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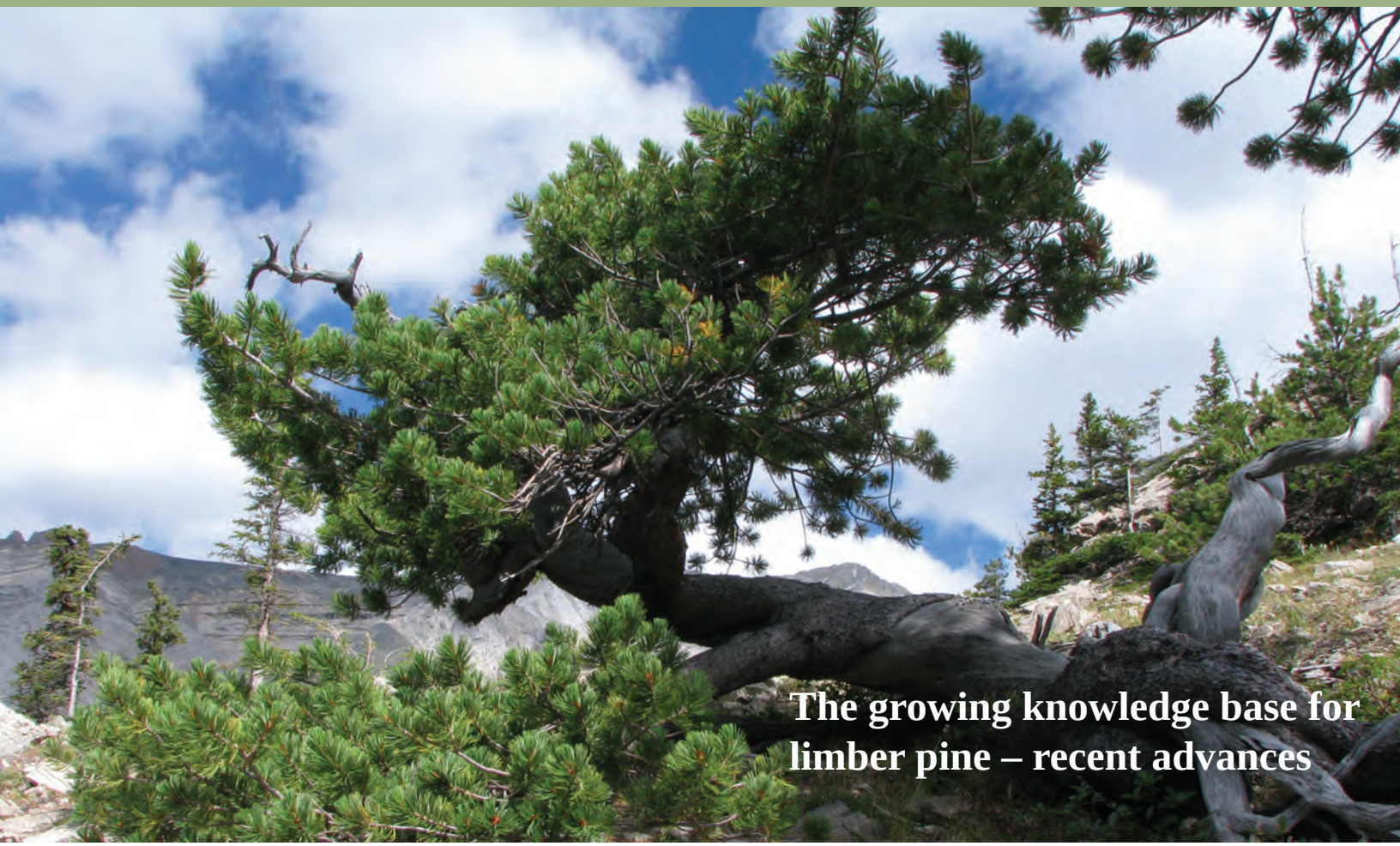

The growing knowledge base for limber pine – recent advances

By Anna W. Schoettle
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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.

