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Why Harwarders for Wood Harvesting?

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Abstract

Currently, the total number of harwarders in industrial roundwood and energy wood harvesting in Finnish forests is slightly over one hundred. Metsäteho Oy conducted a follow-up study of harwarders in industrial roundwood harvesting in Finland, and also investigated the transfers of the harwarders. In the study of Metsäteho, the possibilities of harwarder systems in wood harvesting in the near future in Finland were also evaluated. It was forecasted that the number of harwarders will significantly increase in the near future in Finland; within a few years, the number of harwarders engaged in industrial roundwood and energy wood harvesting may even be as much as 200–300. This development forecast is based on the following factors: I) Cost effectiveness in wood harvesting is being sought at the level of the stand marked for harvesting, as well as from the point of view of the forest machine business. II) The structural change in cuttings is setting new demands on the harvesting machinery. III) As a result of changes in the forest machine business field, the size of forest machine contracting businesses is growing and large regional responsibilities in contracting are increasing.

Keywords: Harwarders, Wood harvesting systems, Cost-efficiency, Industrial roundwood, Finland.

1. Introduction

A harwarder is a forest machine that can be used for both cutting and forest haulage. The active development of harwarders in Finland started in the late 1990's after Lilleberg (1997) demonstrated that the harwarder was a more cost-effective wood harvesting system than a two-machine harvesting system consisting of a harvester and a forwarder, when the average industrial roundwood stem size in the marked stand was less than 150 dm^3. Since then, the productivity and profitability of harwarders in industrial roundwood harvesting, as well as in energy wood harvesting, have been investigated in many studies. However, these trials have been almost

exclusively time studies. Comprehensive, long-term follow-up study data on harwarders have been produced in only two studies: Sirén and Aaltio (2003) in industrial roundwood harvesting, and Kärhä (2006) in energy wood harvesting.

In several studies (e.g. Strömgren 1999, Rieppo & Pekkola 2001, Bergkvist et al. 2003, Rieppo 2003, Sirén & Aaltio 2003, Emer 2005, Nordén et al. 2005, Kärhä 2006) the harwarder has proved to be a more cost-effective wood harvesting system than the traditional two-machine system, especially when the average stem size of the marked stand is relatively small, the removals per hectare/stand low, and the forwarding distance short.

One of the strengths of a harwarder is considered to be the lower transfer costs compared to the two-machine harvesting system. The distance, time consumption, and costs of harwarder transfers have not, however, been reported in the previous harwarder studies. A follow-up study of harwarders in industrial roundwood harvesting, as well as a study on the transfers of the harwarders, were carried out by Metsäteho Oy. In the study of Metsäteho, the possibilities of harwarder systems in wood harvesting in the near future in Finland were also evaluated.

2. Material and methods

2.1. Follow-up study

A total of five harwarders – three Ponsse Wisent Duals (also in this article *Ponsse Dual*) and two Valmet 801 Combis (also *Valmet Combi*) – were covered in the follow-up study. Eleven different harwarder operators participated in the follow-up study. The follow-up period started in September 2004, and continued until May 2005. The follow-up data were collected by Telmu 100 dataloggers. The harvesting conditions were obtained from the wood procurement organizations for which each harwarder was contracted. The total industrial roundwood harvested with the Ponsse Dual harwarders was almost 25,000 m^3. The study material with the Valmet Combi harwarders was smaller, only around 5,000 m^3. The amount of harvested industrial roundwood in the follow-up study totalled nearly 30,000 m^3.

The number of harvesting sites totalled 92, and data about the harvesting conditions were obtained from 70 of the sites. The harwarders were primarily used in thinnings in the follow-up study: 14% of the total volume of industrial roundwood harvested came from first thinnings, and 43% from later thinnings. Less than one-third of the wood quantity came from final cuttings. The proportion of other/combined cuttings was 11%. Furthermore, harwarders were used principally for real harwarder work, i.e. both cutting and forwarding were done by a harwarder at the harvesting site (Fig. 1). Harwarders were also used to balance two-machine (harvester–forwarder) harvesting systems, with the cutting carried out by a harwarder

and the forwarding performed later on by a forwarder. There were only a few harvesting sites where the harwarders carried out only forest haulage at the harvesting site (Fig. 1).

