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TIMBER HARVESTING TECHNIQUES IN SHELTERWOOD SYSTEM

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Abstract: *Sustainable and multifunctional forest management, based on ecological principles, is a major challenge for modern forestry. Forest operations which include appropriate road planning, timber harvesting and extraction should be done by the minimizing the treat to the environment. It is particularly important in shelterwood system where different types of cuts are applied. This paper describes an arboricultural timber harvesting process in these relatively complicated forest conditions. For comparison, traditional method with use of motor-manual cutting was taken into consideration, as well. In the both processes, wood extraction was done by the Ponsse Elk forwarder. On the basis of the research carried out in oak stands following factors have been indentified and compared: underplanting damages, labor efficiency as well as economic aspects. Conducted analysis enabled to pinpoint benefits and drawbacks coming from the arboricultural timber harvesting method.*

1. Introduction

Sustainable and multifunctional forest management, based on ecological foundations, is a great challenge for today's forestry. Economic assignments realized in practice must take into consideration guidelines set forth in numerous legal acts referring to this sphere, aiming to, into a great extent, cultivation of co-natural tree stands.

The manner of felling in cutting utilization of tree stands is usually connected with specific ways of renovation and care. Cutting forms primarily affect the multi-level structure of tree stands, aims for desired species composition and enables its maintenance, and improves the form of mixing and age structure of a future tree stand.

In some European countries, due to specific terrain and tree stand conditions, clear cutting has for example been banned as a form of timber harvesting (Košir, 2008). In Poland, in 2008, 5.9 million m^3 of merchantable timber was harvested under the clear-cut system which corresponds to 19.2 per cent of total harvest. Cutting area in this system was the lowest since 1980's. Reduction in the size of clear-cut areas is indicative of forest management ecologisation progress, and their use is often the result of large-scale damages to forests inducted by wind, drought, fungal infections or insect outbreaks (Polish State Forests...2009).

The consequence of the aforesaid phenomena is extensive application of different complex felling in Polish conditions. Contribution of this manner of felling, in respect to harvested timber, amounts to 20.3%. In complex felling, shelterwood systems are of great importance.

Timber harvesting, consisting of felling and forwarding, causes specific damages to the forest environment. This particularly applies to complex fellings, where opening up of the shelterwood and removal cuts were carried out, necessary for appropriate development of the next tree generation,

often leads to considerable damages and devastation whose extent may threaten, or even make impossible, the realization of originally set objectives. For this reason, an important problem referring to timber harvesting is to employ appropriate techniques and technologies.

The ways of cutting, and resultant saving, should not lead to losses in productivity of future tree stands. Looking at the problem from a time perspective obligates to choosing such a technological process that will cause the smallest possible damages to the remaining tree stand. One of the possibilities in this respect is to apply processes using arboristic techniques (Chisholm, 1998; Seligowski, 2007; Szaban and others, 2008).

2. Material and methods

Survey plots have been located in the Gidle Forest Inspectorate (Kruszyna Forest District, compartments 163c and 137g). In both areas there were oak tree stands with fir and beech underplanting. There two variants of timber harvesting were applied: traditional and that using arboristic techniques, later referred to as the innovative variant. The former entailed tree felling, using Husqvarna 365 chainsaws, into the existing gaps and free spaces. Then the trees were delimbed, and the harvested material was manipulated into 5 m logs. Thus prepared assortments were then forwarded by means of Ponsse Elk forwarder.

In the latter variant the first technological operation was delimbing the trees to be cut „standing". The trees were delimbed from the top downwards in order to slow down the speed of falling branches. For this purpose arboristic techniques were applied using the following equipment:

- tree-climbing saddles Petzl Navaho and Singing Rock,
- lanyards and round slings SherrillTree,
- Gecko II spikes,
- Petzl carabiners and Petzl Grigri descenders,
- static ropes and grigri descenders Samson 12 mm and Tendon 10 mm of 50 m length,
- Petzl Vertex Vent crash helmets,
- surgery and tree care chainsaws Husqvarna 338XPT and Husqvarna 334T.

Delimbed trees were felled perpendicularly to the forwarding routes by means of Husqvarna 365 chainsaws. Other work was done similar to the first variant.

