Optimization of Timber Forwarding from Pedunculate Oak Stands after Salvage Thinning

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Abstract:
The secondary productivity in forestry is also called technical productivity. It depends on inputs of forest operators and used machinery, and it is especially significant in the investigation of forest operations. The aim of a high quality organization of wood assortment production is to increase the yield and reduce costs. This can be achieved by the optimization of the work process. In the area of the Croatian lowland forests, which are even-aged, forwarders are mainly used for the extraction of roundwood. The use of forwarders implies the assortment method of wood processing, so that after motor-manual felling and processing by chainsaws, wood assortments are scattered on the ground of the felling site. Apart from forwarding timber from main felling and late thinning, these vehicles are also used for forwarding timber after salvage thinning. The research involved comparative analyses of data collected during monitoring timber forwarding at two working sites (A and B). Both felling sites had similar terrain and stand characteristics – they were 100-year old pedunculate oak stands. Salvage thinning was carried out (damaged, dead and decayed trees). Felling density was 11.10 m^3/ha at both felling sites. When marking the trees for felling, they were located with the help of a GPS device, and their DBH was measured. After felling and processing, time study was performed during roundwood forwarding by snap-back chronometry method. The characteristics of the forwarded roundwood have been taken over from the IT system of the company that keeps records of the processed assortments. Vehicle travel was recorded by a commercial GPS with the external antenna installed on the vehicle cabin. In the first case (working site A) the driver of the forwarder had no information on tree locations, while at the working site B, guidance was provided to the marked trees (expected timber loading points) with the aim of shortening the vehicle travel and reducing soil damage. The results are in favor of the work system applied at the working site B. In this case, the vehicle travel distances were shortened and on average higher load volumes per work shifts were recorded. The above said resulted in lower time consumption required for travel during loading as well as in lower time necessary for the loaded vehicle travel. Considering the results of this research, it can be concluded that in conditions of lower harvest intensity (salvage thinning), by an adequate work preparation (and namely locating all marked trees and informing the forwarder driver of these locations), the area of the forest stand soil exposed to damage can be reduced, the forwarder productivity can be increased and unit costs can be lowered.

Keywords: forwarder, productivity, costs, salvage thinning, pedunculate stands

1 Introduction and scope

Health condition of forests can be disturbed by biotic and/or abiotic factors such as mutual competition between trees, insect outbreaks, negative climate phenomena, human impact, etc. (Pothier and Mailly 2006). Health condition of stands is determined by monitoring crown condition of individual trees. The increase of defoliation results in exponential increase of tree mortality in the stand (Dobbertin and Brang 2001). Crown damage can be monitored directly and indirectly, and however neither of these two methods is completely objective (Redfern and Boswell 2004). In Europe, health condition of forests is monitored annually in the framework of the International Co-operative Program on Assessment and Monitoring of Air Pollution Effects on Forests (ICP FORESTS). The said program started in 1985, and the Republic of Croatia has joined it in 1992.

From the economic point of view, considering the value of the total volume of roundwood produced, and also its unit price, pedunculate oak is the most valuable tree species in Croatia. The stands of pedunculate oak are located in lowland areas. The management of these forests is affected by the ever increasing drying, dying and decaying of trees. This has a serious impact on primary production, which is affected by the forests health condition. In Croatia, in the period from 1995 to 2007, the share of salvage cut of pedunculate oak was 35% out of the total allowable cut (Matić 2009). The value of wood assortments of damaged trees after salvage thinning of pedunculate oak is lower compared to the assortments produced from regular harvesting operations in healthy stands, primarily due to the disrupted assortment structure (Tikvić et. al. 2009). According to the applicable regulations in the Republic of Croatia (Official Gazette "NN" 2006, 2007, 2009, 2011) when marking trees for felling, in stands where damaged, dry and decaying trees have been observed, all dead trees have to be marked, as well as alive trees:

⇒ if crown defoliation is higher than 80%,
⇒ if more than 60% crown is dead (broadleaves) or if more than 60% crown is dead and decline involves the top (conifers),
⇒ with characteristic symptoms of disease or pest on or under the bark.

