Lessons Learned from the Inland West Whitebark Pine Genetics Restoration Program
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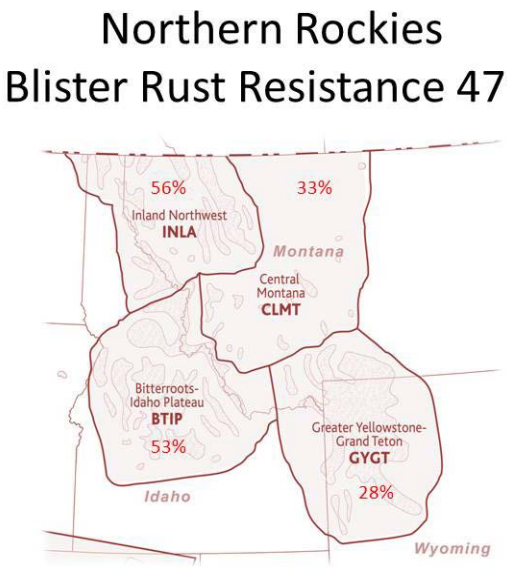
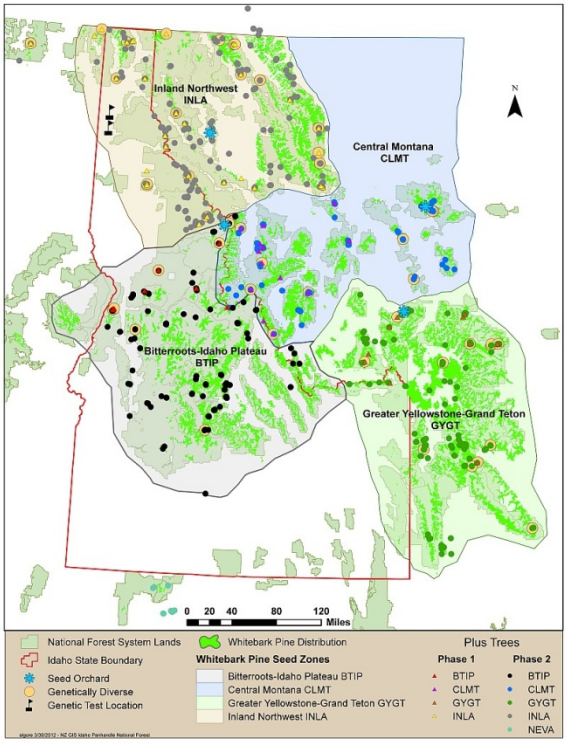
The genetic restoration program is made up a coalition involving three USFS Regions (Northern, Rocky Mountain, and Intermountain Regions) across 20 Forests, three National Parks, the Bureau of Land Management, and our Alberta neighbors to the north (Parks Canada and Alberta Tree Improvement and Seed Centre). We have the benefit of the western white pine blister rust resistance and restoration program to serve as a guide, affording us the opportunity to take one-third of the time to complete a generation of improvement. Studies in genecology, identifying and harnessing blister rust resistance, and molecular genetics yielded some surprising findings. Whitebark pine has a moderate level of blister rust resistance (47%), which is *higher* than comparable open-pollinated western white pine progeny (30%) evaluated in the 1950s. It is as genetically diverse as limber pine and aspen, exhibits no inbreeding, and has ample genetic variation in key adaptive traits, which have moderate to high heritabilities. Simply stated, whitebark pine can favorably respond to selection and breeding. Five-needle pines, including whitebark pine, are just a few conifers where patterns in adaptive traits (survival, blister rust resistance, late winter cold hardiness) closely track with patterns in neutral molecular markers (isozymes, mitochondrial and chloroplast DNA).



Integration of the results of these studies have provided valuable management direction: (1) blister rust resistant stock is available for planting, (2) provisional seed zones have been combined into four seed (breeding) zones, (3) no additional requirements are needed for operational cone collections or seed orchard designs, and (4) a comprehensive genetics profile highlights areas with high levels of rust resistance, cold hardiness and genetic diversity for gene conservation. Dunraven Pass, Yellowstone National Park, one of the most studied whitebark pine populations over the last 40 years, still boasts a high level of genetic diversity.

Our program as of 2011 is comprised of 115 Phase I and 1,110 Phase 2 selections. Since these plus trees were designated, 21% have been lost primarily due to mountain pine beetle and fire, with six total trees lost to blister rust, wind throw or prescribed fire. A tie for the oldest plus tree is between the Bridger-Teton NF and Grand Teton NP. The tallest tree (32 m) is on the Bridger-Teton NF and the largest diameter tree (170 cm) is on the Boise NF. The youngest plus tree (29 years) is on the Flathead NF. Our Alberta partners hold the records for the shortest, smallest diameter and only Krummholz plus trees. Identification of plus trees was not designed to assess age of onset for cone production, but it did reaffirm earlier findings that cone production begins as early as 20-30 years of age; 29% of the plus trees are under the age of 50.



