



CWFC Facts 010

# Canadian Wood Fibre Centre

## Fibre Facts

### Model Uses Terrestrial LiDAR to Help Predict Fibre Quality in Forest Inventory

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 developing new techniques, such as architectural modelling based on light detection and ranging (LiDAR) data, to enhance the measurement of forest characteristics linked to wood fibre attributes. Knowledge of factors influencing wood fibre quality will provide an enhanced capacity for planning the best use of forest resources.



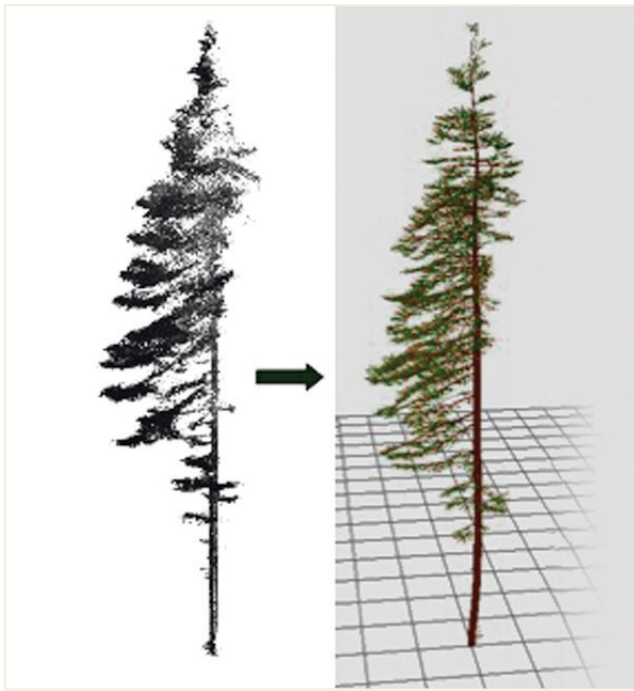
Aerial photographic interpretation has been the backbone of forest inventory in Newfoundland for decades. Although this method provides reasonable estimates of wood volume, it is not a good indicator of wood quality. Research has shown that fibre properties such as wood density, fibre length, microfibril angle, modulus of

elasticity, and cell wall thickness are affected by the physical characteristics of a tree (height, diameter, size and shape of the crown, distribution and size of branches, leaf area, etc.). One of the objectives of the Newfoundland Enhanced Fibre Inventory Project is to study the interrelationships between external tree characteristics and internal fibre properties and use this information to enhance the forest inventory.

Dr. Jean-François Côté, a research scientist with the Canadian Wood Fibre Centre, has evaluated the effectiveness of terrestrial LiDAR (TLiDAR) technology to produce three-dimensional tree reconstructions. Several challenges are associated with the use of TLiDAR in natural forest environments. Since the pulses transmitted by the TLiDAR unit are mainly reflected from the first object encountered, objects lying behind are often occluded or hidden from view and are not detected. It is also imperative to distinguish between the various components of the trees being scanned (main stem, branches, and foliage). The movement of foliage and branches by wind and the intercept of pulse signals by rain or fog can also impact the accuracy of TLiDAR measurements.

To mitigate the effect of occlusion, TLiDAR scans are taken from several view points around each tree. TLiDAR pulse returns vary in intensity depending on the vegetative structures they encounter, making it possible, to a certain degree, to separate the different vegetative components (stem, branches, foliage). This has allowed Dr. Côté to use the pulse returns from the wood portions of the scan to extract vital clues on the main structure of the tree (i.e., the shape of the trunk and the main branches) and to begin generating a skeleton for the trees. The returns from the foliage are used as attractors to add finer branches to the initial tree skeleton. Finally, a light availability model is used to distribute additional foliage within the interior of the tree crown. The result is a set of digital tree models that closely resemble the scanned trees.





**Figure 1.** Co-registered scans of a balsam fir and its 3-D representation build with *L-Architect*.

LiDAR data to tree architecture (*L-Architect*) is an architectural model developed by Dr. Côté that is designed to provide a practical method to synthesize and quantify the spatial distribution of tree components from TLiDAR point clouds. The main strength of the model lies in its ability to generate plausible tree architectures even when scans are taken under less than ideal conditions (occlusions, wind, and moisture). Dr. Côté tested his model on three North American conifers: Douglas fir (*Pseudotsuga menziesii*), western redcedar (*Thuja plicata*), and western hemlock (*Tsuga mertensiana*) and one European species: the Aleppo pine (*Pinus halepensis*). Although the four conifer species represented very different configurations, Dr. Côté was able to create a very accurate representation of the various species using his *L-Architect* model.

After evaluating the effectiveness of *L-Architect* to map individual trees, Dr. Côté expanded its use to the plot level. Forest structure reconstruction was done by using the *L-Architect* model with supplemental help from inventory data. TLiDAR point clouds of individual balsam fir trees were used to compile a catalogue that represented a range of typical balsam fir, in terms of age and form, covering the structural variety present on forest sites (Figure 1). Optimization algorithms using height, diameter, and leaf area were used to match the trees in the plot with the tree catalogue and to provide a best-fit approximation of the information gathered from the TLiDAR scans (Figure 2). The modeling approach developed by Dr. Côté was thus capable of reproducing the overall site characteristics with very high accuracy.



**Figure 2.** Reconstructed permanent sample plot of balsam fir using *L-Architect* and tree map inventory data.

The structural data set obtained with *L-Architect* largely surpasses the information retrievable from current remote sensing technology and offers a major improvement over measurements obtained from ground plots with traditional inventories. The *L-Architect* model, when used in conjunction with other inventory tools, has the potential to have a significant impact on the quality of the information that can be obtained from the forest inventory.

Airborne LiDAR (ALiDAR) systems are capable of covering vast tracts of forested lands and allow partial characterization of vertical and horizontal structure. However, ALiDAR systems are not effective in capturing the type of material, nor the fine geometrical, branching topology, and biophysical attributes of the various forest elements. *L-Architect* is very effective in capturing this information and offers exciting possibilities in its ability to complement ALiDAR, thus significantly improving the accuracy of inventory information at the landscape level.

### For more information, please contact:

#### Dr. Jean-François Côté

Research Scientist – Forest Inventory

26 University Drive

P.O. Box 960

Corner Brook, NL A2H 6J3

**Email:** jean-francois.cote@nrcan-rncan.gc.ca

**Phone:** 709-637-4948