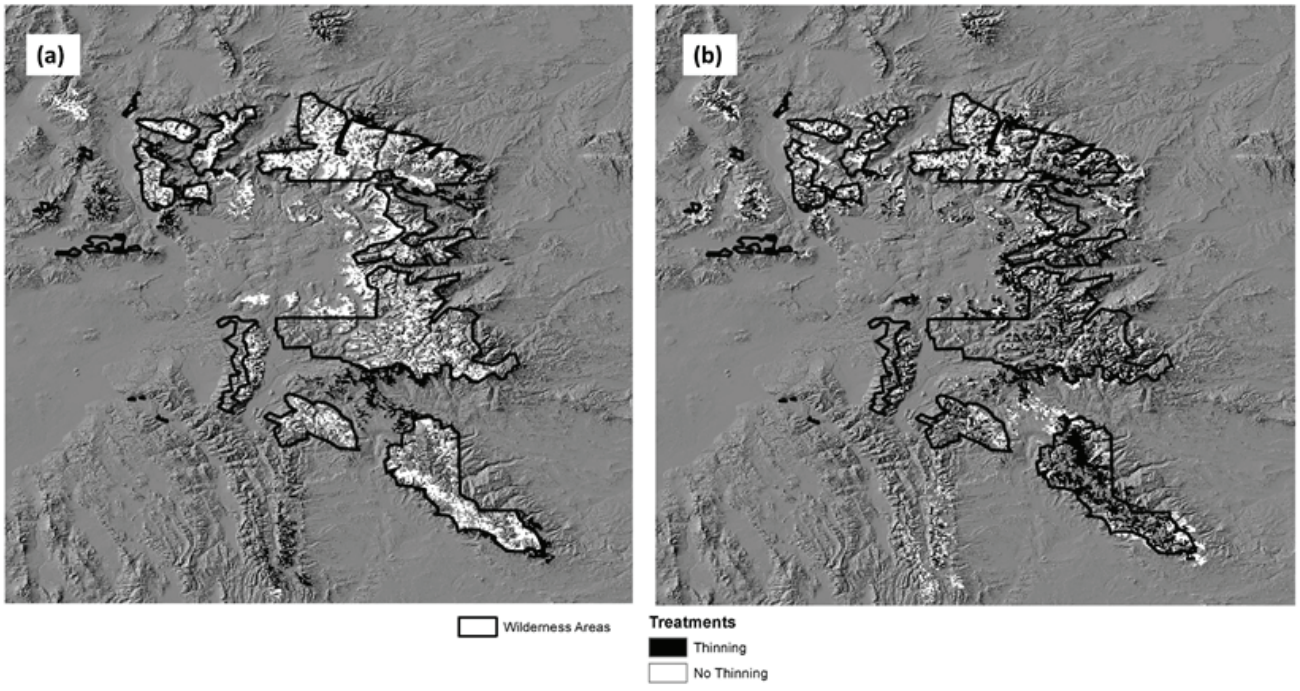
For example, all management activities might be available on general lands administered by the US Forest Service or BLM and within 1-2 miles of accessible roads or trails.

Conversely, options are far more limited on federally designated Wilderness lands, where wildland fire use is the only management activity likely to be implemented. Based on our conversations with the GYCC Whitebark Pine Subcommittee, we mapped the management tools which would be available within the different land allocation class.

Results and Discussion

In general, a larger percentage of whitebark pine's current and potential future distribution is treated under the climate-informed strategy than in the

Figure 1. Spatial prioritization of competition removal thinning under (a) the current strategy and (b) the climate-informed management strategy.



current strategy (Table 1).

Planting, thinning, and beetle protection treatments all occur across a larger proportion of whitebark pine's distribution in the climate-informed strategy. Fire use planning, which includes both prescribed fire and managed wildfire, is included in more areas under the current strategy.

The disparities in land area treated are largely due to differences in the activities permitted among land allocations. The majority (68%) of whitebark pine's current distribution in the GYE occurs in federally designated or proposed wilderness areas, where management options are limited (Hansen et al. 2016) and where, under our mapping criteria, only fire use planning was included as a management tool.

Only 8% of whitebark pine's current distribution is located in multiple use forests and near roads or trails, where the most treatments are available under the current strategy (Hansen et al. 2016).

Our hope is to help our federal partners place their restoration efforts in the settings where they will be most effective for maintaining whitebark pine across the GYE under future climates.

The differences in the two strategies may be illustrated through a look at the spatial distribution of thinning treatments (Table 1, Figure 1). Much more land area (57% of whitebark pine's distribution) would be treated in the climate-informed strategy than under the current strategy (31%). While the majority of thinning treatments in the current strategy would occur on multiple use forest, very little would occur there under the climate-informed strategy.

Under the climate-informed strategy, much more thinning would occur on Wilderness lands because that is where most of the climate suitable habitat for whitebark pine is projected to remain at the end of the century.

The pronounced differences between the two management strategies indicate the need to consider how management constraints, especially in Wilderness, may impact our ability to maintain whitebark pine populations into the future. The species distribution models upon which our prioritization of management activities have several limitations, however.

Disturbances, diseases, pests, and the ability of whitebark pine to adapt to climate change are not accounted for in these methods. Competition is only considered here through the use of additional species distribution models for competitor species. Our next step is to evaluate the effectiveness of these management strategies using a simulation model that incorporates competition, mountain pine beetles, white pine blister rust, fire, and the physiological response of whitebark pine to climatic conditions.

Our hope is to help our federal partners place their restoration efforts in the settings where they will be most effective for maintaining whitebark pine across the GYE under future climates.

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WPEF

Clark's nutcracker breeding season space use and foraging behavior in the Greater Yellowstone Ecosystem

Taza D. Schaming, tds55@cornell.edu, Department of Natural Resources, Cornell Lab of Ornithology, Cornell University *See [1] for full paper.

For effective conservation of both Clark's nutcrackers (Nucifraga columbiana) and whitebark pine (Pinus albicaulis), it is important to ensure stability of Clark's nutcracker populations. In particular, the habitat selected during all important life stages should be considered when designing management plans.

In this study, my objectives were to examine Clark's nutcracker breeding season home range size, habitat selection, territoriality, and foraging behavior. I radio-tracked Clark's nutcrackers in the southern Greater Yellowstone Ecosystem, a region where whitebark pine is declining in 2011, when population-wide nonbreeding followed a low whitebark pine cone crop, and in 2012, when breeding followed a high cone crop [2].

In both years, Clark's nutcrackers selected Douglas-fir (Pseudotsuga menziesii) habitat more than expected compared to availability for their breeding season home ranges. Previous research recorded Clark's nutcracker use of Douglas-fir habitat, but this is the first study documenting selection [3,4].

On the contrary, Clark's nutcrackers only selected whitebark pine habitat in proportion to, or less than expected, compared to availability. Similarly, previous research documented infrequent use of whitebark pine habitats during the breeding season [See 5]. However, the fact that the birds adjusted their use of whitebark pine habitat between years suggests that in some springs, they may use whitebark pine habitat more than expected.

Clark's nutcrackers also consistently foraged on newly extracted Douglas-fir seeds each spring, but foraged on cached seeds less than anticipated based on the literature [3,6,7].

I suggest that the importance of cached seeds during the breeding season may be overestimated, or may be highly variable between regions.

