Preliminary results from the field trials

Productivity in small tree thinning operations - 7 December 2020 (Zoom webinar)

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Evaluation of Bracke C16c SMALLWOOD version

Summary of trials

	Sweden	Finland	Slovenia	SUM
Amount "type" stands	1	2	3	**6**
Amount study units	20	12+3[a]	32	**67**
Thinned surface (hectares)	1.9	1.2+0.3[a]	3.1	**6.5**
Productive machine time (hours)	14.7	10.3+1.6[a]	31.0	**57.6**
Harvested biomass (dry tonnes)	83	42+7[a]	153	**285**

[a] Local driver

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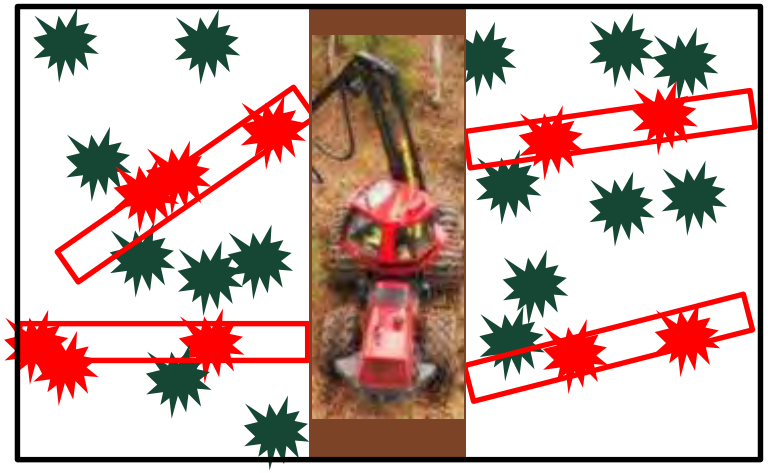
Results

The analysis of pre-inventory data (DBH, height, tree density, etc.) did not reveal statistically significant differences (p-value ≤0.05) between study units within the majority of stands.

This would allow meaningful comparisons between working methods!

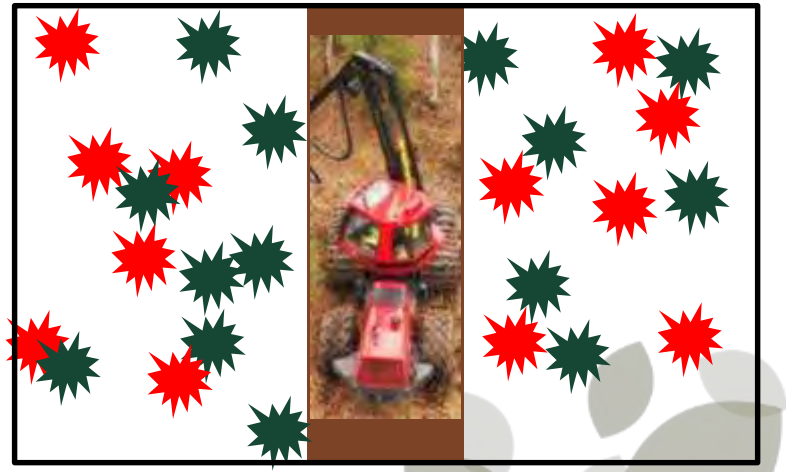
BC

Novel boom-corridor thinning (BC)



versus

Conventional selective thinning (S)



S

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Results

(All drone images in this presentation were taken by Christian Höök, SLU)

