to the Nursery and stored in a cooler at 34°F until it was grafted on Sept. 28. Results of this opportunistic non-dormant or "hot" grafting trial are shown in Table 1 and surviving grafts are shown in Figure 1 (on back cover).

Table 1. Whitebark Pine Non-Dormant Scion Grafted 2 Weeks After Collection.

Area	Tree	Zone	Forest	Scion Collected	Scion Grafted	# Grafted	Live Grafts 10/9/2012	% Survival
Puzzle Hills	6171	INLA	FLHD	9/13/2011	9/28/2011	10	3	30%
Puzzle Hills	6172	INLA	FLHD	9/13/2011	9/28/2011	10	1	10%
Puzzle Hills	6173	INLA	FLHD	9/13/2011	9/28/2011	10	4	40%
Puzzle Hills	6174	INLA	FLHD	9/13/2011	9/28/2011	10	4	40%
Puzzle Hills	6972	INLA	FLHD	9/13/2011	9/28/2011	10	4	40%
Puzzle Hills	6175	INLA	FLHD	9/13/2011	9/28/2011	10	8	80%
Total						60	24	40%

While graft survival of green scion on green rootstock was only half as good as more dormant scion grafted to dormant rootstock, this small trial does show that viable grafts can be produced and cost savings would be tremendous if both cones and scion could be collected in one trip to remote trees.

In summary, the late winter dormant scion-dormant rootstock model of lower elevation conifers has been modified for propagation of whitebark pine. Scion collected as late in the fall as possible but prior to deep snowpacks is safer, less costly and production of viable grafts per rootstock grafted is similar to the late winter model. Grafting of non-dormant scion to non-dormant rootstock produced fewer viable grafts but this approach is an attractive option when both cones and scion need to be collected from the same tree. Since cones are usually caged, delaying the collection until later in the fall would provide more dormant scion and possibly better graft survival without jeopardizing the seed harvest. ■

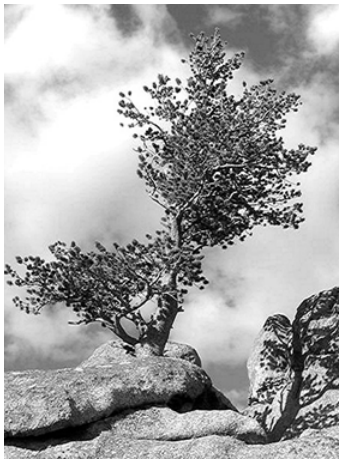

Photo by Erin Borgman

Limber Pine Conservation in Rocky Mountain National Park

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Limber pines are one of the most picturesque trees in Rocky Mountain National Park (RMNP). Growing in some of the park's most exposed rocky sites, the trees' gnarled trunks give testimony to fierce winds that buffet them in winter. Limber pines live to great ages, with some in the park exceeding 1,000 years. An especially photogenic stand of ancient trees defies the wind at Knife's Edge along Trail Ridge Road, and a remarkable old giant stands sentinel on the shore of Lake Haiyaha. Although the species occurs in small stands dominating only about 2,700 acres of the park, limber pine is an ecologically important tree and is the only white pine in the park. Clark's nutcrackers feed on and cache the seeds in the forest floor and the seeds are an important source of nutrition for bears and pine squirrels. The trees are also vital for watershed protection.

Limber pine within RMNP is currently declining due to an outbreak of mountain pine beetle (MPB) that started in 2003 in the lodgepole and expanded into limber pine in 2007. All large diameter limber pine are threatened by mountain pine beetle, and sadly most of the notable old giant limber pines along Knife's Edge are now dead. Also, in 2010 white pine blister rust (WPBR) was confirmed for the first time in the park. Past research has shown that limber pine is highly

susceptible to this disease, and as it becomes more prevalent we can expect high mortality of trees of all sizes.

Due to the combined effect of MPB with the threat of WPBR, the park considers limber pine a species of management concern. The joint impacts of MPB caused mortality on reproductive limber pines and WPBR mortality on susceptible young seedlings has the potential to severely compromise ecosystem resiliency and even could lead to the extirpation of limber pine within the park. Due to lessons learned from whitebark pine in the Northern Rockies, in 2008 the park in collaboration with the US Forest Service decided to take an adaptive proactive approach to managing limber pine (*see* Schoettle and Sniezko 2007, Burns et al. 2008, Keane and Schoettle 2011).

Seventeen limber pine sites in RMNP and 10 sites just outside the park serve as the sampling framework for the limber pine conservation project. Along the Front Range of northern Colorado, limber pine grows from the grassland treeline (lower timberline) up to the alpine treeline. To capture the full habitat diversity of the species, limber pine study areas were stratified by elevation, ranging from 8,300 to 11,300 ft. Almost all of the park sites are within designated wilderness and have been identified as resources at risk. For instance, when the Fern Lake wildland fire started within the park this fall, the incident command team was provided the location information of these areas so they can be protected if possible. Additionally, during fuels reduction operations, guidelines are provided to thinning crews to avoid cutting limber pine.