To my knowledge, whitebark pine

restoration strategies primarily focus on whitebark pine forests. I suggest that instead of managing whitebark pine in isolation, it is important to consider alternative habitats which Clark's nutcrackers use throughout the year.

Maintaining resident populations is particularly important because resident Clark's nutcrackers may be more likely to disperse seeds further from the harvest trees [8]. To maintain a year-round resident population of Clark's nutcrackers in the Greater Yellowstone Ecosystem, I suggest whitebark pine restoration efforts should be located adjacent to Douglas-fir habitat.

By extrapolation, management efforts may consider prioritizing restoration of whitebark pine stands near alternative seed sources in other regions. Though the results of this study may be more representative of Clark's nutcracker behavior in degraded whitebark pine habitat, the importance of alternative seed sources, such as Douglas-fir, may be particularly critical in these degraded habitats.

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Introducing the Crown of the Continent High Five Working Group

By Regan Nelson, Crown Conservation Initiative

Thanks to the commitment, leadership and passion of dozens of individuals, a new Crown of the Continent High Five Working Group (Hi5 Working Group) was formally launched in September of 2016.

The mission of the Hi5 Working Group is to protect and restore functional whitebark and limber pine ecosystems by fostering transboundary collaboration and coordination to transfer sound scientific knowledge, leverage funding opportunities and optimize restoration efforts within the Crown of the Continent Ecosystem.

The Crown of the Continent Ecosystem is one of North America's most ecologically intact - yet jurisdictionally fragmented - landscapes. Whitebark and limber pine suitable habitat can be found across many of the Crown's diverse jurisdictions, and it will take a collective and coordinated effort to restore these species across the Crown landscape.

Recent studies have shown that the Crown of the Continent is the epi-center of the blister rust infection of whitebark and limber pine in the Rocky Mountains: blister rust infection levels are at ~80% for both species, and infection levels increased twice as fast in limber versus whitebark over the last decade (Smith et al. 2008, Smith et al. 2013).

Recognizing that the pace and scale of restoration of five needle pine species needed to be vastly accelerated, numerous agency, tribes and First Nations, industry, community and conservation interests met at the Crown Managers Partnership Annual Forum in March of 2016 to discuss how to work together to address the precipitous decline of five-needle pines in the Crown. (The details of that meeting were detailed in the Spring 2016 edition of Nutcracker Notes and can also be found in a comprehensive workshop report available at http://crownmanagers.org/2016-forum/).

As a top priority, participants agreed to form a multi-stakeholder collaborative group that would advance a collective effort across jurisdictions to effectively conserve, restore, and monitor five-needle pine.

The first meeting of the Hi5 Working Group occurred on September 15, 2016, which was planned in conjunction with the 2016 Whitebark Pine Ecosystem

Foundation Science Meeting, in Whitefish, Montana.

Over 50 individuals representing 32 different entities attended the inaugural meeting of the Hi5 Working Group. Over the course of our day-long meeting, we approved a Working Group charter defining our mission, membership, responsibilities, administrative structure, and subcommittees.

We also identified a leadership team, comprised of two Co-Chairs (Melissa Jenkins, Flathead National Forest and Brad Jones, Alberta Environment and Parks) and two Co-Chairs (Dawn LaFleur, Glacier National Park and Randy Moody, Whitebark Pine Ecosystem Foundation of Canada), and a liaison from the Crown Managers Partnership (Linh Hoang, U.S. Forest Service Region 1).

The Working Group will work under the umbrella of the Crown Managers Partnership. The Hi5 Working Group also identified a set of milestones for our subcommittees to pursue through 2017.

These include:

- By March, a peer-reviewed guide to Best Practices of Fire Use and Management in whitebark and limber pine forests.

- By spring 2017, a peer-reviewed five-needle pine Mitigation Strategy, including best management practices related to avoiding, minimizing, restoring or offsetting the loss of five-needle pine due to management or development activities.

- By January, a scoping document for a Crown-wide Restoration Strategy, and a first subcommittee meeting to draft the elements of the plan.

- In 2017, a user's needs assessment to guide the development of a Crown-wide Inventory and Monitoring database.

- In 2017, the development and execution of a Communications Strategy to bolster awareness of the need for and solutions available to recover whitebark and limber pine in the Crown of the Continent.

- In Fall 2017, the second meeting of the Hi5 Working Group in Jasper, in concert with the 2017 Whitebark Pine Ecosystem Foundation Science Meeting.

Whitebark pine in Valhalla Provincial Park near Slocan, BC *Photo: Michael Murray From the new 2017 WPEF Calendar*

The challenges are formidable, but through the formation of the Hi5 Working Group, we now have commitments from agencies and organizations across the Crown to collaborate around a shared mission that is focused on the persistence of whitebark and limber pine in our landscape.

The Hi5 Working Group will allow us to leverage new funding, new partnerships, and most importantly, new restoration work. Indeed, American Forests, a U.S. based non-profit that has been protecting and restoring American forests for 140 years, has already stepped up to provide seed money to allow the Hi5 Working Group to get off the ground.

We look forward to many more new opportunities to work together to ensure the Crown remains a core area for whitebark and limber pine. Interested in joining us? Contact Regan Nelson at regan@crownconservation.net

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Field crew Rob Johnstone and Natalie Trofimencoff coring and documenting a plus tree

Sapling with every blister rust indicator: sporulating cankers, red flagged branches, swelling, sap leaking, rodent chewing, and rough cracked bark.

Alberta Whitebark and Limber Pine Program Accomplishments 2016-17

By Jodie Krakowski

This summer there was a sparse to no cone crop in Alberta for either species in most regions so field work focused on confirming if Alberta has any potential rust resistant trees in the provincial seed bank.

The field crew of 2 revisited, measured and documented health of 383 trees from which Alberta has collected seed. They also surveyed for more plus trees that appeared likely to be resistant to blister rust, checking many thousands of trees.

One collection site could not be accessed in 2016. 7 trees were dead, 138 trees could not be relocated due to inaccurate location records or poor field marking (e.g. nothing, or old flagging, no tags), and many others had no location data at all to search for. A protocol was developed for accurate location and improved field identification.

Agriculture and Forestry spatial resource specialist Doug Crane customized the ESRI Collector app for 5NP field data – this was terrific, saving enormous time and errors from typing in field notes, naming and organizing photos, etc., and all data collected in the field could be backed up and managed remotely after syncing to a wireless connection. He also built a pilot citizen science app "Save the Pine" using ESRI's Survey123 for recreational users and volunteers to collect location and health data on 5-needle pines. This pilot version was shared with the Whitebark Pine Ecosystem Foundation of Canada board and Parks Canada ecologists for testing.

Jodie, the field crew, and GoA and NGO volunteers identified and documented 51 new potentially rust-resistant limber pine trees and 47 whitebark pine trees, of which 33 limber pine trees and 9 whitebark pine trees have seed in the ATISC seed bank. We now have 136 limber pine and 53 whitebark pine potentially resistant trees in 2 field seasons, of which 100 limber pine and 16 whitebark pine have been sent for testing so far. Not all plus trees have seeds collected yet, and we will continue to identify more plus trees in future years to ensure there is enough genetic diversity for each region for restoration.

No mountain pine beetle was identified at or near field sites, so plus trees did not receive Verbenone protection this year.

