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Accuracy of Photo-Optical Measurement of Wood Piles †

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Abstract: The accurate estimation of timber volume is of utmost importance. For industrial timber, the volume is often estimated as stacked cubic meter. Besides manual measurement, volume estimation is possible with photo-optical systems. Over 100 piles of industrial timber of broadleaved tree species were analyzed. In the study, a standard manual measurement method for the estimation of wood pile volumes was compared with a smartphone based photo-optical application for the determination of woodpile volume. Mean gross volume of the piles was approximately 56 m^3 and mean width of piles was 9.43 m. Strong correlation was found between the manual measurements and the photo-optical measurement. However, volume estimation of large volume piles seems to perform better in comparison to piles with small volumes. Further research is needed to determine the effects of variables such as log quality or quality of pile on volume estimation accuracy.

Keywords: timber stack; volume estimation; logistic; timber trade

1. Introduction

The correct measurement of harvested wood is economically seen one of the most important tasks in the wood supply chain. In Germany, several measurement methods are described in detail in the German framework agreement for timber trade (RVR) [1]. Similar instructions for timber measurement are available for example in Sweden [2] or in Canada [3]. The timber volumes estimated with one of the methods described in the RVR are seen as the legal trade volumes. Besides timber volume estimation methods for roundwood and woodpiles, the RVR describes also how to grade timber by means of quality. For the estimation of woodpile volumes, the RVR favors manual measurement. However, in the course of the fast digitalization process in forestry, several apps for mobile devices are now being used by large forest companies, to facilitate measurement of woodpiles using photo-optical approaches. These measurements are mostly used as control measure, for internal documentation. Up to now, only one system is calibrated and therefore enables legally secure sales processes: The system sScale™ performs the measurement with a stereo camera technology which is mounted on a car [4]. Other measurement systems use photos taken by the user with a smartphone application (app) [5,6]. However, detailed analysis on accuracy of these app-measurements is not yet available.

Thus, the research goal was to evaluate the accuracy of one widespread app compared to the manual measurement method for the determination of woodpile volumes described in the RVR.

2. Material and Methods

For the analysis, 109 piles of different broadleaved tree species were measured. The tree species were mostly European beech (*Fagus sylvatica*, L.), European ash (*Fraxinus excelsior*, L.) or a mix of both tree species. All measurements were performed by a professional forestry worker in Northeastern Germany between October 2019 and April 2020.

The volume of each pile was derived manually using the manual measurement method as described in the RVR [1]. Here, the pile is divided in equal-length sections (plus a last section, which is generally shorter) and for each section the height is measured in the middle of each section (Figure 1).

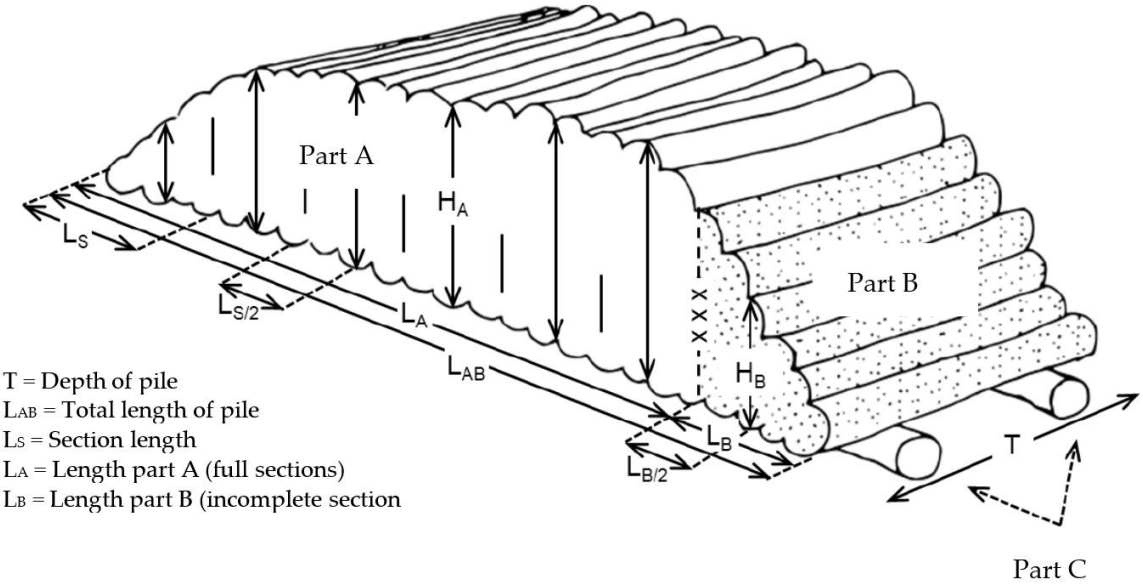

Figure 1. Manual measurement of wood piles according to RVR method [1].

Using the mean height, the total length of the pile and the length of the assortment, the volume of the pile can be estimated. This method was applied twice for each stack: Once starting dividing the pile into sections from the left side (RVR_{left}) and once starting from the right side (RVR_{right}) of the pile.

Volume estimation with the app was done with the widespread app iFOVEA. As a reference, the total length of the pile has to be measured exact to the centimeter. Moreover, the contour of the pile must be delineated manually after the stitching process of the photos. According to the manufacturer, the app was developed for piles with heights between 1.5 and 4.5 m and widths between 4 and 40 m [6].