The efficiency of performed work was then determined, and the costs of timber harvesting were calculated using data obtained from the IT system of the Gidle Forest Inspectorate. At the same time, the extent of damages to fir and beech underplanting was determined, constituting bottom level of the analysed tree stands. The damages were divided into the following categories (first three apply to felling of trees and their delimbing; fourth applies to forwarding):

I – broken top,
II – broken branches, damaged bark,
III – fatal damages not prognosing survival,
IV – broken trees, damaged during forwarding.

3. Results and discussion

In the variant using arboristic techniques in delimbing, 243 trees were cut. In the traditional variant 162 trees were removed (Table 1).

Achieved work efficiency in both cases show a relatively low level close to 1 m^3/h, whereas in the innovative variant it was by approximately 20% lower. It should however be taken into account that average thickness of cut trees, that amounted to 0.43 m^3, was slightly lower than in the traditional variant – 0.57 m^3.

Taking into consideration economic aspect of timber harvesting (Table 2), it should be stated that the application of arboristic techniques involves much higher labour costs, resulting mainly from employment of specialist equipment. In timber harvesting employing the traditional method, unit costs of felling and material processing, according to the data obtained from the IT system of the State Forests,

Table 1. Description of research plots

Specification	Compartment 137g Traditional variant	Compartment 163c Innovative variant
Total area	6.42 ha	2.02 ha
Cutting area	1.80 ha	1.20 ha
Number of harvested trees	162	243
Average breast high diameter of harvested trees	25 cm	26 cm
Standard deviation	7.82 cm	6.30 cm
Coefficient of variation	31.28%	24.23%
Average height of harvested trees	19 m	19 m
Standard deviation	1.96 m	1.76 m
Variation coefficient	10.31%	9.26%
Work efficiency rate in logging	1.05 m^3/h	0.79 m^3/h 1.36 m^3/h (without the time of removal of branches around trees and securing with a rope during wood extraction being taken into consideration)

amounted to 3.0 Euro/m^3. In the innovative method these costs were approximately four times higher, and amounted to as much as 12.7 Euro/m^3. Unit costs of forwarding are at the same level and amount to 4.4 Euro/m^3. Unit costs of the whole processes amount to 7.4 Euro/m^3 and 17.1 Euro/m^3 respectively. It should be noted that in 2008, average cost of timber harvesting and extraction in the State Forests amounted to 10.5 Euro/m^3.

Table 2. Timber harvesting and forwarding costs in both technological variants

Action	Traditional variant			Innovative variant		
	Volume of merchantable timber [m^3]	Costs [Euro]	Unit costs [Euro/m^3]	Volume of merchentable timber [m^3]	Costs [Euro]	Unit costs [Euro/m^3]
Harvesting	88.70	264.7	3.0	98.40	1252.7	12.7
Extraction	88.70	390.7	4.4	98.40	433.4	4.4
Total	-	655.4	7.4	-	1686.1	17.1

In cost analysis, also losses resulting from decreased productivity of tree stands should also be taken into consideration. Initial simulations speak in favour of the employed arboristic techniques. In the future, further studies are planned to deal with this problem.

Surveys, concerning damages that occurred as a result of timber harvesting and extraction with the use of both discussed methods, have been made on the basis of field diaries prepared after completion of work.