Quality Assurance of a modelling

Flimsy aluminum tags attached to close to the tree are subject to wildlife damage and malformation during growth

Durable stamped metal tags are looped around a stout branch with unique tree ID and high-vis flagging

contract for presence/absence habitat suitability for whitebark and limber pine throughout Alberta, excluding national parks is ongoing.

Once complete, the data for all 310 townships will be combined and made available for agency and public use. This represents a significant advance because it is the first reasonably accurate map of these species in Alberta. A federal Species At Risk grant proposal will be submitted in October to complete the work begun last year on density mapping for the provincial species' ranges to identify areas with critical thresholds for recovery action.

Two species of Suillus mycorrhizal fungi were collected for Dr. Roland Treu of Athabasca University to inoculate whitebark pine seedlings, which improves growth and survival by 10 to 15%.

Seedlings from a limber pine adaptation study by Barb Gass of UBC, funded by the Alberta Conservation Association and supported by USDA Forest Service, will be planted in early October in a provenance trial near Saskatchewan Crossing in the Spreading Creek burn. Seed sources range from Alberta to New Mexico and will be used to develop seed zones for limber pine. People from UBC, USDA Forest Service Southwest Research Station, Forest Health and Adaptation, and Rocky Mountain House Agriculture and Forestry will lay out and plant this 1310-tree trial.

Best Management Practices for working with these species at risk, and to support implementation of the pending federal recovery plan for whitebark pine, are being developed in collaboration with a committee of the High-Five Working Group of the Crown Managers Partnership.

Program updates were presented at Alberta Forest Genetics Research Council, provincial Species At Risk meeting, Alberta Native Plant Council AGM, Whitebark Pine Ecosystem Foundation of Canada board meetings.

A huge thank you to Alberta Fish & Wildlife Species At Risk program for supporting helicopter access, Wildfire for covering our food and accommodations, Jonathan Fearns, Megan Evans and Tim Juhlin (Blairmore), Marian Jones (Rocky Mountain House), the Oldman River Watershed Council, Devin Letourneau and his staff (Grande Prairie), Alberta Parks for permitting, Dr. Michael Murray and the BC Ministry of Forests, Lands and Natural Resource Operations for in-kind support screening seeds, and the many others who provided support and assistance. To come out for field work in 2017, or for training on identifying plus trees in your area, contact Jodie.

Devin and Clint mark trees along the transect in Kakwa.

Are High Elevation Pines Equally Vulnerable to Climate Change-induced Mountain Pine Beetle Attack?

By Barbara J. Bentz and Erika L. Eidson

Mountain pine beetle (*Dendroctonus ponderosae)* (MPB), a native insect to western North America, caused extensive tree mortality in pine ecosystems during a recent warm and dry period. More than 24 million acres were affected, including in the relatively low elevation lodgepole (*Pinus contorta*) and ponderosa (*P. ponderosa*) pines, and the high-elevation whitebark (*P. albicaulis*) and limber (*P. flexilis*) pines.

High-elevation pines are hypothesized to be more susceptible to MPB than low elevation pines due to cold, unfavorable temperatures and potentially minimal long-term contact, resulting in less evolved defensive strategies against insect attack (Raffa et al. 2013). Tree-ring and written records indicate that MPB-caused mortality of whitebark pine has been a consistent occurrence throughout the 20th century, with a particularly large pulse in the late 1920s and early 1930s (Perkins and Swetnam 1996).

Warm summer temperatures fueled MPB population growth during this 'dust bowl' period until a record cold event in 1933 caused extensive MPB mortality and halted outbreaks. By contrast, both warm summers and warm winters recently coincided (Fig. 1) to allow sustained MPB population growth, resulting in extensive and severe MPB-caused mortality in whitebark pine ecosystems (Buotte et al. 2016).

While it is clear the recent pulse in favorable thermal conditions contributed to the pulse of MPB-caused high-elevation pine mortality, the role of potentially low defenses in high-elevation pines remains unclear.

While it is clear the recent pulse in favorable thermal conditions contributed to the pulse of MPB-caused high-elevation pine mortality, the role of potentially low defenses in high-elevation pines remains unclear.

Pines have the capacity for both permanently expressed constitutive defenses and stimulated induced defenses in response to attack, and trees with greater concentration and responses are considered more resistant.

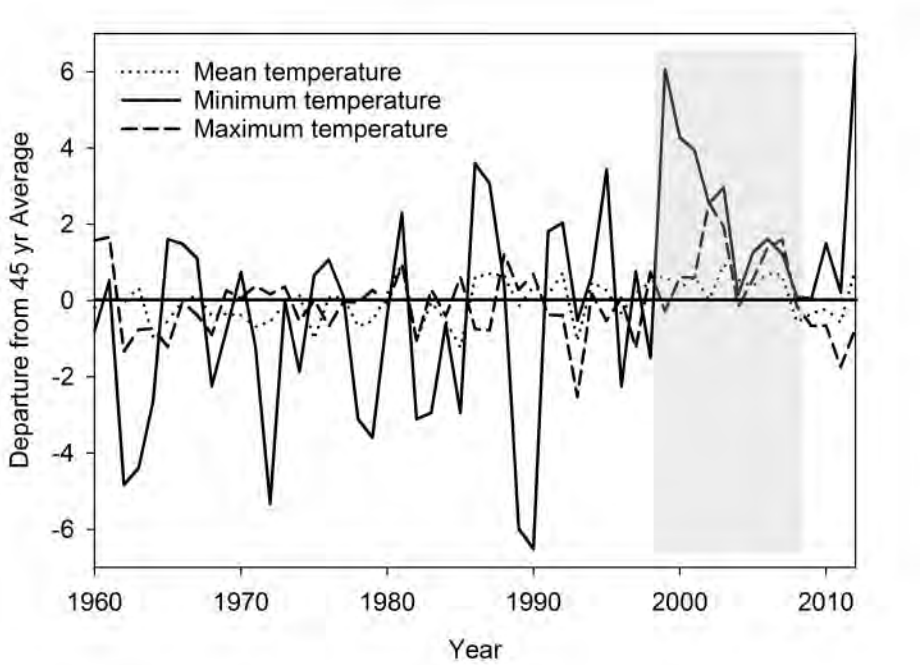

Figure 1. Temperature change from 1960 to 2012 in pine habitats across the western US showing that both summer (maximum) and winter (minimum) temperatures were above average during the period of extensive MPB-caused pine mortality in the 2000s.

Bentz et al. (2015) found no differences in constitutive defenses between lodgepole and whitebark pines growing in mixed stands, although induced defenses in lodgepole pine were found to be greater (Raffa et al. 2013).

Furthermore, more unsuccessful attacks were observed on lodgepole pine at these study sites, suggesting a greater capacity to defend against attack relative to whitebark pine. The number of mass attacked trees of each species did not differ, however, and the defenses of both species were apparently overwhelmed by the large MPB populations.

Although data from additional sites will be necessary to fully understand defense strategies in these species, the extensive mortality in whitebark pine is troubling given the significant ecological roles they play and their advanced age until reproduction. Moreover, other high-elevation pines may be equally vulnerable to climate change-induced outbreaks of MPB.

Great Basin (GB) bristlecone pine (*P. longaeva*) and its close relatives foxtail pine (*P. baulforianae*) and Rocky Mountain (RM) bristlecone pine (*P. aristata*) are high elevation species in the bristlecone or Balfourianae group that have the longest lifespans of all Pinus. GB bristlecone pine is considered the oldest living non-clonal organism worldwide with ages exceeding 5000 years, and foxtail and RM bristlecone pines can exceed 2400 years in age. All three species can grow in mixed stands with the ubiquitous limber pine, which is a known host to MPB.