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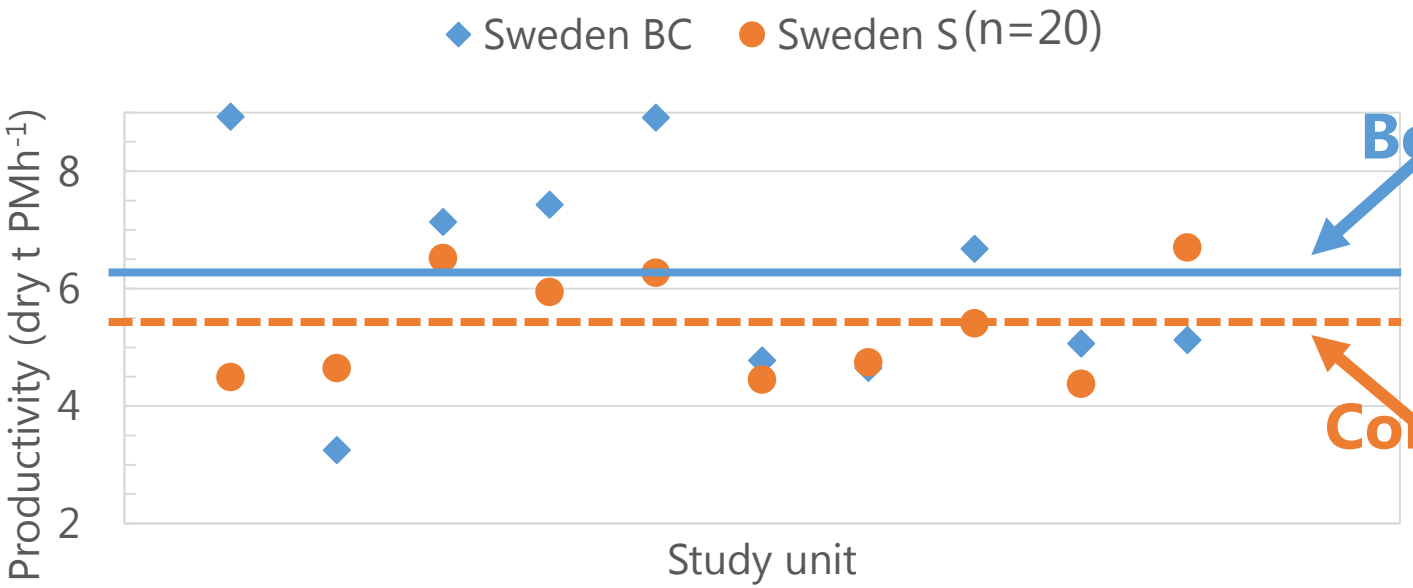
Results



Boom-corridor thinning (BC)

Conventional selective thinning

BC 16%↑

Biomass removal (dry t ha^{-1})	45
Basal area removal (%)	49
Productivity BC (dry t PMh^{-1})	6.2

dry t ha^{-1} = dry tonnes (t) per hectare (ha)
PMh = productive machine hour

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Results

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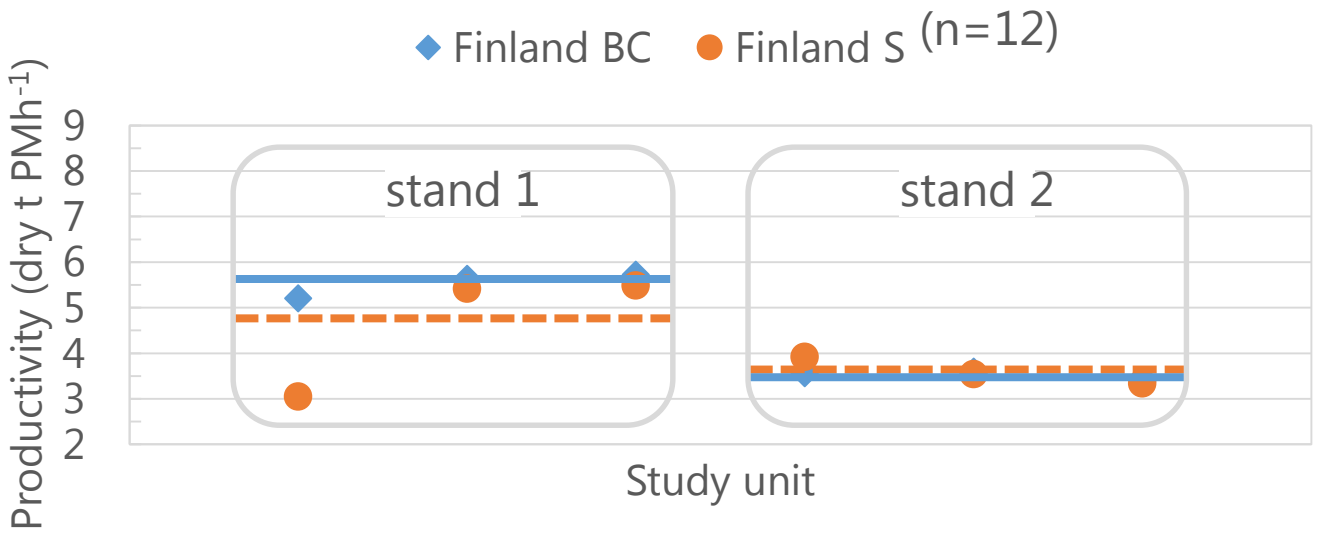