The selective breeding strategy provides broadly adaptable, genetically diverse, blister rust resistant whitebark pine for restoration planting. The emphasis is on durable resistance where selection pressure in the host (whitebark pine) doesn't prompt a negative response in the pathogen (increased blister rust virulence). Past experience tells us we cannot erase blister rust off the landscape, so how does that relate to our strategy? We are still going to see spotting, branch flagging, and cankers in our genetically improved stock, as some rust resistance traits (bark reactions and canker tolerance) *require* infection and canker development before resistance genes can be expressed. Our goal is not immunity or rust-free trees-- neither are desirable or attainable. Rust resistance data also applies to current monitoring efforts. Using the Greater Yellowstone Ecosystem as an example, 20% blister rust infection does not equate to 20% susceptibility, as the frequency of bark reaction and canker tolerance traits (5.6%) needs to be deducted. Susceptibility in this example is 14.4%.

Characterizing progress in the program is assessed with two measures of gain. Expected gain is typically larger than realized gain, as it is calculated on the performance of seedlings planted in experiments designed to control environmental variation, such that the variation expressed can be attributed to genetics. Realized gain is a measure of the performance of genetically improved stock relative to control (woodsrun) lots grown under operational (field) conditions for half a life history or half rotation age. Using western white pine as an example, expected gain is 66% blister rust resistance in F_2 stock, whereas realized gain is around 20%, which is still remarkable in a first generation program of an undomesticated species. Said another way, I wish my bank account returned 20%. But back to whitebark pine, 47% blister rust resistance is *expected* gain.

This spring marks the beginning of our fifth rust screening, keeping the tree improvement staff hopping with four, concurrent rust screenings at Coeur d'Alene Nursery. Another big surprise in the Northern

Rockies was two masting events in 2009 and 2011. We broke our old record with 250 plus tree cone collections and over 555 lbs of operational seed received in 2011, the latter capable of restoring 3,556 acres.

We are just beginning to monitor natural regeneration, with federal and state sources reporting, "It's out there." Accomplishment reporting shows 3,004 acres have been planted with whitebark pine. What does that mean for wildlife? Prior to hibernation, if a hyperphagic grizzly bear consumes 200 pounds of food a day, that equates to 533,638 pine nuts. It was now time to check out the seed inventory. There is enough seed on hand to feed ***one*** bear for two weeks and that food bill exceeds my government purchasing authority. So while the natural and artificial regeneration matures over the next 20-30 years, bears will bulk up on pine nuts from the remaining cone-bearing whitebark and limber pines, false truffles and berries.

But not to be deterred, we have four seed orchards (one for each seed zone) at various stages of development. Since branches remember their position in the crown of the mother tree, 200-year old scion grafted onto four-year old rootstock has the potential to begin cone production 4-5 years after the graft is planted in an orchard. Once the diameter of the graft is over an inch, seed orchard managers can then begin to apply GA 4/7 to stimulate flowering, which will also help overcome cone crop periodicity. Cone production at more regular intervals, combined with accessible locations, will minimize the time and resources spent chasing cone crops across the landscape. Lastly, since there is genetic improvement on both the maternal (cone) and paternal (pollen) sides, we have the capacity to double our blister rust resistance in seed orchard stock. But as the grafts began to produce cones, we'll need to spend a little more time on wildlife-proof seed orchards. I suspect the only wildlife to be excluded and electrocuted will be the Regional Geneticist on a service visit…

For the Greater Yellowstone-Grand Teton seed zone, May 31, 2011 marked a major milestone in the release of the Whitebark Pine Strategy for the Greater Yellowstone Area, prepared by the Whitebark Pine Subcommittee of the Greater Yellowstone Coordinating Committee (GYCC). On April 17, 2012, GYCC Managers representing the USDA Forest Service, USDI National Parks and Bureau of Land Management, and the US Fish and Wildlife Service signed a Memorandum of Understanding for the joint development of the Little Bear seed orchard and a long-term genetic test.

Favorable biology, positive genetic attributes and a generalist adaptive strategy, combined with the energy, enthusiasm, and commitment among our partners, indicates we have the capacity to restore whitebark pine, maintain vital ecosystem processes and biodiversity, and provide critical wildlife habitat. Here's hoping for a good cone crop this field season!