Great Basin bristlecone pine is considered the oldest living non-clonal organism worldwide with ages exceeding 5000 years.

Low levels of MPB-caused mortality have been documented in RM bristlecone and foxtail pines, but not GB bristlecone pine despite high levels of MPB-caused limber pine mortality in the same stands (Bentz et al. 2016) (Fig. 2).

The lack of attacks on GB bristlecone pine and low level of attacks on foxtail pine can be at least partially explained by the high levels of constitutive phloem resin concentration found in these species, relative to co-occurring limber pine. GB bristlecone had double the concentration of total resin compounds found in foxtail pine, and more than eight times the concentration found in limber pine (Bentz et al. 2016).

GB bristlecone and foxtail pines also had significantly greater wood density than limber pine. Moreover, of the thousands of GB bristlecone pines examined, only a few showed signs of MPB parent galleries and in all cases no egg hatch was observed. Is GB bristlecone pine less attractive to MPB, in addition to being potentially more defended, than co-occurring limber pine?

Attraction of mountain pine beetle to GB bristlecone pine

To evaluate potential attraction of MPB to GB bristlecone pine, we used attack boxes attached to living pairs of GB bristlecone and limber pine (Fig. 3). Sets of ten live, unmated female MPB were placed in the boxes which were sealed to each tree.

After 48 hours, MPB activity was recorded as 1) in the exit jar (farthest from the bole), 2) in the attack box, 3) on the tree bark, but not boring and 4) attacking the tree (boring with frass) (Fig. 3). We conducted 36 paired tests at three sites using 720 MPB.

Based on ordinal logistic regression of the data, MPB were over two times more likely to be in a lower attack category

Figure 2. Live GB bristlecone pine surrounded by MPB-caused limber pine mortality in the Snake Mountains, NV.

(i.e., farther from the tree) on GB bristlecone pine than on limber pine. These results suggest that MPB has a low preference for GB bristlecone pine and that it is potentially repellent.

Mountain pine beetle reproduction in GB bristlecone pine

If MPB were to be successful in overcoming the defenses of GB bristlecone pine, could offspring be produced? To answer this question we manually infested MPB into freshly cut bolts of paired GB bristlecone and limber pine trees harvested from two sites.

Sixteen infested bolts of each tree species were placed in incubators at 22.5^{0}C. To evaluate the first steps in the MPB reproduction process, mating and laying eggs, four infested bolts of each species were peeled after 26 days and the number of viable eggs counted. The remaining 12 bolts of each species were left in incubators for brood to complete development and emerged brood adults were collected daily for 100 days (Fig. 4).

Although MPB laid viable eggs in both limber and GB bristlecone pine, there were dramatic differences between the species in brood adult emergence (Fig. 4).

Parent beetles in limber pine produced an average of 30.9 adult offspring per parent pair, yet in GB bristlecone pine only 0.4 adult offspring per parent pair, on average, were produced. Several factors could explain the poor reproduction in GB bristlecone compared to limber pine, including high levels of phloem resin concentration in GB bristlecone as documented from field sampling, in addition to the presence of multiple resin compounds found in GB bristlecone (Bentz et al. 2016) that have previously shown to be toxic or repellent to insects.

Summary

A recent pulse of warm and dry conditions in the western US resulted in extensive MPB-caused tree mortality. MPB equally mass-attacked lodgepole and whitebark pine growing in the same stands, yet few or no mass attacks were observed on foxtail and GB bristlecone

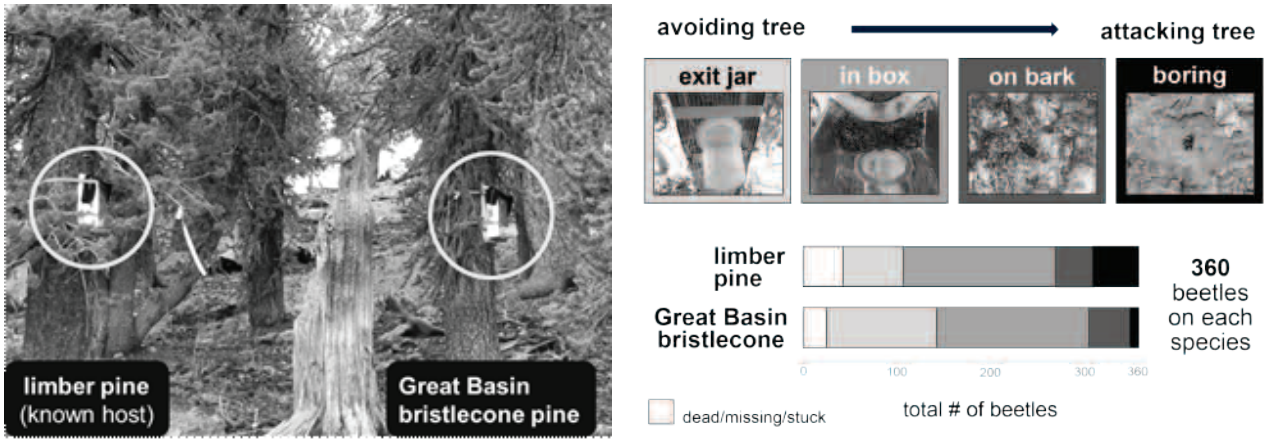

Figure 3. Attack boxes on paired trees. Ten live beetles were placed in each box for 48 hours, then activity recorded.

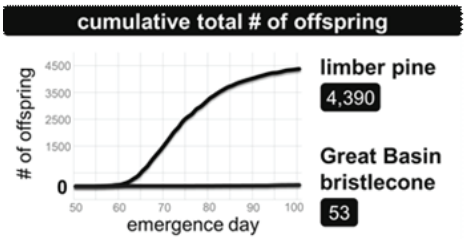

Figure 4. MPB brood produced from an equal number of manually infested bolts of GB bristlecone and limber pines.

pine when they were growing in the same stands with MPB-attacked limber pine.

Although high-elevation pines are hypothesized to be more susceptible to MPB due to historically unfavorable thermal conditions and a subsequent lack of evolved defenses, GB bristlecone and foxtail pines respectively have over eight times and over four times the concentration of total constitutive resin compounds found in co-occurring limber pine, in addition to having higher wood density and toxic compounds not found in limber pine.

Moreover, in our attack box study MPB were more likely to avoid GB bristlecone pine than limber pine, and produced few offspring in GB bristlecone pine when manually forced into cut bolts of each species. Although our results may imply that GB bristlecone and foxtail pines have a more long-term and evolved relationship with MPB than other pine species, the fact that limber pine has been a long-term and common associate with GB bristlecone pine suggests that other factors may also influence tree vulnerability.

The high resin concentration and wood density found in GB bristlecone and foxtail pine contribute to their ability to grow in harsh habitats and to attain very old ages, and these traits may have been co-opted for use in defense against MPB attacks (Bentz et al. 2016).

Tree longevity may also serve to maintain evolutionary signals of past traits that confer resistance to attack.
Predicting climate change-induced MPB-caused mortality is complex due to a need to understand the intricacies of MPB adaptation to temperature, in addition to factors that influence pine susceptibility, including evolved histories.

