Case Study: Extraction Woody Biomass in Thinning Natural Origin Young Stands of Silver Birch

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Abstract:
In the nemoral forest zone where Latvia is situated, silver birch (Betula pendula) is among the pioneer species that most commonly invade clear-cut forest sites and abandoned lands. Still, it would pay to apply silvicultural tending to naturally appearing young stands of birch the more so because top quality birch timber has recently become a desired raw material for plywood industry with its small dimension stems suitable for pulpwood. To maintain high productivity and fast growth of silver birch in naturally established stands a proper timing of early thinning (cleaning) of young stands is crucial. In Latvia, motor manual felling of undesired trees by brush cutter or chainsaw and leaving the felled stems on-site for decomposing is a typical method used in pre-commercial thinnings. However, recovery and utilization of woody biomass in pre-commercial thinnings can provide a potential for compensating a part of expenses, thus increasing the cost-efficiency of cultivating forest crops. The aim of the given study on extraction woody biomass in pre-commercial thinnings of young natural origin silver birch stands was to evaluate the costs and possible gains of motor-manual operations, using chainsaw equipped with a felling handle for small dimensions trees.
In the given study the prime costs of wood chips produced from the material recovered in pre-commercial thinnings of natural origin silver birch stands were EUR 9.02 per m^3. According to the base scenario the harvesting of woody biomass resulted in a positive financial balance of EUR 133.4 per ha.

Keywords: early thinning; silver birch; woody biomass; fuel chips; productivity.

1 Introduction

For Latvia, regaining sovereignty in the early 1990s entailed essential changes in the political and economic system, resulting among other things in cutbacks in agricultural production with a considerable amount of farmlands abandoned and overgrowing since then by trees and shrubs. As typical for natural succession in the nemoral forest zone where Latvia is situated, the broadleaved pioneer species as birches (*Betula sp.*), alders (*Alnus sp.*), common aspen (*Populus tremula*) and sallow (*Salix caprea*) are in most cases the first to appear on uncultivated lands. Normally, similar self-established stands are sparse and unevenly stocked, comprising mainly low value tree and shrub species. However, in some situations natural origin stands on one-time farmlands can by appropriate tending be successfully converted into high value productive forest. In Latvia silver birch (*Betula pendula*) is among the pioneer species that most frequently takes over clear-cut forest sites and abandoned lands. Still, it would pay to apply silvicultural tending to naturally appearing young stands of birch the more so because top quality birch timber has recently become a desired raw material for plywood industry with small dimension stems suitable for pulpwood.

The timing of thinning naturally appearing young growth of silver birch is crucial for maintaining the growth rates and ensuring high stand productivity over the whole rotation cycle. Belated pre-commercial thinnings of young birch substantially reduces the productivity of future birch stands (Zālītis and Zālītis 2007). In Latvia, motor manual felling of undesired trees by brush cutter or chainsaw and leaving the felled stems on-site for decomposing is a typical method used in pre-commercial thinnings. However, recovery and utilization of woody biomass in pre-commercial thinnings has a potential for compensating a part of expenses, thus increasing the cost-efficiency of cultivating forest crops. Because of increasing interest in biofuels as a substitute for fossil ones, studies on the possibilities of economically feasible

preparing, extraction and utilization for fuel of the woody biomass obtained in thinning young stands are well under way in a number of countries around the Baltic Sea (Bergström et al. 2007, Laitila 2008, Laitila et al. 2010, Sirén et al. 2006).

The aim of the given study on recovering woody biomass in pre-commercial thinnings in young natural origin silver birch stands was to evaluate the costs and possible gains of motor-manual operations, using chainsaw equipped with a felling handle for small dimension trees.

2 Materials and methods

The study was performed in a self-established growth of trees on former agricultural land in the vicinity of the town of Mālpils (latitude $57^0 02' 00.04''$N, longitude $24^0 54' 03.11''$N, altitude 89m a. s. l.) in the middle part of Latvia. On the study site, approximately 1.3ha in size, there were young trees of two broadleaved species – silver birch and goat willow. The stand parameters were calculated on the basis of measurements done on four circular sample plots (radius 12.62m, area 500m^2). The stand characteristics before and after thinnings are given in Table 1.