	BC 19%↑	BC 2%↓
Biomass removal (dry t ha^{-1})	32	39
Basal area removal (%)	67	65
Productivity BC (dry t PMh^{-1})	5.5	3.5
Productivity S (dry t	4.7	3.6

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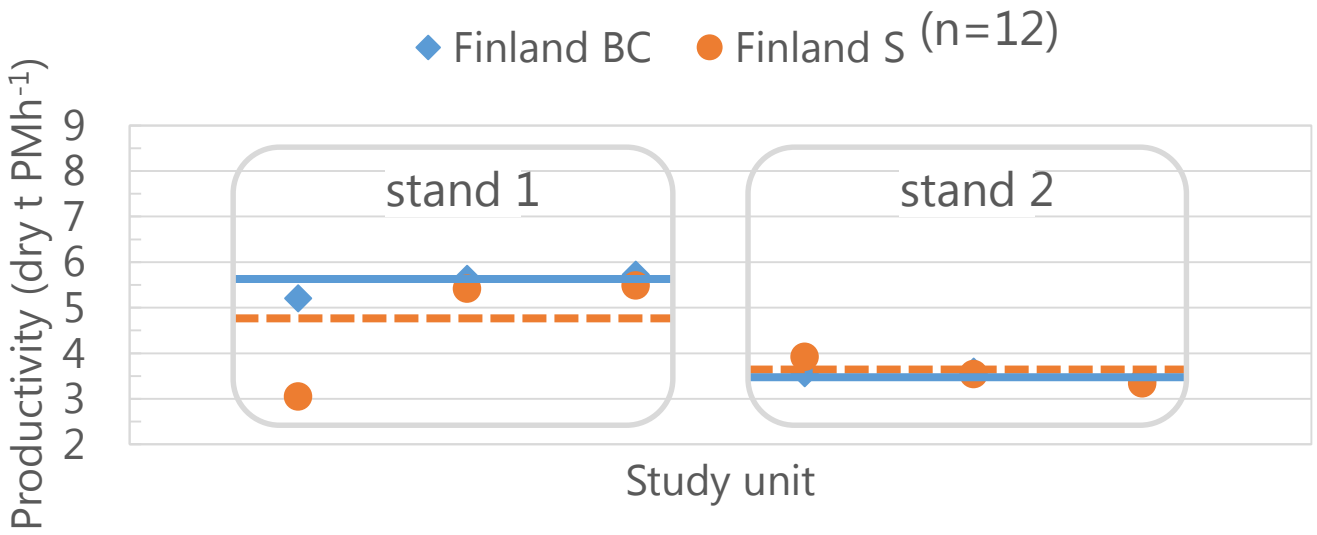
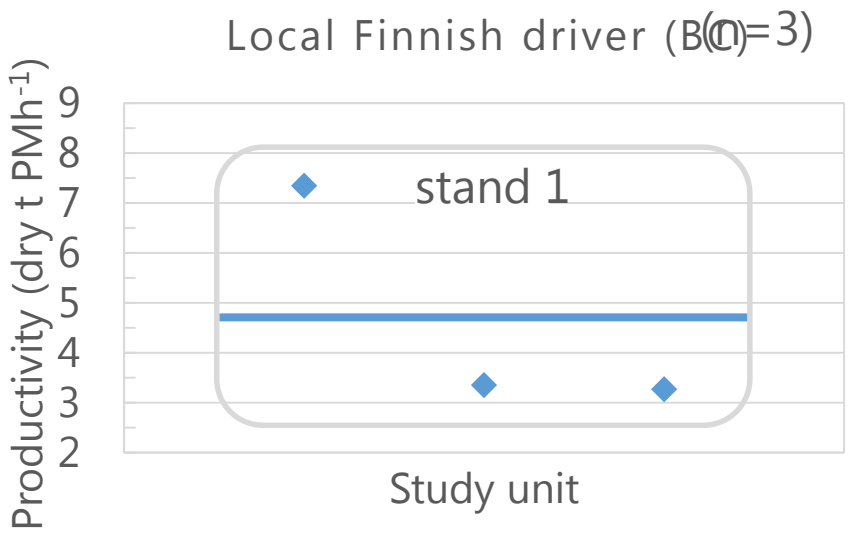
Results