To fully understand future vulnerability of pines to MPB, standardized data is needed on relative defense strategies, including resin quality and quantity and structural mechanisms, among and within pine species that have varying longevity and that grow in multiple environments across the range of MPB.

To fully understand future vulnerability of pines to MPB, standardized data is needed on relative defense strategies.

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WPEF

Understanding the Influence of Fire & Climate on Whitebark Pine

Catherine Airey Lauvaux , PhD Student
Department of Geography, Penn State University

Understanding historical fire regimes and how fire suppression and land-use changes have altered forests is important for restoring and preserving fire prone forest landscapes. This is especially true for whitebark pine forests experiencing beetle outbreaks, blister rust, increased competition from trees that would have been thinned by fires, and climate change.

When and how often did the whitebark pine forest burn? Are fires and tree mortiality related to climate patterns?

As part of my ongoing dissertation research in the Sawtooth National Forest in south-central Idaho, I am reconstructing the pre-Euroamerican settlement fire history and studying the post-settlement forest changes.

Whitebark pine are the dominant tree at the higher elevations and on ridgetops. Some whitebark pine died following pine beetle outbreaks. Blister rust is also present, but relatively limited to date, perhaps due to prevailing wind patterns. While many studies have investigated fire history in specific forest types, fewer have studied fire history at the forest landscape scale. One component of my work is to understand how often fires burned, how they are related to periods of drought or high temperature, and whether forests have thickened since fire suppression began near the turn of the 20th century.

Research questions include: When and how often did the whitebark pine forest burn? How old are the whitebark pine? When did competing subalpine fir in the whitebark pine forests establish? Did the dead whitebark pine found in the landscape die at the same time? Are fires and tree mortality related to climate patterns? Do fires in whitebark forest also burn at lower elevations or are fire years unique to whitebark forest conditions?

The study site in the Soldier Mountains, part of the northern Rocky Mountains, is largely north facing with eastern and western slopes on either side of north-south oriented drainages that run from ridge-top to the South Fork of the Boise River.

Forest composition shifts with the elevation gradient from Douglas-fir *(Psuedotsuga menziensii)* dominated forest at the river around 1700m up to subalpine fir (*Abies lasiocarpa*) at intermediate elevations around 2200m, with whitebark pine at the highest elevations along the ridgetops around 2800m.

Sagebrush (*Artesmia tridentata)* and

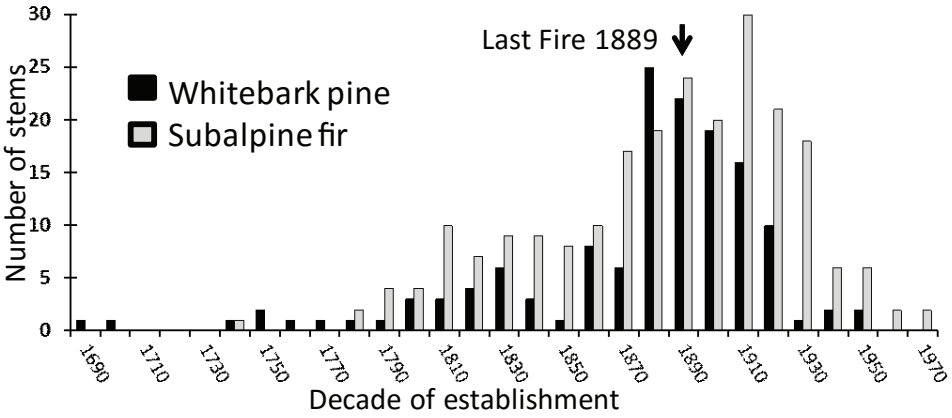

Figure 1. Numbers of whitebark pine (black bars) and subalpine fir (gray bars) establishing in each decade for all age structure plots (n=14) combined with date of last fire (1889) shown with an arrow in the Solider Mountains in Idaho's Sawtooth National Forest, Fairfield District.

grasslands occupy drier slopes across the elevation gradient. Fire suppression has been in effect since the early 1900s. Flocks of sheep graze the area and have been present since around 1890. Fourteen plots were established in whitebark pine to identify temporal trends in tree establishment and mortality. Tree cores from each plot were glued to wooden blocks, sanded to reveal ring patterns, and cross-dated to determine the decade of establishment. Cores were also taken from up to 15 dead whitebark to determine death dates in the plot.

To develop a fire history, snags and downed trees with fire scars were located by surveying the surrounding forest. Sections from 11 dead trees were collected using a chainsaw. Sections were sanded and the ring-widths were measured.

To create a local tree-ring chronology, I collected 2 cores from each of 35 trees growing in especially harsh conditions likely limited by annual temperature and precipitation. Cores were mounted and sanded and the ring-widths were cross-dated and measured.

The measurements were combined to create a site chronology. This chronology was used to date the dead cores and fire scars by matching the ring pattern of the chronology to the pattern of individual cores and cross-sections.

Initial results from sections already dated (n= 7) indicate the occurrence of widespread fires that burned across the landscape from the Boise River up to the whitebark pine forest. These widespread fires occur about once a century during very dry conditions, while smaller fires occurred in the whitebark forest on average every 22 years (range 8 to 41 years). The most recent fire detected in fire scarred trees from the whitebark pine forests was in 1889.

The oldest whitebark pine established in the late 1600s and early 1700s with most establishing in the late 1800s and early 1900s, generally earlier than the subalpine fir (Figure 1).

Across the landscape, pine regeneration has slowed since the early 1900s with few trees establishing after fire suppression began. In contrast, subalpine fir establishment increased during the early 1900s. However, in more open stands (Figure 2A), both fir and pine continued to regenerate through the 20th

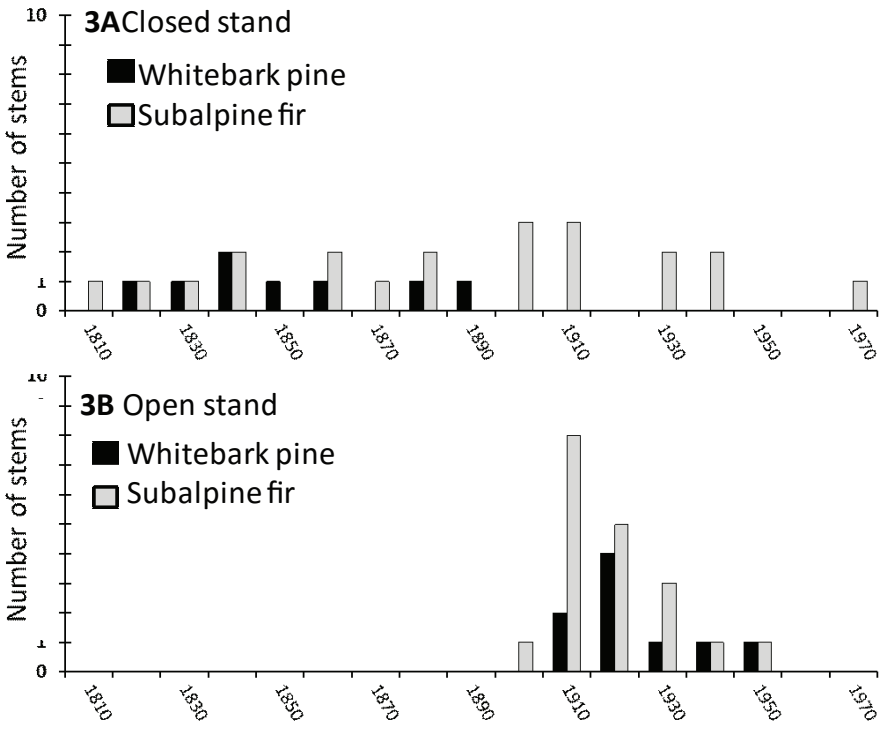

Figure 2. Numbers of whitebark pine (black bars) and subalpine fir (gray bars) establishing in each decade for (A) a stand with a more closed canopy structure where no whitebark have established for many decades and (B) a stand with an open canopy structure where whitebark has continued to establish.

century, compared to closed stands (2B).

