

Cost calculations of fully mechanized thinning of small diameter trees

In this infosheet you will find an overview of the calculation of costs in forestry, the calculation method, technogram and the cost comparison of different technologies and work techniques.

Introduction and Methods

The calculation of costs in forestry began in the early 20th century when machinery was introduced in timber production and there was a need to evaluate operating, investment and labour costs. The various methods have a common background in the structuring of the calculation parameters, but differ in the way they are calculated and how individual parameters are taken into account, e.g. machine rates, salvage value, repair costs and consideration of the costs of tyres and tracks. Most calculations were based on one of two main objectives: determining the cost of a particular machine or setting a price for the work done with the machine (Ackerman et al. 2014).

Some time ago we developed a web-based tool for the preliminary assessment of forestry operation costs. The tool, called WoodChain-Manager (WCM), is publicly available on the web for all internet users (WCM 2018). The purpose of WCM is, on the one hand, to calculate the operating costs for working with a selected machine and, on the other hand, to set the price of the service or product for working with a wider range of forestry machines. The calculation provides useful information about the costs of a particular technology as well as about the entire harvesting system. The main advantage of the web-based tool is the fact that it is publicly available and therefore offered for wide use. Users have the possibility to compare cost calculations with other users. Furthermore, WoodChainManager is regularly updated in terms of default values.

WCM covers a wide range of techniques and tools: Chainsaws (standard, electric, single-handed), tools and personal protective equipment, chainsaw winches, agricultural tractors, forest skidders, tractor equipment (wheel chains, tractor safety cage), 3-point winches, forestry caterpillar tractors, forestry trailers and cranes, harvesters and forwarders, woodchippers, log splitters, firewood processors, forestry trucks and trailers for transporting logs or woodchips, and cable cranes.

We opted for the method already used in Slovenia for the calculation of costs in the "Rules on the list of agricultural and forestry machinery and the catalogue of costs of agricultural and forestry machinery" (Rules on ..., 2016). It is based on the Austrian method for calculating machinery costs in agriculture (ÖKL, 2014) and is described in the following 5 sections:

1 Total cost (€/h) includes all fixed costs (€/h) and variable costs together (€/h):

$$C_{tot} = C_{fix} + C_{var} \quad (1)$$

Where:

C_{tot} - total cost of the selected mechanization, €/h,

C_{fix} - fixed costs (such as depreciation, interest on invested capital, insurance and storage), €/h,

C_{var} - variable costs (such as maintenance, fuel and lubricants), €/h.

2 Fixed costs (C_{fix}) are calculated by the following equation:

$$C_{fix} = \frac{PV/DE + I \times PV}{AU} \quad (2)$$

Where:

PV - purchase value (in €), where the average weighted purchase value of a group of machines takes into account market share

DE - depreciation (in years), which is calculated in view of the factual period of possible use of individual groups of machines before they are worn out or become technologically outdated

I - interest on funds invested (in %), which includes storage and insurance. On an average annual basis, half of the interest rate on invested capital (4 %) is taken into account, and the rest is represented as the share of costs for storage and insurance (2 %)

AU - annual use (number of hours), which enables calculation of fixed costs per hour.

3 Variable costs (C_{var}) are composed of maintenance costs (C_{maint}) and fuel and lubricant costs (C_{fuel})

$$C_{var} = C_{maint} + C_{fuel} \quad (3)$$

4 Maintenance costs (C_{maint}) are calculated according to the following equation:

$$C_{maint} = \frac{M_r \times PV}{100} \quad (4)$$

Where:

M_r - factor of maintenance (0.8–15 % / 100 h), which is an estimated value and indicates the average cost of maintenance as a percentage of the machine purchase value

5 Fuel and lubricant costs (C_{fuel}) are calculated according to the following equation:

$$C_{fuel} = (100\% + L_r) \times U_r \times (F_{cons} \times EP) \times F_{price} \quad (5)$$

Where:

L_r - cost of lubricant (in %) and is estimated at 20 % of fuel costs. An exception is the chain saw, where costs are higher (30 %) due to chainsaw lubrication oil,

U_r - engine load (in %), which is estimated at 70 % for chain saws and 40 % for other machines,

F_{cons} - factor for specific fuel consumption (0.33 l / kWh), which accounts for the relationship between engine power and fuel consumption (ÖKL 2014),

EP - engine power (in kW),

F_{price} - current price of fuel (diesel or gasoline) (in €). Prices of fuel are regularly automatically updated via Web interface. However, the user can always independently adjust the price of fuel.

Production Chain Technogram

In the SMALLWOOD project, we have explored some interesting innovative technologies to help mobilise the immense potential of small diameter wood from European forests. One of them is fully mechanised thinning with the Bracke C16.c felling head, which was developed specifically for such work. Through field trials, we have identified the key features of this technology and the data collected has enabled us to add it to the WCM cost calculation tool.