Spatial distribution of damaged stands is irregular (Tikvić et. al. 2011). The above said causes difficulties in felling, processing and forwarding timber, which results in an evident increase of costs and decrease of productivity of wood harvesting operations. Wood harvesting in lowland stands of pedunculate oak implies motor-manual felling and assortment method of wood processing by chain saws, and timber extraction by tractor assemblies, medium and heavy forwarders to the forest road (Krpan 1996, Poršinsky et al. 2011).

2 Material and methods

Forwarders are self-propelled vehicles for the transport of timber or its parts loaded in the vehicle load space (ISO 2009). Scientific research of primary transport (extraction) of timber by forwarders in the Croatian lowland forests indicates some characteristics conditioned by work technology. This kind of extracting timber differs from other technologies in many ways (short roundwood, assortment method of processing, the vehicle approaches the processed wood within the crane's reach, etc., Stankić et. al. 2012). The difference also lies in the fact that during a work cycle timber is gathered in the area of the felling site that can even exceed several hundred meters, which is not the case when extracting timber by skidders, adapted farming tractors or cable yarders.

Time study of forwarders was carried out by snap-back chronometry method along with collecting data on influencing factors, while monitoring of the vehicle travel was performed with the use of a portable GPS device (Garmin GPSMAP® 76CSx) mounted on the vehicle with an external antenna on the cabin roof. The research involved the analysis of the work of the forwarder Timberjack 1410 during the extraction of roundwood after salvage thinning in lowland stands of pedunculate oak.

The research sites were two stands, 100-year old, covered with pedunculate oak in the management unit „Turopoljski lug" managed by the Forest Office Velika Gorica (Fig. 1.). The working site A is defined by the subcompartment 104A, and the working site B by the subcompartment 103A. The area of the working site A was 16.57 ha, and of the working site B 20.36 ha. At the working site A, a total of 184 m^3 was marked for felling, and at the working site B 226 m^3, meaning that the felling density was identical at both working sites and amounted to 11.10 m^3/ha.

The characteristics of the working site B was that the position of all marked trees was determined by a portable GPS receiver, which was not the case with the working site A. In other words, the forwarder driver had the information of the locations of the marked and felled trees, i.e. the places where wood assortments were processed.

After collecting data, they were processed and analyzed. Program tools ESRI ArcGIS Desktop 9.3, Mcrosoft Excel 2003 and Corel Draw X3 were used for this purpose.

