Mechanized harvesting of aged traditional coppice stands

Scientific Report of the Short Term Scientific Mission:
COST Action FP1301
Period: 21 August to 9 September 2016

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Introduction

Coppice is a traditional method of woodland management used all over the world. By providing a large variety of wood and non-wood products as well as other services, coppice forests are of special importance (Suchomel et al., 2012). In recent decades, in some parts of Europe, the management of coppice forests has been abandoned due to socioeconomic changes (Suchomel et al., 2011). This resulted in aged coppice stands, whose potential of providing wood products remains unutilized, in times where the demand for wood and wood-based products is constantly rising. A possible solution to this problem could be the introduction of small- and medium- sized harvesters in coppice stands. However, limited bibliography is available on the topic compared to SRC harvesting.

This Short Term Scientific Mission (hereafter STSM) has been proposed as an opportunity to review, collect and analyze data of harvesting coppice stands in Poland. This STSM would take place under different conditions than in Greece, with the most notable difference being the use of mechanized harvesting in Poland, compared to motor-manual harvesting in Greece (Koutsianitis and Tsioras, 2016). The objective of this STSM is of absolute practical importance to the Greek producers of timber, as there is a great shortage of forestry-related personnel (Tsioras, 2010) and, despite the totally different work organization and cost management required, there are serious thoughts of introducing such equipment in coppice and high forests of mild to medium slope gradients. Personnel shortage has led to under-utilization of forested areas, especially coppice stands, where the coppiced stools of larger diameter can be found.

STSM Work plan

The STSM started on 21 August and was completed on 9 September 2016, arrival and departure days from Warsaw, respectively. The work plan included three periods:

1. **Preparatory stage:** The first three days (22.8-25.8) were spend at the Host Institution (Fig. 1), the Wood Technology Institute (hereafter WTI) on some coordination/preparation actions necessary for carrying out the field measurements (e.g. preparation of data collection forms and equipment – time studies equipment, electronic calipers - and travel to the field site on 25.8). During my stay at the WTI I contacted researchers with common scientific interests and the Director of the Institute Dr. Ewa Ratajczak. I also visited the Poznan University of Life Sciences (PULS) – WTI

and PULS have established a very close cooperation during the last years, which is documented in common research projects and publications. During this period, I was informed about the forest management in Poland, both of high and coppice forests and had first-hand information on the latest research projects in forest utilization topics.

Figure 1. The Wood Technology Institute in Poznan

2. **Data collection:** The first four days (26.8 – 29.8) were used for marking and numbering the trees that will be harvested. Also, morphological attributes of trees were also recorded (e.g. dbh, tree height). The next three days (30.8 –1.9) were allocated to time studies in the three selected plots. Furthermore, we visited the Forestry District Headquarters located in Zaporowo and had the chance to talk to the Forest Disrtict Director (Fig. 2) and other Polish colleagues on issues related to forest management and utilization and research priorities in the area.

