FORAC

Research Note V.1, n°2, October 2024

Airborne LiDAR: Have We Reached Digital Inventory in Uneven-aged Hardwood Forests? A Case Study in Quebec's Yellow Birch-Spruce-Fir Bioclimatic Domain.

David Normandeau, Daniel Beaudoin (Director) and Martin Riopel (Co-director)

Introduction

In the context of sustainable forest management, having up-to-date forest data across the entire territory is crucial for effective governance, especially in vast areas like Quebec. Currently, in the province, obtaining data on stand dendrometric attributes involves lengthy ground inventories paired with photointerpretation and a k-NN-based data generation method. This data acquisition process takes several years and resources, prompting interest in more efficient alternatives. While area based model developed by the Quebec Forest Inventory Department using airborne laser scanning (ALS) has shown promising results in predominantly coniferous stands in the northern Quebec (Leboeuf & al., 2022), its accuracy in deciduous stands in southern Quebec remains unassessed. This study aims to; (i) Measure the accuracy of stand basal area predictions obtained from the current ALS model in three stand types: mixedwood, shade intolerant hardwood, and shade tolerant hardwood. (ii) Analyse the inputs of the model and search for new ones (iii) Propose adjustments to the current ALS model to increase prediction accuracy.

Method

Our study concentrates on the balsam fir and yellow birch forest bioclimatic domain in Quebec. This domain is of particular interest because it forms a transition between Quebec's boreal and hardwood forests. Ground data sourced from government inventory were used to validate the accuracy of ALS based predictions. A total of 12,506 validation plots were chosen to align with the ALS data acquisitions carried out between 2011 and 2020.

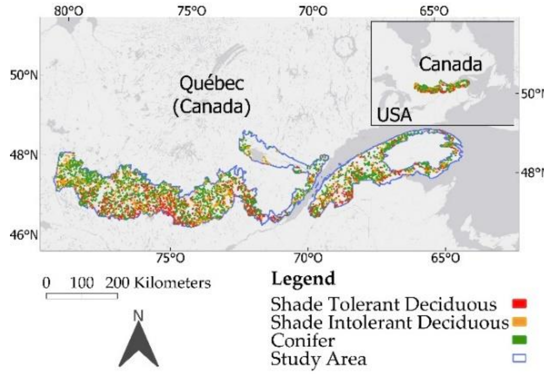

Figure : Validation plots distribution by species composition (color dots) in the Balsam Fir-Yellow Birch Forest of Quebec (Study Area)

The prediction accuracy was measure for the three stand types using R^2. Then, the input analysis proceeded in three steps: firstly, examine the correlation between each model inputs and the observations; secondly, evaluate the influence of the main tree species on accuracy; and thirdly, test new inputs to identify the optimal combination. Improvements to the model were then conducted through three approaches: updating the linear parametric model, exploring non-linear parametric models such as quadratic functions, and employing an automated machine learning approach. Subsequently, these approaches were compared to determine the most effective.

Results

The ALS based Quebec Forest inventory department model was tested across three stand types: shade-tolerant deciduous, shade-intolerant deciduous, and coniferous, with respective R^2 values of 25%, 47%, and 53%. These results highlight a weakness in model predictions generated over shade-tolerant stands. Consecutively to search for new inputs, we found three factors that helped improve prediction accuracy: proportion of each species basal area in the stand, geographical coordinates, and meteorological data associated with location. Then, tree methods, including machine learning, quadratic, and linear approaches, were employed to improve accuracy of the prediction.

Table : Impact of the Correction on the Initial Model from the Different Approaches for All the Commercial Species

Approaches	All the Commercial Species			
	N	MAE	Bias	R^2
Initial Model	2482	5,38	0,11	44,3%
H20 AutoML	2482	4,71	0,06	56,9%
Linear Cor.	2482	4,96	0,14	52,8%
Quadratic	2482	4,94	-0,10	53,0%

Although the three approaches improved the model's performance, the machine learning method achieved the highest improvement in R^2 value. The machine learning method also achieved the highest improvement of R^2 (36.1%) in shade-tolerant deciduous stands.

Discussion

The study's results reveal a discrepancy in the accuracy of predicting basal area for shade-tolerant species when using the Quebec Forest Inventory Department's laser airborne scanning model, a result observed in other research studies as well (Spriggs & al. 2019). Three new data inputs were implemented in the machine learning technique to enhance the model. The objective of incorporating these georeferenced inputs was to assist the machine learning categorizing data and personalizing the model for each stand types. A limitation is the method used to determine species basal area proportions, which relies on photointerpretation and grouping by forest stand, which doesn't allow the machine learning model's full potential.

These corrections resulted in significant improvements in accuracy within shade-tolerant forests. However, these improvements did not reach the same accuracy as the Quebec Forest Inventory Department ALS approach achieved in the boreal forest. Nonetheless, the promising results surpassed those of traditional parametric methods for all kind of forest, suggesting potential advancements in forest inventory practices. These findings provide valuable insights for the forest industry and its partners, assisting in the selection of appropriate approaches for forest inventory and management. This is especially relevant in areas like southern Quebec, where shade-tolerant hardwood forests are widespread.

Conclusion

While significant improvements in accuracy were achieved through the incorporation of new data inputs and the application of automated learning techniques, further refinement is needed to match the accuracy levels of existing approaches in other forest types. Incorporating additional variables and harnessing technologies such as satellite imagery could provide promising avenues for improving forest assessment techniques. Ultimately, addressing these challenges will advance knowledge and innovation within the field, enabling more informed decision-making and sustainable forest management practices.

literature

Leboeuf, A., et al. 2022. https://doi.org/10.3390/F13070985

Spriggs, R.A., et al. 2019. https://doi.org/10.1371/JOURNAL.PONE.0215238

Examiner : Alexandre Morin-Bernard

Editor : Shuva Gautam