Partnerships in the Pacific Northwest Help Save an Endangered Species, Whitebark Pine (*Pinus albicaulis*): an Example of Dynamic Genetic Conservation[1]

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Whitebark pine (WBP, *Pinus albicaulis*) is a keystone species distributed widely at high elevations across western North America. It is in decline due to a combination of threats including infection from white pine blister rust (WPBR, caused by the non-native fungal pathogen *Cronartium ribicola*), mountain pine beetle (*Dendroctonus ponderosae*) predation, climate change, and altered fire regimes (Lintz et al. 2016, Smith et al. 2013, Tomback and Achuff 2010) (figs. 1, 2). Whitebark pine has been classified as Endangered on the latest IUCN Red List of Threatened Species (Mahalovich and Stritch 2013). It is a federally listed endangered species in Canada under the Species at Risk Act (SARA) (Government of Canada 2012), and was found warranted (but currently precluded) for listing under the Endangered Species Act (ESA) in the United States (USFWS 2011a, 2011b, 2015).

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Figure 1—Extensive recent whitebark pine mortality from mountain pine beetle in Crater Lake National Park. (Photo: R. Sniezko)

Figure 2—White pine blister rust resistance trial conducted at U.S. Department of Agriculture Forest Service's Dorena Genetic Resource Center in Cottage Grove, Oregon. The frame above shows family variation by row in resistance to rust. Rows 3 and 11 have resistant families from Crater Lake National Park and Deschutes National Forest, respectively. (Photo: E. Heck)

Partnerships and cooperation among organizations are essential in order to efficiently and effectively maximize the conservation needs of threatened species such as WBP. Collaborations between land managers and stewards across organizational boundaries in the Pacific Northwest portion of WBP's geographic range have set the stage for beginning the recovery of WBP ecosystems (fig. 3). In fact, the majority of WBP habitat is controlled by conservation-oriented land management agencies and tribes in the United States and Canada, presenting a unique opportunity to combine institutional research and land management objectives to support the longevity of this iconic species, and to implement government restoration policy such as U.S. Department of Agriculture Forest Service's (USDA FS) directive to "achieve landscape restoration goals by engaging the public, state and local governments and consultation with Indian Tribes (USFS 2016)." Universities and government research units provide a conduit to examine basic research issues, while the various land management groups seek to apply actions to retain or restore the species (fig. 3).

For the USDA FS Pacific Northwest Region (Oregon and Washington, Region 6), concerns about WBP began to escalate in the early 1990s, and staff of the Genetic Resources and Forest Health Protection groups initiated an information survey (Sniezko et al. 1994). Seed collections for WPBR resistance testing (from USDA FS and partners) began soon afterwards, and the first full scale test of

genetic resistance began in 2002 (Kegley et al. 2012; Sniezko et al. 2007, 2011a, 2011b, 2012). Formal surveys of the health of WBP began in 1998 (Goheen et al. 2002). Continuing concerns led to a 2005 conference, 'Whitebark pine: A Pacific Coast perspective' (Goheen and Sniezko 2007), and the 2008 publication of an initial restoration strategy for the Pacific Northwest Region (Aubry et al. 2008). Seed collections specifically for genetic conservation began in 2008 (Sniezko et al. 2011c).

Genetic conservation activities continue and tremendous progress has been made in WBP *in situ* and *ex situ* genetic conservation in the Pacific Northwest. The joint efforts between tribes, government agencies, and academic institutions have provided a chance to examine WPBR resistance, collect seed for long term genetic conservation, initiate provenance trials, examine genetic variation, plant the first restoration trials, develop new genomic resources, and educate the public (e.g., Jahn 2003; Man et al., Joining forces for genetic conservation, these proceedings). Genomic advances that have generated new tools to describe patterns of genetic variation and population structure in WBP (Gruhn 2016, Liu et al. 2016, Syring et al. 2016), research characterizing patterns of adaptive genetic variation in needle and growth traits (Bennett et al. in press; Hamlin et al. 2011, Sniezko et al. in press a, b), investigations into variation of fungal endophyte communities in needle tissue and their relation to WPBR (Bullington 2017), and recent trials to confirm the longevity of seed storage and refine stratification and germination protocols (Sniezko et al. 2017), provide crucial background information for ongoing and future restoration work, seed collections, and other genetic conservation efforts.

To date, seeds from over 1000 parent trees from the Pacific Northwest part of WBP's geographic range have been collected. The seedling families being grown from these seeds are in testing at Dorena Genetic Resource Center (DGRC) for genetic resistance to WPBR. Resistance ratings from many of these parent trees are now available and have been disseminated to the cooperating partners in the United States and Canada, and useful levels and frequencies of genetic resistance have been found in some populations of WBP (Sniezko and Kegley 2015, Sniezko et al. 2007, 2011a, 2011b, in press b) (fig 2). Seeds are being collected from the parent trees to use for restoration and long-term genetic conservation, resistant parents or progeny are being grafted and placed into seed orchards or clone banks, and field trials have been established to study the adaptive genetic variation within WBP. The first restoration plantings (and combination genetic trials) with WPBR resistant seedlings have been established in the United States and Canada to validate the results of the seedling WPBR resistance testing and in situ and ex situ genetic conservation purposes, and as a conservation education opportunity (e.g., Beck and Sniezko, in press; Cartwright et al. 2016[20]). Additional field trials, conservation plantings and seed orchards are slated for 2017. A subset of the Oregon and Washington seed collections is stored at the National Laboratory for Genetic Resources Preservation (NCGRP) in Fort Collins, Colorado, and recorded in the GRIN-Global database (GRIN-Global 2016). Additional collections and duplicates of many collections at NCGRP are also stored at DGRC.

