Improving the Cost-Efficiency of Small-Diameter Energy Wood Harvesting from Early Thinnings in Finland

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Abstract:
In studies carried out by Metsäteho Oy, Metsähallitus and TTS Research, the total removal of integrated wood harvesting was found to have increased significantly compared to that of conventional, separate roundwood harvesting. When the total removal from the harvesting site increased considerably, there was a significant increase in the productivity of cutting work in integrated wood harvesting compared to that of separate pulpwood harvesting. In addition, the delimbing quality and bucking accuracy of the pulpwood poles obtained in multi-tree processing were comparable to those produced in single-tree handling. The measurement of work output was conducted with a crane scale, attached to the boom of the forwarder. The studies indicated very promising results in integrated wood cutting and suggest integrated harvesting is likely to continue to increase in both first and later thinnings in Finland.

Keywords: integration, energy wood, early thinnings.

1 Introduction

According to the National Forest Programme, the estimated annual need for first thinnings is 250,000 hectares (Anon., 1999). Based on the latest forest inventory calculations, the target for first thinnings should be approximately 300,000 hectares/year during the next ten years (Korhonen et al., 2007). During the 2000's, however, only 156,000–256,000 hectares were thinned annually (Juntunen & Herrala-Ylinen, 2010; 2011).

In 2010, 6.3 million m^3 (12.5 TWh) of commercial forest chips were used for energy generation in Finland (Ylitalo, 2011). 41% (5.1 TWh) of the total amount of forest chips was produced from small-diameter ($d_{1.3}$<10 cm) trees in young stands (Ylitalo, 2011). Several national targets have been set to increase the annual use of forest chips up to 8–12 million m^3 (16–24 TWh) by 2015, and up to 13.5 million m^3 (25 TWh) by 2020 (Anon., 2008; Pekkarinen, 2010). These targets project that the harvesting of small-sized thinning wood will double or even triple, over the current harvesting volume.

High harvesting costs, particularly cutting costs, is the main problem when harvesting both energy wood and pulpwood in early thinnings. The small stem size, low removal per hectare, high number of remaining trees, and dense undergrowth, result in low productivity and high cutting costs (e.g. Kärhä et al., 2004; 2005; Oikari et al., 2010). In order to increase the harvesting volumes of energy wood and pulpwood in young stands, the harvesting costs will have to be reduced significantly. One way to do this is to integrate the procurement of industrial roundwood and energy wood in early thinnings (e.g. Kärhä, 2007).

The integrated harvesting of industrial roundwood and energy wood by the so-called 'two-pile cutting method' has increased strongly in young forests in Finland during the last three years. Industrial roundwood and energy wood harvested from the logging area are stacked in the cutting phase into two separate piles: a roundwood (i.e. pulpwood) pile and an energy wood pile (Fig. 1). The tops and branches of pulpwood-dimensioned trees, as well as small, undersized trees and undesirable tree species, are stacked in the energy wood pile. The pulpwood fraction is designated for the pulping forest industry, and the energy wood fraction for energy generation.

Figure 1: The integrated wood procurement system based on the two-pile method, in which pulpwood and energy wood fractions are stacked into separate piles in early thinnings.

Three years ago Metsäteho Oy and the University of Joensuu (Oikari et al., 2010) conducted a survey which ranked the potential approaches for increasing the cost-efficiency of small-diameter energy wood and industrial roundwood harvesting from early thinnings. The main group of actors in wood harvesting in Finland, i.e. managers in wood procurement organizations, forest machine contractors, forest machine manufacturers and vendors, and wood harvesting researchers, were interviewed in the survey. The interviewees emphasized that there is a significant potential to increase the cost-efficiency of wood harvesting in young stands by improving harvesting methods. In particular, the interviewees underlined the great potential of multiple-tree handling in industrial roundwood cuttings, crane scale measuring, and the integration of roundwood and energy wood harvesting in early thinnings (Oikari et al., 2010).

