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Deriving Internal Crown Geometric Features of Douglas-fir from LiDAR in Tree Improvement Programs

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Trees are very important for the economy of British Columbia. The forestry industry contributes billions of dollars to the provincial GDP, and accounts for more than 30% of all provincial exports. As a result, scientists have been using tree breeding programs to develop high yield seed sources. These programs don't just grow bigger trees, but also help to maintain genetic diversity and develop sustainable plantation forests. Douglas-fir is one of the most important species commercially in the Pacific Northwest, and has been bred to have increased volume over several generations. While these programs have been very successful, little is known about **HOW** these trees are different.

My work looks at describing the structural differences between wild trees, and those that have been genetically improved. In order to increase stem volume, programs aim to change gene frequencies for a few key traits. In Douglas-fir, this means selecting for increased height and increased diameter at breast height.

Currently, these measurements are expensive and labour intensive, and time consuming, without being particularly informative. Remote sensing can address several of these limitations, as well as supplement the tree improvement process. LiDAR is an active remote sensing technology that produces 3-dimensional point clouds which allows to measure trees and go beyond the simple ground measurements. The 3D point clouds allow us to describe the vertical complexity of the crown.

In my study, we look at the utility of LiDAR to produce metrics that describe branch attributes, such as branch length, branch angle, and branch volume, using a point clustering approach. These attributes were chosen as they influence on wood quality. We then tested whether these attributes showed differences among trees with different genetic improvement levels, planted at different spacings.

We found that at the wide spacings, the top trees were indeed different from those that were unimproved. However, these differences dissipated as spacing was decreased. We also found out that our measurements matched up well with manually measurements for branch angle. Which is encouraging as we try to build links between genetic improvement, and how this manifests in nature.

These data collection technologies increase the flexibility of how and when we can collect data as well as decrease the cost. Technological improvements also mean that these trees can now be analyzed at a higher resolution than was previously possible.

The data collection techniques and analysis described here can be integrated into large-scale programs and can help us not only monitor trees, but also potentially find new trees that display the attributes associated with those larger volumes, thereby increasing the value of the plant forests in British Columbia.