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OPTIMIZED CLEARING AND EARLY THINNING BY SPACER AND CHAINSAW

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Abstract: *A time study was done to evaluate two different methods in early thinnings: a schematic reducing of stem number by spacer and chainsaw and a future crop tree orientated clearing by chainsaw. In both cases 2 m logs have been produced if the trees were not more than 5 m away from skid trails. The study showed that it is economically not efficient to process trees with a diameter less than 12 cm. For felling without stem processing 32.98 PWH_{15}/ha for schematic reduction or 12.11 PWH_{15}/ha for future crop tree option are needed. In both cases 1.5 h/100 m for establishing walking paths are needed. Damages on remaining stand were minor with 5.7% for schematic reduction and 2.9% for future crop tree option.*

Key words: *early thinning, clearing, spacer, time study, damages.*

1. Introduction

On18th and 19th of January 2007 the storm Kyrill destroyed a great number of stands. In Germany, 37 mio. m³ were wind thrown, solely 15.7 mio. m³ in the federal state North Rhine-Westphalia (NRW). Kyrill destroyed 50,000 ha in NRW. Three quarters of the damaged area in NRW were private forests [3].

After processing the timber of the storm area, planting (70.6%) or natural regeneration (29.4%) was used for reforestation (data by forest administration NRW). In addition, natural regeneration was dominated by light-demanding softwoods with high growth potential, mainly birch, arrived at the succession areas. These species grow also in the planted stands.

Some years after regeneration, precommercial thinning is the standard method to manage species composition, stand stability, individual quality and diameter growth. For dense young stands, established methods are used like ring barking, manual snapping, snapping by scissors or handsaw, removing with handsaw, axe or billhook [9]. Very often, trimmers/brush saws [5] and [8], are used as a semi-mechanized system for precommercial thinnings. A new machine, which can be handled by a single forest worker is the Husqvarna FBX 535 (also known as spacer). In young stands, the spacer seems to be an efficient alternative to conventional precommercial thinning methods. 21.96 PWH_{15}/ha (Productive work hours including delays and service time until 15 minutes) in stands with a

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DBH of 2.3 cm for the remaining trees and 1,600 remaining stems/ha are needed in a spacer survey [5] and [11]. Stands with diameter > 8cm can be handled by chainsaw [9]. Also, fully mechanized systems like those using feller-bunchers are an option for stands with a minimum tree volume of 0.032 m^3 (≅ dbh 8 cm) [6]. The highest cost efficiency for processing stem wood can be reached with stem volume of 0.6 m^3. With lower stem volume, production of fuel wood is more cost efficient [2].

But today, more than 10 years after the storm Kyrill, not all stands run through a precommercial thinning. With increasing age, diameter and tree height, the thinnings are getting more time consuming and more expensive.

The goal of this study was to identify practical precommercial thinning methods for smaller scaled private and unmanaged regenerated stands after storm event Kyrill. Because of the smaller stand sizes, specialised big machines had not been the means of choice. Furthermore, it was of interest if it is possible to utilize the timber of these early precommercial thinning in a profitable way.

2. Research Area and Methodology

2.1. Research Area

The selected stand is located in the region of Sauer land/NRW, UTM: 0419970, 5696190. The size of the total thinned area was 1.01 ha. Water and nutrient supply is good, the soil is composed of unconsolidated sediments over Devonian bedrock. The terrain is slightly inclined (< 5%).

The stand (dbh ≥ 7cm) was composed of birch (*Betula pendula* Roth.) (53.3%) and spruce (*Picea abies* L. (H. Karst.)) (37.4%). Additional tree species were alder, pine, willow and wild cherry. The lower layer (dbh < 7 cm) was composed of birch (32.9%), beech (25.5%), spruce (22.7%), alder (8.2%) and rowan, willow, oak, pine, ilex and wild cherry.

Total number of trees with a dbh ≥ 1 cm was 13,526, and trees with a dbh ≥ 7 cm was 1,936. Medium diameter was 4.8 cm (± 3.1) for all trees measured (≥ 1 cm) and 8.8cm (± 1.7) for trees ≥ 7cm.

