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Canadian Forest Service

CANADIAN WOOD FIBRE CENTRE

Fibre Fact nº 25

Real world tree breeding: growth and yield projections are met or exceeded in Douglas-fir

(Photo credit: M. Isaac-Renton).

Tree breeding allows forest professionals to grow stock with increased growth potential, disease resistance, or desirable wood qualities. However, to increase confidence in genetic selection (tree improvement) programs, performance must be validated under 'real world' conditions. Researchers conducted a study to confirm stand volume projections from growth and yield models using genetically selected Douglas-fir tree data. Evidence showed that growth and yield projections are met or exceeded across multiple sites and planting densities, highlighting the reliability of genetic selection systems used in tree improvement programs. Researchers were able to outline optimal genetic gains in volume with minimal losses in wood quality.

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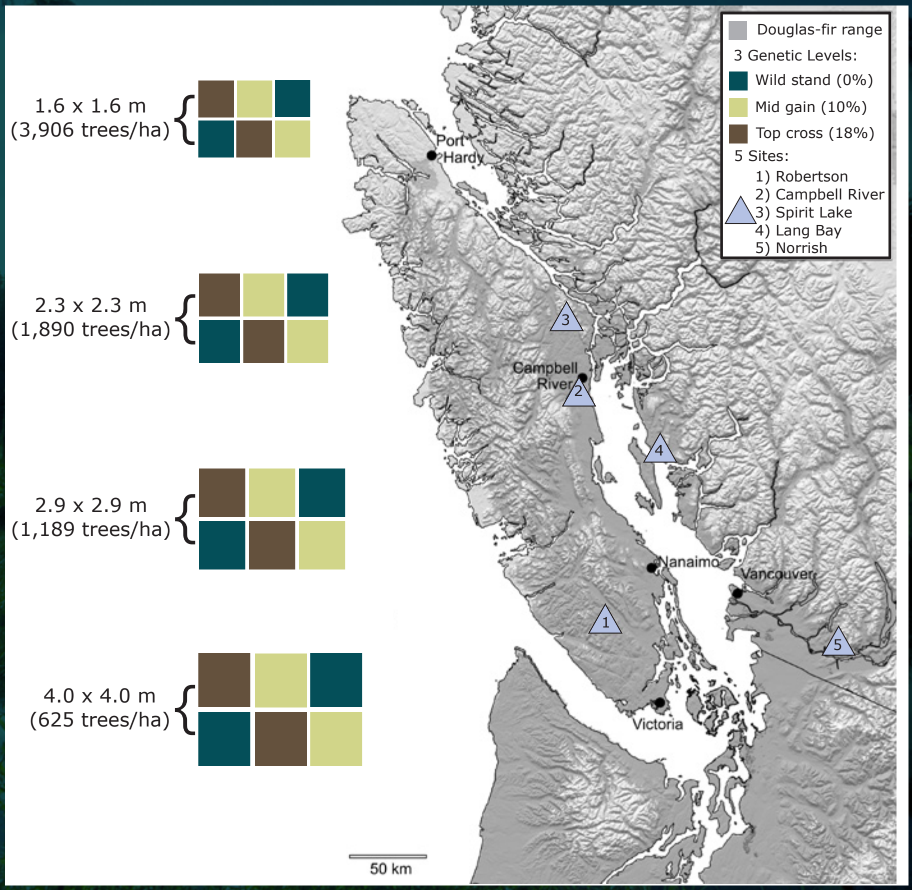

Figure 1: Experimental design including site location and plot density.

Seed Selection

Selecting the most appropriate seed sources for planting after harvesting is one of the most important decisions a forest professional can make to maintain long-term forest health and productivity. Since the 1960s, selecting trees based on naturally-occurring genetic variation, known as tree improvement or "genetic selection" has played an increasingly important role in reforestation in British Columbia. Seedlings planted from breeding and seed orchard programs offer many advantages over wild stock; namely, they can increase resilience against climate-change related impacts, return the landscape to a forested state more efficiently and reliably, reduce rotation times, and increase economic gains when widely planted. However, the main data sets used to track the superiority of selected trees over wild stock come from progeny trials, which are planted in ideal field sites without a wide range of site quality and spacing that are found in 'real-world' conditions.

A provincial-federal team of researchers from the Canadian Wood Fibre Centre and the Province of British Columbia (Ministry of Forests) analyzed 20-year-old realized-gain trials for coastal Douglas-fir across five sites in British Columbia, representing a range of site qualities (Figure 1). The source population of these trees were natural stands in the breeding region and north-western Washington. The analyses were done on 12,000 trees across two factors: genetic gain level and planting density. Multiple growth (e.g., height, diameter, volume), survival, and wood quality (e.g., density, resistance) variables were also assessed.