Considerable improvements have been achieved during the past year in these harvesting methods: Machine and device manufacturers have been developing harvester heads capable of multiple-tree processing for industrial roundwood cutting in early thinnings. New multi-tree processing harvester heads have been introduced and extensively tested (e.g. Kärhä, 2008; Kärhä & Mutikainen, 2008). The integrated harvesting of pulpwood and energy wood has also been used more in young stands. National guidelines and agreements have also been drawn up for the crane scale measurement of energy wood and pulpwood (Melkas, 2009; Lindblad et al., 2010).

The studies carried out by Metsäteho Oy, Metsähallitus and TTS Research:

i) determined the time consumption and productivity in cutting work when using the integrated cutting of first-thinning wood,
ii) clarified the development of the total removal in integrated harvesting operation, and
iii) investigated the quality of pulpwood poles when using integrated cutting with multi-tree handling.

The future prospects of integrated harvesting in thinnings were also examined in the study.

2 Material and methods

2.1 Harvester head

The working method comparisons were conducted with a new Ponsse H53e harvester head (Fig. 2). Based on the Ponsse H53, the Ponsse H53e was launched by Ponsse Plc in 2008 (Anon., 2010). A multiple-tree processing function was integrated into the Ponsse H53e harvester head, thereby undergoing a drastic redesign. Roundwood cutting with the Ponsse H53e is also possible in the traditional fashion by the single-tree processing method.

The Ponsse H53e is also suitable for the integrated cutting of roundwood and energy wood, and for separately cutting energy wood as whole trees and as delimbed stemwood. The Ponsse H53e is suitable for felling trees of less than 50 cm in diameter. The weight of the new Ponsse H53e is 850 to 900 kg (Anon., 2010).

2.2 Working methods

Time studies were carried out in four first-thinning Scots pine (*Pinus sylvestris* L.) dominated stands in forest owned by UPM Forest at Kontiomäki (64°21’N, 28°09’E) in June 2008 and at Loppi (60°43’N, 24°27’E) in August 2008. The harvester was the same in all the studies (Ponsse Beaver of N & K Lukin Ky), but the operators of the harvester were changed. Both operators had several years of experience in the “traditional” cutting of thinning wood by the single-tree processing method, but only a couple of months’ experience in integrated cutting and multi-tree handling of pulpwood before the studies.

In the time study, the integrated cutting of industrial roundwood and energy wood, as well as separate cutting of roundwood (i.e. only roundwood was harvested), were tested in the studies. Multi-tree processing was utilized as much as possible in both cutting methods. A third working method was also employed in the time study carried out at Loppi: conventional pulpwood cutting by the single-tree processing method. In the time studies, all the timber classified as roundwood was cut into pulpwood.

Visual bucking was used in the integrated cutting and multiple-tree processing of pulpwood. Harvester measurement was used in cutting pulpwood by the single-tree processing method. The target top diameter of the cut pulpwood poles was 4 to 8 cm, and the target length of the Scots pine and Norway spruce (*Picea abies* L. Karst.) pulpwood poles 2.7 to 5.1 m and of birch pulpwood about 3 m. Conifer pulpwood and birch pulpwood were cut separately in all of the cutting methods.

Figure 2: The Ponsse H53e harvester head with a multiple-tree processing property.

2.3 Crane scale measurement

A total of 4,000 trees were cut in the time study at Loppi and more than 1,200 trees at Kontiomäki. All the trees felled during the time study were hauled to the roadside landing and weighed with a crane scale. Ponsse LoadOptimizer crane scales were used for weighing. A total of 223 green tonnes were produced in Loppi, 182 of which was pulpwood, mainly pine pulpwood, and 41 tonnes of energy wood. A total of 63 green tonnes were produced in Kontiomäki (53 tonnes of pulpwood and 10 tonnes of energy wood).

3 Results

3.1 Multiple-tree processing

In the integrated cutting of pulpwood and energy wood and the multi-tree processing of pulpwood, more than half (52% to 72% by time study plot) of the cut trees were multiple-tree processed at Loppi. Less multiple-tree processing was used at Kontiomäki, where about 39% of the harvested trees were multi-tree processed.

