The Effect of Tree Species and Seasonality on Forest Height Measurements Using an Aerial Laser Scanner – A Case Study in Latvia

J. Ivanovs[1], A. Lazdins[1], M. Lang[2,3]

[1]Latvian State Forest Research Institute Silava, Rigas street 111, LV-2121, Latvia
Email: {janis.ivanovs, andis.lazdins}@silava.lv

[2]Tartu Observatory, University of Tartu, Tõravere, Tartumaa 61602, Estonia
Email: lang@to.ee

[3] Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, Kreutzwaldi 5, Tartu 51014, Estonia

1. Introduction

Forest resource inventory can be done in different ways and scales. In Europe and elsewhere in the world, national scale information is obtained through the National Forest Inventory (NFI), while surveys of specific stands are carried out to get information in local scale. Typically, forest stand surveying is done manually, but this process is time consuming. Time consumption can be reduced by using remote sensing technologies such as aerial laser scanning (ALS). Scientific publications indicate that there is a high correlation between ALS measurements and actual tree height (McRoberts, Andersen, & Næsset, 2014).

Using ALS data, various forest inventory-related parameters are modeled, such as tree height, biomass volume, tree species distribution, and other parameters, but various authors point out that statistical models based on single-scanner data cannot be used for areas scanned with different ALS scanner settings, because that may introduce systematic errors (Næsset, 2014). The same applies to data collected during different growing seasons (Villikka, Packalén, & Maltamo, 2012). This study uses ALS data collected nationally for the period 2013-2019 in both leaf-off and leaf-on periods to develop statistical models to determine tree height across the country. NFI plots were used as field data in the development of the models, while a database of forest parcels was used for validation.

1. Data and Methods

Latvia is located in the hemiboral zone, where both conifers and deciduous trees are found. The most popular tree species are *Betula pendula*, *Pinus sylvestris L.* and *Picea abies*. The acquisition of ALS data in the territory of Latvia has been organized by the Latvian Geospatial Information Agency in the period from 2013 to 2019 and the work has been performed by various companies. Measurements were performed using Leica ALS70, Riegl LMS-Q680i and Riegl LMS-Q780i scanners as shown in Figure 1. The flights are performed in both leaf and leafless periods and the minimum point density is 4 points per square meter. This study uses ALS data obtained in the period from 2013-2018.

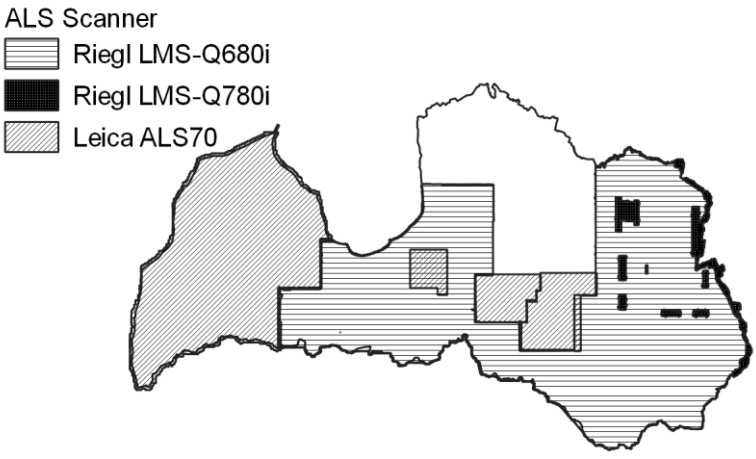

Figure 1: ALS coverage in Latvia 2013-2018

Published in: Markus Hollaus, Norbert Pfeifer (Eds.): Proceedings of the SilviLaser Conference 2021, Vienna, Austria, 28–30 September 2021.
Technische Universität Wien, 2021. DOI: 10.34726/wim.1861
This paper was peer-reviewed. DOI of this paper: 10.34726/wim.2001

NFI data are obtained over a 5-year cycle and in total more than 16,000 permanent plots are surveyed on both forest and non-forest land. More information about Latvian NFIs is available at Tomppo, Gschwantner, Lawrence, & McRoberts, 2010.

During this research, tree height models were developed, taking into account the information on the composition of tree species and the season. Only a part of the NFI plot centers have coordinates determined with a high-resolution GPS sensor, so the models are developed stratified, in one case using all plots, while in the other only plots with well-defined coordinates. The accuracy of the coordinates of the centers of the NFI plots before the precise measurement was with an average deviation of 2 m from the center. Fusion software is used to cut out NFI plot areas from the ALS point clouds and to calculate the vertical distribution of points.

ALS statistical information was compared with NFI measurements with a + - 2 year lag and the 75th, 80th, 90th, 95th and 99th ALS height percentiles were compared with NFI tree heights. The models are stratified by conifers and deciduous trees, different tree species and different seasons. R squared and RSE values were compared between different height percentiles and the most accurate height prediction models were selected. Tree height models have been developed only for those tree species in which at least 30 observations have been recorded.

1. Results and Discussion

During the research, models were developed to predict the height of trees in the distribution of conifers and deciduous trees, as well as different tree species and also seasonally. Isolated tree species include species such as *Pinus sylvestris L., Picea abies, Betula pendula, Alnus glutinosa, Populus tremula* and *Alnus incana*. R squared values range from 0.730 to 0.964 and RSE values range from 1,508 to 2,812. The lowest values are observed for deciduous tree species leaf-on and in the intermediate state between leaf-on and leaf-off. The highest R squared values are for *Pinus sylvestris L.*, regardless of the season.

The Riegl LMS-Q780i scanner showed the highest accuracy among ALS scanners, however, the number of observations for the development of individual models for different tree species was too small. Riegl LMS-Q680i and Leica ALS70 scanners have been used in large areas of the country and tree height models have been developed for all the above-mentioned tree species. The Leica ALS70 scanner shows on average slightly higher accuracy than the Riegl LMS-Q680i, with R squared values averaging 0.904 and 0.873, respectively.

Acknowledgements

This study was funded through the FACCE ERA-GAS project INVENT (NO: NRC 276398, SE: FORMAS FR-2017/0006, DK: DIF 7108-00003b, LV: ES RTD/2017/32)

References

McRoberts, R. E., Andersen, H.-E., & Næsset, E. (2014). Using Airborne Laser Scanning Data to Support Forest Sample Surveys (pp. 269–292). https://doi.org/10.1007/978-94-017-8663-8_14

Næsset, E. (2014). Area-Based Inventory in Norway – From Innovation to an Operational Reality (pp. 215–240). https://doi.org/10.1007/978-94-017-8663-8_11

Tomppo, E., Gschwantner, T., Lawrence, M., & McRoberts, R. E. (2010). *National Forest Inventories : pathways for common reporting*. Springer.

Villikka, M., Packalén, P., & Maltamo, M. (2012). The Suitability of Leaf-off Airborne Laser Scanning Data in an Area-based Forest Inventory of Coniferous and Deciduous Trees. *Silva Fennica*. Retrieved from http://www.metla.fi/silvafennica/full/sf46/sf461099.pdf