2.2. Harvesting Methods and Machinery

We used two different thinning methods and surveyed the establishing of skidding trails:

(i) Schematic reduction (SR): clearing all trees except a single tree every 2-2.5 m. Furthermore, bigger trees were felled and processed to 2 m logs if they were close to the skid trails (≤ 5m) and were not part of the systematically spaced remaining trees and had a top diameter of minimum 6 cm. A hand grapple was used to extract logs manually to the piles at the skidding trails. Equipment used for the thinning operations were spacer and chainsaw, while in a first phase (duration of one tank felling) thinner trees and shrubs were removed by the spacer. Then, bigger trees were felled and processed by chainsaw;

(ii) Future crop tree Plus (FTP): for a future crop tree orientated thinning, average spacing of future crop trees was 7 m. Within a radius of 2-2.5 m around the future crop tree, all other trees were removed. Therefore, work was concentrated to the future crop trees. Additional bigger trees were felled and processed to 2 m logs if they were close to the skid trails (≤ 5m) and had a top diameter of minimum 6 cm. A hand grapple was used to extract manually logs to piles

at skidding trails. Tree felling was done by chainsaw;

(iii) Skidding trails (ST): For the clearing of skidding trails, the spacer was used first (for the duration of one tank of fuel), then bigger trees were felled and processed by a chainsaw. Skid trail width was 4 m.

We conducted a time study following the snap back timing approach [10] with a 1/100 min stop watch to analyse time consumption and influencing parameters. Description of motor-manual work is given in Table 1. DBHs of processed trees were recorded as well as the middle diameter (with calliper) of every single log, tree species and the number of cleared trees.

Table 1

Sequences of motor-manual work

Operation	Description	Break point
Clearing	Walking, clearing of young trees with DBH < 7 cm	Arrive at tree for felling
Felling	Felling of trees DBH > 7 cm (trees which can be processed for logs)	Tree touches ground
Processing	Processing of felled trees with DBH > 7 cm	Chainsaw off and put to ground
Hand skidding	Skidding of 2 m logs to skid road	Grapple back in holster, chainsaw in hand and ready to work
Switching tools	Switching the tool from chainsaw to spacer or from spacer to chainsaw	New tool ready to work
Other	Other work	

The used equipment consisted of a Husqvarna FBX 535 (spacer), a small chainsaw Husquarna550 XPG (2,8 kW) and a Ponsse Wisent 8-wheel forwarder (129 kW, 17.25 t gross weight) equipped with a Ponsse K70+S 8 m crane for the extraction of the 2 m logs. The forwarder sorted the pre-concentrated logs into two piles by hard- and softwood.

2.3. Damages on the Remaining Stand

After the time study, damages on the remaining stand were recorded in 2 m wide strips orthogonal to skidding trails until a minimum of 160 trees were sampled. Bark damages 5-9.9 cm², bark damages ≥ 10 cm, break of branches, top breakage, inclination of stem and the tree species were noted. An estimation if the tree was a complete loss or just a damaged was also done tree-wise.

3. Results

3.1. Time Study

In total (Table 2), 48.63 hours of thinning operations were observed for motor-manual work, which have been 35 PWH_0 (productive working hours without delays), respectively 40.55 PWH_{15} (work hours including delays and service times until 15 min.). The difference of observed time to PWH_{15} can be explained by meal times and study caused disturbance time for gathering information and discussions. 1.97 PWH_0 were observed for the forwarder. 5.052 trees had been cut during the clearings. 484 trees had been felled and processed. 378 of them were birch, 76 spruce, 10 alder, 9 pine and 11 other hardwood species. 855 logs were produced. Stem number was reduced by 5,750 per ha to 7,776 per ha in the schematic reduction and by 1,260 per ha to 12,265 per ha in the future crop tree plus. Overall, 11.28 m³ were processed.