The average bunch size at Kontiomäki was 1.26 trees/bunch. The average size of a bunch in integrated cutting and the multiple-tree handling of pulpwood at Loppi was higher (1.48 trees/bunch) than at Kontiomäki. The diameter at breast height of the biggest trees that were multi-tree processed in the time studies was 13 to 14 cm.

3.2 Removal and cutting productivity

When integrated cutting was used, there was a considerable increase in the total volume of removal from a stand (Fig. 3): The removal roughly doubled at Loppi, when cutting most of the tops and branches of pulpwood-dimensioned trees, undersized trees and undesirable tree species for energy wood. The removal at Kontiomäki increased nearly 40% in integrated cutting (Fig. 3).

There was also a significant increase in productivity in integrated cutting in the time studies: productivity in integrated cutting at Kontiomäki was almost 20% higher than in the multiple-tree cutting of pulpwood (Fig. 4). The results at Loppi were similar: productivity in integrated cutting was 11 to 37% higher than when cutting only pulpwood (Fig. 4). The increased removal in integrated cutting was the main reason for the increase in the productivity of cutting work.

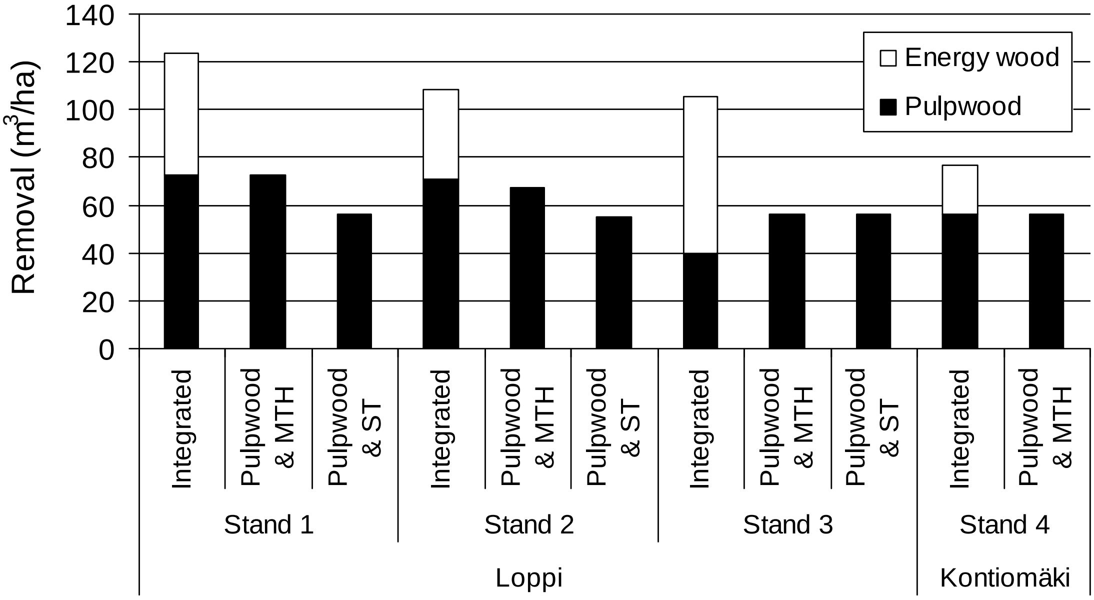

Figure 3: Total removals (pulpwood and energy wood) by time-study stand and cutting method tested: i) Integrated cutting, ii) Separate pulpwood cutting by applying multiple-tree handling (MTH), and iii) Separate pulpwood cutting based on single-tree (ST) processing.