Already there is evidence of success—in 2015 the U.S. Fish and Wildlife Service downgraded the endangered species listing priority number for WBP (USFWS 2015). This was due, in part, to the recognition that some whitebark pine show genetic resistance to WPBR; key evidence for this comes from the Pacific Northwest program (Sniezko et al. 2007, 2011b; Sniezko and Kegley 2015). The status of WBP is re-evaluated annually, however, and a decision on its listing under ESA may come in 2018. Continued cooperative effort across organizational boundaries will provide the best avenue for dynamic genetic conservation and retaining WBP as a keystone species in high-elevation forest ecosystems.

[20] **Cartwright, C.; Ukrainetz, N.; Murray, M. 2016.** Whitebark pine field screening for blister rust resistance. (Establishment Report – 2015/2016). Unpublished report. 15 p.

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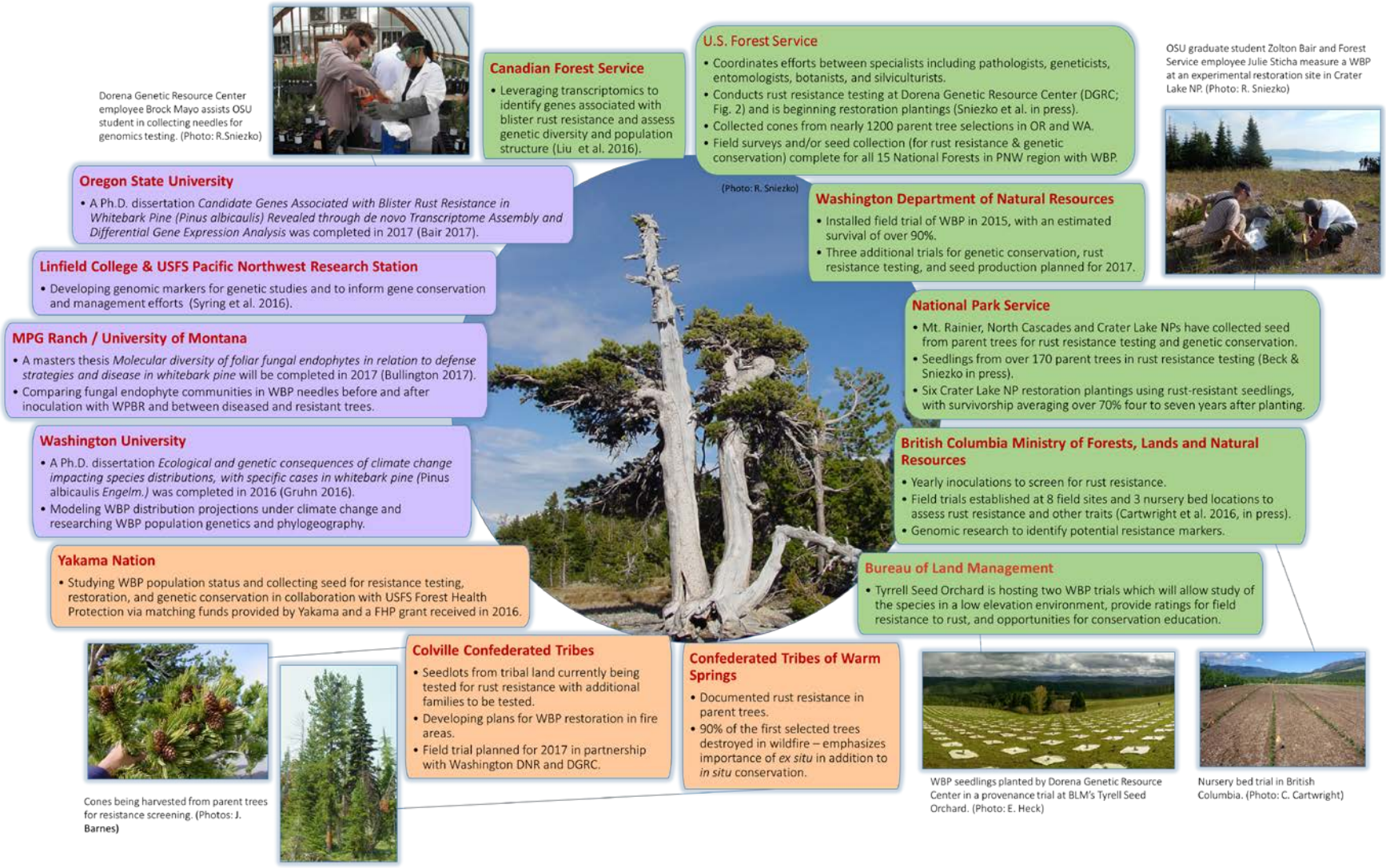

Figure 3—Contributions of partnerships and organizations instrumental to whitebark pine conservation in the Pacific Northwest. All rust resistance screening in this Region conducted at Dorena Genetic Resource Center.

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