

Small diameter stands harvesting and supply cost analysis : **case study Slovenia**

The pathway for efficient utilization of small diameter wood

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Slovenian trials

Unused wood biomass potential



- ✓ The total growing stock of small diameter trees in Slovenia is estimated to be up to 8 million m³ (Slovenian forestry institute, 2017).
- ✓ According to data from forest management plans thinning operations are planned on nearly 10 000 ha of SDS yearly, but the realization of planned thinning operations in private forests was only 22 % (Slovenian forest service, 2017).
- ✓ The main reasons for low realization are high costs of harvesting and no income since the felled trees are left on the ground.



Study location

Livold / Onek



Young dense beach pole stands

Motor-manual thinning - 15 plots

Method - tree selection:

- **7x ST: 1400-1600 candidate trees per ha**
- **8x MT: 400 crop trees per ha**

Fully mechanized thinning - 10 plots

Method – work technique:

- **5x ST: Situation thinning**
- **5x BCT: Boom-corridor thinning**

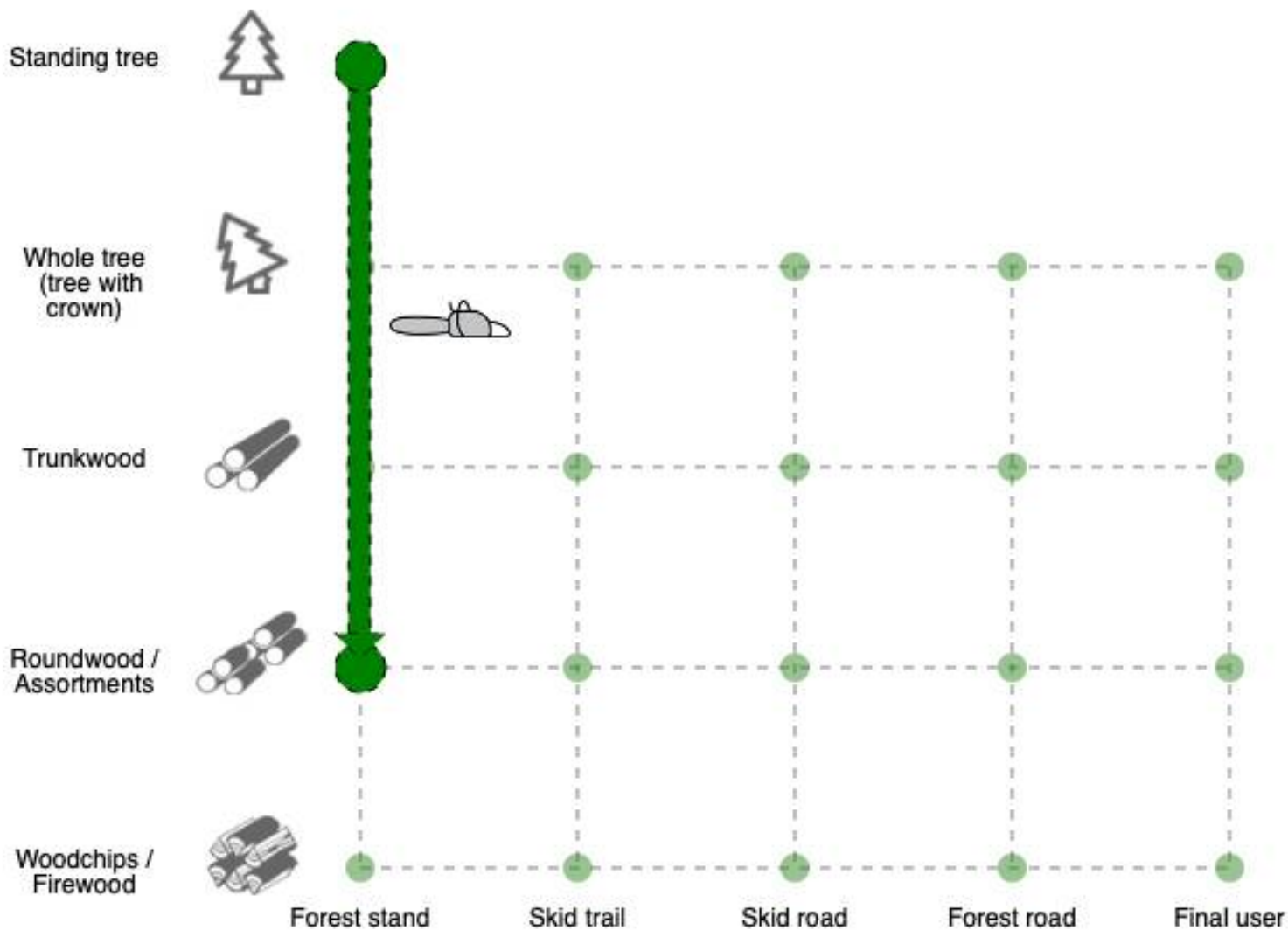


Reference system 1