Harvested area and observed time Table 2

Parameters	Opening of skid trail	Schematic reduction	Future crop tree Plus	Overall
Harvested area [m²]	1,895 (474 m length)	3,746	4,481	10,1022
Motor-manual work				
PWH_0 [min.]	1,106	553	441	2,100
PWH_{15} [min.]	1,287	652	494	2,433
Observed time [h]	26.35	12.45	9.83	48.63
Harvested trees				
Trees ≥ 7cm [N]	282	60	142	484
Average DBH [cm]	9.2	9.0	10.0	9.4
Minimum DBH [cm]	5.0	6.0	6.0	5.0
Maximum DBH [cm]	27.0	20.0	20.0	27.0
Standard deviation of DBH [cm]	2.4	2.3	2.4	2.4
Average tree volume [m^3]	0.023	0.020	0.026	0.023
Felled trees < 7 cm (clearing) [N]	2,535	2,094	423	5,052

A. Establishing of 4m wide skid trails

Effective work time was 89.2% of total observed time, while delays and service time had a proportion of 10.8%. Clearing needed 44.4% of PWH_0 while felling had a proportion of 5.9%, processing 25.4% and manual extraction 9.5%; allocating processing and skidding to the trails, the two work processes which are needed for producing logs, had an overall proportion of 34.9% in the PWH_0.

B. Schematic reduction

Effective work time was 86.9% of total observed time, while delays and service time had a proportion of 13% (Table 3). The clearing time in this intensive operation accounted for most of the observed time (71.8 %).

C. Future crop tree Plus

90.4% of the total work time was spent for effective work, and 9.6% of the time accounted for delays and service. In contrast to high time consumption for clearings, the time spent in this work was with 38.3% lower than in the schematic reduction, but still had the highest proportion.

To take the forest workers skill level into account a standardized skill performance was estimated. The observed subject was a professional, well trained forest worker, with a lot of experience in spacer handling and chainsaw work. He is an instructor for motor-manual forest work. Though the total procedure was new for the forest worker, the skill level was set to 1.2 compared to a standardized skill level (SSL).

Table 3

Productive work time per 100m of skid trail, per ha for schematic reduction and per ha for future crop tree plus option and the observed delay and service times

Time consumption	Skid trail (per 100 m)		Schematic reduction (per ha)		Future crop tree Plus (per ha)	
	[min_{100}]	[%]	[min_{100}]	[%]	[min_{100}]	[%]
Work Time						
Clearing	103.77	39.6	1220.47	71.8	416.00	38.3
Felling	13.75	5.3	35.48	2.1	68.49	6.3
Processing	59.23	22.6	116.44	6.9	319.33	29.4
Manual extraction	22.14	8.5	40.44	2.4	125.70	11.6
Switching tools	9.79	3.7	27.92	1.6	--	--
Other	24.94	9.5	35.21	2.1	51.22	4.7
Delays and Service Time						
Personal Time	1.81	0.7	10.89	0.6	7.61	0.7
Service Time	11.80	4.5	76.40	4.5	19.55	1.8
Preparatory Time	9.31	3.6	87.21	5.1	64.41	5.9
Rest Time	5.35	2.0	48.26	2.8	13.30	1.2

The time consumed as delays and service up to 15 min. has been 16.3% of PWH_0 for ST, 17.9% for SR and 11.9% for FTP. In the following calculations, delays and service time were assumed to be standardized at 25% (Fig. 1).

3.2. Forwarding Performance

To extract 11.28 m³, the forwarder needed 1.97 PMH_0. Loading (42.7%) and unloading (30.4%) were the highest time-consuming work phases. The maximum distance from the forest to the road pile was 150m.

3.3. Costs and Utilization of Timber

An analysis of time consumption per harvested tree for motor-manual work and for skidding by considering the corresponding diameters showed that the break-even of cost efficiency of each precommercial thinning operation will be reached at a diameter of 12 cm for softwood and hardwood. Beyond a DBH of 12 cm, it becomes uneconomically. Yet, in the studied case only 90 trees/ha were bigger than 12 cm.

Because cost efficiency could not be reached for the surveyed stand, the time consumption was modelled for an alternative option without utilizing the timber, so without processing and hand skidding.