Seedling and sapling counts show fir regeneration currently exceeds pine in all plots (Table 1). Whitebark pine death dates were concentrated in four decades. Most whitebark pine trees died in the early 2000s (75%), with additional peaks in the 1990s (7%), 1970s(7%), and 1930s(4%) with all other decades representing 6%.

Years of widespread fires recorded in both the whitebark and lower elevation Douglas-fir forests suggest fire acts as a connective process across the landscape and across forest types. Smaller fires also occurred within whitebark pine forests and served to maintain a mosaic of stand ages and open environments conducive to pine regeneration.

Whitebark pine and subalpine fir showed an increase in establishment coinciding with the decades following the most recent widespread fire. However, many trees that established before the fire also survived suggesting fire effects were not severe.

The decrease in regeneration of whitebark pine after the 1920s suggests the 127 year absence of fire disturbance has contributed to reduced whitebark regeneration. Since fire suppression, subalpine fir has continued to regenerate and has surpassed whitebark pine regeneration.

The decades with higher rates of whitebark pine mortality, the 2000s, 1970s, and 1930s, were decades with several dry years in a row. Drought stress appears to have weakened the trees' resistance to beetle and blister rust attacks. Analysis of the tree ring data will be used to determine whether widespread fires and tree mortality coincide with local droughts.

Understanding the influence of fire and climate on whitebark pine establishment and mortality and how fires in whitebark are related to fires across the larger forest landscape may be useful to managers deciding how to promote conditions for whitebark resilience into the future.

WPEF

	Seedlings		Saplings	
Plot	fir	pine	fir	pine
1	14	5	2	2
2	9	0	4	0
3	23	0	1	0
4	12	2	8	3
5	18	0	7	0
6	7	6	3	3
7	60	1	4	0
8	10	3	1	2
9	23	6	0	1
10	23	3	6	1
11	5	0	0	0
12	4	0	4	1
13	12	0	10	2
14	4	0	3	2
Total	224	26	53	17

Table 1: Numbers of seedlings (<5cm dbh ; <1.4m tall) and saplings (<5cm dbh > 1.4m tall) of subalpine fir (fir) and whitebark pine (pine) in 10mX10m subplots within the age structure plots

Wind blown specimen at Ajax Lake, Montana.
By Barry Bollenbacher

Whitebark Scientists & Managers Meet In Whitefish, Montana September 16-18, 2016

By Melissa Jenkins

WPEF Secretary and 2016 Workshop Committee Member

By all measures, the annual WPEF Science and Management Workshop in Whitefish, MT was a rousing success. Almost 180 people attended the workshop at the world class O'Shaughnessy Center on Friday, September 16th.

Presentations began at 0800 with a welcome from Flathead NF Forest Supervisor, Chip Weber. Regan Nelson, Crown Conservation Initiative Coordinator, gave the keynote address focusing on the recently inaugurated Crown of the Continent Ecosystem High 5 Needle Pine Working Group. The CCE High5 group had met the previous day, agreed to a charter in principle, and charted a path forward for its seven subcommittees to accomplish their goals.

The theme for the WPEF workshop was "Successes and Challenges in Managing the Jewel in the Crown of the Continent". A full day of fascinating speakers brought new information to light regarding the management of high elevation 5-needle pines in the Crown of the Continent ecosystem and beyond.

The presentations were recorded and can be viewed on the Northern Rockies Fire Science Network website or YouTube channel: http://nrfirescience.org/event/2016-whitebark-pine-ecosystem-foundation-science-and-management-workshop or https://www.youtube.com/user/NRFireScience

The evening social event for meeting attendees and concurrent evening program for the public were both well attended. While those who had attended the formal presentations during the day enjoyed food and drink in the O'Shaughnessy foyer, approximately 50 people, most of them interested community members, attended the evening program.

Dr. Diana Tomback, WPEF Executive Director, and Karl Anderson, Flathead NF Lead Culturist, gave presentations on the general ecology and management of whitebark pine. The public seemed intrigued with the information; the question and answer period lasted for a half an hour!

Approximately 100 people gathered together at Whitefish Mountain Resort Base Lodge on Saturday for the WPEF members meeting and Whitefish Mt Resort "Whitebark Pine Friendly Ski Area" certification presentation.

Edie Dooley, Chair of the WPEF Ski Area Certification Committee, presented a plaque to Brian Carper, one of the resort's managers. Whitefish Mountain Resort is the first ski area to be certified through the program. Most participants then braved the inclement weather and took the ski lift up to the top of Big Mountain to view whitebark pine plus trees and a tree climbing/cone collection demonstration and discussion.

Twenty four participants joined together for Sunday's field trip to Glacier NP. The hardy group walked about half a mile through cold, wind and rain, up the Scenic Point trail to a site that had been planted with limber pine in 2012. Both whitebark and limber pine were observed growing on the site.

Everyone had the opportunity to plant limber pine seedlings and try out different planting tools. Seeing the size of the 2012 seedlings helped people understand how slowly 5-needle pines grow and why we need to take a long term perspective in our restoration efforts.

Thank you to everyone who attended the 2016 WPEF Science and Management Workshop. Your participation is the reason it was such a success. Don't miss next year's meeting being held in Jasper, Alberta in mid-September. It should be another great workshop!

Silent Auction Raised $1,100 for Student Research Grant

By Cyndi Smith, *Associate Director, WPEF*

The Silent Auction held during the science meeting at Whitefish on September 16th, 2016, was very successful, raising $1,100.

The auction ran throughout the meeting, and concluded during the evening social at the O'Shaughnessy Cultural Arts Center. The Board of Directors is again dedicating the 2016 auction funds to the Student Research Grant, which is a competitive process that awards an annual grant worth $1000 towards a student's whitebark pine research.

The WPEF has distributed $4,000 in research grants to students since 2012. Your donations and purchases have made this happen!

The Board would like to thank Laura DeNitto for running the Silent Auction again with such skill and enthusiasm – we couldn't do it without her. I know that she had a few helpers at various times, including our Treasurer, Glenda Scott, who tallied the funds.

We would also like to thank both the donors (including a couple that were anonymous) and purchasers:

Amy Nicholas
Blubird Apparel
Bonnie Thomson
Cairn Cartographics
Cara Staab
Carl Fiedler
Cyndi Smith
Dana Perkins
David Walker
Dawn LaFleur
Deb Bond
Diana Tomback
Glenda Scott
Gnam Photography
Harry Hutchins
Jennifer Costitch-Thompson
Jodie Krakowski
Justin Hynide
Laura & Greg DeNitto
Liz & Bob Keane
Liz Davy
Martha Jenkins
Michael Murray
Michelle Carlson
Peter Achuff
Rachel Potter
Randy Moody
Reed Kuennen
Robin Garwood
Robin Gutsell
Sandy Kegley
Sean Sweeney
Steve Arno
Travis Stovuld
Udderly Fresh
Vita Wright

ELECTION NEWS

Nominations Needed for FIVE Board Positions

By Cyndi Smith, Associate Director

As per the Foundation's bylaws, our founding Director, Diana Tomback, reached her term limit (9 years) in 2016. Unfortunately, the board has been unable to recruit anyone to fill the position, so Diana has stayed on as Interim Director. We continue to seek a highly motivated volunteer to lead the Foundation during this exciting phase of our existence.

