Improved wood delivery by new scaling methods of log piles

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Introduction

The forest sector in Germany is traditionally diverse in terms of harvesting systems, technology applied and actors involved. Many separate entities are performing discrete segments of the wood supply chain (cf. Figure 1). For planning and control purposes information about quantities and qualities of the products produced need to be collected and exchanged between involved entities. Although traditional motor-manual logging and skidding systems still play an important role especially in mountainous regions and in privately owned forest, the forest sector has seen a steady increase of fully-mechanized harvesting systems in the last 20 years, predominantly of single-grip harvesters and wheeled forwarders. Today approximately 50 % of the timber is harvested by CTL systems in Germany (Dietz & Seeling, 2013).

During felling and processing of logs single-grip harvesters collect a wide range of information, such as dimension (diameter, length), quality, product type. Federal laws generally do not allow the use of harvester information, in particular diameter, length and volume, as a base for timber sales agreements (Eichordnung, 2011). However, harvester data – sufficient accuracy provided – can be used for other purposes and increase precision through persistency of information along the wood supply chain, e.g. as production, logistics and dispatching or control measurement and for further business processes (KWF, 2013).

In contrast to the processes harvesting and bucking and the subsequent process mill intake with automatic generation of volume and quality data, the processes forwarding, piling and transport lack tools for efficient process control (cf. Figure 1) as the required data is usually either roughly estimated or measured manually, which is accurate but time-consuming. In some German federal states, forest state service intends to utilize harvester data for internal allocation purposes and therefore designed standards for the calibration process of the harvester heads to ensure high quality of the collected data.

Figure 1: Process chain in German CTL systems. The unfilled cells of the processes Forwarding, Piling and Transport symbolize the lack of automatic data generation for process control and show room for optimization in the wood supply chain.

The goal of this study was to evaluate the accuracy of timber data collected by a single-grip harvester calibrated to standard and to analyze the potential use of derived mean log volumes per assortment and photo-optical log scaling methods to allow for automatic estimation of log pile volumes at the landing. This information is needed for varying purposes including quality control of the extraction process and control of transportation and delivery volumes.

Material and methods

The study compares log diameters and lengths of about 1300 Norway spruce saw logs derived by two different measuring methods: by the calibrated harvester and by certified mill measurements. For detailed investigation only logs without bark strip-off during harvester-processing were considered (n=1031). The ordered log length was 5 m + cross-cut allowance of 10 cm with a minimum small end diameter of 13 cm ub and average mid diameter was 23.8 cm ub (min. 14 cm, max. 42 cm). In addition a photo-optical method (Polterluchs) is used to automatically count the number of logs in the log pile.

The Polterluchs camera, mounted on a vehicle roof or wind shield, takes a series of pictures during slow driving along a pile. These are stitched together and the number of logs are automatically counted by the Polterluchs software without the need for reference markers. A picture with a dot on every counted log allows for verification and corrections can be made with the software. The resulting count and the average log volume per assortment imported from the harvester data are combined for individual log pile volumes and compared to derived data at the mill. All logs aggregated in five piles of differing volumes between 25.9 and 131.8 m³ub were considered in the analysis.

Results

Results show that the difference between harvester and mill measurement derived log volumes is between 0.4 and 3.9 %. This depends on the bark deduction applied. Mill measurement under bark compared to standard harvester measurement including a standardized bark deduction depending on log size class results in 3.9 % difference between harvester (average log volume: 0.226 m³ub) and mill derived log volume (average log volume: 0.234 m³ub). The use of stand specific bark deduction reduces the difference to 2.8 % (average harvester log volume: 0.228 m³ub. The comparison of the actual volumes over bark for both mill and harvester reveals only a slight difference of 0.4 % (average harvester log volume: 0.249 m³ob; mill: 0.248 m³ob).

