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Comparative study of logging with harvester and chainsaw in poplar stands

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ABSTRACT

In the course of forest use in Hungary, multi-operation logging machines are already suitable for logging noble poplar stands. The present work discusses the development of the duration and specific time requirements of decision-making and felling with chanisaw, as well as logging with a harvester in relation to the net timber volume groups. During the extraction of noble poplar stands, field data collection was performed using a continuous time measurement method, during which, among other things, the process elements and their completion date, the number and size of the assortments produced per tree (length, peak diameter) were recorded. Based on these, it was possible to determine the duration of the operation elements, the duration of the harvest of the tree, the net volume of each tree. Furthermore, the specific time requirement based on the quotient of duration and net tree volume. In the case of work with a chainsaw, the following process elements are usefull for the present research: Seeking out the tree , cleaning the area around tree, felling, delimbing. In the case of work with a chainsaw, the following process elements are usefull for the present research: Seeking out the tree , felling, processing.

INTRODUCTION

The harvesters were originally specialized in harvesting Scandinavian pine forests. The appearance and development of early machines was induced by the need to mechanize the most time-consuming and costly operation element, the branching. Nowadays, they are also successful in the harvesting of poplar stands, which are very similar to pines. This can already be observed in our country, thanks to the increase in the number of harvesters and the labor shortage in the sector. The number of harvesters in Hungary has increased significantly, while around 2010 there were only one or two machines working in the country, until today there are around 90.

EXPERIMENTAL METHODS

Compared to the extraction of noble poplar stands with a chainsaw (motor-manual technical level), harvesting with harvesters already represents a more advanced level (process mechanized logging). Our research focused on the extent to which the duration and specific time requirements of the work performed at the two technical levels differ for given tree specimens, projected on the net wood volume. During the extraction of noble poplar stands, we carried out field data collection using a continuous time measurement method, the operational elements and their end date, the number and size of the assortment per individual tree (length, top diameter) were recorded. Based on these, it was possible to determine the duration of the operational elements, the duration of harvesting the individual tree, and the net tree volume of each individual tree. The specific time requirement can be calculated based on the quotient of the duration and the net tree volume.
In case of work with a chainsaw, the following operational elements are important from the point of view of this research:

- Seeking of the tree (ST): the approach, the visual inspection and the determination of felling direction of the tree to be felled;
- Cleaning of the tree area (CT): the eradication of vegetation that obstructs the felling and is in the way of escape route;

- Felling (F): the time elapsed from the beginning of making the hair until the tree falls;
- Debranching (D): the debranching of felled trees in the felling area.

In case of work with a harvester, the following operational elements are important of this research:

- Seeking of the tree (ST): grasping the trunk of the tree with the harvester’s head;
- Felling, processing (FP): operational element including felling, preassembly, debranching, conversion into assortments, bucking and stacking the assortments according to quality.

It can be seen that the two logging solutions are significantly different from each other, and it is difficult to compare them. The comparison was made even more difficult by the fact that the logging took place in a different way, as a result of some of the data series with chainsaws lack data on debranching. When evaluating the data, we used the data of the 'Felling' and 'Debranching' in case of a chainsaw, and the data of the 'Felling, processing' operation element in case of a harvester. We have omitted the action items Seeking of the tree' and 'Cleaning of the tree area', as they take considerably longer in case of a chainsaw, which would have distorted the data and made the comparison even more difficult.

RESULTS AND DISCUSSION

Fig. 1 shows the logging time and net tree volume for each harvested tree from the field measurements. The data set from logging with a harvester is located in a large area. Typically, 0.3 - 0.9 nm^3 trees were harvested (from felling to stacking) in 0.5 - 1.2 minutes. In case of a chainsaw, if we only take the 'Felling' as a basis, we find that a relatively vertical cloud of points has formed in 0.2 - 0.6 minute time frame. Examining 'Felling' and 'Debranching ' data together, we can see, that the data is more scattered in the right-up direction. The felling-branching of 0.2 nm^3 trees took 1.0 - 1.5 minutes, 1.4 nm^3 trees took 2 - 2.5 minutes.

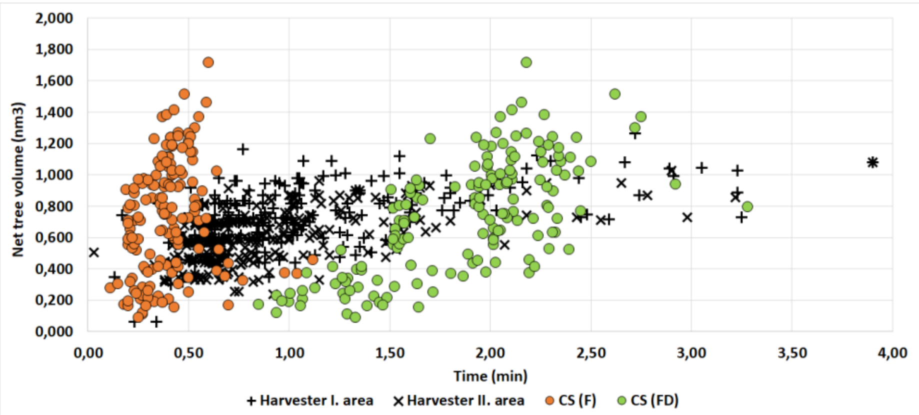

Figure 1: Felling and felling-debranching with a chainsaw, as well as the duration of harvesting with a harvester depending on the net tree volume