Motor-manual thinnings



Photo: Urban Žitko

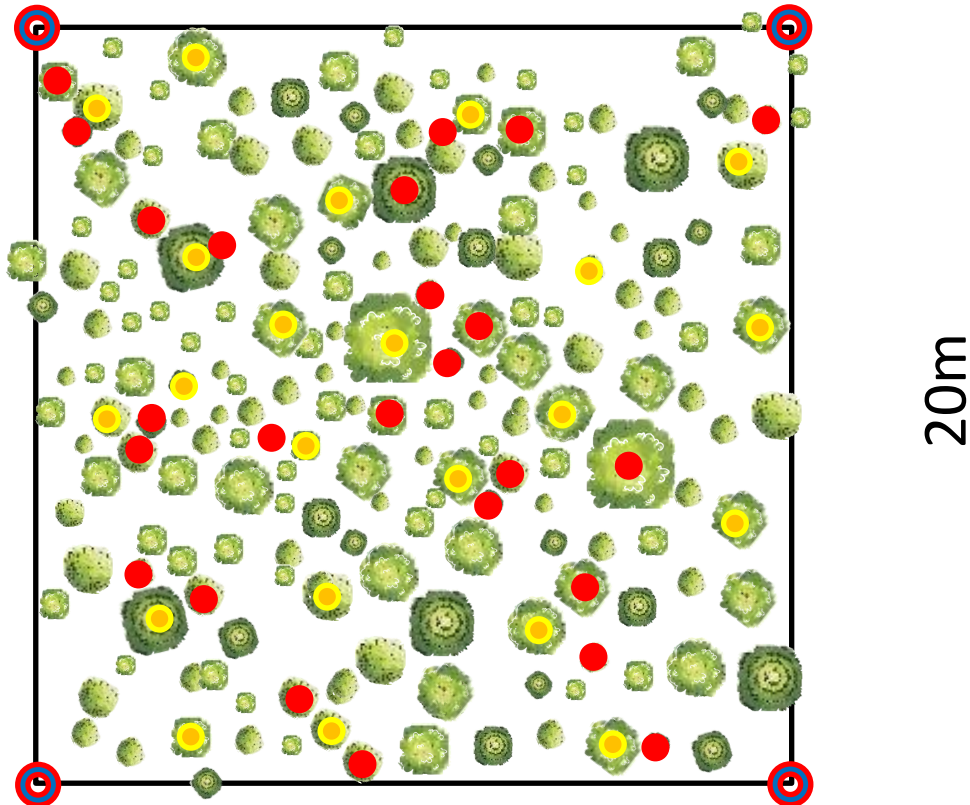


Work method

Motor-manual thinnings



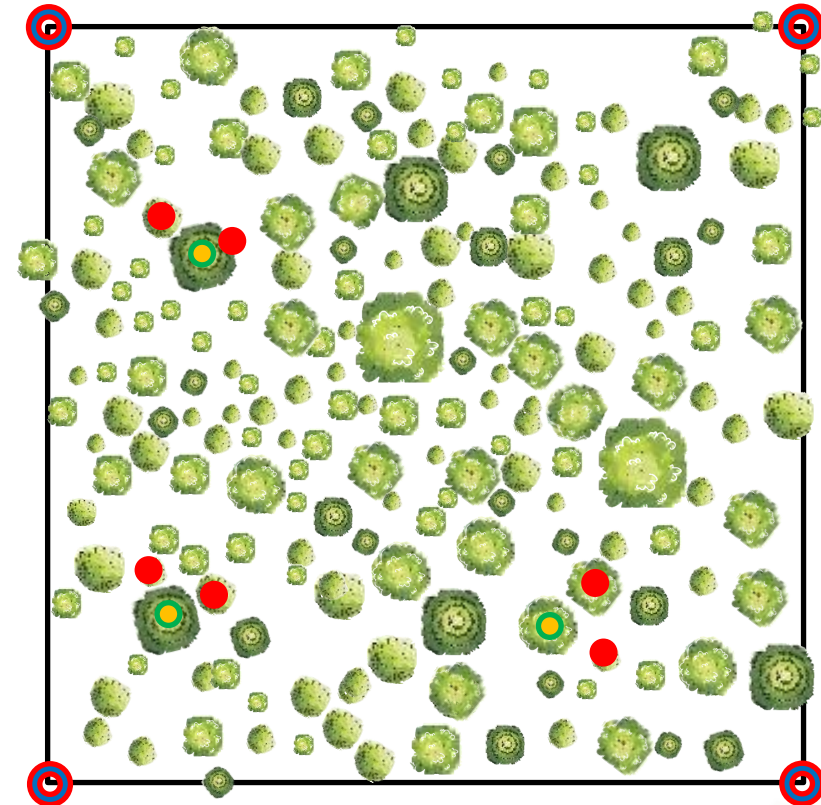
Selective thinning



20m

- Candidate trees
- Crop trees
- Competition trees

Minimal (situation) thinning



20m

Materials and Methods



Beech pole stand

	Age of the stand	20 years
	Species	99% beech, 1% other broadleaves
	Mean DBH	3.6 cm
	Mean height	4.7 m
	Mean density (trees ≥ 1 cm)	11 565 / ha (4 200–20 300)
	Mean density (trees ≥ 4 cm)	3 430 / ha (1 900– 5 600)
	Mean standing volume (stem+branches)	104 m ³ / ha