Figure 2. Visit of the Zaporowo Forest District Headquarters

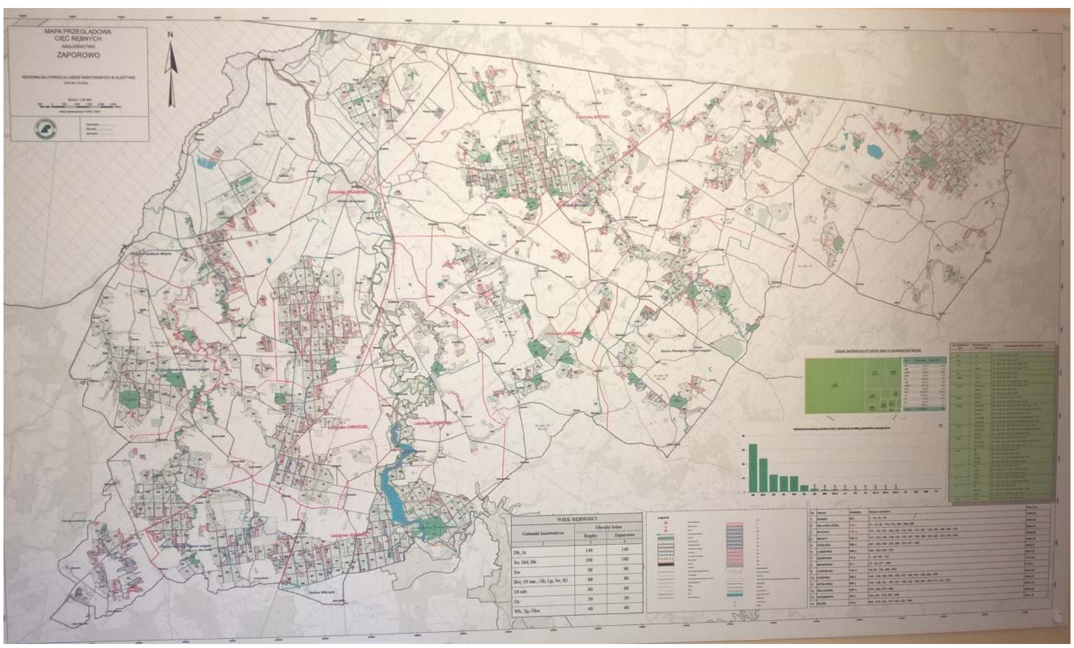

Figure 3. Responsibility area of the Zaporowo Forest District

3. **Data analysis:** The remaining days in Poznan (3.9 – 8.9) were focused on the analysis of the collected data and the preparation of the report.

Materials and methods

The study was carried at three especially designated coppice plots located in Northern Poland (Fig. 4) managed by the Polish State Forests (PSF). The harvesting sites are close to the Baltic Sea and in close proximity to the Polish-Russian borders. According to the initial plan three or four coppice would be chosen, each one having different characteristics, such as stand age and conditions, in an effort to acquire a broader insight on the harvesting productivity and costs of coppice stands in the area. Unfortunately, our choices were limited considerably due to the rainy weather. Increased soil moisture reduced the trafficability of many stands that we had initially chosen by the Polish colleagues prior to the STSM as candidates for study plots. The final choice of the plots was done together with the forest district officer and the forest contractor at the site. This resulted in the final setup of three coppice plots, one oak (hereafter Site 1) and two alder (hereafter Site 2 and 3, respectively). Special permission has been asked from the PSF and all forest operations were conducted under the supervision of the responsible forester for this compartment (part of the Forest District Zaporowo).

Figure 4. Location of the study plots (Google maps, 2016)

After the plots were set, the research team started to mark the trees to be felled (Fig. 5 and 6). Additionally, morphological attributes of the trees to-be-felled were recorded. Table 1 presents some of them:

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Figure 5. Checking the terrain trafficability and tree marking

Figure 6. Marked tree by the research team

The only assortment produced was 2.5 m long industry logs. The smaller diameter of these logs were at least 7 cm, which according to Polish standards is the limit for merchantable timber.

The initial sample size comprised of a total of 600 coppice stems (around 200 stems per plot). The selected plots, one oak and two alder plots, differed in terms of tree dimensions (Table 1) in an order to calculate the productivity and cost of harvesting operations under different stand conditions. Unfortunately, we also experienced trafficability issues in Site 3 as well (Fig. 7) resulting in reduced number of felled and processed trees (103 trees vs 215 initially marked).

Table 1. Stand descriptions and tree dimensions at the three study plots

	Site 1	**Site 2**	**Site 3**
Name	Kwidzyn	Zaporowo	Zaporowo
Stand number	6b	92 h	62 l
Species	Oak (70%) Pine (20%) Birch (10%)	Alder (90%) Birch (10%)	Alder (90%) Birch (10%)
Age (years)	55	31	18
Standing Volume (m^3)	196	232	98
Felled trees (n)	216	173	103
dbh mean (cm)*	18.06	14.69	14.65
dbh range (cm)*	7 - 34	9 – 22	9 – 42
Tree height mean (m)*	17.55	17.36	13.57
Tree height range (m)*	7 - 29	11 - 21	9 - 19

*Morphological attributes of the marked trees

Figure 7. Harvester stuck at the harvesting Site 3

A typical time and motion study was carried out in order to determine machine productivity (Magagnotti and Spinelli, 2012). Time studies data were collected by means of a hand-held chronometer and especially designed data collection forms. Each tree was stopwatched individually, using a digital hand chronometer. The continuous, time measurement was used in our study (Magagnoti and Spinelli, 2012). Each cycle considered separately all the main time elements that were considered typical of the harvesting process (Table 2).

Table 2. Description of time elements of the harvesting process

Time element	Description
Move and Fell	Any period the tracks are rolling. Includes the positioning of the head around the standing tree and the tree felling. It stops when the head is horizontal ready to process the tree.
Process	Begins when the head is horizontal and includes the delimbing and debarking (tree is being fed through the delimbing knives) and the crosscut (time when the saw is cross-cutting the logs). Ends when the last assortment has been processed.
Delays	Non-productive time including mechanical, operational and personal delays.

Productive time was separated from delay time (Björheden et al., 1995). One TBM Preuss 84V.II 6WD harvester (Fig. 8) equipped with a Kesla harvesting head (Fig. 9) was used for the felling and processing - including delimbing, debarking and cross-cutting. After the harvesting operations that cross-cut logs were measured by members of the research team. (Fig. 10).