The focus of the limber pine project to date has been to protect the limber pine in the short-term and gather scientific data to develop a management strategy to sustain limber pine for the long-term. The efforts include: (1) *in situ* protection and *ex situ* conservation of limber pine and (2) research on the frequency of resistance to blister rust, regeneration dynamics and genecology for limber pine in and near the park. Some details of the on-going project are described below.

In situ protection of limber pine from MPB attack

Over 275 individual limber pines have been treated with verbenone at the 17 limber pine sites in the park since 2008. The trees are tagged and geo-referenced for relocation. Verbenone pouches are placed before and during beetle flight each summer. At the time of site establishment in 2008 approximately 40% of the sites had active MPB activity while 5 years later almost all sites had some level of activity. As of 2009, the proportion of non-treated limber pine being infested by MPB on these sites was similar to the proportion of other MPB-host trees being infested (Klutsch et al. 2011). Over the last five years, 15% of the verbenone-treated trees have experienced some MPB activity, ranging from unsuccessful pitch outs to mass attacks. Approximately 34% of treated trees within the stands with beetle activity have not experienced any fading of the crown to date. Only 5 trees treated with verbenone have died from MPB attack (1.8%). MPB pressure peaked and appears to be declining in limber pine in this area. The verbenone treatments are scheduled to continue in 2013.

Table 1

Mountain pine beetle activity summarized by year for limber pine trees treated with verbenone at 17 sites in RMNP. In 2008, 130 limber pine trees were treated and 277 trees were treated each year thereafter.

Year	Number of trees with beetle activity	Number of trees with *first-time* beetle activity	Number of trees with *repeat* beetle activity	Mortality
2008	8	8	-	-
2009	18	14	4	2
2010	21	11	10	1
2011	6	5	1	1
2012	9	3	6	1

E*x situ* seed conservation of limber pine

Target seed collections from each of 10 seed trees per limber pine site (a subset of the trees protected with verbenone) have been attempted since 2008. Cone production and seed yield varied among sites and years. Over 200 individual-tree seed collections have been made from the 17 limber pine sites in the park; bulk seed collections have also been made from each site. The additional 10 sites just outside the park on National Forest lands were also sampled to provide a more regional collection for a total of over 300 individual-tree and 26 bulk lot seed collections to date across all 27 study sites. The seeds are being used for research (see below) and are archived for gene conservation and future restoration efforts.

White pine blister rust resistance research

Paramount to the sustainability of limber pine populations in the presence of WPBR is genetic resistance to the disease. Estimates of the frequency of resistance in the populations provide baseline information from which to predict potential outcomes of WPBR invasion. To define the frequency of resistance in the Park and surrounding areas and to explore the geographic variation in those frequencies, rust resistance testing of progeny from 179 seed trees (121 from RMNP) and 26 population collections are

underway (see Schoettle et al. 2011). Select trees of high value to park visitors were also included in the testing. Early results indicate that resistance to WPBR occurs in RMNP limber pine populations and that the frequencies of resistance in the park are similar to those found in the greater northern Colorado landscape.

Understanding regeneration dynamics

Maintaining successful regeneration into the future will be critical for the recovery of limber pine after MPB and to sustain these populations after WPBR becomes more prevalent (Schoettle and Sniezko 2007). The regeneration dynamics of the species in different habitats is being explored across the 27 study sites. More intensive research in the Ouzel Fire of 1978 demonstrates that ample successful regeneration of limber pine in the park is possible (Coop and Schoettle 2009). The recent Cow Creek Fire (2010) and Fern Lake Fire (2012) burned habitat near several of our sites and will likely provide valuable regeneration opportunities for limber pine.

Genecology studies of limber pine

While the habitats differ among the study sites with elevation, it is not known to what extent the limber pine of RMNP are locally adapted to those habitats. A common garden study underway to test for genetic differentiation among sites will provide information to guide seed-transfer recommendations to avoid outplanting failure due to maladaptation.

In conclusion, over the coming year this information will be integrated to provide the science foundation to develop interventions to promote self sustaining limber pine ecosystems that have resilience to disturbances and genetic resistance to WPBR. The park is fully taking advantage of the opportunity to protect, conserve and learn from the limber pine ecosystems before they are impacted by WPBR to improve efforts to sustain these valued ecosystems into the future as they continue to face new challenges. In 2013, park staff working with the US Forest Service will develop a long-term sustainability plan for preserving limber pine in a rapidly changing environment due to climatic warming.

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Mapping Whitebark Pine at Crater Lake National Park

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Introduction

For future management decision support, it is necessary to first identify the baseline distribution of whitebark pine. Prior efforts to map whitebark pine at Crater Lake National Park were at a resolution too coarse to effectively measure changes in whitebark pine distribution and were unable to differentiate mountain hemlock (*Tsuga mertensiana*) from whitebark pine. Therefore, a collaborative project between the Institute for Natural Resources (INR) at Portland State