Saving Our Trees and Forests through Resistance Breeding

BY RICHARD SNIEZKO

Some of our native tree species are under attack, and some face a perilous future. Forest pathogens and insects are causing high levels of damage or mortality that imperil the commercial viability of some species or the ecosystem function and biodiversity of our natural forests and urban forests. In many cases, the "villains" are non-native pathogens (and the associated diseases that they cause) or non-native insects; in other cases, a changing climate, change in forest management, or unknown factors have altered the balance in favor of a native pathogen or insect. Land managers around the world are facing these issues and are asking for solutions. A potential natural solution is to utilize the natural genetic variation in our native species to help counter the damage by these pathogens and insects.

Genetic variation within a species is a key to its potential to evolve in the face of biotic and abiotic threats, including threats caused by pathogens and insects in the cases where they can't be eradicated or controlled by other means. In the case of insect or disease threats, it generally comes down to genetic resistance of our native tree species and how we can use that resistance to keep forests healthy or restore unhealthy forests.

Basic questions arise such as:

(1) Is there genetic resistance?

(2) What is the level of resistance?

(3) What types of resistance are there?

(4) What is the frequency of resistance across the range of the species?

(5) Is the level of resistance sufficient for immediate use or will breeding be required?

(6) Is the resistance durable (will it last for decades or hundreds of years)?

(7) What is the timeline and effort needed to make use of the genetic resistance?

In the cases discussed here, we are looking only at resistance already present in our native species and the use of classical selective breeding, not the potential for genetically engineered resistance.

In the Pacific Northwest, white pine blister rust (caused by the fungus *Cronartium ribicola*) and Port-Orford-cedar root disease (caused by *Phytophthora lateralis* pathogen) are two of the most well-known examples of non-native forest tree diseases that have caused significant mortality in our forests. All eight species of five-needle pine native to the western US are highly susceptible to white pine blister rust (WPBR). Port-Orford-cedar is the only forest tree species currently known to be highly susceptible to *P. lateralis*. Damage to spruce by the native white pine weevil (*Pissodes strobi*) is a notable example of insect damage that greatly impairs the use of Sitka spruce and interior spruce in reforestation. Fortunately, there is some genetic variation in our native tree species and breeding programs are underway in the US and British Columbia.

Breeding programs to develop blister rust resistance in sugar pine and western white pine started more than 50 years ago by the US Forest Service (USFS), with more recent efforts in western white pine in British Columbia. There are USFS regional resistance programs for the Pacific Northwest, Pacific Southwest, and Interior West (with rust screening facilities at Dorena Genetic Resource Center in Cottage Grove, Coeur d'Alene Nursery, and Placerville Nursery).

In many areas, land managers are reluctant to plant these species without the availability of resistant seedling stock since greater than 95% of seedlings can be killed on sites of high incidence of blister rust. In the rust resistance programs, trees were selected across an array of land ownership, and seedling offspring of these parent trees were inoculated (infected) with the rust pathogen to identify parents and families with resistance. Seed orchards of resistant trees have been established by various groups including the USFS and Bureau of Land Management (BLM), as well as state, tribal, and private organizations. Recent data suggest the BLM Horning seed orchard, composed primarily of parents from the western Cascades area of northern Oregon and southern Washington, produces seedlings with the highest level of rust resistance in western white pine, suitable for planting in many areas of western Oregon

PHOTO COURTESY OF EVAN HECK

Controlled pollinations with western white pine at Washington State Department of Natural Resources' Meridian seed orchard. The full-sib seed produced in these pollinations will be used in blister rust resistance tests to provide advance-generation selections for rust resistance.

and Washington. In the Rocky Mountain Region, where western white pine forests once dominated moist, mid-elevation sites, landowners have been planting resistant seedlings for decades. Many of these stands are well stocked and are approaching harvest age, while others have succumbed to intense rust pressure or failed for other reasons. Additional cycles of resistance breeding are underway to further increase the level of resistance in the orchard seed available to forest managers.

In addition to breeding for rust resistance, the programs strive to maintain both genetic diversity and adaptability within the species, and the geographic range of each species is divided into breeding zones to help facilitate this. The product for reforestation is thus generally a genetically diverse mix of seed from orchards using many parent trees from the breeding zone to be planted. Field trials of the resistant seedlots play an important role. One notable series of field trials of western white pine seedlots established by the Washington State Department of Natural Resources and other partners and cooperators examines blister rust resistance as well as well as the adaptability of seedlots from different geographic areas on sites from Oregon to British Columbia. In addition, the field trials serve as sentinel plantings to monitor for other damaging agents and as demonstration plantings for conservation education.

Programs to develop blister rust resistance in whitebark pine started more recently, but are making great strides. Whitebark pine, a high-elevation conifer in western North America, is proposed for listing under the Endangered Species Act, with a decision expected in 2019. The identification of resistant parent trees and development of blister rust resistant populations would greatly facilitate success of restoration of the species. Restoration plantings of whitebark pine using rust resistant seedlings have been started on USFS and National Park lands, and genetic trials and conservation plantings on BLM, WA DNR and British Columbia Ministry of Forests, Lands and Natural Resource Operations lands. More limited resistance screening of the other five western species of white pines is underway.

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Breeding for resistance in Port-Orford-cedar containerized orchards.

Spruce is an important species for reforestation. The program to develop resistance to the white pine weevil is based in British Columbia. Seed is now available from orchards for both Sitka spruce and interior spruce, and an increased use of these species for reforestation has occurred. For interior spruce, over 40 million seedlings from orchard seed are being planted annually in Canada with an estimate of approximately 30% less weevil damage relative to unimproved (wild stand seedlots) stock in the areas of highest incidence of the weevil. Increased levels of resistance are anticipated as the orchard is rogued and new resistant parents are added.

Port-Orford-cedar is a conifer native to northern California and southwestern Oregon but has been grown horticulturally (often referred to as Lawson's cypress) in many places around the world. The root disease threatens not only the native stands of Port-Orford-cedar but also many of the horticultural plantings in both North America and Europe. The program to develop genetic resistance, based at Dorena Genetic Resource Center, is a joint endeavor of the USFS and BLM with technical assistance from Oregon State University and with cooperation from many land managers. The program is one of the fastest developing applied forest disease resistance programs in the world, and significant increases in resistance are available. The geographic range of the species has been divided into 13 breeding zones, and innovative containerized seed orchards are now producing resistant seed for many of these zones. Resistant seed is being used for reforestation and restoration on USFS, BLM, National Park Service, state, county, tribal, and private lands. Breeding is underway to increase the level of resistance further.

Resistance is not immunity. In most cases, only a percentage of seedlings from orchards will be resistant, and it varies by species. For resistance, success is a journey. The programs in the Pacific Northwest are world leaders in development of populations of trees with genetic resistance to diseases or insects. With a true integration of research, applied tree improvement, smart reforestation and restoration, and support of the public, the road to successfully maintaining these species in our forests continues and illuminates the pathway to follow as new invaders affect our forests. The future is sometimes cloudy, but resistance is an important tool in the path to future healthy forests. ◆

Richard Sniezko, an SAF member, is a geneticist for the US Forest Service Dorena Genetic Resource Center in Cottage Grove, Ore. He can be reached at 541-767-5716 or rsniezko@fs.fed.us.