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Pilot Study reveals high volume and carbon storage in very large deciduous trees

Christian Vonderach [Δ 1,2], Muna Chaudhary[1,3], Zoe Schindler[1], Christopher Morhart[1]

[1]University of Freiburg, Chair of Forest Growth and Dendroecology, Freiburg/Germany;
[2]Forest Research Institute Baden-Württemberg, Freiburg/Germany, Wonnhaldestraße 4
[3]Univerity of Eastern Finland, Yliopistokatu 2, Joensuu/Finland; [Δ] christian.vonderach@forst.bwl.de

Introduction

Aboveground biomass (**AGB**) or coarse wood volume at the level of individual trees, at stand or even national level is often **estimated by allometric functions**. In addition, these estimates are often used as ground truth reference for biomass or volume estimates derived from remote sensing data. The currently used biomass and taper functions of the German National Forest Inventory (NFI) are calibrated with trees of diameters at breast height (Dbh) of up to 80 cm. This seems to be sufficient for usual forest management, but the results of the past NFIs show a **continuous increase in large and old trees**. Hence, it is important to improve the data basis for future inventories.

The **aim** of this pilot study is twofold: (i) to **assess the volume and biomass of overly large deciduous trees** and (ii) to **compare a remote sensing based method** for recording and measuring trees of large dimensions with an already recognised method. Here, we employed **Randomized-Branch-Sampling** (RBS) being an unbiased reference, while **Terrestrial Laser Scanning** (TLS) with subsequent processing by **Quantitative Structure Models** (QSM) was used as remote sensing approach for comparison.

Data and Methods

Trees
5 Oak and Beech trees with Dbh > 80 cm and height > 30 m around Freiburg

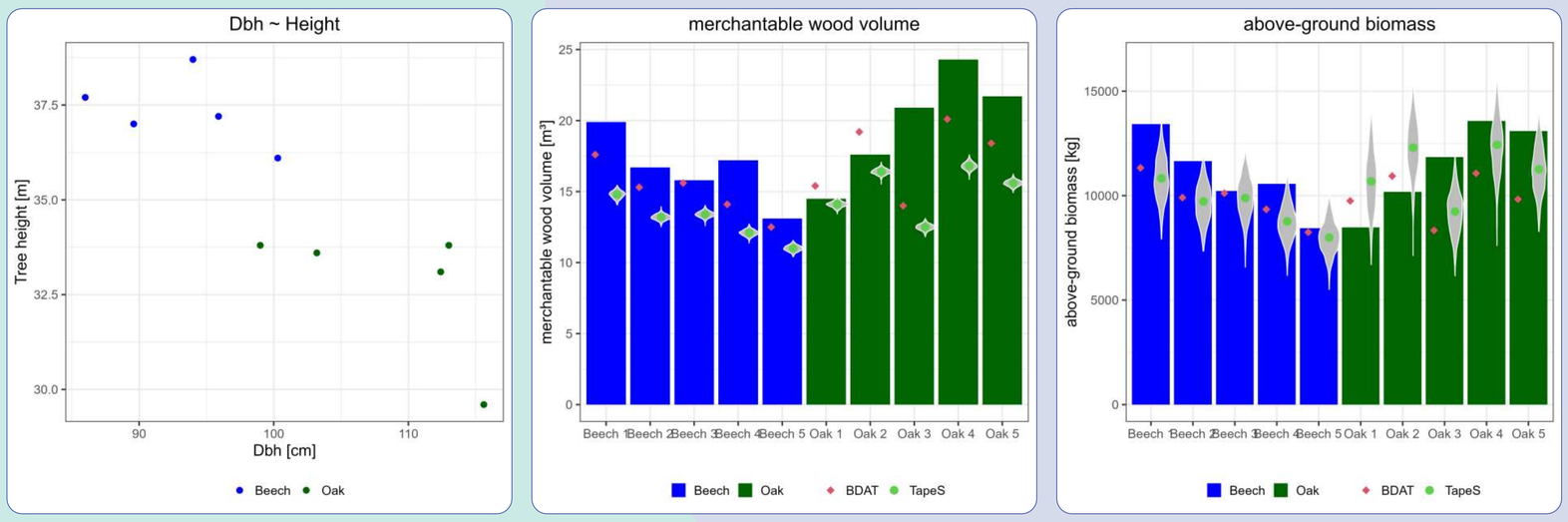
RBS
- unbiased reference
- measurement of segment length and diameters at standing trees:
- 3 to 7 paths by professional tree climbers
- upscaled to whole tree
- approach of Gaffrey & Saborowski (1999)

TLS
- RIEGL VZ-400i-Lasercanner
- each tree scanned from 3 sides
- post-processed using CloudCompare

