



CWFC Facts 016

Canadian Wood Fibre Centre

Fibre Facts

Predicting Wood Quantity and Quality Attributes Using Airborne Laser Scanning

The Newfoundland Enhanced Fibre Inventory Project is a multi-stakeholder initiative whose objective is to maximize the value of Newfoundland's fibre resources through the development of an enhanced inventory of forest fibre attributes. Researchers are using innovative approaches and developing new techniques that will enable woodland managers to better predict forest structure and fibre attributes. Knowledge gained from this research will improve the competitiveness of the forest industry.

Forest inventory in Canada over the past half century has relied mainly on aerial photographic interpretation and field sampling to supply estimates on the inventory of wood products. Although this method provides reasonable estimates of wood volume, more precise information on tree- and stand-level structure is important for habitat and biodiversity studies, whereas attributes related to the quality of wood fibre are needed to expand the economic benefits from wood raw material. Research carried out over the past decade using airborne laser scanner (ALS) data is transforming the way forest inventory is done and is providing land managers with a more detailed and accurate inventory of the forest resource.

The bulk of ALS-based forest inventory to date has focussed on modelling relationships between ALS data and attributes related to stand structure to provide volume estimates of

raw wood materials. Common variables of interest have included mean tree height, mean diameter at breast height (DBH), and timber volumes. However, very limited research has examined the use of ALS technology to map the attributes that relate to fibre quality. The research conducted under the Newfoundland Enhanced Inventory Project is of particular importance because, in addition to modeling attributes relating to stand structure, the project also used ALS data to model attributes relating to the quality of the fibre.

A team led by Joan Luther, research scientist with Natural Resources Canada's Canadian Forest Service, used ALS data to develop models that predict the attributes of forest structure and fibre quality for the two main tree species in Newfoundland: balsam fir (*Abies balsamea*) and black spruce (*Picea mariana*). The ALS data used for the study had a pulse density of 1 to 4 points per m² with up to four returns being recorded for every pulse. The surveyed area consisted of sample plot transects to support model development and a series of parallel transects which covered around 106 000 hectares representing about 1.2% of the commercial forest area of Newfoundland. Once collected, the ALS data were calibrated and the data were tiled, aligned, cleaned and classified as ground and non-ground laser returns and by single, second, third, and last return. Further processing produced digital terrain models (DTM), digital surface models (DSM), canopy height models (CHM), and a suite of other stand metrics that were used in the development of the models.



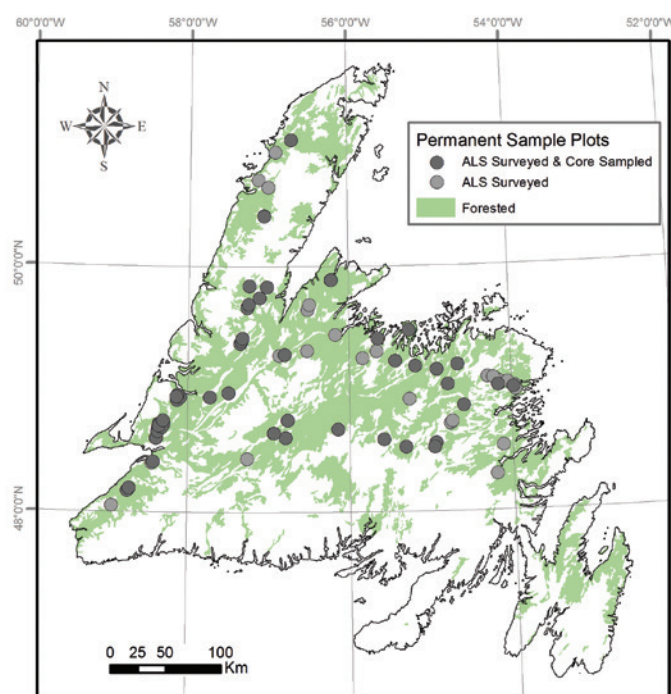


Figure 1. Sample plot locations used to model forest attributes.

Data from permanent sample plots (PSPs) representing balsam fir- and black spruce-dominated stand types were acquired from the forest management service of Newfoundland and Labrador. These plots were representative of the range of species, height, crown density and site quality classes for the merchantable forest of Newfoundland. Information from these PSPs was used in the development of the stand structure models. Wood core samples taken from trees adjacent to these PSPs were collected and processed using a combination of analysis techniques and used to determine the fibre attributes (fibre length, wood density, radial and tangential diameter, coarseness, microfibril angle, modulus of elasticity, wall thickness, and specific surface) of the trees in the plots.

Forest Structure Attributes

The models developed by Luther *et al.* rely on statistically-based relationships between the distribution of ALS points and the corresponding data acquired from ground plots. The models were highly significant ($P < 0.0001$) with excellent correlations between the observed values (plot measurements) and the predicted results (ALS-based models). The models were effective in predicting forest structure

attributes such as quadratic mean diameter, height (average and dominant), stem density, total volume, gross merchantable volume, basal area, and biomass and were able to explain 52–90 % of the variation in these forest structure attributes.

Fibre Quality Attributes

Unlike stand structure attributes, the relationships for predicting fibre attributes are indirect and depend on the strength of the links between forest structure and fibre attributes and related environmental variables. Consequently, the models were weaker than those used to predict stand structure. Nonetheless, most models were significant ($P < 0.05$) explaining 18–53 % of the variation in fibre attributes. The relationships between the observed values (core samples) and predicted results (ALS-based models) were better than expected.

The findings of the Newfoundland Enhanced Inventory add to the body of work that support the use of ALS technology in predicting stand structure attributes and provide a proof of concept for the use of this technology in mapping fibre quality attributes. Further research should shed more light on the benefits of using ALS to help predict wood quality attributes which will lead to a more competitive forest sector.

Reference

Luther, J.E.; Skinner, R.; Fournier, R.A.; van Lier, O.; Bowers, W.W.; Côté, J.-F.; Hopkinson, C.; Moulton, T. 2013. Predicting wood quantity and quality attributes of balsam fir and black spruce using airborne laser scanner data. *Forestry* 87:313–326.

For more information please contact:



Joan Luther

Remote Sensing Scientist
Canadian Forest Service
Natural Resources Canada
26 University Drive
P.O. Box 960
Corner Brook, NL A2H 6J3
JoanE.Luther@NRCan-RNCan.gc.ca

Photos on front page, from left to right: Extraction of core samples for measurement of wood fibre attributes, Aerial photography showing a forest area, Newfoundland.