Development of Cooperative Tree Improvement Programs in the Pacific Northwest

BY KEITH JS JAYAWICKRAMA AND TERRANCE Z YE

Keith JS Jayawickrama

Terrance Z Ye

The Pacific Northwest (PNW), similar to other forestry areas growing temperate conifers, has a long history of applied cooperative tree improvement. With multiple landowners typically managing forestland within a given geographic area, it has been logical to pool resources for the expensive, long-term endeavor of field testing and breeding. Tree improvement leadership was first provided in the PNW via the Industrial Forestry Association and the US Forest Service PNW Research Station (jointly coordinating the Progressive Tree Improvement System) from 1966 to 1985 and after 1986 by the Northwest Tree Improvement Cooperative (NWTIC).

Establishment of first-cycle Douglas-fir tests began in 1967 and continued to 1993. A typical first-cycle cooperative tested 200-300 trees selected at an intensity of about three trees per 1,000 acres on 6-10 test sites. Local adaptation was emphasized leading to small breeding zones. In addition to testing programs designed as cooperative programs, four independent programs (Bureau of Land Management, Georgia-Pacific, Simpson, Washington State Department of Natural Resources) came later under the NWTIC umbrella. About 1,000 first-cycle Douglas-fir tests were established, in which approximately 30,000 first-generation selections were tested. The earliest full-sib second cycle test was planted in 1984, but the rest were planted after 1996 with establishment scheduled to continue through 2022. Second-cycle Douglas-fir sites have been established from Skagit County in Washington near the Canadian border south to Curry and Douglas counties in Oregon (and eventually to the northwest tip of California).

Tree height was assessed from the first measurements around 1975, and diameter at breast height (DBH) from the first age-10 measurements. Stem defect (forking, ramicorns, and stem sinuosity) and wood density were routinely assessed from the early 1990s after those traits were shown to be heritable and measurement protocols established. Three additional traits (spring budbreak, second flushing, and fall cold hardiness) are now being scored in second-cycle tests. Needle retention is assessed in the area of the northwest Oregon coast exposed to Swiss needle cast disease. Non-destructive acoustic tools for assessing wood stiffness in tree improvement became available around 2005, and so far about 32,000 trees have been assessed. Other traits (e.g., drought damage, top break) are assessed in certain tests.

PHOTO COURTESY OF CASCADE TIMBER CONSULTING

Genetic gain demonstration from a second-cycle test showing row plantings of a good cross, a cross near the population mean, and woodsrun seedlings. Both height poles are set at the same height.

Third-cycle breeding orchards were established starting in 2006. All the second-cycle cooperatives decided to proceed to third-cycle breeding and testing. Compared to a delay of 20-34 years from the start of individual first-cycle programs to establishment of second-cycle tests, the goal is to establish third-cycle tests within 15-20 years after second-cycle tests were planted. The first group of third-cycle tests was established in March 2017 on six sites on the Oregon coast.

Breeding and testing of western hemlock has been essentially a small-scale version of the Douglas-fir effort. First-cycle testing began in 1975, and a second-cycle program for the coastal strip of Oregon, Washington, and southwest British Columbia started in 1992. Age-10 data collection for all these second-cycle sites, testing 539 full-sib crosses, was completed by 2009-10. Third-cycle breeding is underway. There was also a small first-cycle testing program for noble fir.

Cooperative seed orchards play a vital role in advancing tree improvement. Many cooperators have too small an annual seed need to justify establishing their own seed orchard; other larger entities do not wish to add a specialized task such as seed orchard management, plus specialized staff, facilities, and equipment, to their forestry operation. Since seed production takes 8-15 years and can be affected by many factors (rainfall, soil type, incidence of frost, precipitation), it is often far safer to co-locate an orchard block on a known successful operation than take chances on an unproven piece of ground. Economies of scale also make concentrating seed production on a few productive sites more efficient. The Oregon Department of Forestry and the Bureau of Land Management have been the main hosts of cooperative seed orchards.

Based on responses from an NWTIC survey, the number of forest tree seedlings planted in western Oregon and Washington originating from tree improvement programs in 2017 (coastal DF, hemlock, ponderosa pine, noble fir, and western redcedar) stood at about 65.2 million with about 10.0 million woodsrun trees planted. The 2017 species summary (in millions) was 61.7 Douglas-fir, 7.9 western hemlock, 2.1 noble fir, 2.4 ponderosa pine, and 1.2 western redcedar.

NWTIC has a strong interest in realistic rotation-age estimates of realized gain in operational conditions, and as a result are investing heavily in establishing gain trials. Age-20 data have been obtained from the oldest realized genetic gain trial (Molalla, planted 1997), with the elite treatment showing 19.6% superiority over woodsrun in volume per acre at a tighter spacing. In the younger trial (Grays Harbor, planted 2005 and 2006), the best performing full-sib cross had age-9 realized gains of 19.9%, 20.3%, and 62.3%, respectively, for height, DBH and volume, based on 480 progeny planted on six sites. Second-cycle realized gain trials are currently being established for Douglas-fir and western hemlock.

NWTIC is an umbrella unit providing specialized, highly technical services that would be expensive and inefficient for each cooperator or regional cooperative to provide on their own. Data analysis is the most vital of those services, and includes advanced Best Linear Unbiased Prediction analyses, which has made it possible to provide predicted genetic gains and combine data across breeding zones or across generations. Detailed reports are provided that explain, visualize, and interpret the results.

Computer simulation and data resampling are routinely conducted for seeking optimal breeding strategies. Management of tree improvement data is also important: a very large number of records (including information on 3.38 million first-generation and 0.67 million second-cycle progeny) are now housed in an SQL Server database with a Microsoft Access interface.

Since 2001, NWTIC has aided the establishment/upgrading of high-gain 1.5-generation or second-generation production orchards, and has provided candidate selection lists for most of them. This impacts a substantial amount of current and future reforestation in western Oregon, Washington, and California. NWTIC faculty have been first authors or co-authors on 22 peer-reviewed publications and 40 conference and meeting presentations or other reports since 2000. NWTIC has also organized or helped organize workshops and short courses to take relevant, practical, technical information and make it accessible to busy practitioners in tree improvement and forestry. Finally, the NWTIC routinely pools resources with other university-based cooperatives to address questions important to plantation forestry in the region. For example, NWTIC, in collaboration with the Pacific Northwest Tree Improvement Research Cooperative, has initiated a genomic selection project on Douglas-fir; the preliminary results are promising.

Looking to the future, the next decade will see emphasis on establishing third-cycle progeny sites. We can anticipate some increase in species diversification, with recent interest in noble fir and western redcedar. Cooperatives will need to adapt to rapid changes in land ownership, which are generally disruptive to long-term projects; we look to find new participants for cooperative work—especially stable landowners with a strong stake in long-term forest health, productivity, and value improvement. To the extent supported by data, it will be possible to consolidate breeding zones and make them more efficient, increasing gain per unit cost and time. ◆

Keith JS Jayawickrama is director of the NWTIC at the College of Forestry, Oregon State University, Corvallis, while Terrance Z Ye is quantitative geneticist for the NWTIC. Keith can be reached at 541-737-8432 or keith.jayawickrama@oregonstate.edu. Terrance can be reached at 541-737-9881 or terrance.ye@oregonstate.edu.