Cost calculation

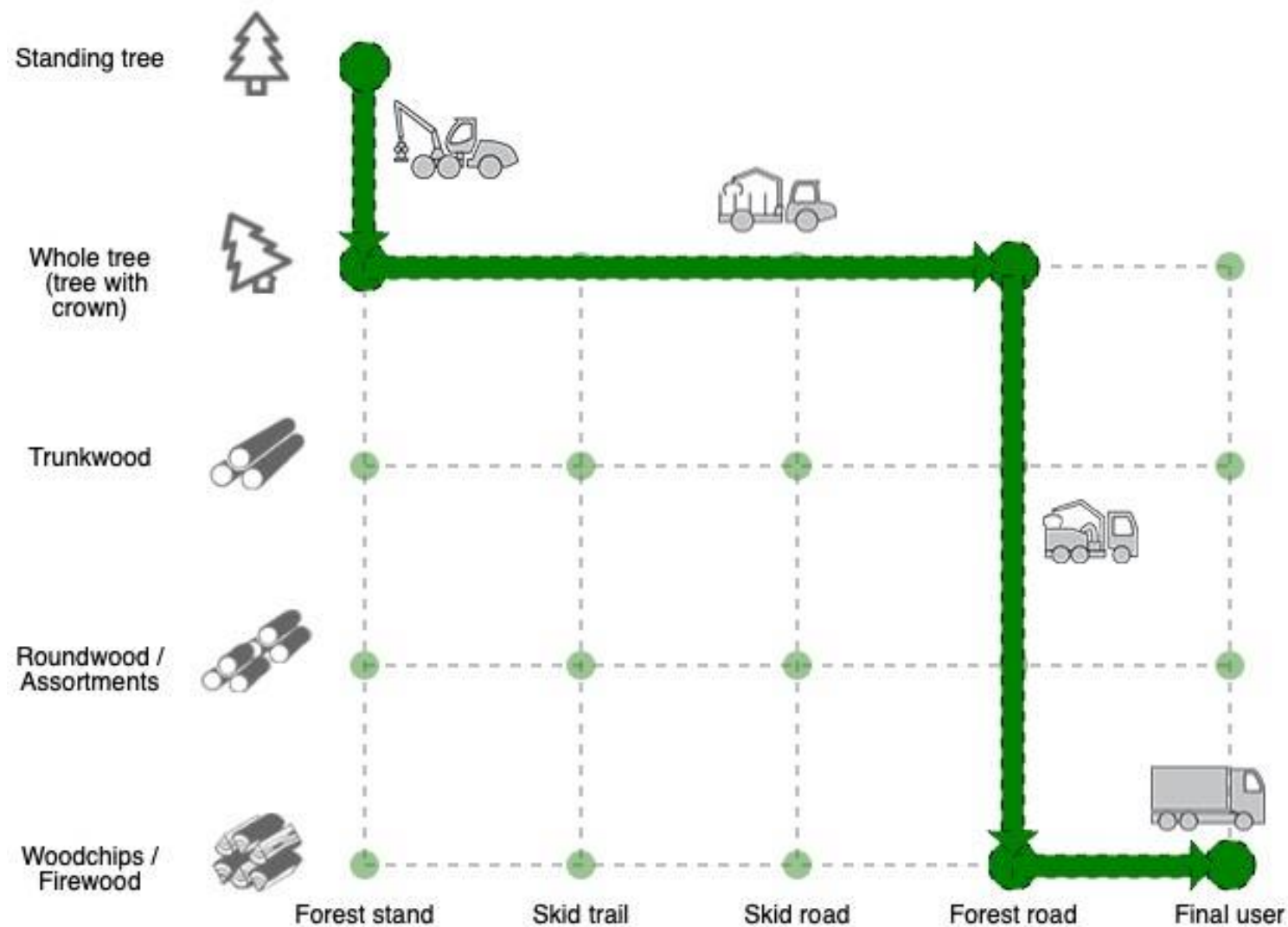


Triplat, M., Krajnc, N., 2020. Assessment of Costs in Harvesting Systems Using WoodChainManager Web-based Tool. Croatian journal of forest engineering 41, 49-57. <https://doi.org/10.5552/crojfe.2020.583>

Method	Machine	Fixed costs (€ / Depreciation period)	Fixed costs (€/h)	Variable costs of fuels and lubricants (€/h)	Variable costs of maintenan ce (€/h)	Total material costs of the selected machine (€/h)	Labour costs (€/h)	Total costs of work processes (€/h)	Total costs of work processes (€/m3)
ST	Chainsaw (4 kW)	315,00	2,86	1,36	2,4	6,62			
	Small tools and personal protective equip.	236,00	2,15		2,57	0,98	17	23,62	113,12
MT	Chainsaw (4 kW)	315,00	2,86	1,36	2,4	6,62			
	Small tools and personal protective equip.	236,00	2,15		2,57	0,98	17	23,62	102,12

Reference system 2

Fully mechanized thinnings (AHF Bracke c16)



Work methods

BCT

Boom-corridor thinning (BCT)



Selective thinning (ST)



ST

Materials and Methods



Beech stand

10 study units



Age of the stand

20 years

Species

99% beech,
1% other broadleaves

Mean DBH

3.6 cm

Mean height

6.2 m

Mean density (trees ≥ 1 cm)

11 565 / ha (8 000–14 900)

Mean density (trees ≥ 4 cm)

3 430 / ha (2 000– 5 400)

Mean standing volume
(stem+branches)