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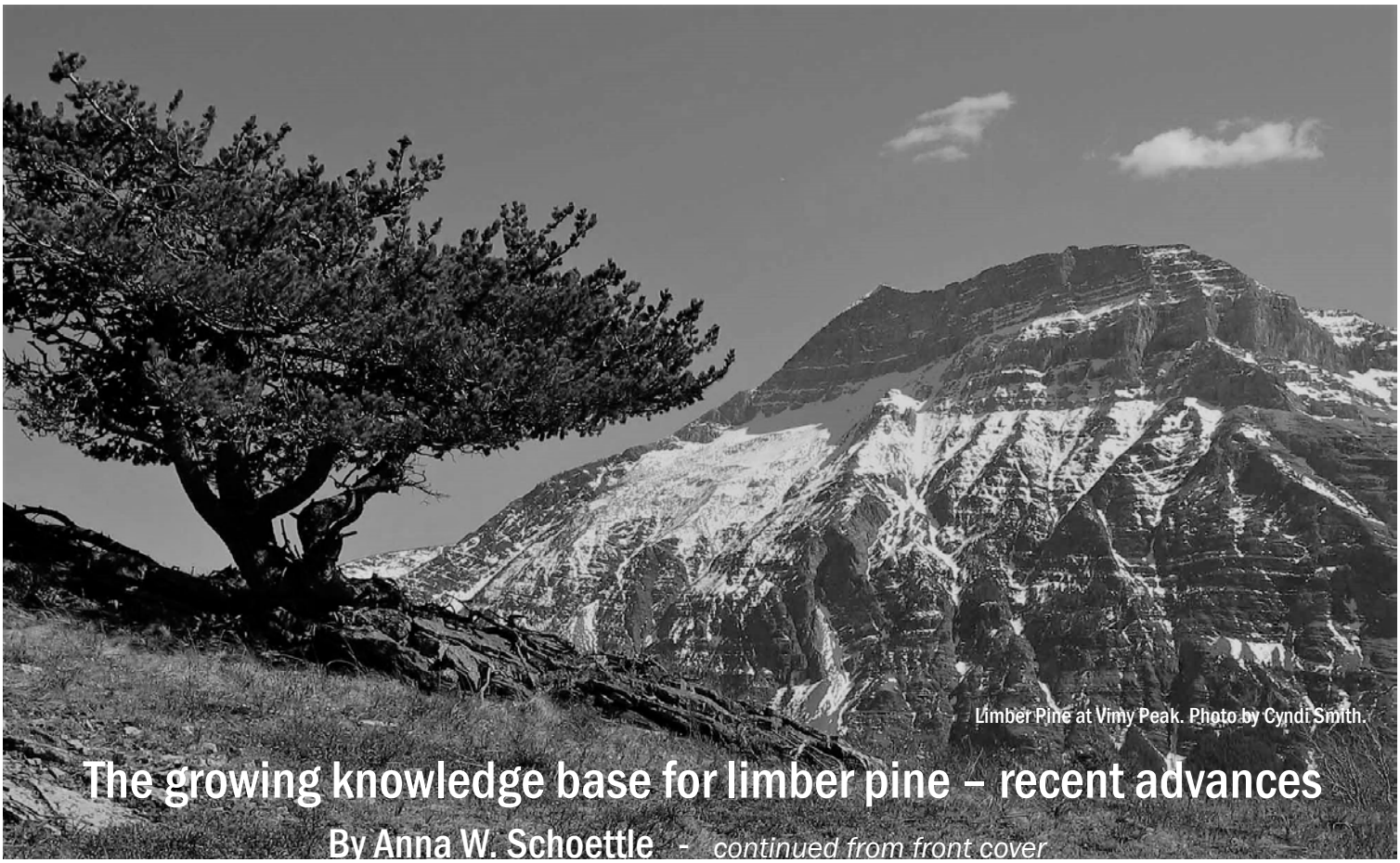

Limber Pine at Vimy Peak. Photo by Cyndi Smith.

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).

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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!***