

Cooperative Advanced-Generation Breeding and Testing of Coastal Douglas-fir and Western Hemlock – Strategy And Implementation

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FIRST-GENERATION TESTING OF DOUGLAS-FIR

As in many temperate regions of the world, forest tree improvement got underway in the Pacific Northwest of the USA in the 1950s, with a number of companies and agencies starting independent tree improvement programs. Booth-Kelly Lumber Co., Crown Zellerbach Corp., the Industrial Forestry Association, Port Blakely Mill Co., Simpson Timber Co., Timber Service Co., the US Forest Service, and Weyerhaeuser Co. were among the first to select coastal Douglas-fir trees and graft them into clonal orchards. Graft incompatibility, both immediate and delayed, became evident by the early 1960s and dampened enthusiasm for grafted clonal orchards for this species (Silen and Copes 1972). The problem of graft incompatibility was eventually greatly reduced due to work done by Don Copes of the PNW Research Station, but by that time it had played an important role in shaping tree improvement in the region.

The IFA-PNW “Progressive Tree Improvement System” was launched in 1966 due to the failure of grafted clonal orchards (Silen 1966, Silen and Wheat 1979). The emphasis here was on forming local cooperatives to share costs, and on progeny testing large numbers of trees using wind-pollinated seed in small testing zones. Silen and others felt that due to steep variation in environmental factors (e.g. temperature) caused by the mountainous topography of the Pacific Northwest, it was not appropriate to move Douglas-fir seed far from the source. Improved seed was to be delivered from seed orchards established using full-sib crosses made on the parent trees.

The first-generation testing phase ran from 1967 till 1993, during which over 28,000 first-generation Douglas-fir and western hemlock parents were tested in 115 breeding units, with over 3 million progeny test trees planted. The typical measurement schedule was five, 10 and 15 years from seed. Height was usually measured on each occasion, while diameter was usually measured at age 15 and sometimes at age 10 as well. The incidence of ramicorn branches, forks and stem sinuosity was assessed in some of the later testing programs, as information was collected on the inheritance of these traits (e.g. Adams and Howe 1985, Temel and Adams 2000).

ADVANCED-GENERATION BREEDING AND TESTING

Data from the first-generation tests were used to draw several conclusions relevant to advanced-generation breeding and testing; other decisions were based on computer simulation and inferences from other breeding programs (Johnson 1997, 1998a, 1998b; Johnson et al. 1997). It was recognized that full-sib breeding had several advantages over open-pollinated breeding. It appeared that there would be little marginal gain per test beyond six successful progeny tests (in terms of ranking families), that two or three crosses would give a reasonable estimate of a

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parent's GCA, and that final selection around age 12 years would be efficient. An advanced-generation breeding and testing strategy for coastal Douglas-fir was developed between 1996 and 1997.

Implementation of the advanced-generation testing program has been fairly similar to the proposed strategy, although there have been some deviations. First-generation testing programs have been merged in the north-south direction into larger *testing zones* to share genetic material. To date, 52 first-generation programs have been consolidated into 8 second-generation breeding programs. The emphasis has been on low to mid-elevation lands (up to 3,000 feet). While there were several first-generation programs above 3,000 feet, it appears that the limited advanced-generation progeny-testing dollars now available should be concentrated on the most productive timberlands.

Breeding population size for a second-generation program is at least 200 selections, but most are greater than 300. Within a breeding population, *breeding groups* of 20-30 selections were constructed, each breeding group was from a single first-generation program. This resulted in sublimes to manage inbreeding, and multiple populations to maintain locally adapted gene complexes. The rule of thumb in choosing second-cycle selections has been a 1 in 10 among-family selection intensity. Most selections were made on age-15 height; information on DBH, stem form and wood specific gravity were also considered. The top 10 percent of selections within a breeding population were assigned to an *elite population*.

The breeding population for each new testing zone includes families/selections from the "local" breeding groups that come from the testing zone, and only the highest-ranked selections from breeding groups originating further away from the testing zone. Each selection is used in at least two crosses, with elite selections being used in up to four crosses. Some of the elite crosses are made across first-generation zones. Unimproved checklots have been included in all tests planted after 2001. Two types of tests have been used: family-ranking/selection tests and longer-term stability tests which are thinnable. Some second-generation programs may implement adaptability-screening tests (probably by collecting tissue samples from field tests and evaluating them in laboratory tests).

In total, the Douglas-fir breeding effort will be comprised of over 2,600 crosses (80% have been completed), 95 tests (41 have been established) and about 300,000 test trees planted. Thus the total number of trees will be around 10% of the trees planted in the first generation; this is similar to the reduction of number of test trees in the CFGRP slash pine program (White et al. 2003). Between five and six tests are established per testing zone, with 20 trees per cross per site in single-tree plots.

Trials established to date have contained from 143 to 283 full-sib crosses, planted as containerized seedlings and fenced for protection against browse. When crosses of a given program are planted in two Phases, the separate Phases are linked by at least 10 common linker crosses. The goal is to keep the tests weed-free for three years after planting, and control harmful competitors (such as aggressive hardwoods) until crown closure. Tests will probably be measured twice, when the trees are 15 and 30 feet (4.5 and 9 meters) tall respectively. This may

take only five and 10 years from planting on the most mesic southern sites, in contrast to seven and 13 years on colder, mid-elevation, northern sites.

WESTERN HEMLOCK

Western hemlock is a prolific and dominant species in the coastal forests of the Pacific Northwest. First-generation testing got underway in the 1970s, but interest in this species increased markedly after growing incidence of Swiss Needle Cast disease on Douglas-fir on the Oregon Coast, and the white pine weevil on Sitka spruce from Oregon to Alaska. A single advanced-generation testing zone has been developed for western hemlock, from the middle on the Oregon coast (44° 30') to northern Vancouver Island (51°). The parental selections (no forward selections) come from six first-generation programs, selected on age-10 height. The main population has 150 parents (chosen from over 1,500 parents) crossed in six-parent disconnected diallels forming 342 crosses. The elite population of 30 parents has 166 crosses (Jayawickrama 2003). Over 130,000 test trees were planted between 1997 and 2001 in single-tree plot tests and in family blocks. Age-5 heights for all these trees are to be collected by the end of 2004.

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