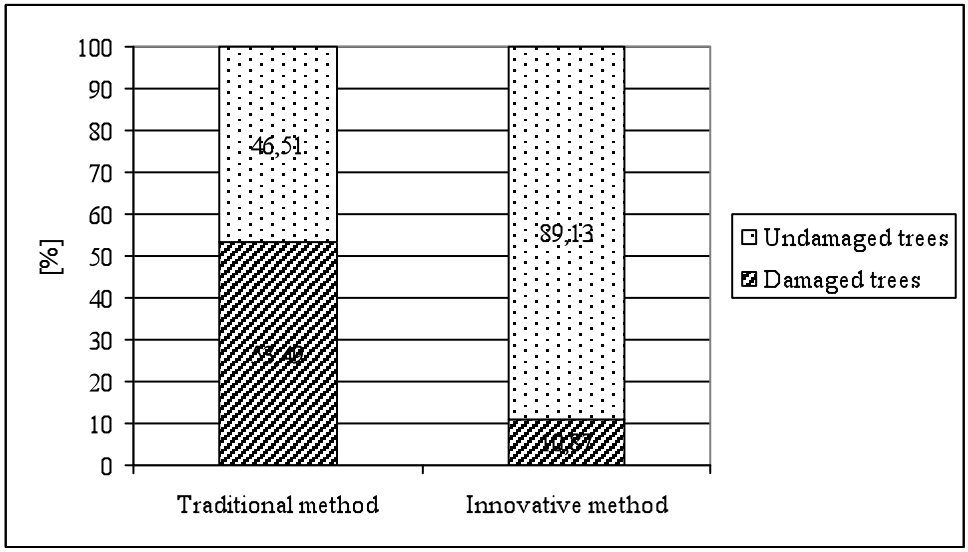

Figure 1. Share of damages to the fir-beech underplanting after logging operations

The above figure (Fig. 1) shows clearly the differences in the results obtained in the compared survey areas. The number of damages in the traditional variant was approximately five times higher than in the other studied variant. In the areas where chainsaw operator worked, undamaged trees constituted less than 50%. The experimental method however allowed to avoid damage in almost 90% of trees.

Small share of damaged trees in the innovative method was caused by the fact that the trees were delimbed from the top down. The speed of falling branches was slowed down by the branches located at lower levels before they have been delimbed. Thanks to this the force of impact of falling branches was low. They often remained hanging on firs and beeches without causing any damages. Delimbed trees were felled into spaces between rows of trees, therefore the possibility of causing any damages was inconsiderable. Side branches in the underplanting were usually only brushed by the felled trunks.

Obtained results, particularly those referring to damages to the bottom level of the tree stand in traditional timber harvesting, are consistent with the data in literature. Studies carried out by Muszyński (1995) showed that in mountains tree stands, where horse skidding was conducted, share of damages to the underplanting amounted to 25%, while extraction by means of a farm tractor to 35.5%. Suwała (2003) said that over 50% of damages to the underplanting and shrub layer occurs as soon as during felling. In the application of the length wood method in beech tree stands, with felling and processing with the use of chainsaws, and two-stage horse skidding (extraction to strip road) and a skidder (extraction along the strip road), a definitely lower percentage (6.8%) of damaged underplanting was observed (Sowa and Szewczyk, 2000).

Also interesting is the structure of damages to the underplanting (Table 3). In the traditional method the majority of damages, approximately 70%, were already observed during felling and delimbing of trees. Other damages occurred during wood extraction. In the innovative method, due to the fact that the trees were delimbed before felling, approximately 2/3 of damages to the underplanting were observed at the stage of wood extraction.

Table 3. Percentage of each category of damages in relation to the total number of the fir and beech underplanting

Classes of damage to trees		Innovative variant (compartment 163c)		Traditional variant (compartment 137g)	
		Number of trees [pcs.]	Share [%]	Number of trees [pcs.]	Share [%]
Without damage		1523	89.13	405	46.51
Harvesting	I – Broken top	24	1.40	138	15.84
	II –Broken side branches, damaged bark	43	2.51	121	13.89
	III – Fatal damages to trees	5	0.29	69	7.92
Extraction	IV – Broken trees, damaged during extraction	114	6.67	138	15.84
Total		1709	100	871	100

Differences in damages to the bottom level, observed during studies, clearly speak to the advantage of employment of arboristic techniques in the tree stands in which underplanting or underwood are particularly valuable.

4. Conclusion

Conducted surveys allow to formulate the following conclusion:

1. Sustainable and multi-functional forest management, based on ecological principles with broad use of complex fellings, is a great challenge for today's forestry. Over the past years, in timber harvesting, increasingly stronger emphasis is being put on employment such technologies and technical measures that have the lowest possible negative impact on forest environment.
2. Work related to timber harvesting using arboristic techniques, particularly in tree delimbing, contributes to significant reduction of damages to the bottom level of tree stands. The number of such damages, comparing to the traditional method, is about five times lower.
3. Application of arboristic techniques however involves much higher costs of timber harvesting, comparing to the traditional method. One of the factors that cause this situation is the need for using specialist and expensive equipment, and involvement of properly trained personnel having appropriate qualifications for working at heights.
4. The timber harvesting process in complex fellings is the cause of damages and devastations significant to the future tree stands. For this reason, it is essential to carefully select tree felling techniques. One of the possibilities in this respect is employment of processes using arboristic techniques.

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