Also in 2016, Bob Keane, another founding member, reached his term limit. Bob is staying involved, though, as editor of Nutcracker Notes. Another long-time board member, Michael Murray, also reached his term limit, but will continue to serve on some committees.

We are seeking nominations to fill the following positions on the WPEF board of directors (BOD):

- Director
- Associate Director
- Treasurer
- General Board Member
- General Board Member

These new members would start serving on the BOD in October, 2017 Nomination forms are available in this issue of Nutcracker Notes on pages 33-34, and on the Foundation's website … www.whitebarkfound.org, along with a list of responsibilities for each of the positions.

Nominations close on 1 February 2017.

Please consider running for one of these positions, or nominating someone else – nominees do not have to be members of the Foundation, but if elected would have to join. Your active participation is critical to keeping the Foundation relevant to the general membership.

If you have any questions about any of the positions or the nomination process, please contact me at cyndi.smith9@gmail.com.

MEET OUR BOARD

GLENDA SCOTT

1.Who are you and what are your interests? I am a gardener, community volunteer, knitter, hiker, skier, traveler, happily retired Forest Service Silviculturist, mother to three great kids and wife of one great husband, Dave. We had dual Forest Service careers, Dave in fire, me in silviculture, so after a number of moves while raising the kids, we settled in Missoula in 2000 and have made it our home.

2.What piqued your interest in whitebark pine? I love the high country and the unusual structure of the WBP krumholtz which is similar to bristlecone pine I grew up with in the Sierras. I was first introduced to the plight of whitebark pine during a field trip to a project on the Rocky Mountain Front in the mid-90s. From there, my love for reforestation coupled with the unique niche that WBP fills, caught and kept my fascination.

3.Why did you decide to be a board member? I felt I had some time that I could commit to being a board member AND I missed the association with some of the great silviculturists and scientists so passionate about whitebark pine, that I accepted the nomination as treasurer when Vick Applegate felt he needed to step down- he's got big shoes to fill but I am enjoying being on the Board.

continued on next page

STUDENT RESEARCH GRANT

Call for Proposals for the 2017 Whitebark Pine Student Research Grant

The mission of the Whitebark Pine Ecosystem Foundation (WPEF) is to "promote the conservation of whitebark pine and other high elevation five needle white pine ecosystems through education, restoration, management, and research."

In support of this mission, the WPEF will be offering a **research grant of $1000** to an undergraduate who is writing an undergraduate thesis or graduate student (MS or PhD) conducting research on whitebark pine.*

Relevant areas of research include, but are not limited to: threats to whitebark pine, including mountain pine beetle, white pine blister rust, successional replacement, and climate change (only in whitebark ecosystems); interactions with wildlife, such as Clark's nutcracker or other birds, red squirrels and grizzly bears; restoration strategies for white-bark pine, including both field operations and nursery seedling production; ecosystem level impacts of whitebark pine die off; and, social or policy aspects of whitebark pine decline and restoration, including wilderness issues.

Monies will only be awarded for travel expenses for field work, or consumable research supplies. Grants shall not be used to buy equipment that will be used beyond the duration of the project (and thus would be retained by the lab in which the student works).

Please submit a short (two single-spaced pages at most, not including references) proposal covering:

1. The purpose and need for the research
2. A brief description of the study plan and methods, including expected dates of data collection and writing completion
3. Expected outcomes of the research
4. A brief explanation of how the money will be spent
5. Contact information and academic affiliation of the student

Grant recipients are encouraged to present their research findings at a subsequent WPEF annual science meeting and are expected to publish a research summary in our bi-annual journal Nutcracker Notes.

In addition to the proposal, applications should include a CV as well as a letter of recommendation from the student's research advisor. All applicants are encouraged to join WPEF and the grant recipient will receive a free subscription to Nutcracker Notes for one year.

Please send application materials (electronic only) to <cyndi.smith@whitebarkfound.org> by February 1, 2017.

**While the WPEF is concerned about all five-needled pines,*

More from GLENDA SCOTT

4.What is a book and movie that changed your life? In my early life, I would probably say The Wilderness World of John Muir, made an impact on my interest in wild country and how its cared for. In more recent times, I was touched by the book, Three Cups of Tea, as I learn more about the necessity for educating children especially girls and especially in the Mideast to build strong communities with less terror.

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? Definitely whitebark pine over subalpine fir, but I have a fondness for ponderosa pine, aspen and white pine as well, and love to be in the company of the very passionate scientists who work with those species as well!

TOMBACK continued from page 2

the September 17th launch at Whitefish Mountain and Resort, MT, of our Whitebark Pine Friendly Ski Area Certification Program, a project developed over the last few years by former board member Edie Dooley (see Spring/Summer 2016 Nutcracker Notes). The event took place on Saturday following our annual Whitebark Pine Science and Management Workshop, and generated local press coverage. We have several ski areas in the U.S. and Canada also interested in certification and will be working with them to achieve this.

With respect to new endeavors, the WPEF is a member of the Crown of the Continent (CC) High Five Working Group, which crystallized from the "We need the needles" Workshop, organized by Regan Nelson, following the Crown Manager's Partnership Annual Forum last March in Fernie, BC. This is an important and inclusive effort to organize and implement restoration of both whitebark pine and limber pine across the many different governmental, tribal, and private land holdings in the U.S. and Canada in the Crown region (see Spring/Summer 2016 Nutcracker Notes). We held a very productive CC High Five Working Group meeting the day before the WPEF Science and Management Workshop this past September. Another future endeavor: We are planning the next high elevation five-needle white pine symposium, slated for 2020.

All of us who serve as board members and members of the WPEF can be considered the ultimate "tree-huggers." Our work to preserve whitebark pine is based on deep appreciation for this one particular tree that we call a keystone and foundation species. The meaning transcends whitebark pine ecology: the tree is symbolic of the interconnections among all organisms, including us. Ancient, wind-sculpted whitebark pine inspire us and connect us to the past and to the future. The image of whitebark pine with its lyrate branches reaching skyward, offering cones to nutcrackers flying overhead, symbolizes the high elevation forests of the West. It is my hope that over the next decade we can make progress to ensure that whitebark pine has a future in these forests.

Our Whitebark Pine Friendly Ski Area Certification Program launched at Whitefish Resort on September 17, 2016.

Housekeeping and transitions

Our annual WPEF Science and Management meetings take a lot of organizational effort. Our September Whitefish, MT, meeting was hosted by the Flathead National Forest, and we thank Forest Supervisor Chip Weber for his support for this event. Chief organizer and WPEF Secretary, Melissa Jenkins did a phenomenal job of orchestrating this meeting in a great venue—the O'Shaughnessy Cultural Arts Center in downtown Whitefish – as did the rest of the organizing committee – Val Walker and Rob Sissons.