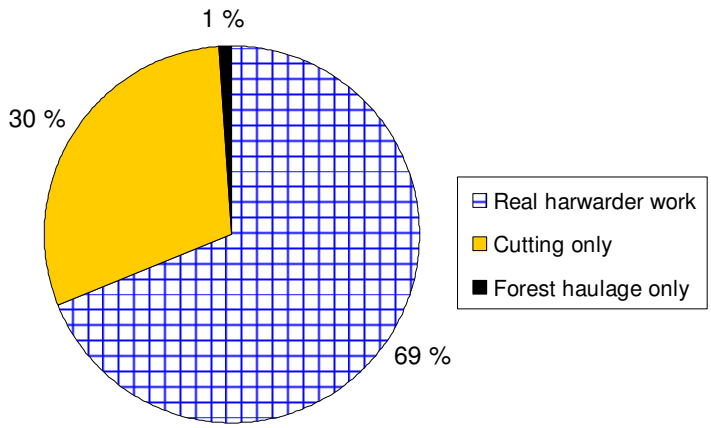

Figure 1. Proportion of different modes of operation out of the total volume of industrial roundwood harvested by harwarders in the follow-up study. Real harwarder work consists of both cutting and forwarding with a harwarder at the harvesting site.

The cutting was initially mainly performed by the Ponsse Dual harwarders included in the follow-up study and, after that, the machines were outfitted for forwarding and used to haul the felled timber to the roadside. In thinnings with the Valmet Combi harwarders, the following working method was mainly applied. The harwarder was driven forward into the stand while, at the same time, the trees along the strip road were cut and both sides of the strip road were thinned. The felled timber was bunched mainly into piles along the strip road. At the end of the strip road the harwarder was turned around and driven back along the harvested strip road while, at the same time, the bunched stems were loaded. In final cuttings, the Valmet Combi harwarders were driven forward parallel with the edge of the stand while cutting along one side. Direct loading was not carried out with the Valmet Combi harwarders in the follow-up study in either final cuttings or thinnings.

2.2. Studies on transfers

The research data on transfers with harwarders were collected by interviewing 13 harwarder entrepreneurs, in addition to conducting time studies on two harwarder transfers. The interviews were conducted during April 2003, and the time studies were carried out in October 2003 and

January 2004. Research data on harwarder transfers were also collated from the follow-up study on harwarders.

2.3. Cost calculations and system analysis

Cost calculations were prepared for two harwarders, of which the purchase price of the Harwarder II was 100,000 € (VAT 0%) higher than that of Harwarder I, and for the two-machine harvesting system which consisted of a harvester for thinnings (weight: 13–15 tons; e.g. John Deere 1070D, Ponsse Beaver, Valmet 901) and a medium-duty forwarder (carrying capacity: 10–12 tons; e.g. John Deere 1110D, Ponsse Wisent, Valmet 840) (Table 1). For all the machines, the annual operating hours were standardized as 2,574 E_{15}-hours in the calculations. In the cost calculations, the proportion of thinnings was 40% of the total volume of roundwood harvested. The operating hour costs for the harvester for thinnings were 79 €/E_{15}-hour and for the medium-duty forwarder 57 €/E_{15}-hour (Table 1). The operating hour costs of the Harwarder I were 73 €/E_{15}-hour and of the Harwarder II 82 €/E_{15}-hour.

Table 1. The purchase prices, operating hour productivities and annual outputs used in the cost calculations, as well as the calculated operating hour costs of the machines.