The objectives for the researchers were firstly to observe whether predicted stand level productivity materialized as expected after 20 years. Secondly, to determine whether trees selected for volume gain show declines in wood and stem quality – and if so, whether they can be effectively managed by altering planting densities. The conclusions based on long-term trial data, offer important management implications on the reliability of genetic selection systems across a range of sites and subsequent optimization in volume gains.

Results

Across all sites, average stem volume gain per tree after 20 growing seasons was 29.3% and 21.7% higher in the top-cross and mid-gain trees, respectively, when compared to non-selected wild-stand controls (Figure 2). Additionally, volume per hectare increased with higher planting density. However, the genetic gains relative to wild-stand controls varied.

Averaged across all sites, at medium and high planting densities, there was more observed volume per hectare of wood for top-cross and mid-gain compared to non-selected wild-stand controls. Observed volumes after 20 growing seasons were also higher than projections from expected volumes based on growth and yield modeling (Figure 3).

Large gains in stem-volume growth were associated with relatively minor reductions in wood quality (Figure 4). The lowest wood quality came from plots with the lowest initial planting density (625 stems per hectare).

The average survival rate was 92% and was relatively consistent across genetic classes and stand spacing within normal operational planting densities.

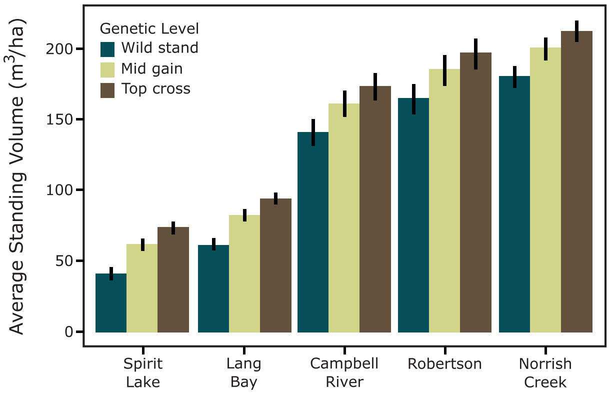

Figure 2: Measured standing volume after 20 growing seasons by site and genetic gain level.

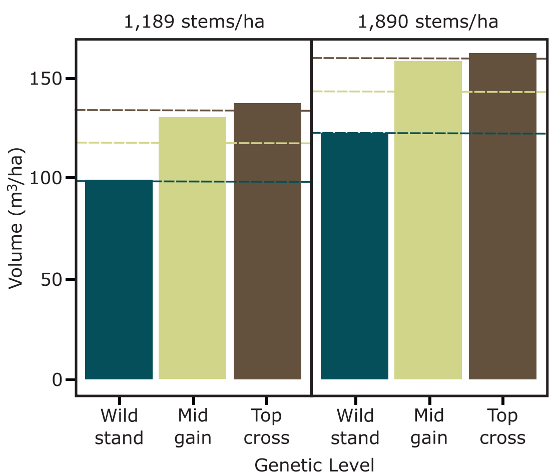

Figure 3: Data are averaged over five sites and shown for the two operational stand densities. The dashed lines represent what would have been expected after 20 growing seasons according to the growth and yield model that accounts for genetic worth. The bars refer to the actual measurements after 20 growing seasons.

Figure 4: In-field wood quality measurements being taken. (Photo credit: M. Isaac-Renton).

Management Implications

The study supports high confidence in genetic selection programs. The increase in volume realized in these trials met or exceeded estimates from growth and yield model values when averaged across a range of site conditions. Furthermore, the increases in wood volume observed with improved planting stock do not come at the expense of decreasing wood quality, within the operational planting densities of 1,100 to 1,800 trees per hectare. This is crucial for sustainable forest management since growth and yield models incorporating genetic gain estimates are used to establish provincial harvest rates.

Collectively, the results of this study have important implications for management. Genetic selection has the potential to deliver higher gains than initially predicted based on traditional estimation, suggesting increased mitigation potential for pests, higher tolerance for drought or greater harvests than anticipated. Increased volume per hectare can potentially allow more area to be set aside for non-timber objectives, such as maintaining old-growth forests, protecting water quality, or increasing recreational value.

(Photo Credit: M. Isaac-Renton).

For more information (reference):

Isaac-Renton, M., Stoehr, M., Bealle Statland, C., and Woods, J. 2020. Tree breeding and silviculture: Douglas-fir volume gains with minimal wood quality loss under variable planting densities. Forest Ecology and Management 465 (2020): 118094.

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AUTHORS:

Dasvinder Kambo,
Canadian Wood Fibre Centre

Jack Woods,
SelectSeed Ltd.

Michael Stoehr,
Canadian Wood Fibre Centre

Catherine Bealle Statland,
Ministry of Forests, BC

Miriam Isaac-Renton,
Canadian Wood Fibre Centre

CWFC CONTACT PERSON:

Anthony Bourgoin
Forest Program and Project Coordinator
Canadian Wood Fibre Centre
fibrecentre@nrcan-rncan.gc.ca

cwfc.nrcan.gc.ca

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