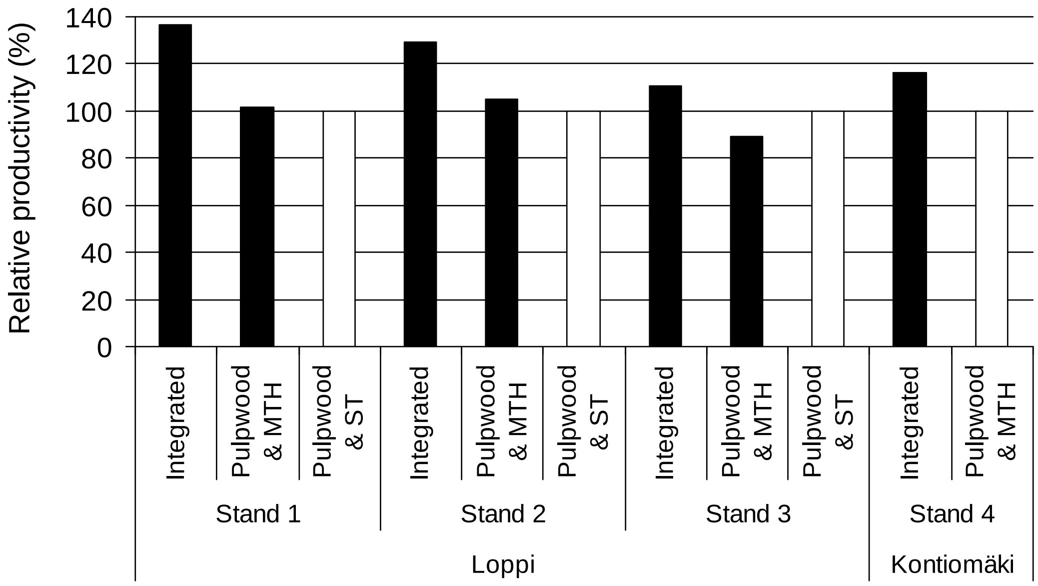

Figure 4: Relative cutting productivity by time-study stand and cutting method tested. Productivity level of 100 (white bars) = at Loppi the cutting productivity in Separate pulpwood cutting based on single-tree (ST) cutting, and at Kontiomäki in Separate pulpwood cutting by applying multiple-tree handling (MTH).

3.3 Bucking accuracy of poles

The extent to which the length and top diameter of cut pulpwood poles corresponded to the instructions in the integrated cutting and multiple-tree processing of pulpwood was also investigated at Loppi. According to the measurement results, the bucking of pulpwood poles was also successful in the integrated cutting and the multi-tree handling of pulpwood: the proportion of undersized pulpwood poles was only a few percent in the study (Fig. 5).