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Productivity BC (dry t PMh^{-1})	5.5	3.5
Productivity S (dry t	4.7	3.6

Biomass removal (dry t ha^{-1})	25
Basal area removal (%)	58
Productivity BC (dry t PMh^{-1})	4.7

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Results

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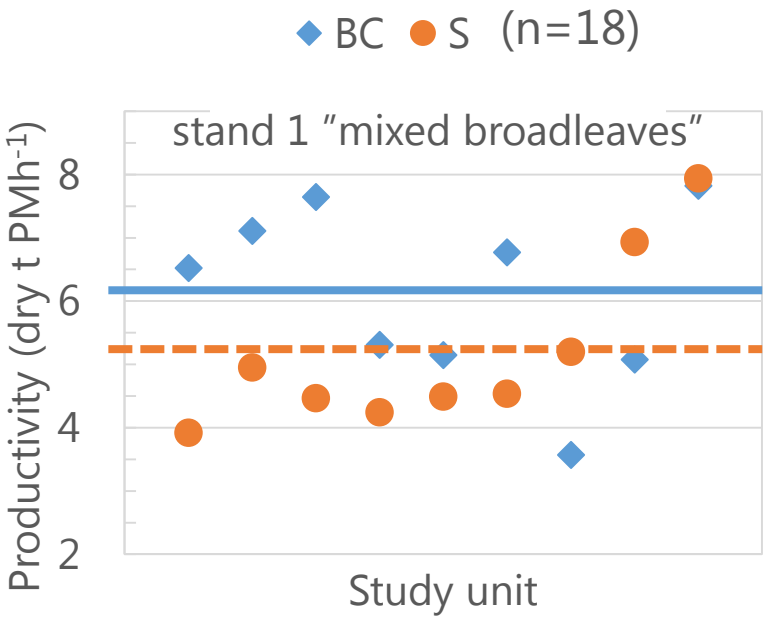
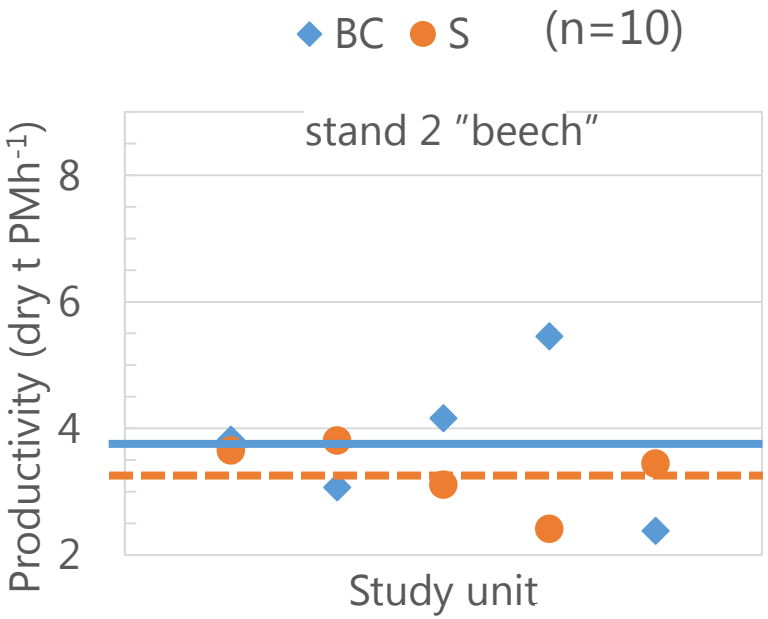
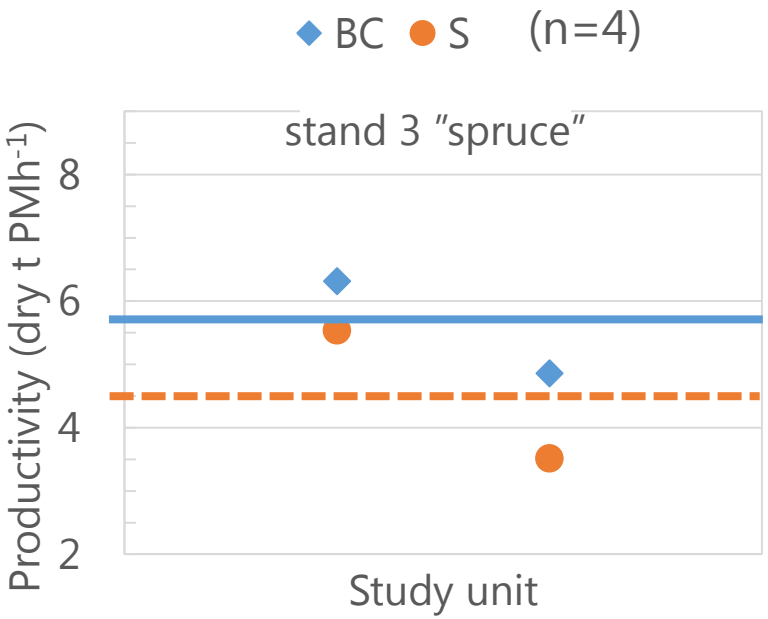
Results