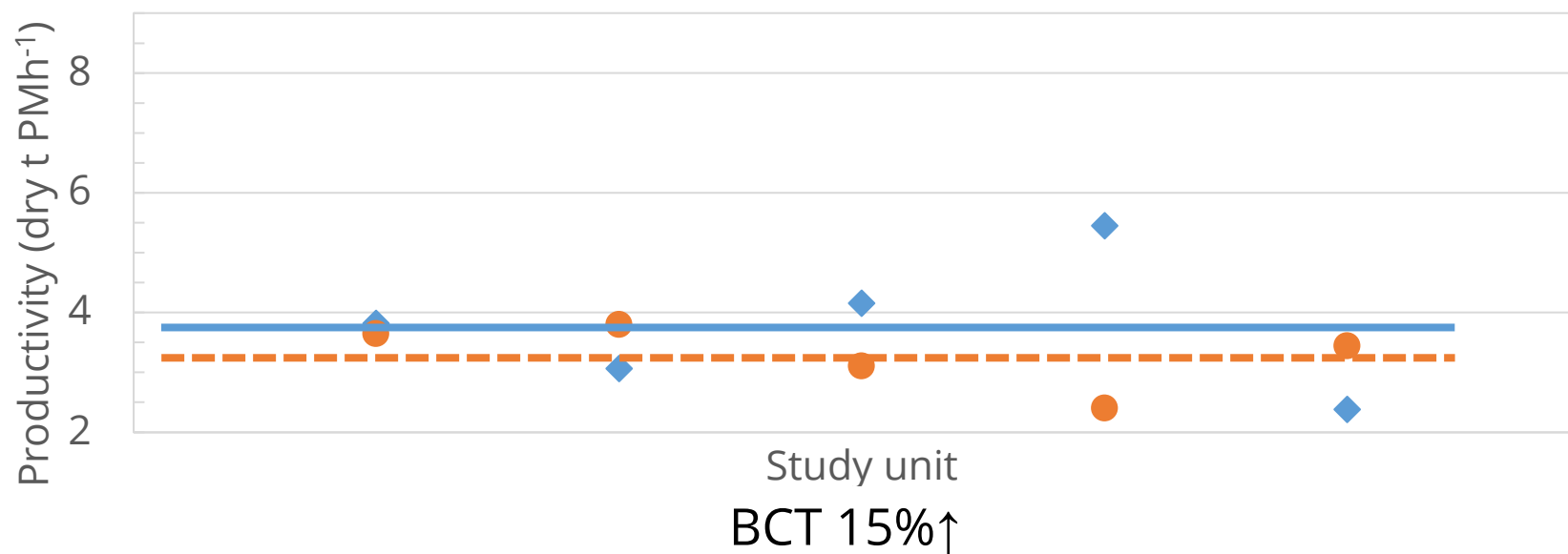
110 m³ / ha

Productivity of harvester

Komatsu 901 + Bracke c16



◆ BC ● S (n=10)



Biomass removal (dry t ha⁻¹)

30

Basal area removal (%)

47

Productivity BC (dry t PMh⁻¹)

3.8

Productivity S (dry t PMh⁻¹)

3.3

Cost calculations



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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 (€/m3)
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
	Woodchipeer	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	

