The AWARE Project:
Overview and Outcomes

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CIF Meeting / October 2019
Canadian Forest Sector

- Industrial Forest Companies and both Provincial and Federal forestry agencies also key roles in forest management decisions under legislation and for public oversight

- As a result industrial companies, provincial and federal agencies have a history of working together to improve forest inventory and Canadian competitiveness
In 2010/11 the Federal Government Research agency (NSERC) with advice from the Canadian Wood Fibre Centre / Canadian Forest Service and FPInnovations indicted advanced remote sensing of wood properties a research priority.
Advanced Remote Sensing

• Light Detection and Ranging (LiDAR) is a relatively new technology which is being actively adopted by forest companies / agencies globally

• Can be acquired from the ground, plane or satellite. Aircraft most common – known as Airborne laser scanning (ALS)

• In addition, high spatial resolution imagery, acquired from satellite, aircraft, or drones is also being processed in such a way as to allow 3D representation of forest information.
LIDAR / ALS

- Precise GPS location of aircraft required \((x_p, y_p, z_p)\)
- Precise inertial measurement unit (IMU) of aircraft required (pitch, roll, and yaw)
Digital Aerial Photogrammetry

- Digital manipulation of many aerial imagers with high degree of overlap to produce a 3D point cloud
- Images can be from existing aerial campaigns or drones
AWARE

AWARE = Assessment of Wood Attributes from Remote Sensing

NSERC Collaborative Research and Development 5 year project

Collaboration between Industry and Universities with Provincial / Federal support

In 5th year.
Forest Inventory in Canada occurs at a range of scales from strategic broad scale assessments to operational inventories driving daily decisions.
Shane Furze (UNB)

SOIL PRODUCTIVITY MAPPING
Soil Mapping Limitations

• In the past, soils delineated by broad polygons
  – ‘soil associations’

• LIDAR DEM and Terrain Attributes
  – Paradigm shift
    • Map soil properties continuously based on soil-forming factors
    • Models to compare soil properties to climate, geology, and topography
    • Requires “accurate” representations of soil-forming factors
• Numerical prediction of key soil attributes using soil plot information and spatial coverages including LiDAR.
• Roll out predictions across the entire forest estate
• Link these fine scale models with individual tree responses
Spatial Database

Topographic Derivatives

Total:
50+ Data sets

- Topographic and climate based on DEM

Surficial Geology

Climate Data

Parent Material

Mode of Deposition

- Ablation
- Ablation Residual
- Ablation Residual
- Aluvium
- Boreal
- Colluvial & Waterre-worked Silt
- Glaeicohumus
- Glaicostratified & Marine
- Glaicomarine
- Glaicomarine Basal
- Marine
- Organic
- Residual
- Residual & Colluvium
LIDAR Curvature Classification

A – 10m resolution, B – 50m resolution, C – 10m resolution with 50m² smoothed, D – 50m resolution with 250m² smoothed.
WS Plantations
Avg. Height/ Age
- 0.002 – 0.1
- 0.1 – 0.15
- 0.15 – 0.2
- 0.2 – 0.25
- 0.25 – 0.3
- 0.3 – 0.35
- 0.35 – 0.4
- 0.4 – 0.45
- 0.45 – 0.5
- 0.5 – 0.55
- 0.55 – 0.6
- 0.6 – 0.65
- 0.65 – 0.7
- 0.7 – 0.75
- 0.75+

Waterbodies
Soil Associations
Rachel Perron, Jean-Francois Prieur (UQAM/ Sherbrooke)

IDENTIFYING SPECIES
Classifying species

- Random forest classifier
- ALS + aerial images
- Three levels of classification:
  - Coniferous vs deciduous (2 classes)
  - Genus (8 classes)
  - Species (11 classes)
- Accuracy: see JF’s talk!
Chris Mulverhill (UBC), Piotr Tompalski (UBC)

PRODUCT MIX

New Structural Metrics for Forest Stand Descriptions

Predictive Modeling for ecological site classification, habitat and forest health

Growth Rate

Hydrological Mapping and Productivity
Stem diameter distributions in boreal mixedwoods

Testing different ground-based and ALS-based techniques for separating structurally simple and complex areas and then predicting structurally appropriate models.
Application


https://doi.org/10.1016/j.foreco.2019.117586
Sean M. Lamb (UNB), Piotr Tompalski (UBC), Joseph Rakofsky (UBC)

STAND GROWTH
Spruce Plantations in New Brunswick

1. Impute tree-level inventory for LiDAR grid cells in spruce (*Picea* sp.) plantations
   - Match plot measurements with LiDAR grid cells based on planted species and 6 inventory variables
   - Use tree-level inventory from matched plot as a surrogate for each LiDAR grid cell

2. Forecast forest inventory using imputed tree lists and a locally calibrated tree-list growth model
   - Input imputed tree lists into tree-list growth model (Open Stand Model) to forecast inventory
   - Compare predicted annual increment from tree lists imputed by plot matching with measured tree lists

Growth Model
Variables generated from imputed tree lists highly correlated with those from measured trees

Imputed and measured tree lists had statistically equivalent basal area distribution by species

Modelled inventory increments from imputed tree lists highly correlated with those from measured plots

Volumes forecasted 3-5 years for 15 test plantations using imputed tree lists statistically equivalent to actual harvest

Linking ABA with growth models

- Existing method based on ABA-derived attributes (HMAX, HL, QMD, V)

Curve matching

- Two scenarios:
  - Based on T1 data only
  - Based on T1 and T2 data

- Template database generated with GYPSY
Karin van Ewijk (Queens)

MODEL TRANSFERABILITY
Transferability of LIDAR models
Transferability design

FRI attributes

ALS metrics

Structural height metrics relating to:
dominant trees
gaps and understory
variation in tree height
canopy complexity and crown closure

HEF

SLF

Modeling approaches
Parametric (OLS)
Non-parametric (RF)

Evaluation criteria
Model output: RMSE (%), Bias (%), $R^2$; Equivalence test
• The best transferability scenarios were within ± 5% relative error and an increase 10% in relative bias.

