

Ex Situ Gene Conservation in High Elevation White Pine Species in the United States—A Beginning

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Overview

The eight white pine species native to the western United States face an array of biotic and abiotic challenges that impact the viability of populations or the species themselves. Well-established programs are already in place to conserve and restore *Pinus monticola* Dougl. ex D. Don and *P. lambertiana* Dougl. throughout significant portions of their geographic ranges. More recently, programs have been initiated for the other six species: *P. albicaulis* Engelm., *P. aristata* Engelm., *P. balfouriana* Grev. & Balf., *P. flexilis* James, *P. longaeva* D.K. Bailey, and, *P. strobiformis* Engelm. In December 2008, concerns about the future of one of these species, *P. albicaulis* (whitebark pine), led one group to propose 'Listing' of this species under the Endangered Species Act (Natural Resource Defense Council 2008); a status review of the species is now underway, and a 12-month petition finding is expected in July 2011 (U.S. Fish and Wildlife Service 2010).

Gene conservation activities provide a conduit to help ensure the genetic variation within a species is potentially available for future utilization. Preserving genetic variation is important because it provides the foundation for species to evolve and respond to challenges such as white pine blister rust (caused by the non-native, invasive fungal pathogen *Cronartium ribicola* J.C. Fisch.), mountain pine beetle (*Dendroctonus ponderosae* Hopkins), and a changing environment (including climate change). Until relatively recently,

few seed collections had been made for the six high elevation white pine species, with only a limited number available for *ex situ* gene conservation. Seed collections are also required for studying neutral and adaptive genetic variation, including blister rust resistance. High mortality of *P. albicaulis* and *P. flexilis* from mountain pine beetle attack is occurring in several geographic areas (Schoettle and others 2008), and some *P. albicaulis* trees exhibiting rust resistance have already been lost in southern Oregon (Stubbs, personal communication; Jensen, personal communication). Seed collections or clone banking of these relatively rare parents can help preserve valuable material for future use.

Since 2000, interest in the high elevation species has increased and the USDA Forest Service successfully organized many additional seed collections for whitebark pine (coordinated by National Forest Systems & Forest Health Protection), limber pine (*P. flexilis*) and Rocky Mountain bristlecone pine (*P. aristata*) (coordinated by Rocky Mountain Research Station). In 2007 a USDA Forest Service national workshop on genetic conservation identified the nine white pine species native to the United States as a focal point for genetic conservation. Subsequent funding in 2008 and 2009 from Forest Health Protection and in-kind support from other branches of the Forest Service facilitated and accelerated several gene conservation activities, including individual tree seed collections of *Pinus albicaulis*, *P. aristata*, *P. balfouriana*, *P. flexilis*, *P. longaeva*, and *P. strobiformis* (table 1) and

Table 1. Individual tree and bulked seedlots collected in 2008 or 2009 as part of national gene conservation efforts for six high elevation white pine species.

Species		Area	Year	# Individual Tree Collections	# Bulk collections	# Sites
<i>P. albicaulis</i>	Whitebark pine	CA	2009	23	0	1
<i>P. albicaulis</i>	Whitebark pine	OR/WA	2009	276	0	33
<i>P. aristata</i>	Rocky Mountain bristlecone pine	CO	2008	95	9	9
<i>P. aristata</i>	Rocky Mountain bristlecone pine	CO	2009	79	5	5
<i>P. balfouriana</i>	Foxtail pine	CA	2009	44	0	2
<i>P. flexilis</i>	Limber pine	CA/NV	2009	46	0	2
<i>P. flexilis</i>	Limber pine	CO/WY	2008	44	6	7
<i>P. flexilis</i>	Limber pine	CO/WY/MT	2009	149	16	15
<i>P. longaeva</i>	Great Basin bristlecone pine	CA	2009	22	0	1
<i>P. longaeva</i>	Great Basin bristlecone pine	NV	2009	300	0	3
<i>P. strobiformis</i>	Southwestern white pine	NM	2008	54	0	3

maintenance of small clone banks for *ex situ* conservation for *P. albicaulis* and *P. flexilis*. For several of these species, these were the first or among the first-ever substantial collections of seedlots from individual trees.

Additional and higher levels of support for gene conservation in 2010 has significantly increased the total number of collections as well as the extent of the range of these species for which seed collections are available for *ex situ* conservation. For some species such as *P. aristata*, collections are now available for much of its range, while for *P. flexilis* and *P. albicaulis* (with much larger geographic ranges) there are more gaps. Two of these six species are also of concern in Canada and one of them in Mexico (Tomback and Achuff 2010), so information exchanges between the U.S., Canada and Mexico will help strengthen the gene conservation efforts. Such seed collections will provide long-term archiving of the genetic diversity of these white pine species and provide opportunities for new and continuing studies that will expand our understanding of the patterns of genetic variation in adaptive traits, including resistance to *C. ribicola*. Some larger bulked collections for restoration efforts have also been made.