Figure 8. TBM Preuss 84V.II 6WD harvester

Figure 9. The Kesla head equipped to the harvester

Figure 10. Measuring the final products

Results

The results show a wide range of productivity rates: 10.43m^3/PMH_0 (9.30m^3/PMH_{15}) for Site 1 (oak), 4.99m^3/PMH_0 (4.29m^3/PMH_{15}) for Site 2 (alder) and 3.76m^3/PMH_0 (3.13m^3/PMH_{15}) for Site 3 (alder) (Fig. 11). Tree dimensions and form affect the production rate as well as the driving skills of the harvester operator and the soil moisture at the harvesting site.

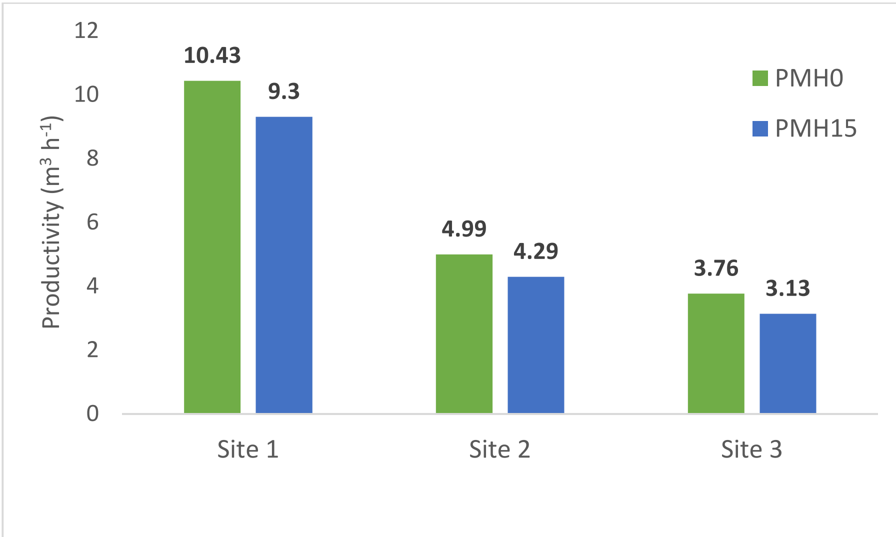

Figure 11. Net productivity (PMH_0) and productivity including delays (PMH_{15})

Increased difficulty in approaching the trees to-be-felled, as experienced in Sites 2 and 3 resulted in higher time consumption during the "Move and fell time element" (Fig. 12). On the contrary, oak stems demanded less time for processing compared to the alder ones and when combined with limited working experience even more unnecessary maneuvers are observed. Finally, the delay time percentage varies greatly form 24.6% up to 28.3%.

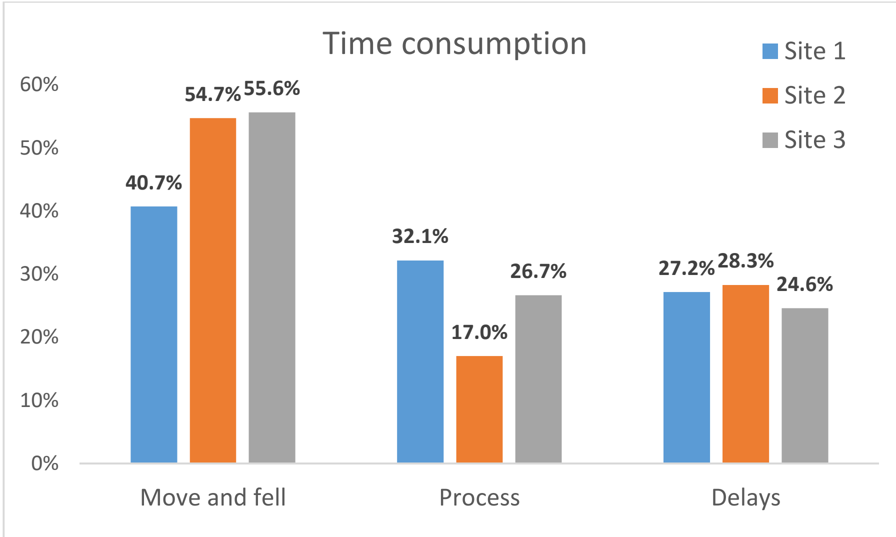

Figure 12. Time consumption per work element and harvesting site

The production cost has been calculated both based on PMH_0 and PMH_{15} in order to show the effect of day time. It ranged from 10.22 € m^{-3} (in Site 1) up to 34.05 € m^{-3} in Site 3 (Fig. 13).