Machine	Purchase price, € (VAT 0%)	Productivity, m^3/E_{15}-hour		Industrial roundwood, m^3/a	Operating hour costs, €/E_{15}-hour
		Thinnings	Final cuttings		
Harwarder					
- I	288,000	6.1	7.7	17,939	73
- II	388,000	6.1	7.7	17,939	82
Harvesting system					
- harvester	279,000	8.5	18.0	32,015	79
- forwarder	187,000	11.0	15.0	33,657	57

The wood harvesting costs in thinnings with Harwarders I and II were compared to the harvesting costs with the two-machine harvesting system. The effective (E_0) hour productivities in thinnings with the two-machine harvesting system in cutting and forest haulage were determined by the time consumption models presented by Kärhä et al. (2006). It was assumed that, when the average stem size in the stand increased from 50 dm^3 to 250 dm^3, the roundwood removal increased from 36 m^3/ha to 81 m^3/ha (cf. Kärhä 2007). There were 500 Norway spruce (*Picea abies* L. Karst.) undergrowth trees per hectare in the thinning stand, and the average height of the spruce undergrowth trees was 2 m. The average load size was 11.0 m^3 in forest haulage with a forwarder.

3. Results

In the follow-up study, the technical utilization rate was 88.1% on the average, and the operational utilization rate was 82.6%. In real harwarder work, based on the entire follow-up study material (average stem size in marked stand 198 dm^3 and average forest haulage distance 239 m), on the average 57% of the effective working time was used for cutting and 43% for forest haulage (Fig. 2). With first thinnings (89 dm^3 and 280 m), the cutting took on the average 63% and forwarding 37% of the effective working time. With final cuttings (326 dm^3 and 179 m), the effective working time was split almost equally between cutting and forest haulage (Fig. 2).

In real harwarder work within the follow-up study, the productivity per operating hour in first thinnings was, on the average, 5.1 m^3/E_{15}-hour and in other thinnings 6.4 m^3/E_{15}-hour. In the case of thinnings, the productivity per operating hour of real harwarder work was best explained by the average stem size in the marked stand (Fig. 3). The forest haulage distance also had an impact on the operating hour productivity. In the final cutting of the real harwarder work within the follow-up study, the average productivity was 7.7 m^3/E_{15}-hour.

The harwarder systems were more competitive than the two-machine system when the average stem size of the marked stand was relatively low, i.e. less than 120–180 dm^3 (Fig. 4). In this case, the industrial roundwood removal is below 60–70 m^3/ha (cf. Kärhä 2007). Furthermore, harwarders were the most competitive in low-removal stands, particularly at harvesting sites that were below 50 m^3. As the stem size in stand and roundwood removal per hectare/stand increased, the competitiveness of the two-machine harvesting system improved in comparison to that of the harwarder systems (Fig. 4).

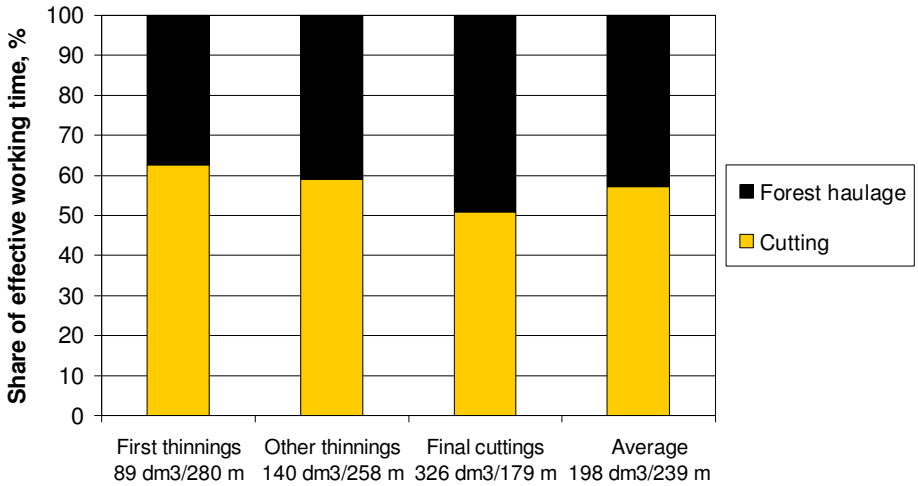

Figure 2. Distribution of the effective working time in real harwarder work by cutting method, and on the average in the follow-up study. The average stem size of the marked stand and average forwarding distance at sites for which the data of harvesting conditions were available are also shown.