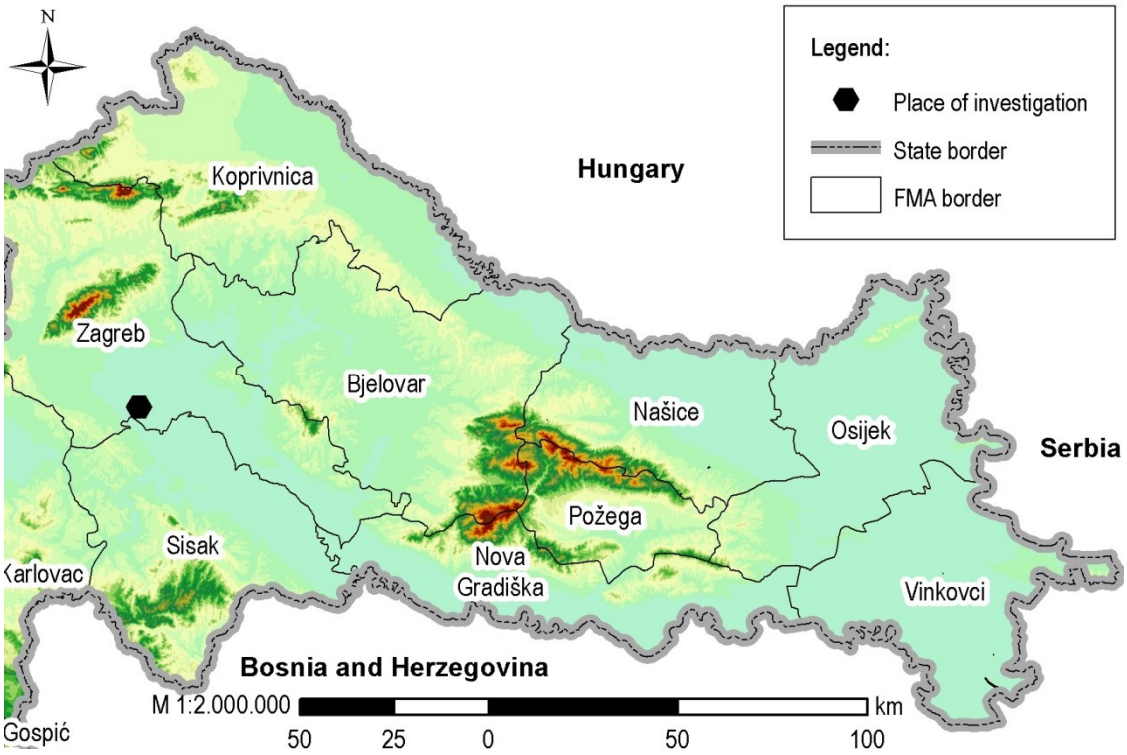

Figure 1: Place of investigation

3 Results

Considering time consumptions of individual work components at two working sites, it is evident that there are differences in the percentage share of four components and namely: timber crane loading, vehicle traveling during loading (relocation), loaded vehicle travel on the felling site and timber crane unloading.

Differences in loading and unloading timber by hydraulic crane can be explained by larger average load volume at the working site B (10.17 m^3) than at the working site A (9.2 m^3), so that the percentage share of time consumption of these work components is higher. At the working site B, lower values have been observed for the percentage share of time consumption for the vehicle transfer during timber loading (by 21.58%) and for loaded off-road travel (by 24.81%). This can be explained by the above described situation at the felling site, where the forwarder driver had the information about the space distribution of the marked and felled trees. The differences between time consumptions of the remaining work components were negligible.

The productivity achieved at the working site A was 10.72 m^3/h, while the productivity norm planned for this working site was higher and namely 11.02 m^3/h. At the working site B, the achieved productivity was 14.37 m^3/h, and the planned norm was lower and namely 13.01 m^3/h. Lower level of productivity than planned at the working site A and higher at the working site B are caused by the information on the distribution of the processed wood, and the way of calculating the productivity norm, which takes no account of the information on the location of marked trees.

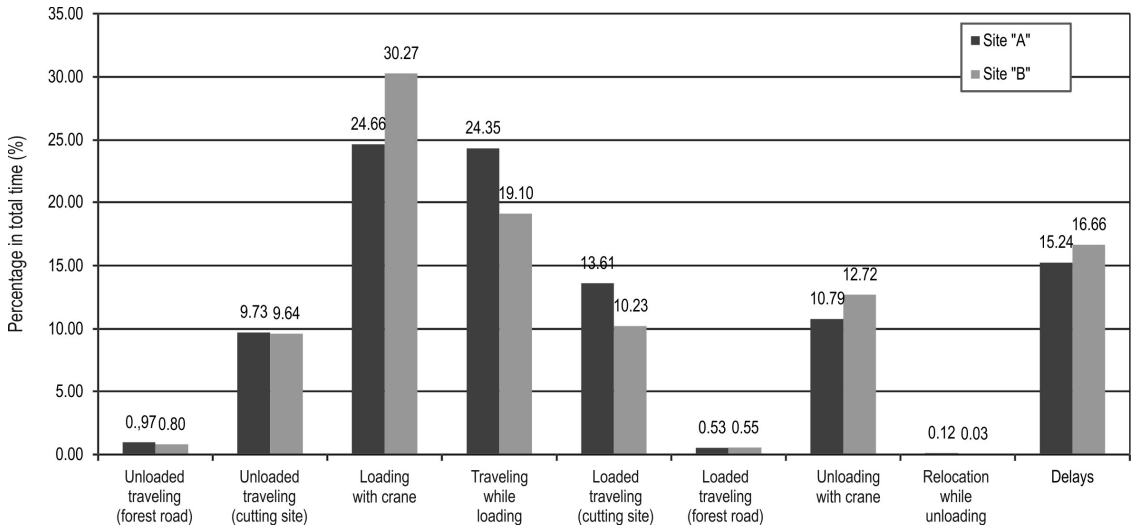

Figure 2: Share of time consumption of work elements in total time

Comparing the achieved productivity by comparative analysis between the investigated working sites, it can be concluded that the forwarder productivity is higher by 34.05% in case when the driver is informed on the locations of the marked trees. It should be emphasized that here we deal with salvage felling of low felling density in lowland forests of pedunculate oak, smaller logs, and assortment method of processing with the extraction by medium forwarders.