Table 1: Stand characteristics of the study site

	Before thinning		After thinning
	B.pendula	***S.caprea***	***B.pendula***
$D_{1.3}$, cm	5.9	5.4	7.7
Mean height, m	10.2	9.3	11.2
Basal area, m^2 ha^{-1}	12.84	2.5	7.2
Stand density, ha^{-1}	4,765	1,060	1,535
Stand volume, m^3 ha^{-1}	69.6	-	41.5

The thinning operations were carried out in December 2011 after the trees had shed foliage. The method used was that of full-tree logging, comprising motor-manual felling and piling of the trees cut down with subsequent forwarding, chipping the stuff at the roadside, and road transportation of chips to the terminal. Two different felling techniques were tested: one by using chainsaw *Husqvarna 550XP* (power output 2.8kW) and the other by using the same chainsaw equipped with a felling handle for small dimension trees (manufacturer *ApuriTuote OY* of Finland). Both felling tools were operated by two workers. The study area was divided into 12 parcels of equal size to ensure three replications for each variant of operations. During operation the trees to be thinned out were cut down and piled with the tops of tallest trees cut off to limit the stem length to 7…8 meters for efficient forwarding.

The harvesting costs with chainsaw were calculated by using the method described by Spinelli and Magagnotti (2011), applying the labour cost of EUR 5 per h. The productivity and costs of other operations were simulated by using the prime cost model for biofuel procurement in pre-commercial thinnings due to Lazdiņš and Thor (2009). The technic units used in working out the model were *Ponsse Gazelle* dual forwarder with slash gripper, *Jenz HEM 420* chipper driven by farm tractor *Valtra T161*, and *Scania 124C 420* chip truck with a load capacity of 70LVm^3. The prime costs of logging operations were calculated according to the base scenario: the average forwarding distance was set to be 500m and the distance to the terminal (road transportation distance) 50km. The market price of wood chips used in calculations is EUR 10/LVm^3.

The total amount of biomass in tons of dry weight (t_{DW}) of the felled trees was calculated by using the weight equations elaborated by Korsmo (1995). These allometric equations are worked out in Norway for determining the dry weight of biomass of young hardwoods in natural origin stands. Breast height diameter is the parameter used in these equations.

Conversion factor 1:5 was used for converting the woody biomass expressed in t_{DW} to loose volume cubic meters (LVm^3).

The productivity in our study is defined as the amount of woody biomass (LVm^3) processed per effective hour (LVm^3/E_{15}-h).

The sensitivity analyses were carried out to determine the effect of transportation distances on the cost-efficiency of recovering woody biomass in pre-commercial thinnings.

3 Results and discussion

The total amount of woody biomass recovered was 143.5LVm^3/ha. In pre-commercially thinning (cleaning) natural origin silver birch stand the productivity of harvesting ranged from 2.54 to 3.19 LVm^3/E_{15}-h, depending on the worker skills and the techniques used (Figure 1). Similar productivity of motor-manual operations in thinning small dimension pine stands is reported in a study performed in Finland – 1.2 to 3.8LVm^3/h (Harstela and Tervo 1977).

Figure 1: The productivity in harvesting woody biomass in pre-commercial thinning of natural origin silver birch stand (*chainsaw; **chainsaw equipped with a felling handle)

Although there are some differences in work productivity between both workers, the use of felling handle resulted on the average in about 10% increase in the productivity of harvesting. Compared to work with conventional chainsaw, cutting of trees by using chainsaw equipped with a felling handle is preferable also from the viewpoint of ergonomics. More comfortable work position in the cutting phase is the major advantage of having a felling handle since the worker can make the felling cut without bending over. When using chainsaw with a felling handle it is easier for the worker to control the operation since the chainsaw can be operated by one hand, allowing to push the tree cut off with the other hand.

Chainsaw equipped with a felling handle, developed in Finland and now used in many countries, is a conventional tool for use in pre-commercial thinnings. In Latvia, this tool has no wide use since the woody biomass recovered in pre-commercial thinnings is so far utilized for wood fuel on a limited basis. According to our study, the chainsaw with a felling handle can be a good choice for felling small dimension trees in pre-commercial thinnings in small-scale forestry where human labour is the major factor in forest operations. The said equipment can be especially useful in situations where the tree dimensions are too big for efficient work with a brush cutter. In case of using brush cutter additional effort is needed for piling felled trees whereas it is more convenient to collect the stems cut down when using chainsaw with a felling handle.