Summary of 2008 & 2009 Gene Conservation Activities

The USDA Forest Service national gene conservation workshop in 2007 'Genetic Conservation of US Forest Trees Threatened by Invasive Insects and Pathogens' provided the impetus for a coordinated national gene conservation effort for the white pine species. Since the Workshop, Species

Profile Sheets (Genetics and Gene Conservation) have been completed for several of the white pine species and a range of activities have begun. These species profiles will be posted at one or more websites, including <http://www.fs.fed.us/rm/highellevationwhitepines/> and www.fs.fed.us/r6/dorena. These profiles are compiled by a number of different people and are intended to be dynamic documents that will be updated as new information becomes available. Contact Richard Sniezko (rsniezko@fs.fed.us) or Anna Schoettle (aschoettle@fs.fed.us) for more information or updated information for the species profiles.

The 'seed money' (~\$50,000/year) for gene conservation work in 2008 and 2009 was provided by Forest Health Protection (FHP). Most recipients were also able to leverage the FHP funds with other monetary and in-kind contributions. The gene conservation activities of 2008 and 2009 covered a range of species and locations (table 1). All groups submitting projects received at least partial funding in one or both years (including some work with eastern white pine, *P. strobus* L). The primary activity funded was cone collection, but clone bank maintenance and grafting tests were also included. Most collections were on Forest Service lands, but the Bureau of Land Management (BLM) has also chosen to participate and contribute seeds collected from their land. Additional seed collection efforts for these species or other white pines, funded through other avenues, are ongoing or have been started by the Forest Service, National Park Service, and Indian Nations. These efforts have primarily centered on evaluating white pine blister rust resistance or examining genetic variation in the species (table 2). It was fortunate that the species had a good cone crop in one or both years, greatly facilitating the collection of seed. The

Table 2. Current inventory of seedlots for six high elevation white pine species^a.

Species	Region or Province	# Individual Tree Collections	# Bulkied Collections	TOTAL # indiv tree collections
<i>P. albicaulis</i>	Alberta	163	10	2457
	British Columbia	263	5	
	Interior West-NFS	1,020	51	
	Pacific SW-NFS	201	2	
	Pacific NW-NFS	810	30	
<i>P. aristata</i>	Interior West-RMRS	341	29	341
	Interior West-NFS	0	2	
<i>P. balfouriana</i>	Pacific SW-NFS	166	-	166
<i>P. flexilis</i>	Alberta	180	28	1034
	British Columbia	0	3	
	Interior West-RMRS	786	44	
	Interior West-NFS	1	11	
	Pacific SW-NFS	67	2	
<i>P. longaeva</i>	Pacific SW-NFS	22	0	337
	Pacific SW-PSW	315	0	
<i>P. strobiformis</i>	Interior West-FHP	88	3	88

^a Numbers cited for each species represent information available via phone and email survey of programs, summer 2010. The amount of seed per seedlot varies and significant numbers of new collections are expected in 2010 or 2011 for several species. U.S. collections include seedlots from cooperators (Forest Service, National Parks, BLM, Tribes).

seed collections, to date, are an excellent beginning to the first nation-wide *ex situ* conservation program to safeguard the genetic resources of high elevation white pine species. The collections also provide an opportunity to learn more about adaptive genetic variation and blister rust resistance in these species. Some studies have already begun utilizing these collections (e.g., screening of *P. strobiformis* and *P. flexilis* families for resistance to blister rust); others are planned or awaiting funding. These collections will complement other seedlots collected on National Forest and other lands (BLM, National Park Service and Indian Nations).

The current plans for these collections include long-term gene conservation storage at the USDA's Agricultural Research Service National Center for Genetic Resources Preservation (ARS-NCGRP). Back-up and working Forest Service collection(s) will be retained by the collecting National Forest (usually at their regional forest genetics facility) or Research Station involved in the collection. Working collections may be used for gene conservation, blister rust resistance screening, and studies to examine genetic variation and the potential impacts of climate change, etc. Information on the collections will be entered into a central database.

The small prototype clone banks/orchards, such as the whitebark pine clone bank at Dorena GRC, will serve as an *ex situ* conservation resource as well as provide an area to more easily study the biology of the species, do control pollinations, and provide demonstration/education to schools and other groups interested in learning more about this species.

The extraordinary efforts put forth in the gene conservation work in just two years (2008 and 2009) have helped garner support for a significant increase in funds for gene conservation in 2010. These funds will bring about a significant increase in seed collections for several of the white pine species. There is potential for further funding in 2011. In addition to the U.S. efforts, additional collections of limber pine and whitebark pine are underway in 2010 in British Columbia and Alberta by government agencies there. Individual tree cone collections for gene conservation are anticipated for many areas in 2010 or 2011, including (partial listing): *P. albicaulis* (California, Oregon, Idaho, Montana, Wyoming, Washington, British Columbia, Alberta), *P. aristata* (Arizona, New Mexico, Colorado), *P. balfouriana* (California), *P. flexilis* (California, British Columbia, Alberta), and *P. longaeva* (California).

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