Corey Gucker and Vita Wright of the Northern Rockies Fire Science Network did an outstanding job assembling the scientific program and communicating with speakers. Karl Anderson and Rebecca Lawrence organized and led field trips. Laura DeNitto did a great job, as always, with our silent auction. Thanks to WPEF staffer Julee Shamhart and former board member Kate Kendall for help at the merchandise table, and thanks to members of the board and friends who pitched in to help with registration, the social, and clean up.

I would like to express my gratitude to two long-term board members who, like me, have been term-limited this year: Bob Keane and Michael Murray. Bob has taken on the task of editor of Nutcracker Notes, which means he will continue as a non-voting member of the Board of Directors. We owe Bob and Michael a debt of gratitude for their long-term service and work on various projects over the years, including annual Science and Management Workshops and our High Five symposium and proceedings.

We also welcome three new board members: Mike Giesey and Cathy Stewart were elected this spring by the membership to board positions vacated by Bob and Michael, and Scott Smith was elected by the Board of Directors to one of the board-appointed positions. Scott, who comes from the Pacific Northwest, not only diversifies our board geographically but brings an outdoor recreationist perspective. Congratulations also to Melissa Jenkins on her re-election as WPEF secretary. Her energy and can-do attitude is always an inspiration!

Nominations for 2017 Whitebark Pine Ecosystem Foundation Board Elections

Our bylaws dictate that elections are to be held every year for various positions – this way there is always a rotation of experienced Board Members and Executive Committee officers and we would never face a complete turnover of officers and the uncertainty that could ensue. Please consider running for one of these positions!

Board members and officers commit to working collectively to advance the business of the WPEF and the conservation and restoration of high elevation pines. This includes attending two board meetings per year, one of which is usually in March or April in Missoula, MT, and the second is in conjunction with the annual WPEF science meeting and field trip in mid-to-late September somewhere within the range of whitebark pine. To find out more about the duties of these positions, please refer to the back of this form, consult the WPEF Executive Handbook on the website www.whitebarkfound.org, or contact one of us.

Diana F. Tomback, Ph.D.
Director: diana.tomback@ucdenver.edu

Cyndi Smith
Associate Director: cyndi.smith@whitebarkfound.org

Nomination Form – Whitebark Pine Ecosystem Foundation

Nominations are being sought for the following five (5) positions, to begin serving on the Board of Directors in October, 2017. All positions are for a 3-year term:

- Director
- Associate Director
- Treasurer
- Board Member
- Board Member

RULES:

- All board members can serve up to 3 terms consecutively [Bylaw E(h), E(i) and F(a)].
- A nominee to the BOD does not have to be a member of the WPEF, but voting privileges on the BOD are restricted to members in good standing [Bylaw E(c)], so once elected the nominee must become a member.
- Any nomination must be made by 2 members in good standing [Bylaw F(b)(i)], and consented to by the signature of the nominee; signatures can be on one form, or on separate forms.
- **Only one nomination per form**. If you need more forms, please copy this one, or download another one from our website <www.whitebarkfound.org>.
- Send nominations by mail [Box 17943, Missoula, MT, 59808], E-mail melissa.jenkins@whitebarkfound.org.
- Complete nominations must be postmarked/dated no later than **01 Feb 2017**.

We, the undersigned, nominate _____ for the position of

DIRECTOR ___ ASSOCIATE DIRECTOR ___ SECRETARY ___ BOARD MEMBER ___
[*please check ONE only*].

Nominator #1: _____ _____ _____
Signature *Print Name* *E-mail address*

Nominator #2: _____ _____ _____
Signature *Print Name* *E-mail address*

Nominee: _____ _____ _____
Signature *Print Name* *E-mail address*

The purpose of the Board of Directors (BOD) is to make decisions affecting the general membership of the WPEF. This includes making policy, deciding on major spending, or solving major problems concerning the organization.

1. Responsibilities of the Director:

General

- Oversight of all WPEF activities
- Oversee fund raising and public relations
- Participate in meetings, make presentations at important events relative to WPEF mission
- WPEF will provide reimbursement for activities that are of impact to WPEF and not funded by external sources, upon authorization by Board of Directors

Specific

- Call board meetings twice a year; develop agendas for board and annual members meeting
- Call for host/location for annual science and members meeting
- Propose and call for initiatives meeting WPEF mission
- Follow potential leads for fund raising and WPEF mission

2. Responsibilities of the Associate Director:

- Take over duties of the Director if he/she is incapacitated
- Facilitate BOD and Executive Committee meetings
    - Serve as time-keeper
    - Keep order and facilitate discussion from all board members
- Serve as the Chair of the Nominating Committee
    - Oversight of board member terms and status
    - Solicit nominations, prepare a list of candidates and create a ballot
    - Advise newly elected BOD members and thank outgoing BOD members
- Serve as Chair of the Proposal Evaluation Committee
    - Prepare any request for proposals as approved by the BOD, such as the Student Research Grant
    - Convene a committee to evaluate each proposal and prepare a recommendation to the BOD for approval
- Serve as Chair of the Bylaws Committee
    - Prepare proposed Bylaw changes for BOD review and vote
    - Once approved by BOD prepare Bylaw changes for membership vote

3. Responsibilities of the Treasurer:

- Manage the finances of the WPEF
    - Deposit all receipts for membership dues, donations, merchandise purchases, grants, and other income
    - Store all bank statements, receipts, and financial correspondence
    - Disburse payments for all invoices and other financial obligations
    - Balance monthly checking and savings account statements
    - Coordinate cost-share agreements in cooperation with the Director and other WPEF officers
    - Submit forms regarding non-profit status, and other related forms and payments, as needed
    - Have accounts reviewed as necessary for tax and audit purposes
    - Coordinate with accountant for submission of tax material to IRS
- Maintain records of the financial status of the WPEF
    - Attend BOD meetings and present a Treasurer's Report containing a summary of next year's budget and last year's expenditures, income, and current holdings
    - Prepare budget and yearly expense reports as needed

4. Responsibilities of a general board member:

- Attend all BOD meetings (in person or via conference call)
- Attend all WPEF annual meetings
- Chair at least one Committee or Working Group
- Organize annual meetings as appropriate
- Perform fundraising as needed
- Participate in other WPEF tasks and activities when appropriate

Newly installed sign at blister rust disease trial of seedlings above Slocan Lake (Idaho Pk., New Denver, BC)

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

WHITEBARK PINE
ECOSYSTEM FOUNDATION

The Burmis Tree, on Highway 3 east of Crowsnest Pass.

Limber pine trees of renown in Alberta
For decades, the province of Alberta has documented trees that are unique, ancient, and have special heritage or cultural value on provincial land through the Trees of Renown program. The Heritage Tree program also documents such trees on private land, which covers nearly 30% of the province.

Several limber pines are included on the list. Two of the most prominent are the well-known Burmis tree, a beloved landmark in the eastern side of the Crowsnest pass; and what may be Alberta's oldest tree, confirmed to have 1100 rings but is even older.

The 650+ year old Burmis tree succumbed in the 1970s to an unknown agent of mortality, and in 1998 the wind blew it over. Albertans were so attached to this famous tree that it was re-erected with support poles and features a large interpretive sign highlighting its scenic and historic importance.

The giant living limber pine tree is near Crowsnest Lake. It was commemorated with a ceremony involving local forestry staff and the provincial minister of the day, acknowledging its unique value as part of the Trees of Renown program.