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Energy wood harvesting productivity of three harvesting methods in first thinning of scots pine (*Pinus sylvestris* L.)

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ABSTRACT

Energy wood harvesting in young forests presents an economical challenge and has been dependent on subsidies in Finland. Whole-tree harvesting systems have proved to be most productive when carrying out energy wood harvesting in cleanings and early thinnings in young forests. The application of integrated energy wood and pulpwood harvesting is less common.

It was hypothesized that multi-tree harvesting (MTH) with the OM-Waratah 745 single grip harvester head could change harvesting logistics and improve productivity for integrated energy wood and pulpwood thinnings. Two variations of MTH were compared with single-tree harvesting (STH). The logging methods studied were: (1) conventional single-tree harvesting with pulpwood and energy wood processed at the strip road; (2) multi-tree harvesting with pulpwood and energy wood processing along the strip road (MTH1); and (3) multi-tree harvesting at the stump where the aim was to leave the logging residues distributed evenly over the harvesting area and not on the strip roads (MTH2).

MTH methods were 28–35% more productive than the single-tree harvesting. The biggest differences in work stages were found in the felling and delimbing stages. In single-tree harvesting felling was 9–26% and delimbing 14–27% slower than in multi-tree harvesting. MTH2 distributed 13% of residues further than 7 m from the strip road center. With STH and MTH1 only a good 1.2–1.7% was placed this far, and 74.4 and 62.0% respectively within 3 m.

1. Introduction

According to Kyoto's climate agreement Finland, as part of the European Union (EU) is committed to decreasing the greenhouse gas emissions to the level of the 1990s. To achieve this, goal Finland is aiming to increase the amount of energy wood harvesting to 5 $Mm^3\ y^{-1}$ by the year 2010 [1]. Although most of this wood will come from regeneration cuttings, an increasing amount will be obtained from delayed first thinnings and silvicultural cleanings in young forests. The goal to replace fossil fuels with forest based fuel stocks has created an opportunity to develop new methods for the integrated energy and pulpwood wood harvesting.

Finland saw a rapid increase in mechanized harvesting from the 1980s to 2000. In 1985 less than 20% of the annual harvest was made with mechanized harvesting systems. In the early 1990s the share had increased to over 50% of the harvested volume. Today the figure stands at 97% [2]. From the onset the development of harvesting mechanization was based on cut-to-length (CTL) systems. The first harvesting machines were based on pulse feeding, delimbing and cross-cutting. In the late 1970s the first two-grip harvesters were built and single grip harvesters replaced them to become the major machine type at the beginning of the 1980s [3].

A form of multi-tree harvesting equipment, capable of handling more than one stem at a time, was tested in the

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1970s. The base machine was usually an earth moving machine equipped with a feller-buncher unit [4–6].

Single grip harvester based multi-tree harvesting (MTH) methods in the CTL harvesting systems were developed in the 1990s by Outokummun Metalli, a Finnish company. With a MTH harvester the operator cuts and accumulates trees to the single grip harvester head keeping the bunch vertical. Once the harvester head is full, the operator fells the bunch and delimbs the trees simultaneously by feeding the entire bunch through the harvester head.

Volumetric scaling of wood was invented in the early 1990s. This ceased the development work on the MTH methods as scaling of multiple stems proved to be too much of a challenge. This stage of development still prevails. However, MTH equipment has reappeared during this decade, thereby increasing the efficiency of energy wood harvesting.

MTH has remained a rather uncommon system in the wood harvesting world. In the last two decades Outokummun Metalli has been the sole provider of accumulative arms for Timberjack single grip heads. Their major market was not in Finland but in Quebec, Canada. Consequently the literature on this method, which comes from Canada, Denmark, Finland and Sweden, reports variable results. Thus in Danish conditions MTH lowered the harvesting productivity by 12% [7], while in most other studies it increased productivity by about 20–40% depending on the stand density and tree volume [8–14].

The MTH method was studied also in two-age stands in northern Finland [15]. In this particular study the number of the multi-tree handled understory trees was quite small. However, time consumption decreased by 25% when a second tree was added into the processing phase.

The study reported here aimed to compare the traditional single-tree harvesting productivity and distribution of time consumptions with two new MTH methods in an integrated energy and pulpwood wood harvesting operation for the first thinning in Scots pine (*Pinus sylvestris* L) stands. It was hypothesized that MTH methods would increase harvester productivity. A secondary aim was to identify where the bolts and residues were placed by the different methods. It was hypothesized that MTH methods would distribute residues more uniformly over the harvesting area than the traditional single-tree method.

2. Material and methods

2.1. Study stand

The time study was conducted in the autumn 2004 in Central Ostrobothnia, Finland (lat 63° 55.61′ lon 24° 0.952′). Harvesting and forest haulage were observed during first thinning on easy terrain, where pulpwood and energy wood were being produced [17]. The stand size was 3.4 ha and it was divided into six 3900–7600 m^2 blocks with two blocks per method in a randomized design. The 30-year-old stand was pure Scots pine (*P. sylvestris* L) with a stocking of 1850–2400 stem ha^{-1}. The average stem volume was 56 L and stand volume 120 m^3 ha^{-1}. The dominant tree height was 10.7 m, average

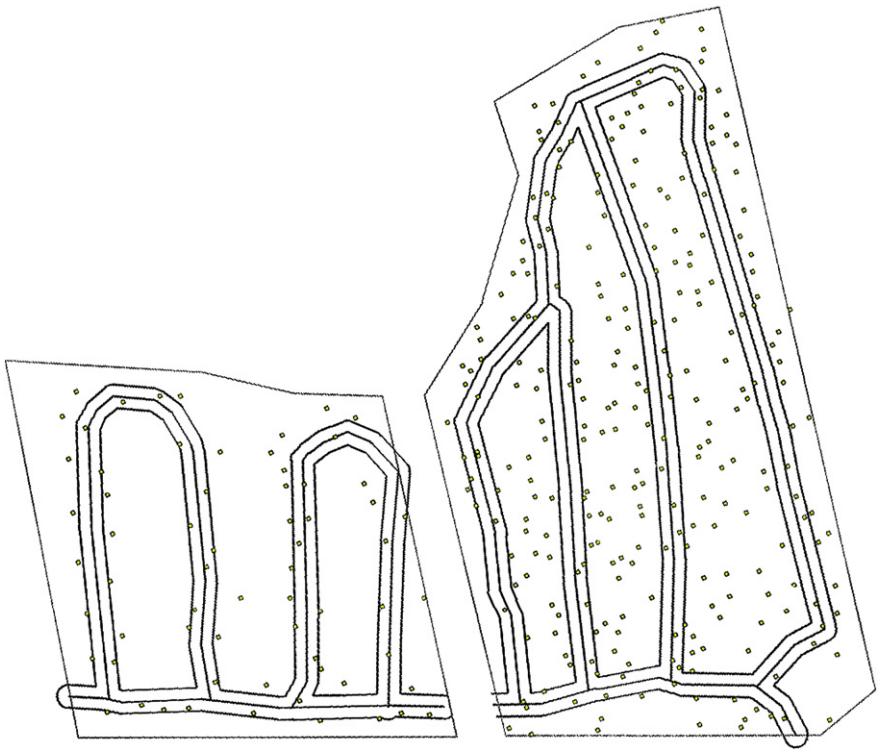

Fig. 1 – Example of the distribution of logging residues after single-tree harvesting (STH) on the left, and multi-tree harvesting (MTH2) with processing at the stump on the right.