Cost calculations



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	Forwarder	48000	53,33	33,91	30,00	117,24	20	137,24	58,89
	Woodchipeer	48000	53,33	64,73	30,00	148,07	17	165,07	
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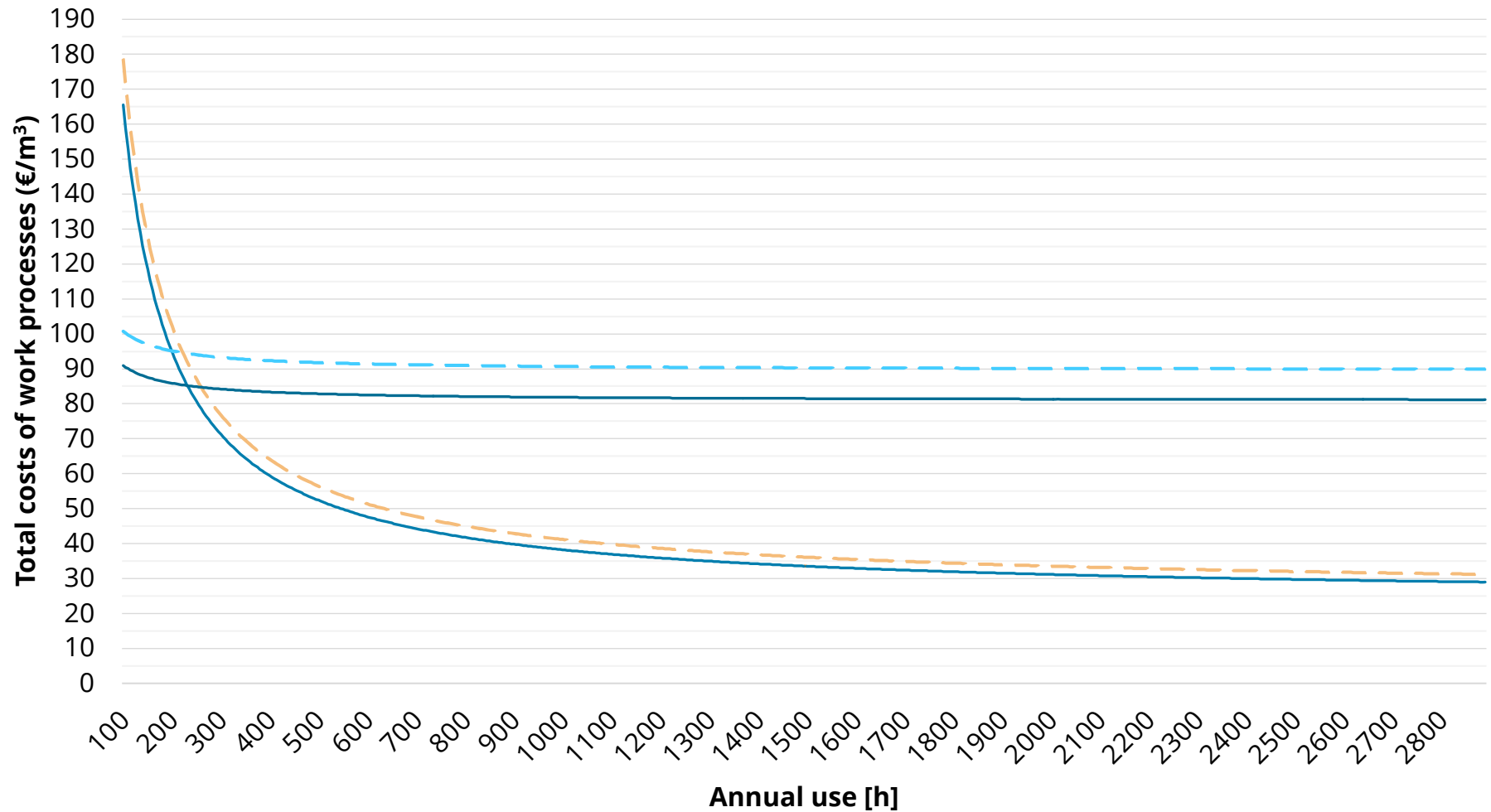
Machinery cost comparision



Reference system 1
vs. Reference system 2

Factors affecting costs:

- Annual use of machinery
- Time consumption
- Price of fuel



— Fully mechanized harvesting (BCT) — Fully mechanized harvesting (ST)
— Motor-manual harvesting (ST) — Motor-manual harvesting (MT)

Harvested biomass



VS.



Photo: Jaša Saražin



Photo: Špela Ščap

Harvested biomass



Table 4. Mean values (and SD) of thinning quality, stand properties, and harvested biomass per block and treatment. Significant differences between treatments per block is indicated on three levels: * = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$.