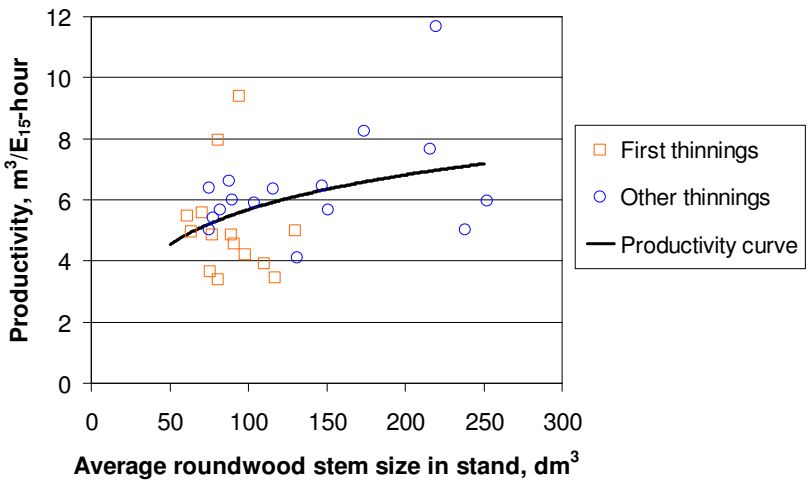

Figure 3. Operating (E_{15}) hour productivity in thinnings in real harwarder work by harvesting site, and the productivity curve as a function of average stem size.

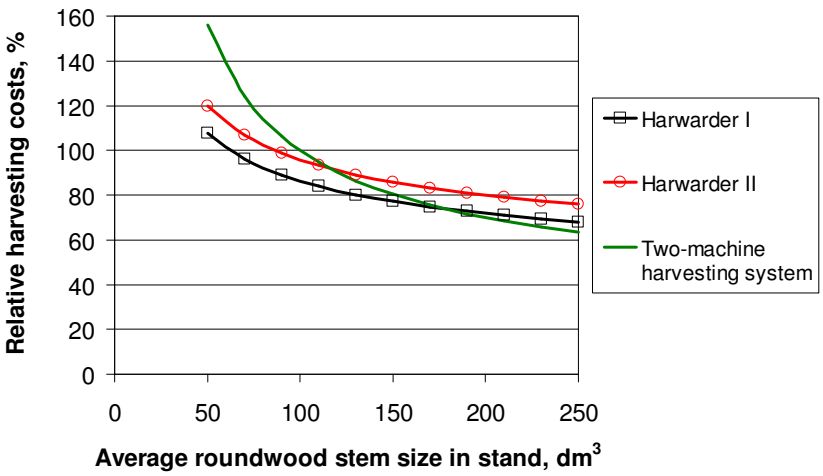

Figure 4. Effect of average stem size on the relative harvesting costs of thinning wood with Harwarders I and II and with a two-machine harvesting system. The purchase price of Harwarder II was 100,000 € (VAT 0%) higher than of Harwarder I. Industrial roundwood removal increased from 36 m^3/ha (average stem size 50 dm^3) to 81 m^3/ha (250 dm^3), and the

forwarding distance was 250 m. Harvesting costs 100 = Harvesting costs with a two-machine harvesting system at an average stem size of 100 dm^3.