In case of harvested trees, we determined the specific time requirements. Fig. 2 shows the specific time requirements for felling and felling-debranching with a chainsaw, as well as harvesting with a harvester, for each tree. The data on the specific time required for the felling lie around the average of 0.65 min/nm^3 with a relatively small dispersion (min.: 0.086 min/nm^3, max.: 4.148 min/nm^3). The data on the specific time required for felling-debranching are located around the average of 3.28 min/nm^3 with a larger deviation (min.: 1.271 min/nm^3, max.: 14.588 min/nm^3). While in case of harvester, the data are very scattered compared to the average value of 1.53 min/nm^3 (min.: 0.059 min/nm^3, max.: 7.742 min/nm^3). The average value with a chainsaw (felling and debranching) is more than twice the specific time requirement as the harvester. Furthermore, in case of motor-manual logging, conversion into assortments and bucking have not yet taken place. Based on these, it can be said that harvesting noble poplar stands can be achieved with greater performance at the process mechanized level than at the motor-manual level with chainsaws.

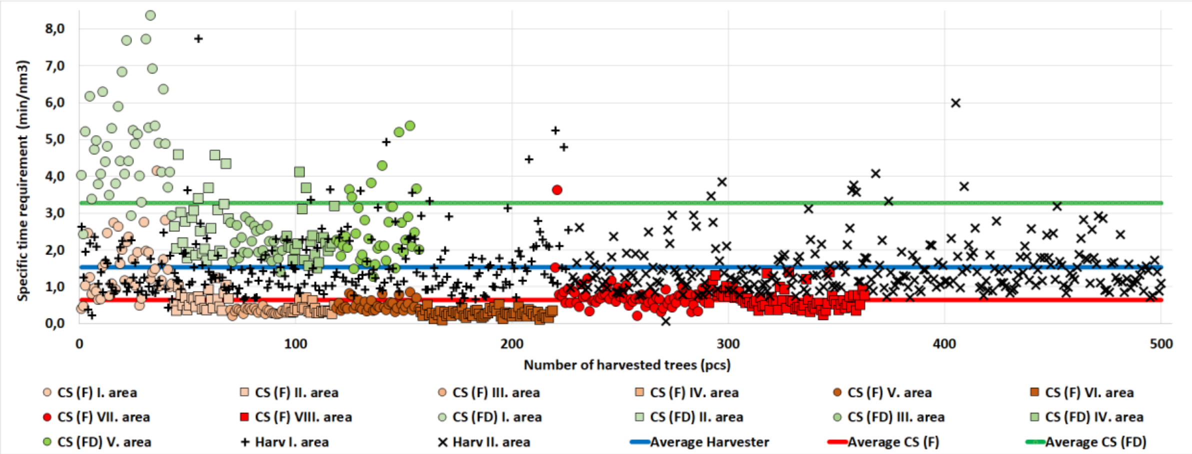

Figure 2: Specific time required for felling and felling-debranching with a chainsaw, as well as harvesting with a harvester

Fig. 3 shows the averages and medians of the harvesting time and specific time requirement of the net tree volume groups. In case of chainsaws, the averages and medians of the felling times follow the increase of the net tree volume with a slight increase. The felling-debranching time shows a more intensive rise. The optimization of the harvester's heads for the diameter range can be clearly observed in the data on the specific time required for logging with a harvester. It takes more time to harvesting trees, which are smaller than 0.3 nm^3 and larger than 1 nm^3 takes more time (due to size and shape).

