Choosing traits for genetic selection: economic and technical considerations

The objective of tree improvement is to select, produce, and deploy seed (or cuttings) with the genetic potential for greater economic value in a planted stand and acceptable levels of genetic diversity. This simple concept becomes complex as tree breeders attempt to choose traits and select for more than one trait.

When choosing traits for genetic selection, fast growth, straight stems, and fine branching are often a priority, as they influence timber production and saw-log value. Wood-quality traits are often of interest because wood density and fiber length influence board strength, while micro-fibril angle impacts longitudinal shrinkage and warping when drying. Other wood traits might include extractive content to increase rot resistance in a species like western redcedar, or reducing lignin content for more efficient pulping. Moreover, pest resistance is of primary importance for species like western white pine (blister rust), or Sitka spruce (terminal leader weevil).

Photos

Top: Second-growth Douglas-fir logs.

Left: Sitka spruce leader weevil attack.

Right: Good stem form in a third-rotation Douglas-fir plantation on Vancouver Island.

(J. Woods, J. King)

A difficulty arises when considering different potential products. While wood density is an asset for lumber and some types of pulping, it can reduce value for other pulp and paper products due to thicker cell walls. Similarly, increasing extractive content may benefit western redcedar lumber quality for exterior uses, but reduce value for some types of fine-fiber pulp.

A biological limitation faced by tree breeders is the ability to simultaneously advance the genetic quality of multiple traits. This limit is driven by the genetic correlation among traits. For example, in many species diameter growth rate and wood density have a negative genetic correlation in the range of 0.6 (0.0 = no correlation and 1.0 = complete correlation). This implies that selecting trees for fast growth will result in a reduced genetic potential for wood density. Because this correlation is < 1.0, there are opportunities to select and increase value for both traits, but gains in stem growth are slowed when wood density is also improved.

In BC, tree breeders conduct research to understand the genetic correlations among commercially important traits. Knowing these correlations is key to selecting trees with the greatest potential to add value in planted stands. Another important consideration is the relative economic value of different traits. For example, what is the worth of greater volume production relative to an increase in wood density, resistance to a pest, or a straighter stem? Answering these questions is difficult as there are many product types, product values change over time, and some traits are

better controlled through silvicultural management of a stand (i.e. branch size can be reduced by managing for more stems per hectare).

In addition, engineering solutions at the product conversion stage may be more effective than breeding solutions for some traits. Predicting both future product type and future conversion technologies is highly speculative.

So why not select for all traits of value at the same time? This is where the genetic correlations among traits become important. In general, when selecting for more traits less genetic gain is made on any single trait. Tree breeders often solve this complex biological, economic, and silvicultural problem by using a selection index that mathematically combines available information on genetic correlations, economic values, and on the inherent degree to which a trait is passed along to its offspring (heritability), to guide tree selection.

The unfortunate reality of all breeding, whether for trees, agricultural crops, or horses, is that it's very difficult to improve more than two or three traits simultaneously. As a result, tree breeders focus on key traits of known importance and seek to understand the limitations. In BC, all programs focus on increasing the genetic potential for timber production on a per hectare basis through selection on growth rate or pest resistance. Other traits are given consideration on a species-by-species basis with the intent of maximizing future value.

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