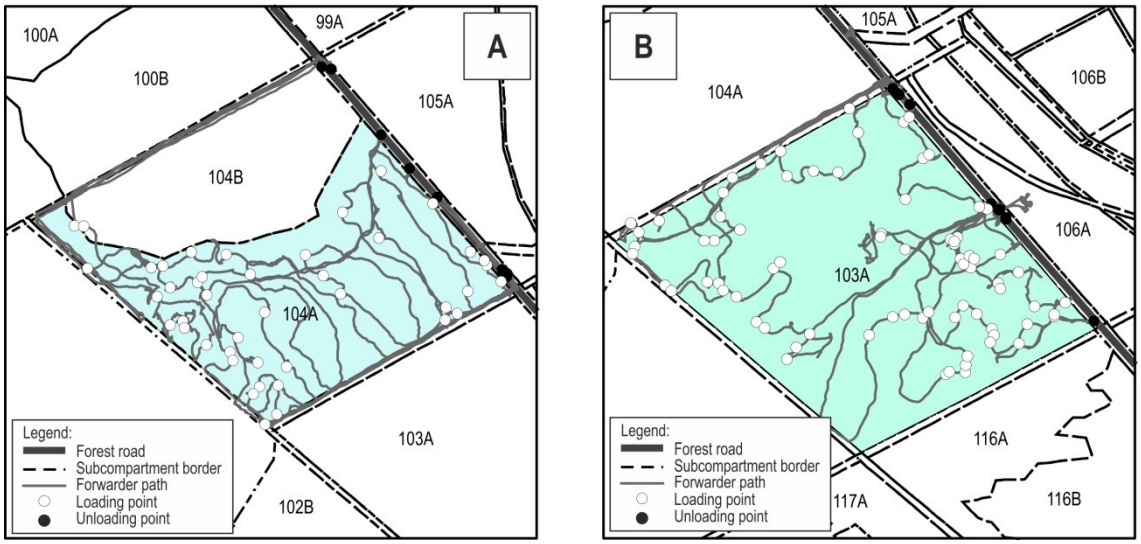

Figure 3: Tracking forwarder path at working sites A and B

When speaking of timber forwarding, the available scientific and professional literature gives different definitions of the term „extraction distance“ and different ways of measuring this influencing factor. In the Croatian forestry, the most commonly used definition is the one that implies that the forwarding distance is the arithmetical mean of the sum of travel distances of unloaded and fully loaded vehicle of individual cycle (s_d=[s_{loaded}+$s_{unloaded}$]/2), and hence it was used in this research, too. Thereby, the travel distance of the unloaded vehicle is the distance from the roadside landing to the first loading point, and the travel distance of the loaded vehicle is the distance from the last crane loading point to the roadside landing. Fig. 3 shows the research working sites with the tracks of vehicle travel, and timber crane loading points and unloading points can also be noticed. On the basis of GPS data on vehicle travel and GIS analysis of space data, the actual timber forwarding distance has been established. It is 429.8 m for

the working site A, and 270.0 m for the working site B. This is also the reason why higher productivity was achieved at the working site B.

At the time of recording the work process, the conditions of work were satisfying because the soil bearing strength was good. Analyzing environmental viability of timber forwarding, primarily forest soil compaction, it has been determined that the trodden area of the working site A was (for the vehicle width) 2.324 ha (13.68% of the subcompartment area), and for the working site B 1.863 ha or 9.14% of the subcompartment area. Vehicles mostly passed across the area only once, and the share of repeatedly trodden area was negligible.

