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A method for integrated extraction of logging residues and soil scarification on a small scale

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Abstract

A new method for integrated haulage of logging residues and soil scarification on a small-scale has been evaluated. The base machine was a farm tractor to which a grapple loader trailer was attached. The grapple loader had an attachment on the grapple used for the integrated recovery of forest energy from logging residues and soil scarification. The machine was in this case, when hauling the logging residues fresh, also used for hauling round wood. It may even be used for, e.g. spreading wood ashes (only simulated). Conventional machine systems with special machines for all four types of work result in very high fixed costs for moving, etc. which makes cost unacceptable for many small sites.

Effective time per dry ton of logging residues was 28.4 min in the integrated method, of which soil scarification was 14.3 min. Average load size was about 1.3 ton dry matter (about 2.9 m^3 solid). The soil scarification plots covered 12% of the surface.

Cost calculations show that the integration of several activities results in substantially lower costs for small harvesting sites. For sites of about 1.5 ha the cost is about the same as for conventional machines. The studied method creates new possibilities for self-employed forest owners to do the work themselves and, in case of lower personal cost and no moving cost, reduce cost further.

Keywords: Harvesting residues; Forest energy; Forwarding; Soil scarification; Site preparation; Farm tractor; Ash recycling

1. Introduction

Logging residues from final felling is today the most important source of primary forest energy in Sweden. A steady growth in the number of heating plants (and total consumption) using wood fuel makes the economically most favourable sites (short transport distance, large volumes of forest fuel both per hectare and per harvesting site and good terrain conditions) a limiting resource especially in urban areas. To reach the required volumes of forest fuel less favourable sites need to be utilised.

Private, non-industrial forest owners hold more than half of the forest land in Sweden, of which the majority own less than 25 ha of productive forestland [1]. Many harvesting sites within the private forest owners are too small for rational and economic harvesting of forest fuel using conventional large-scale technology. In Sweden, approximately half of the final-felling area within private forest owners is smaller than two hectares as a mean [1]. Also, costs for soil scarification and recycling of wood ashes gets high on small sites with conventional large-scale technology. The high cost is mainly due to the need of many specialised machines, all having high starting- and moving-costs.

Different methods exist for extraction, processing and haulage of the logging residues. The most common method in Sweden is using a modified forwarder with extended loading space and a special grapple for extracting the residues to a stack close to roadside where the material is stored and often covered to make drying easier. Extraction of logging residues with a farm tractor and a trailer has been studied in Finland also [2]. Chipping is mostly done with a forwarder-mounted chipper with a high-tipping bin to fill standard road transport bins. The chipper may also, but not often, be used in the stand without residue-extraction by forwarder.

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Another method includes extraction of the residues with a forwarder followed by the hauling of the loose residues to a central processing terminal or plant, often using a large crusher. It is also possible to bundle the logging residues, a technology developed in Scandinavia. The Scandinavian technology, in this case the Timberjack Fiberpack was also imported to Central Europe and tested on a variety of species and the result was satisfying [3]. The bundles may later be transported to a heating plant [4].

The use of many specialised machines makes total cost higher than the value of the forest fuel on many smaller objects. The use of small-scale methods in utilising logging residues for energy is very limited. However, some forest owners use tops and large branches for conventional firewood or wood chips for their own use.

Soil scarification is often needed to achieve natural regeneration or good planting spots for plants or seed. When it is used under shelter wood trees the scarification improves conditions for natural regeneration [5]. Taking out logging residues for energy facilitates the work as the residues are otherwise often hindering the scarification.

According to Gemmel and Örlander [6] soil scarification should give less competition (water, nutrition, light), increased soil temperature, optimum soil humidity and good growing conditions for roots (loose soil and access of oxygen). The common devices for scarification are large and are mounted on forwarders. Large-scale scarifying technology is very efficient on larger clear-cutting areas but give high costs on small sites due to high initial costs for moving, etc. [7]. Conventional soil scarification is also often considered as being too aggressive. Fjeld pointed out that large-scale scarifying technology often causes damage on the roots of the seed trees [8]. This will in its turn lead to an increased risk for wind throws and growth losses.

This is very important in today's environmentally adapted forestry as final felling areas often have seed trees or shelter trees, irregular shape and limited size. The risk of wind throw was also pointed out as one of the main arguments against the use of shelter wood and seed-tree stands [9]. The risk for root rot is obvious if spruce (*Picea abies*) is used as shelter wood trees.

This indicates a need for alternative methods and equipment, which is less sensitive to the size of the harvesting site if larger volumes of forest energy shall be economically available. Small-scale technology with relatively low level of investment is less sensitive to the size of the harvesting site. Another way is to do more than one work with one machine and thereby reduce the number of machine moves.

Von Hofsten and Nordén [10] have studied a large-scale machine system for both extracting logging residues and for soil scarification. The system is based on a forwarder equipped with a scarifying unit mounted on the articulated chassis frame between the forwarder's tractor and trailer sections. Scarification is mainly done when the machine is moving during transport of logging residues. Results show lower costs than for purpose-built machines on small sites/areas. However, machine cost is too high for many self employed forest owners. Laitila et al. [11] carried out another study on a dual-purpose machine (''slash forwarder/scarifier'') which proved to be rather competitive.

As many forest owners in the Nordic countries already have grapple loaders mounted on farm tractors or old forwarders they have indicative possibilities for self-employment in soil scarification and extraction of forest energy. Different crane mounted soil scarifying devices have already been tested in difficult terrain [12]. The devices were mounted on base machines such as forwarders and backhoe loaders. They found the technical result as being acceptable. The tested method was probably less expensive than ''conventional'' soil scarifying under the tested conditions. Another crane-mounted prototype device was also tested by Moberg [13].

A new soil scarification attachment consisting of two pipes with spring harrow pins bolted onto the grapple has been developed and studied [14]. Soil scarification is done by opening the grapple, placing it to the ground, closing it, lifting and dropping the vegetation and humus layer beside the patch. The attachment made environmentally friendly and useful scarification patches on the most typical Swedish forest soil with blueberry or cowberry vegetation. The attachment was also found to be good for lifting hindering logging slash. The attachment may be used on both forwarders and farm tractors with grapple loader trailers, which are common in the non-industrial private forestry in the Nordic countries.

A poorer scarifying result was achieved in case of large amounts of logging residues [14]. The patches should (for reasons of site preparation) be made where the amount of residues is low. This also means that a high stocking of residues leads to a high recovery of forest fuel, easier site preparation and a better economy.

The system includes other possibilities also such as extraction of round wood and spreading of ashes with the same machine. Up to four kinds of work can be done at a time with one machine. Work methods where several works are integrated give, except for reduced moving costs, other positive effects and cost savings also by, e.g. reduced driving time and simplified work. The system was studied for integrated extraction of logging residues and soil scarification.

The hypothesis is that forest owners or contractors with this new technology get a system, which is adapted to the conditions discussed above, e.g. small objects, shelterwoods and environmental restrictions which make more volumes of forest energy available.

2. Material and methods

2.1. Equipment

The device was mounted on a conventional grapple loader and consists of two metal pipes with harrow pins bolted onto the grapple (Fig. 1). The number of harrow