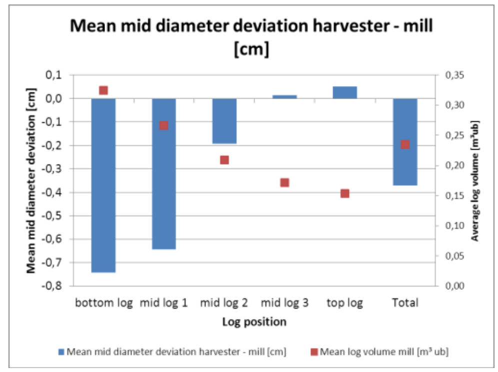

Figure 2: Mid diameter deviation between harvester and mill measurement for different log positions in the processed stems

Provided that the required cross-cut allowance is respected, mid diameter differences seem to be mainly responsible for these volume differences as log volumes are calculated based on mid diameter and nominal order length. Including log position within the processed stem in the analysis reveals that the log mid diameters measured by the harvester are too low for logs from lower stem sections and slightly too high for upper logs (Figure 3).

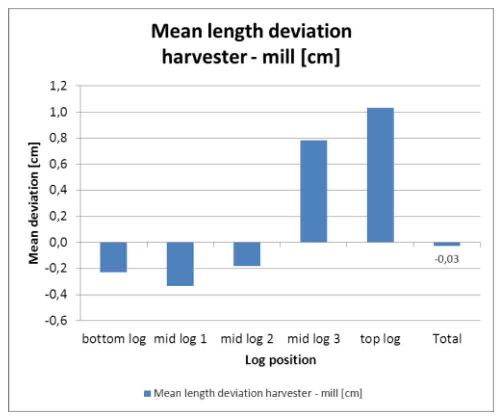

Figure 3: Length deviation between harvester and mill measurement for different log positions in the processed stems

The average log length deviations are highest for the upper logs, while bottom logs do not show exceptional length differences (Figure 2). The analysis also showed that the quality parameters *taper* and *ovality* had no clear influence on diameter and length accuracy of the harvester measurement.

The comparison of accuracy and time consumption of three different scaling methods for five sawlog piles showed a substantial possibility for increase of efficiency by use of automated or semi-automated methods. For sawlogs in Germany, the end-face method is accepted as accurate – in contrast to the harvester data. The aggregated results in Table 1 show that it is neither the fastest nor the most exact method. Polterluchs uses the mean log volume of a given assortment from the harvester production data to calculate pile volumes based on the captured number of logs per pile. It showed to be the most efficient of the evaluated methods, taking into account individual man times (min/m³ub).

Table 1: Time consumption of pile assessment (volume, count, data entry; calculation) in minutes per m³ub and volume accuracy for three different methods

Scaling method	Time consumption [min/ m³ub]	Time consumption in relation to end-face method	Volume in relation to mill volume [%]
Sections	0.544	85.0%	96.9%
End-face	0.639	100.0%	107.1%
PolterLuchs	0.131	20.5%	96.5%

In comparison to the manual scaling methods (*sections* and *end-face*) Polterluchs shows considerable advantages, particularly regarding time consumption and documentation of road side log piles by photos. However, in the case of inhomogeneous distribution of the logs across several piles, the individual pile volume accuracy can be substantially lower.

Conclusions

The standardized bark deduction factors seem to be mainly relevant for the observed mid diameter deviations. Branchiness can be assumed as one major source for harvester measurement errors, but this seems to affect only length and not diameter measurement. Other quality parameters such as taper or ovality could be excluded as potential sources of error.

Although harvester measurement of logs is still not as accurate as mill measurement, they are fairly accurate when it comes to log volume. The use of stand specific bark reduction factors or better integrated log specific bark thickness assessment methods instead of standardized tables could improve harvester performance. Besides the quality control of processes such as forwarding and transport, that are to date usually difficult or time-consuming to examine, the use of harvester data in connection with additional photo-optical log count methods is an efficient way to overcome gaps in the wood supply chain while increasing pile volume assessment efficiency compared to traditional scaling methods through substantial savings in time without trade-off in accuracy.

References

Eichordnung (2011). *Eichordnung vom 12. August 1988 (BGBl. I S. 1657), die zuletzt durch Artikel 1 der Verordnung vom 6. Juni 2011 (BGBl. I S. 1035) geändert worden ist.*

Dietz, H.-U. & Seeling, U. (2013). Verfahren in der Holzernte. *Lecture notes University of Freiburg*. Freiburg.

KWF (2013). *Lastenheft Harvestervermessung.* Kuratorium für Waldarbeit und Forsttechnik e.V., Groß-Umstadt.

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