4 Conclusions

Considering the above said results of this research, it can be concluded that in conditions of lower felling density (salvage thinning) in lowland oak forests, adequate preparation of work (and namely locating all marked trees and informing the forwarder driver of these locations) can reduce forest soil damage caused by forwarders, lower the shares of time consumption of vehicle transfer during loading and loaded vehicle travel, which results in lower forwarding distance, and finally in productivity increase. Consequently, better utilization of the forwarder load space is achieved and operating costs of primary timber transport are lowered.

5 References

Dobbertin, M. and Brang, P., 2001: Crown defoliation improves tree mortality models. Forest Ecology and Management 141(3): 271–284.

ISO, 2009: Machinery for forestry – Mobile and self-propelled machinery – Terms, definitions and classification (ISO 6814:2009). Machinery, 1–7.

Krpan, A. P. B., 1996: Problem privlačenja drva u nizinskim šumama Hrvatske (Problem of skidding timber in Croatian lowland forests, in Croatian). Šumarski list 120(3/4): 151–156.

Matić, S., 2009: Gospodarenje šumama hrasta lužnjaka (Quercus robur L.) u promijenjenim stanišnim i strukturnim uvjetima. Zbornik radova sa znanstvenog skupa Šume hrasta lužnjaka u promijenjenim stanišnim i gospodarskim uvjetima. HAZU, Zagreb, pp. 1–22.

NN 2006: Pravilnik o doznaci stabala, obilježavanju drvnih sortimenata, popratnici i šumskom redu. Ministarstvo poljoprivrede, šumarstva i vodnoga gospodarstva RH. Narodne novine 116/06.

NN 2007: Pravilnik o izmjenama Pravilnika o doznaci stabala, obilježavanju drvnih sortimenata, popratnici i šumskom redu. Ministarstvo poljoprivrede, šumarstva i vodnoga gospodarstva RH. Narodne novine 74/07.

NN 2009: Pravilnik o izmjenama i dopunama Pravilnika o doznaci stabala, obilježavanju drvnih sortimenata, popratnici i šumskom redu. Ministarstvo regionalnog razvoja, šumarstva i vodnoga gospodarstva RH. Narodne novine 55/09.

NN 2011: Pravilnik o izmjenama i dopunama Pravilnika o doznaci stabala, obilježavanju drvnih sortimenata, popratnici i šumskom redu. Ministarstvo regionalnog razvoja, šumarstva i vodnoga gospodarstva RH. Narodne novine 25/11.

Poršinsky, T., Stankić, I. and Bosner, A., 2011: Djelotvorno i okolišno prihvatljivo izvoženje drva forvarderom temeljem analize nominalnoga tlaka na podlogu (Ecoefficient Timber Forwarding Based on Nominal Ground Pressure Analysis, in Croatian). Croatian Journal of Forest Engineering 32(1), 345–356.

Pothier, D. and Mailly, D., 2006: Stand-level prediction of balsam fir mortality in relation to spruce budworm defoliation. Canadian Journal of Forest Research 36(7): 1631–1640.

Redfern, D. B. and Boswell, R. C., 2004: Assessment of crown condition in forest trees: comparison of methods, sources of variation and observer bias. Forest Ecology and Management 188(1): 149–160.

Stankić, I., Poršinsky, T., Tomašić, Ž., Tonković, I. and Frntić, M., 2012: Productivity Models for Operational Planning of Timber Forwarding in Croatia. Croatian Journal of Forest Engineering 33(1), 61–78.

Tikvić, I., Ugarković, D. and Gašpar, J., 2011: Prostorna analiza odumiranja stabala hrasta lužnjaka (Quercus robur L.) za potrebe adaptivnoga gospodarenja šumskim ekosustavima u Hrvatskoj (Spatial Analysis of Pedunculate Oak Mortality Rate for Adaptive Forest Ecosystem Management in Croatia, in Croatian). Croatian Journal of Forest Engineering 32(1), 43–56.

Tikvić, I., Zečić, Ž., Ugarković, D. and Posarić, D., 2009: Oštećenost stabala i kakvoća drvnih sortimenata hrasta lužnjaka na spačvanskom području (Damage of forest trees and quality of timber assortments of pedunculate oak on Spačva area, in Croatian). Šumarski list 133(5-6), 237–248.