• The worst were a 23% increase in error and 29% increase in bias.

• The worst thing to do is a straight transfer; combining plots from both models was more successful.

• Overall models of height (such as Lorey’s height) were the most accurately transferred, whereas volume and diameter were the poorest.
Jean-Romain Roussel

ACCESSIBLE, FREE CODE
Jean-Romain Roussel

Jean-Romain.roussel.1@ulaval.ca

https://github.com/Jean-Romain/lidR

lidR does not aim to provide predefined processes, it is designed to enable users to build their own.

Support for multi-core processing

Processing of Large Datasets

Examples:
  - Multiple algorithms to create CHM
  - Multiple algorithms to segment crowns
  - Custom metrics
AWARE Legacy:

- Provided funds for 25 Graduate Students, Postdocs and Research Associates
- 9 students have graduated to date, with more completing
- 18 journal review papers to date; 8 in review and more to come
- 25 posters, conference proceedings, reports
- Quarterly newsletter
- Industry – Government – University Collaborations
- Long Term Website for Data / papers / reports being developed

AWARE.FORESTRY.UBC.CA

University Investigators:
Nicholas Coops; Peter Marshall (UBC)
Alexis Achim (Laval)
Paul Treitz (Queens)
Benoit St-Onge (UQAM)
Richard Fournier (Sherbrooke)
Paul Arp, Chris Hennigar (UNB)
Jeff Deck (Nipissing)
John Caspersen (Toronto)

Government Investigators:
Joan Luther (CFS)
Oliver van Lier (CFS)
Adam Dick (CFS)
Jean-François Côté (CWFC)
Doug Pitt (CWFC)
Murray Woods (Govt Ontario / CWFC)
Chris Bater (Govt. Alberta)
Joanne White (CFS)
Udaya Vepakomma (FPI)
Denis Cormier (FPI)

International Reviewers:
Ross Nelson (Retired / NASA)
Sorin Popescu (Texas A and M University)
Final Annual General Meeting with Open Showcase Day will be held in

Toronto February 19 – 20\textsuperscript{th} 2020
E-LECTURE SERIES: An Update on Canadian Forestry Applications of LIDAR and Digital Photogrammetry. The AWARE Experience.

September 25, 2019

The AWARE Project: Results and Outcomes

- Nicholas Coops
  Professor, UBC
  Canada Research Chair in Remote Sensing
  Principal Investigator: Assessment of Wood Attributes from Remote Sensing (AWARE)

October 2, 2019

Digital Soil Mapping in New Brunswick

- Paul Arp
  Professor in the Faculty of Forestry and Environmental Management, UNB

- Shane Forrester
  Research Scientist, Forest Watershed Research Center UNB

- Greg Adams
  Advisor, Tree Improvement and Development, J.D. Irving

October 16, 2019

New LIDAR Technologies on the Horizon - SPL and Multi-Spectral LIDAR

- Jean-François Prieur
  Graduate Student, UQAM

- Martin Ouimette
  Graduate Student, UNB

- Grant McCartney
  Forest Information Systems Coordinator, Chief Foresters Group (Ontario)

- Joanne White
  Research Scientist, Canadian Forest Service

- Ian Sinclair
  Senior Analyst, Ministry of Natural Resources and Forestry, Govt. of Ontario

October 23, 2019

Assessing Non-Timber Values Using LIDAR and Advanced Remote Sensing Data

- Richard Fournier
  Professor, Department of Geomatics, Université de Sherbrooke

- Alexis Achim
  Graduate Student, Université de Sherbrooke

- Chris Mulderhill
  Forest Management Specialist, Alberta Agriculture and Forestry, Govt. of Alberta

- Christopher Bater
  Graduate Student, UBC

- Sam Hemmingsen
  Graduate Student, Université de Sherbrooke

October 30, 2019

Digital Photogrammetric Applications to Enhanced Forest Inventory

- Tristan Goodbody
  Postdoctoral Research Fellow, UBC

- Adam Dick
  Forest Research Project Leader, Canadian Wood Fibre Centre

Co-presenters:
Chris Mulderhill & Joanne White
What’s next?

A shared sense of urgency about pressures and stresses on forests

- Difficulty of predicting forest losses in a changing climate
- Fibre supply access, security and competitiveness
- Social license and public engagement

Participants from forest industry, provinces, and research organizations came together to start building a coordinated national research initiative in silviculture

Aim: to provide tools and tactics to decision makers and managers for tackling priority issues and needs related to fibre supply
SILV@21

Advancing Silviculture in Canadian Forests:
Adapting to a new Socio-Environmental Reality from Seed to timber

Development of Themes and Projects for a NSERC Research Grant
Thank you!

aware.forestry.ubc.ca

www.researchgate.net/project/
AWARE-Assessment-of-Wood-Attributes-from-Remote-Sensing

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IRSS_UBC

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