In the given study the prime costs of wood chips produced from the material recovered in pre-commercial thinnings of self-established silver birch stands were EUR 9.02 m^3. According to the base scenario the harvesting of woody biomass resulted in a positive financial balance of EUR 133.4/ha.

It is traditionally believed that thinning naturally established young broadleaved stands yields no profit because of tree dimensions too small and no roundwood assortments (mainly pulpwood) available. Our study confirms that the immediate costs of pre-commercial thinnings can be compensated by utilizing the woody biomass of harvested stems, and in individual cases pre-commercial thinnings can even produce profit.

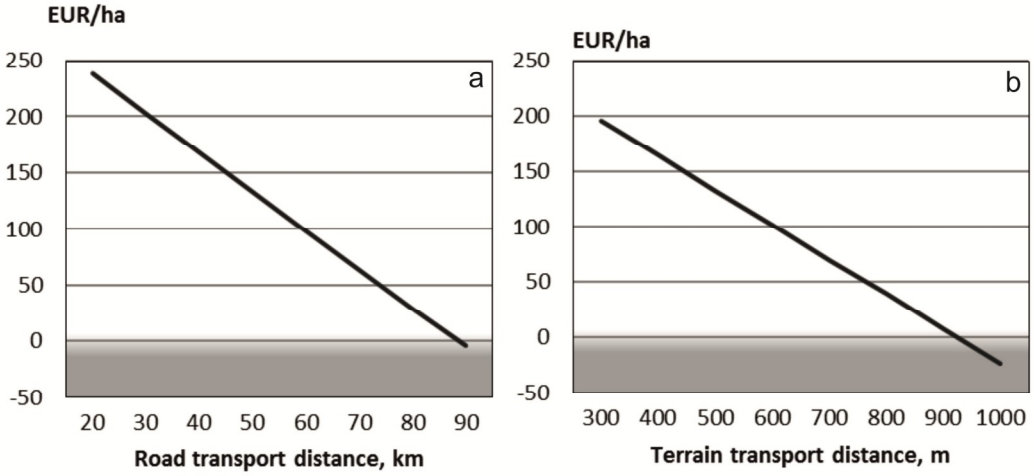

Figure 2: The profitability of harvesting woody biomass in thinning natural origin silver birch stand depending on road (a) and terrain transportation distances (b)

The target density of remaining stand after thinnings was set to 1,500 trees/ha. According to the thinning intensity applied to silver birch the density of remaining stand can be 1,200 or even 1,000 stems/ha, thus offering the chance to take out a higher amount of woody biomass. In our case the thinning intensity was moderate to minimize the risk of snow damages during the winter to come which can often happen after too intensive thinning of overstocked young stands. The stand under study may be thinned once again after 4…5 years when the mean height of trees would be 14…15m, reducing the stand density to 1,000 stems/ha. At that stage the trees to be thinned out are expected to meet the specifications for pulpwood. Although our study confirmed the cost-efficiency of recovering woody biomass in early thinnings of silver birch stands, additional research is needed to analyse the factors that limit the profitability of thinning sapling or pole-stage stands. The procurement costs of wood chips recovered in thinning young stands depend on a number of factors: thinning intensity, tree volume, harvesting conditions, and to great extent transportation distances. According to the given study the production of wood chips for fuel from the material recovered in pre-commercial thinnings is profitable provided the distance to the terminal is below 90km and the off-road transportation (forwarding) distance is no longer than 900m (Figure 2).

It is to be noted that woody biomass can be recovered mainly from the sites where soil bearing capacity allows forwarding. On sites with soft peaty soils or a high level of groundwater table logging residues are normally placed on striproads to improve soil bearing capacity.

Acknowledgment

This project is part-financed by the European Union's European Regional Development Fund (ERDF). Project No. 2010/0319/2DP/2.1.1.1.0/10/APIA/VIAA/136.

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