Block	Treatment	n	Properties of harvested trees							Properties of remaining stands						
			Bio mass ^a	Removal density (trees ha ⁻¹)	DBH ^b (cm)		Whole-tree volume ^c (dm ³)	Pro-portion of basal area removed (%)	Thinn-ing ratio ^e	Species ^f	DBH ^g (cm)		Height (m)	Whole-tree volume ^c (dm ³)	Stand density (trees ha ⁻¹)	Basal area
			(dry t ha ⁻¹)	DBH ^b ≥4 cm	Arith-metic	BAW ^c	Arith-metic			(%)	Arith-metic	BAW ^c	BAW ^c	Arith-metic	DBH ^b ≥4 cm	(m ² ha ⁻¹)
1	ST	10	48.4 (13.8)	2 240 (848)	3.9 (0.6)	9.4 (0.8)	15 (4)	49 (14)	0.71	b:o:p:s	5.1 (1.0)	13.3 (1.0)	11.2 (0.4)	34 (10)	1 120 (354)	14 (4)
	BCT	10	40.7 (14.2)	2 400 (1057)	4.1 (0.7)	10.0 (1.4)	16 (5)	48 (12)	0.75	b:o:p:s	4.4 (0.7)	13.3 (1.2)	11.0 (0.5)	27 (8)	1 315 (266)	15 (4)
2	ST	3	30.7 (16.3)	2 550 (278)	4.4 (0.7)	7.2 (2.2)	14 (6)	69 (14)	0.82	b:o:p:s	4.3 (1.4)	8.7 (1.8)	9.0 (2.2)	17 (10)	833 (475)	4 (1)
	BCT	3	33.5 (15.8)	3 600 (1457)	4.7 (0.7)	7.4 (1.1)	15 (5)	64 (15)	0.72	b:o:p:s	5.2 (0.8)	10.7 (3.4)	9.9 (0.9)	27 (13)	1 183 (333)	8 (4)
3	ST	3	43.6*** (1.1)	4 317 (355)	4.7 (0.4)	7.7 (0.9)	16 (3)	69 (9)	0.75	b:o:s	5.0 (1.7)	10.3 (1.1)	11.7 (1.2)	26 (15)	1 250 (695)	8 (2)
	BCT	3	34.7*** (0.2)	3 917 (333)	4.4 (0.2)	7.2 (0.4)	14 (2)	61 (4)	0.81	b:o:s	4.6 (0.4)	8.9 (0.8)	10.8 (0.8)	19 (4)	1 833 (236)	9 (1)
4	ST	9	67.3 (19.9)	4 444 (695)	5.1* (0.5)	10.0 (1.0)	19* (4)	70 (9)	0.75*	a:b:c:f:h:o:t	8.6*** (1.5)	13.3 (1.0)	12.8 (0.5)	52 (15)	1 100 (371)	12 (3)
	BCT	9	60.4 (13.6)	4 628 (988)	4.6* (0.3)	9.3 (1.0)	15* (3)	67 (11)	0.66*	a:b:c:f:h:o:t	6.6** (0.9)	14.4 (3.2)	12.8 (1.0)	43 (15)	1 278 (789)	12 (5)
5	ST	5	29.2 (6.3)	1 690 (399)	3.0 (0.2)	6.7 (1.6)	7 (2)	47 (6)	0.57	c:f:h	4.1 (0.4)	12.1 (3.3)	10.9 (0.7)	16 (4)	1 220* (476)	9 (1)
	BCT	5	30.3 (10.1)	2 100 (659)	3.6 (1.0)	6.5 (1.4)	8 (4)	46 (9)	0.73	c:f:h	5.1 (1.3)	9.0 (1.4)	10.4 (0.7)	16 (6)	1 850* (322)	11 (3)
6	ST	2	30.5 (6.8)	1 100 (141)	7.2 (0.3)	12.6 (0.0)	40 (2)	32 (7)	0.85	c:f:s	11.3 (0.3)	14.8 (0.9)	14.1 (0.4)	85 (6)	1 800 (212)	25 (3)
	BCT	2	33.3 (17.1)	1 475 (742)	6.9 (2.0)	12.9 (1.4)	30 (11)	36 (10)	0.75	c:f:s	10.2 (2.3)	17.3 (2.8)	15.4 (1.4)	103 (52)	1 300 (424)	22 (3)

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 (€ per ton)	/	/	5.56 €	3.89 €

Discussion and conclusions



- Efficiency
- Market condition
- Wood price
- Small scale technology





THANK YOU

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