QSM
- Raumonen (2022)
- tree-individual optimisation of parameters
- repeated evaluation (n=20) of point cloud

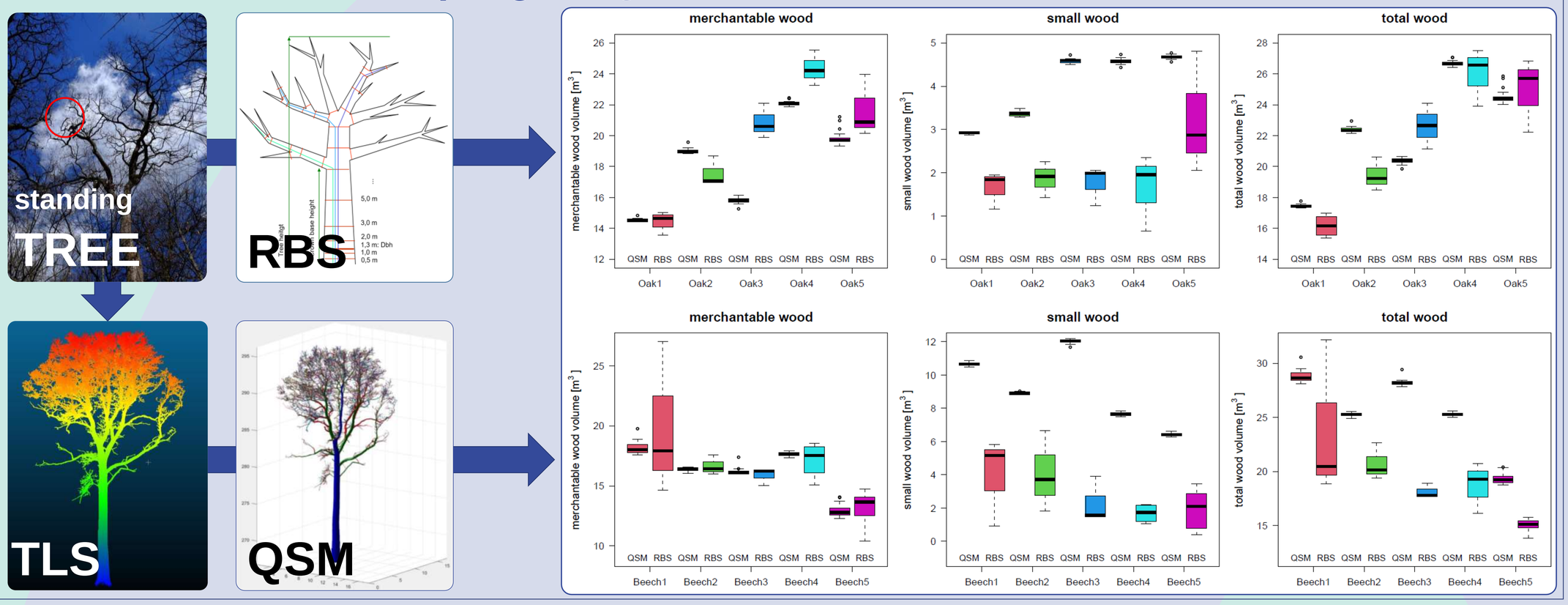
More details in Chaudhary (2023) or Vonderach et al. (2024)

Randomized Branch Sampling vs. Allometric / Taper Models



Results of the volume and biomass estimation with the reference method RBS (bars) and the taper curve models (dots) BDAT (Kublin, 2003) and TapeS (Vonderach and Kändler, 2021; Vonderach et al. 2018). Predictors are Dbh, D_7 (diameter at 7 m height) and Ht (tree height). For the estimates, the expected value and, in the case of TapeS, simulated confidence limits (α=0.05) for a new observation are given (violin). If the violins are outside the bars, this indicates significant difference between observation (RBS) and model prediction.

Randomized Branch Sampling vs. Quantitative Structure Models



Conclusions

On average, TLS and QSM gave relatively **good estimates of the merchantable wood volume** of the chosen large-dimensioned trees. However, the volume of the **small wood fraction was clearly overestimated** and, hence, total tree volume was overestimated as well. Due to the direct relationship between volume and biomass, these findings also apply for biomass estimates. It is assumed that the main reason for the poor representation of the small wood fraction can be attributed to the **high measurement distance** in combination with increasingly **small twig diameter**, which is challenging for TLS measurements.

In comparison to NFI volume and biomass functions, it can be stated that the **observed volumes are generally at the upper end or outside the confidence range** of the currently used volume models.

The **biomass functions fit slightly better but still tend to underestimate** the analysed trees. Here, confidence bounds are wider and more often include the true value. The slightly better performance of the biomass functions can be explained by the fact, that they indeed model more variable total above-ground biomass and not only the coarse wood fraction.

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