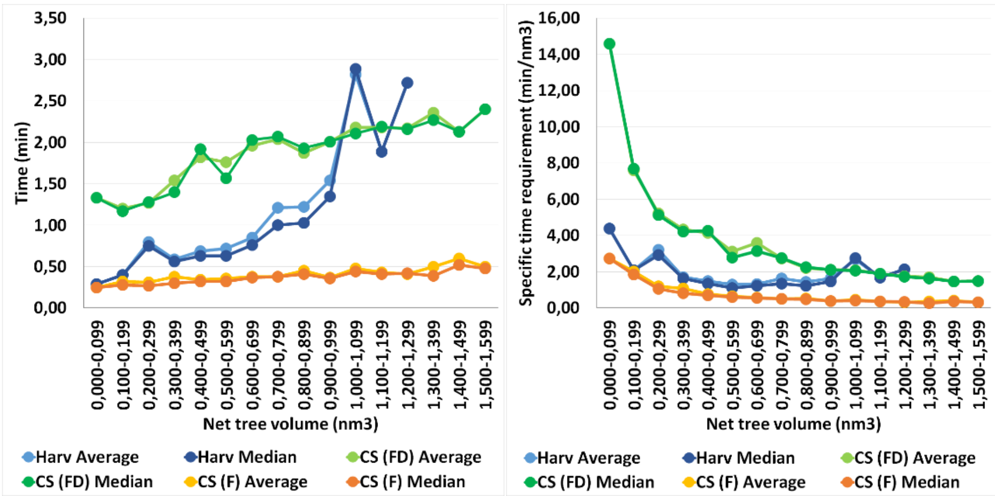

Figure 3: Evolution of average and median values of duration and specific time requirement per net tree volume group

The analysis of the distribution of net tree volume by group shows deeper correlations in case of extraction time data and specific time requirement data. Based on Fig. 4, it can be established that the conclusions (drawn on the basis of Fig. 3) are correct, the datas contains few outliers, so the average and median values are not distorted. The net tree volume boxes per group shown in Fig. 4 contain the interquartiles, i.e. the middle 50% of the datasets. So, the trends of the durations and specific time requirements (felling, felling-debranching, tree harvesting) are outlined by the most characteristic data, which are thus reliable.

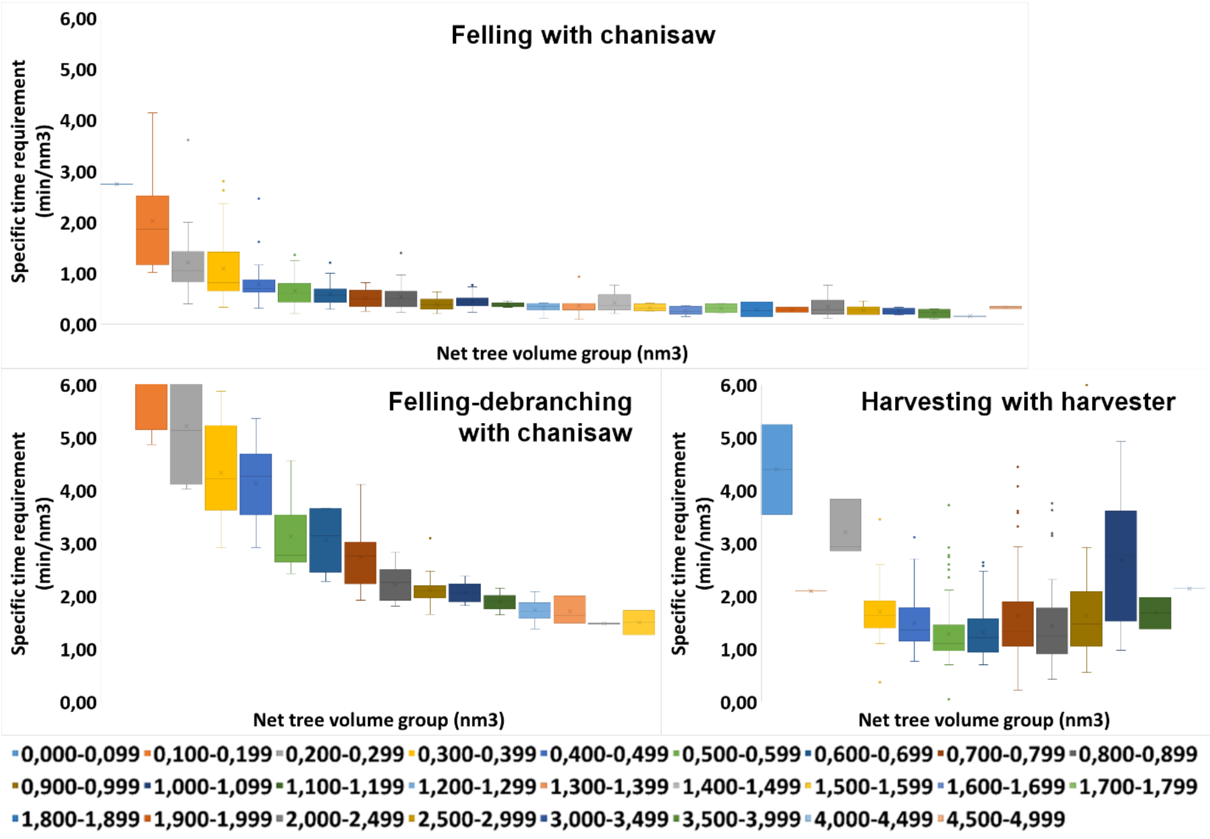

Figure 4: Distribution of the specific time required for felling and felling-debranching with a chainsaw, as well as tree harvesting with a harvester, by net tree volume group

CONCLUSIONS

The research confirmed that harvesters are capable of achieving higher performance harvesting in logging than is possible in the traditional way with a chainsaw. This statement is only correct if we use machines that match the parameters of the stock to be extracted.

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