Modelling was done for both silvicultural options without timber processing under the following assumptions:

(i) Only 10% of all the felled trees will be felled in the case of not processing any timber when giving neighbour trees more crown space;

(ii) Instead of skidding trails, only walking paths will be established to structure the stand and simplify orientation for the thinning operation; time for establishing walking paths is of 1.5 h/100m [10];

(iii) All other work in both silvicultural options remains the same.

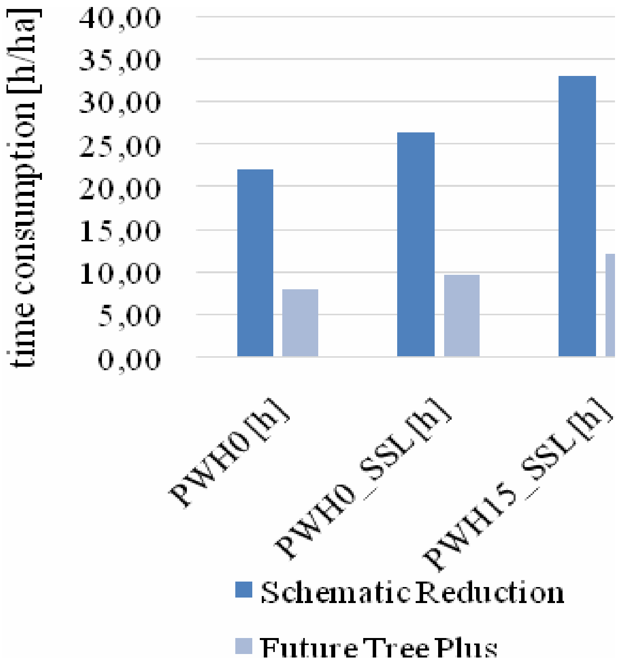

Fig. 1. *Time consumption of precommercial thinning for SR and FTP without processing and skidding, PWH_0, standardized skill level PWH_0 and standardized skill level PWH_{15}*

The time consumption would be obviously reduced. Without timber processing, 32.98 PWH_{15_SSL}/ha for schematic reduction or 12.11 PWH_{15_SSL}/ha would be needed (Fig. 1). In both cases 1.5 h/100 m for establishing walking paths are needed.

3.4. Damages

The damages on the remaining tress had a proportion of 5.7% (without damaged trees on skid trails) for the schematic reduction and 2.9% for the future crop tree scenario. In the future crop tree option none of the future crop trees was damaged.

4. Discussion

The influence of the type of precommercial thinning approach on the diameter growth is not very significant. In spruce stands, it was proved that the difference in diameter growth between different precommercial thinning approaches (schematic reduction, future tree and deadhead) is 2-3 cm higher diameter compared to natural differentiation [1]. Therefore, the selection of the silvicultural method should be done by other arguments. Because of missing information about the effect of un-thinned stands or future crop tree orientated thinnings on harvesting efficiency, the effect of high-density stands (in uncleared stands or parts of stands) compared to stands with reduced (thinned) stem number is unclear. However, uncleared and very dense stands seem to need a much higher effort for harvester or motor-manual workers in the upcoming thinning operations.

Diameter and the number of stems per hectare are influencing the time consumption in clearing operations which is in line with the results reported by many other studies [4] and [5].

Damages on the remaining trees (5.7% and 2.9%) were minor and in line with the data of German National Forest Inventory which shows that 5.3% of all trees have a felling or skidding damage [12]. Studies measuring damages right after the harvesting, reported figures such as 13% in motor-manual felling and tractor skidding [7]. Damages on regeneration after felling trees was with 13% also higher [7]. Then, the trees are in their differentiating phase that is characterised by a high number of stems while the damages in this early stage are not so important as further development may replace such trees.

5. Conclusion

Utilization of timber is economically not profitable in the young stands damaged by Kyrill storm. But a future crop tree orientated precommercial thinning operation can be a low-impact solution for these stands. Only 12.1 PMH_{15} plus 1.5 h/100 meters are needed for structuring walking paths. The effect of low input operations to later thinning is not surveyed yet and more studies would be needed to this end. Damages on the residual stand were minor and they may be mitigated by natural differentiation in the following years.

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