Requirements for both RVR and iFOVEA are amongst others that the front of the pile should be accessible, that it does not contain foreign matter (e.g. branches, slashes, snow…) and that the logs on the front side are levelled out [1,6].

For the analysis, the piles were grouped into eight volume categories: from 0 to 10 m^3, >10 to 20 m^3, >20 to 40 m^3, >40 to 60 m^3, >60 to 80 m^3, >80 to 100 m^3, >100 to 150 m^3 and >150 m^3. All volumes were calculated as gross stacked cubic meter without reduction factors (i.e. including bark and interstices).

3. Results

The mean gross volume across all piles was 56.53, 57.22 and 55.50 m^3 for the measurements RVR_{left}, RVR_{right} and iFOVEA, respectively. No significant difference of the means was found doing a t-Test between the approaches. The mean and standard deviation of the width of the piles was 9.43±6.05 m. As expected, the total length of the pile increased with volume of the pile (Figure 2).

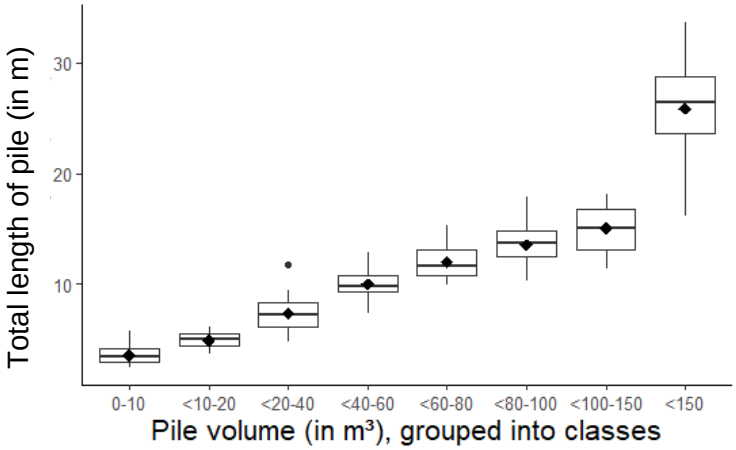

Figure 2. Total length of pile (in m) in relation to pile volume (in m³), grouped into classes.

When comparing the results obtained with the RVR method with the results obtained with the app, the slopes were near to 1 and R^2 over 0.99 (Figure 3). However, the results showed that when measuring small piles with volumes less than 20 m³, the variance between the different measurement methods is higher in comparison to measuring piles with larger volumes. The mean variance between the different pile volume estimation methods for piles <20 m³ was ±4.02 % while for piles >100 m³ the mean variance was ±1.82 %.

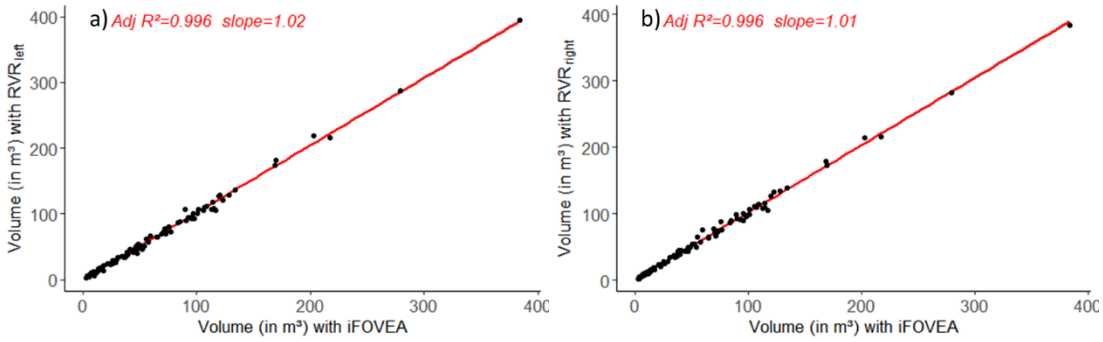

Figure 3. Volume estimation comparison between a) RVR_{left} and iFOVEA and between b) RVR_{right} and iFOVEA.

4. Discussion and Conclusion

The results of this study show that gross volume measurement of piles with the photo-optical app is highly congruent with the manual measurements using the RVR method. The strong correlation between the manually derived estimation of wood piles and the photo-optical measurement is in accordance with previous results [7]. Moreover, the higher variance between the measurement methods for small piles is in accordance with the requirements formulated both in the RVR and by iFOVEA, such as a minimum volume of piles of 20 m³. However, even when these requirements were fulfilled, differences in volume between methods can be found. Reasons for such differences may be found in the tree species: The quality of industrial timber from broadleaved tree species can be determined as much lower compared to industrial timber from coniferous tree species. Especially, the proportion of crooked timber is higher which often leads to more interstices in the pile. Thus, the effect of log and pile quality on the volume measurement accuracy should be studied in more detail.

Nevertheless, based on these results, it can be said that photo-optical approaches can offer a meaningful solution for woodpile measurement. It can be an attractive alternative compared to

manual measurement of woodpiles, especially when marketing large volumes of wood of good quality.

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Conflicts of Interest: The authors declare no conflict of interest

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