Transilvania University of Brasov

HABILITATION THESIS

SUMMARY

Title: Implications of the measurement of tree size characteristics on the accuracy of trees and stand volume estimated by mathematical methods

Domain: Forestry

Author: Assoc. Prof. Dr. Eng. Maria Magdalena Vasilescu

Transilvania University of Braşov

BRAŞOV, 2020

The habilitation thesis, entitled “Implications of the measurement of tree size characteristics on the accuracy of trees and stand volume estimated by mathematical methods”, gives a synthesis of the academic achievements of the author in the forest sciences during the post-doctoral stage.

The first chapter describes the author’s main research directions placed in the context of new developments in the forestry-related measuring tools and of the recent requirements related to tree volume estimation. Errors in the measurement of the tree diameter and height are the most important inaccuracy sources when developing tree and forest stand volume estimates. In addition, mathematical models which are used to estimate different variables of the tree size are incurring errors which are brought by the variability in shape of the trees. As such, the chapter describes the author’s achievements on this topic based on the latest published papers and unpublished results of ongoing studies.

The second chapter takes a closer look at the measurement accuracy of the tree size variables and describes these topics in two subchapters. Since the capabilities of measuring diameters in the upper stem tree parts have been recently enhanced, two of the state-of-art instruments able to measure the trees’ diameters along the stem (laser dendrometer and caliper with laser pointers) are analyzed in the view of measured variables and produced errors (subchapter 2.1). Based on the outcomes of these studies, a careful use of the Criterion ® RD 1000 ® is recommended when measuring diameters in the upper tree parts as a measure to overcome inaccuracy in the volume estimates. The results also emphasize the usefulness of the Mantax Black ® calipers equipped with Gator Eyes ® which should be preferred if combined with an additional instrument to support height measurements. To evaluate the accuracy of height measurement based on ultrasound technology, non-destructive and destructive methods were used based on two separate studies (subchapter 2.2). The aim of the first study was to estimate the standard error of tree height measurement using a Vertex III ® instrument in optimal conditions. This approach enabled the separation of the error caused by the accuracy of the line-of-sight. The results are based on a number of 104 independent measurements taken on a sample of 3 trees and they revealed that the line-of-sight error due to the inter-user variability was in range of 0.2-0.3 m when aiming by measurement at the top of the tree. The second study estimated the height measurement errors brought by the use of a Vertex IV ® instrument and it was based on control data which was collected on 145 Silver fir (*Abies alba* Mill.) and 138 Norway spruce (*Picea abies* (L.) Karst) felled trees. The results showed that 71.03% of the silver

fir trees and 59.42% of the Norway spruce trees were measured with height errors less than 1 m, while for 23.45% of the silver fir trees and for 32.61% of the Norway spruce trees, respectively, the height was either underestimated or overestimated by 1-2 m.

The third chapter introduces the median diameter of the stem profile as a way of describing the shape of the tree stem and as a particular stem diameter to be used in taper and volume equations. A novel, more rapid method to get the median diameter using the area of the stem profile was proposed. A total of 218 height/diameter classes from 5,403 spruce trees were used to compute the median diameter using the classical method. In parallel, a regression model to estimate the median diameter was developed. The strongest predictor of the median diameter of the stem profile was the diameter at the breast height (R^2 = 0.9985). Statistical analysis revealed that the location of the median diameter on the stem profile was at $0.3 \cdot h$ (tree height). The model was validated on standing and felled trees, revealing that differences between classical estimations and the proposed model were less than 2% in most cases (86.24% of trees). The median diameter of the stem profile provides valuable information on the architecture of forest stands that could help in advancing our understanding on the mechanical stability of Norway spruce trees (*i.e.*, delineating breakage point), growth model predictions, and competition among trees.

In the fourth chapter, the author has provided arguments for the need of harmonizing the regulations that include details for the volume estimation of the round wood in Romania. Disagreement between some regulations regarding the standardized information flow in the SUMAL system, the flow and marketing of wood, and methods used to estimate the volume of wood before harvesting, is highlighted in order to improve the law accuracy. The author recommended some addendums to the laws on the round wood inventory based on references from the forestry literature, and also on the development of studies to estimate the standard error of round wood measuring and volume estimation. The chapter provides evidence of the influence of the section length in estimating the volume of samples of round wood and tree stems, respectively, by using the Huber's formula. Introducing terms and limitations for the round wood volume estimation provides both economic operators and control staff, the possibility of reducing forestry contentious situations. Moreover, a new equation for volume estimation of tree stems was developed using median diameter of stem profile. This work is based on the volume equation for solids of revolution defined originally by Mathiesen in 1925. The study is based on previously published data for more than 5000 Norway spruce trees from Romania grouped in 218 height/diameter categories. For each of these categories, median diameter and area of stem profile, as well as volumes by Mathiesen's formula and Huber's formula were computed. The volume equation was obtained using quick methods for determining the median diameter and the

area of stem profile. The proposed model provides more accurate results than the original equation developed by Mathiesen. Furthermore, it allowed the development of an easy-to-use equation aiming to predict the over-bark stem volume, based on the median diameter of stem profile.

The effects of the method and tree height errors on the stand volume are presented in fifth chapter. The method of relative volumes was applied for 20 samples of trees including a total number of 341 silver fir trees and 348 Norway spruce trees. In this study, the influence of the mean height error on the mean volume, which is the key of the forest stand's volume accuracy, was simulated for both species. In order to explain the differences between the wood volume estimates of standing and felled (extracted) trees, the losses related to harvesting technology were emphasized.

The last part of the thesis presents the author's academic evolution and the academic development plan which are supported by a brief presentation of the professional evolution from the graduation of the faculty to the present and, also, of the expected evolution directions of the professional activities in research and teaching.