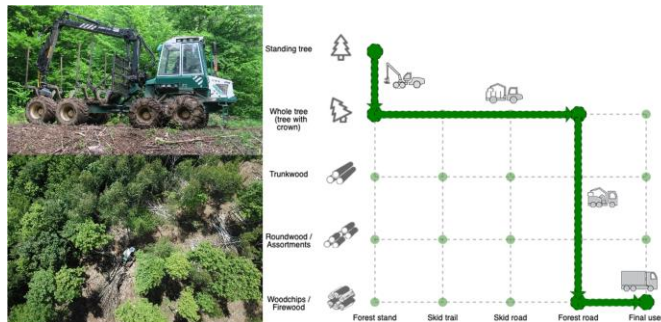


Figure 1 Fully mechanized thinning technogram.

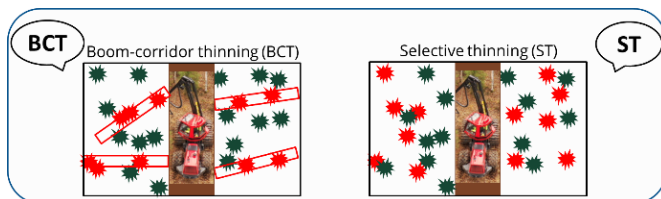


Figure 2 Two work techniques (selective ST and boom-corridor thinning BCT).

Results of Calculations

We tested two different work techniques, conventional selective thinning (ST) and boom-corridor thinning (BCT). Factors that affect costs are the annual use of machinery, the time consumption and the price of fuel (Table 1).

Table 1 Fully mechanized thinning - cost comparison, two work techniques.

Method	Machine	Fixed costs (€ / Depreciation period)	Fixed costs (€/h)	Variable costs of fuels and lubricants (€/h)	Variable costs of maintenance (€/h)	Total material costs of the selected machine (€/h)	Labour costs (€/h)	Total costs of work processes (€/h)	Total costs of work processes (€/m ³)
BCT	Harvester	57160	63,51	33,91	39,88	137,30	20	157,30	
	with Bräcke C16.c	8388	9,32	0,00	5,85	15,17	20	35,17	
	Forwarder	48000	53,33	33,91	30,00	117,24	20	137,24	53,50
	Woodchipper	48000	53,33	64,73	30,00	148,07	17	165,07	
	Woodchips truck	33300	47,57	72,66	14,80	135,03	20	155,03	
ST	Harvester	57160	63,51	33,91	39,88	137,30	20	157,30	
	with Bräcke C16.c	8388	9,32	0,00	5,85	15,17	20	35,17	
	Forwarder	48000	53,33	33,91	30,00	117,24	20	137,24	58,89
	Woodchipper	48000	53,33	64,73	30,00	148,07	17	165,07	
	Woodchips truck	33300	47,57	72,66	14,80	135,03	20	155,03	

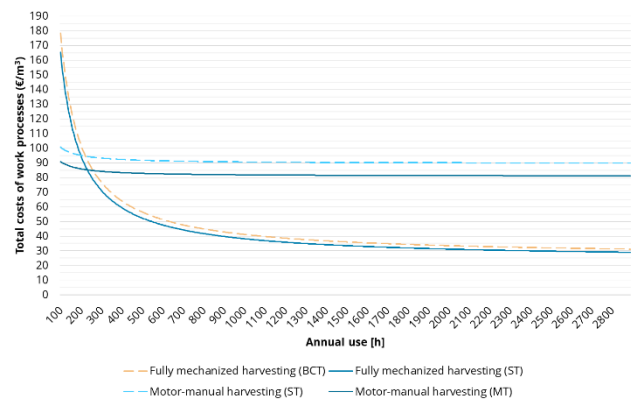


Figure 3: Cost comparison of fully mechanized thinning and motor-manual thinning, in respect to annual use (h)

Table 2 Comparison of conventional and fully mechanized thinning by net revenue (preliminary results)

	Reference system			
	Motor-manual thinning (ST)	Motor-manual thinning (MT)	Fully mechanized thinning (BCT)	Fully mechanized thinning (ST)
Costs (in €)	108,83 €	82,92 €	1.749,66 €	1.944,26 €
Harvesting (in €)	108,83 €	82,92 €	857,45 €	926,82 €
Haulage (in €)	0,00 €	0,00 €	440,78 €	476,44 €
Wood chipping (in €)	0,00 €	0,00 €	255,18 €	275,83 €
Wood chips transport (in €)	0,00 €	0,00 €	196,26 €	265,17 €
Revenue from sales (in €)	/	/	1.913,18 €	2.067,98 €
Price of wood chips (EUR per ton)	/	/	65	65
Quantity of wood chips (t)	/	/	29,434	31,815
Time consumption (hours per ha)	9	6	8,2	8,9
Worksite area (m ²)	2800	3200	5000	4800
Net revenue (in €)	-108,83 €	-82,92 €	163,52 €	123,72 €
Net revenue (€ per ha)	-388,67 €	-259,11 €	327,04 €	257,75 €
Net revenue (€/ton)	/	/	5,56 €	3,89 €

Conclusion

We have updated the WCM cost calculation tool with added features that allow you to compare the costs of different technologies, including innovative fully mechanised thinning. Importantly, the tool is freely accessible to everyone.

References

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