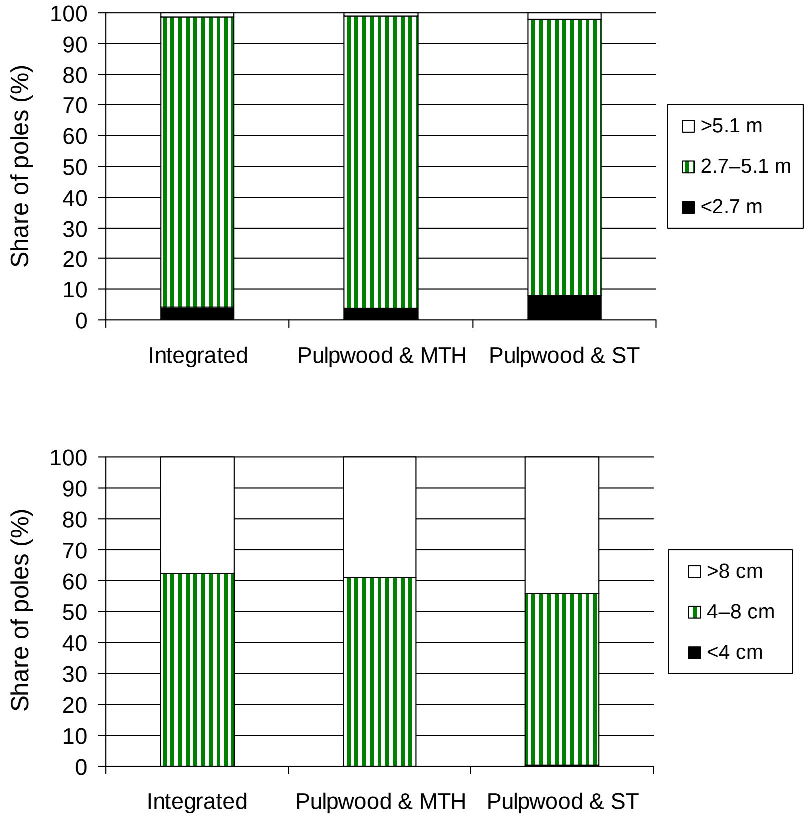

Figure 5: The length and top diameter distributions of bucked pulpwood poles by tested cutting method at Loppi.

4 Discussion and conclusions

In the time studies, the new Ponsse H53e harvester head worked well with the multiple-tree handling function. The integrated harvesting of pulpwood and energy wood was also found to be very promising: There was a significant increase in the removal and productivity of integrated cutting, which has a positive influence on the cutting and, additionally, the harvesting costs (cf. Kärhä, 2008). One of the strengths of integrated harvesting is that it is also possible to diversify the sources of raw material for forest chips and improve their availability (Table 1) (Kärhä & Mutikainen, 2008; Kärhä et al., 2009).

Table 1: The main strengths and weaknesses of integrated wood harvesting in early thinnings.

Strength
- Expanding the recovery of forest biomass, including traditional first thinnings.
- Improving the availability of forest biomass.
- Multi-tree handling.
- Flexibility (changes for top diameter of pulpwood poles).
- The quality of multi-tree processed pulwood.
- Crane scaling of both fractions.
- Cost-efficiency.
- No burning of pulpwood.
Weakness
- If undergrowth hinders traditional pulpwood cutting, it also hinders integrated harvesting.
- Low pulpwood and/or energy wood removals.
- Variety of timber assortments.
- Felling heads in cutting.
- Bucking of small logs.
- Terrain with poor carrying capacity in harvesting operations undertaken during the summer.

The results indicate that integrated harvesting is likely to continue to increase in both first and later thinnings. The demand for pulpwood and energy wood, as well as their stumpage prices and price at the mill/plant gate, will be determined by the volume of integrated harvesting in Finland (Fig. 6).

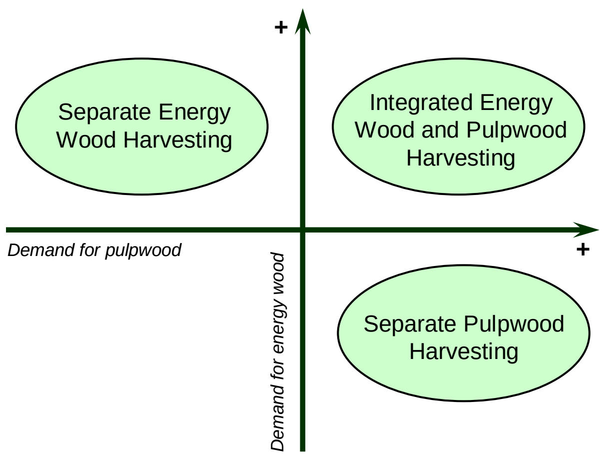

Figure 6: Principal impacts of the market situation (demand for pulpwood and energy wood, and their stumpage prices and prices at the mill/plant gate) on the volumes of integrated harvesting (Kärhä & Mutikainen, 2008; Kärhä et al., 2009).

According to the study, the quality of multiple-tree processed pulpwood is almost as good as that cut by the single-tree processing method: The top diameters and lengths of the pulpwood poles remained constant, and not too many branch stubs or poorly delimbed branches were left on the poles. We now know that, from a stand marked for harvesting, it is possible to harvest by integrated cutting more pulpwood and energy wood with a high productivity. Furthermore, the measurement of work performance does not result in any problems when a crane scale is used. Nevertheless, development work has still to be carried out in order to enhance the working methods applied in multi-tree cutting and integrated harvesting.

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