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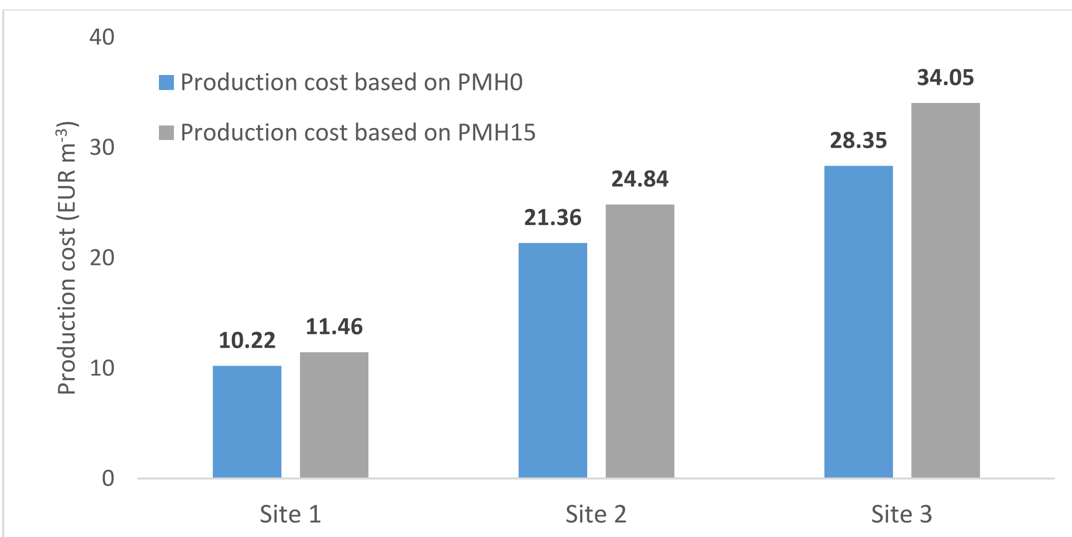

Figure 13. Production cost at the study sites

The results may be attributed to a number of reasons, with the most pronounce of them being the terrain condition. Increased soil moisture demanded more effort and time on behalf of the harvester operator to approach a tree. Especially in Sites 2 and 3 more maneuvering compared to Site 1 was necessary, which in turn also affected the production cost.

Conclusions

The net harvester productivity (PMH_0) ranged from 10.43 m^3 h^{-1} to 3.76 m^3 h^{-1}. When delays were included (PMH_{15}) productivity ranged from 9.3 m^3 h^{-1} to 3.13 m^3 h^{-1}. The mean dbh per site had a strong effect on productivity.

Soil trafficability is another factor affecting productivity rates and production cost. Early recognition of moist locations in the stand can prevent unnecessary time consumption and even costly machine breakdowns.

Similar second-hand equipment could be purchased and used in Greek forests, where the terrain is not a limiting factor. However, the effects of machine passes on soil should be also examined in future research.

The introduction of mechanized harvesting in coppice stands should be the result of careful consideration on behalf of the forest enterprise otherwise low production rates and poor financial outcomes are to be expected.

Research on the topic should continue, by developing (when possible) and new types of equipment as in (Schweier et al., 2015).

This STSM promoted the closer cooperation among the Wood Technology Institute (WTI) in Poznan, the Poznan University of Life Sciences and the Lab of Forest Utilization of Aristotle University of Thessaloniki (LFU-AUTH).

Acknowledgements

This study wouldn't be possible without the active participation and continuous guidance and support of Dr Karaszewski coming from the Host Institution (WTI Poznan). Special thanks goes to Dr Mariusz Bembenek, Dr Piotr Mederski and other scientists from the PULS and the WTI, for assisting me and the interesting information they provided me during my stay in Poznan. Finally, Marcin Janowski, the forest officer responsible for the study plot and employees of the Polish State Forests are to be especially thanked for all their kind efforts during my stay at the Zaporowo Forest District.

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Poznan 20th September 2016

Subject: Confirmation of the host of the successful execution of the STSM COST Action FP1301 of Petros A. Tsioras Lab of Forest Utilisation, Aristotle University of Thessaloniki, Greece

I confirm that PETROS A. TSIORAS from the Lab of Forest Utilisation / Aristotle University of Thessaloniki, visited the Wood Technology Institute in Poznan, Poland during the period 21st August 2016 to 9th September 2016. During his stay, Dr Tsioras conducted a research on the topic of mechanised harvesting of coppice stands.

The visit has been successful and developed a highly valuable link between partners. A future closer co-operation can be forecasted in areas of common scientific interest related to forest based sector. Herewith, I also acknowledge acceptance of the STSM report prepared by Dr. Petros A. Tsioras

Sincerely yours,
On behalf of the Wood Technology Institute

Dr Zbigniew Karaszewski
(The signed document will be send attached)