In the follow-up study, the proportion of the total work-time of harwarders used in transfers between harvesting sites was 2.5%, and the effective transfer time was, on the average, 1.3 hours/transfer (Fig. 5). The harwarder entrepreneurs interviewed calculated that the transfer distance with a harwarder from one stand to another is, on the average, 28 km. The study showed that, in addition to the primary harwarder transfer, a lot of time is spent in both the preparatory work phases prior to the transfer (e.g. transmitting cutting and forwarding data, cleaning the harwarder, driving the harwarder onto the transfer truck, binding the harwarder) and the finishing work phases of the transfer.

The average transfer costs of the harwarder, according to the estimates of the entrepreneurs interviewed, were 203 €. The average transfer costs of a two-machine harvesting system were 469 €/transfer/harvesting system. On the basis of these figures, the transfer costs of a harwarder were less than half (43%) those of a two-machine harvesting system.

4. Discussion and conclusions

Currently, the total number of harwarders in use in Finnish forests is slightly over one hundred, of which more than half are mainly engaged in industrial roundwood harvesting and the remainder in energy wood harvesting. Harwarders have not been as widely adopted as would be expected in the light of the positive results of harwarder studies.

The reasons for the relatively slow growth in harwarder usage have not been documented. Possible reasons include resistance and prejudice towards harwarders, together with entrenched preferences for traditional harvesting technology. These factors came to light in Metsäteho's investigation on the increasing use of tracked excavators in harvesting operations in Finland (Bergroth et al. 2007).

The number of harwarders will undoubtedly significantly increase in the near future in Finland; within a few years, the number of harwarders engaged in industrial roundwood and energy wood harvesting may even be as much as 200–300. This development forecast is based on the following factors:

1) *Cost effectiveness in wood harvesting is being sought at the level of the stand marked for harvesting, as well as from the point of view of the forest machine business*. A harwarder has a clear competitive advantage in small-removal thinnings and final cuttings, forest fellings in the archipelago, the harvesting of wind-felled trees, and in seed tree and shelterwood fellings (Kärhä et al. 2001). It makes sense to harvest

relatively small-removal and small-diameter stands marked for harvesting with a harwarder while, conversely, it is more worthwhile to harvest sites with larger removals and trees using a two-machine harvesting system, thereby raising the profitability of two-machine harvesting systems.

A forest machine contractor's reserve of stands marked for cutting essentially determines how optimally a harwarder can be used. The larger the stand reserve volume the forest machine contractor has, the better are the opportunities to effectively utilize his forest machine stock (Jylhä et al. 2006).

2) *The structural change in cuttings is setting new demands on the harvesting machinery*. Wood harvesting volumes of thinnings and on peatlands will grow during the next ten years (Nuutinen et al. 2000, Nuutinen & Hirvelä 2006). The harvesting conditions described above (small stem size and low removals) are ideally suited for harwarder.

   The use of harwarders also means less driving is needed during harvesting operations, thus minimising strip road rutting. In peatland harvesting, however, long forwarding distances may reduce the profitability of harvesting based on a harwarder.

3) *As a result of changes in the forest machine business field, the size of forest machine contracting businesses is growing and large regional responsibilities in contracting are increasing*. These changes are creating a potential for the use of specialized harvesting machinery. In this respect, the acquisition of a harwarder alongside two-machine harvesting systems may be a sensible alternative.

When evaluating the competitiveness of harwarders, the relatively short development track of harwarders must be kept in mind. Harwarders have been actively developed for only about ten years. By developing harwarders and their working methods and organization, it will be possible to further improve the competitiveness of harwarders.

One potential development trend is the additional versatility of harwarders, whereby the same base machine is used to carry out several different types of work, up to 3–4 different tasks, on each return to site (cf. Kärhä & Peltola 2004). Possible work type combinations include, for example, different silvicultural tasks, forest regeneration, and industrial roundwood and energy wood harvesting. The large number of different work tasks is not, however, in itself the primary objective; rather the aim of versatility is to offer a means of improving operational profitability.

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