BC 18%↑



BC 15%↑



BC 24%↑

Biomass removal (dry t ha^{-1})	64	30	32
Basal area removal (%)	68	47	34
Productivity BC (dry t PMh^{-1})	6.1	3.8	5.6

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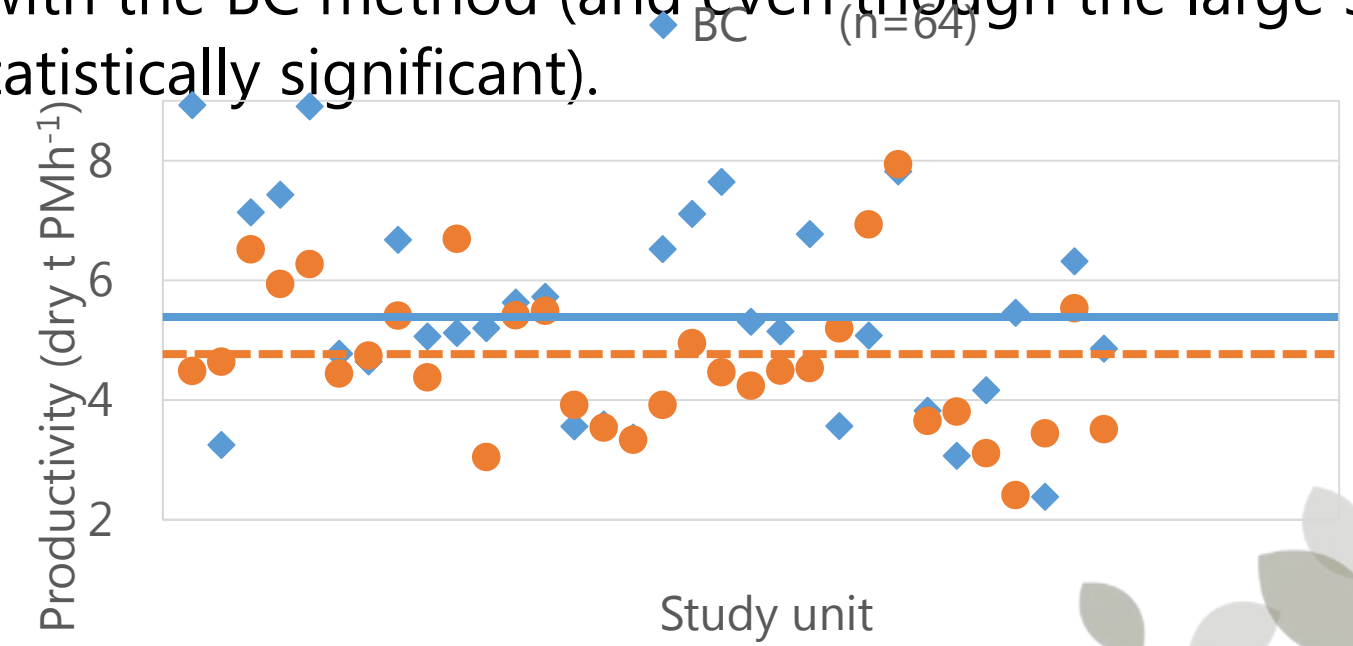
Results

In the majority of stands, the novel BC thinning method presented a comparatively higher productivity than the conventional S method, and the relative difference between methods was recurring.

If considering all study units in all countries and same driver: 16% higher productivity with the BC method (and even though the large spread, this difference was almost statistically significant).



BC 16%↑

p-value=0.054

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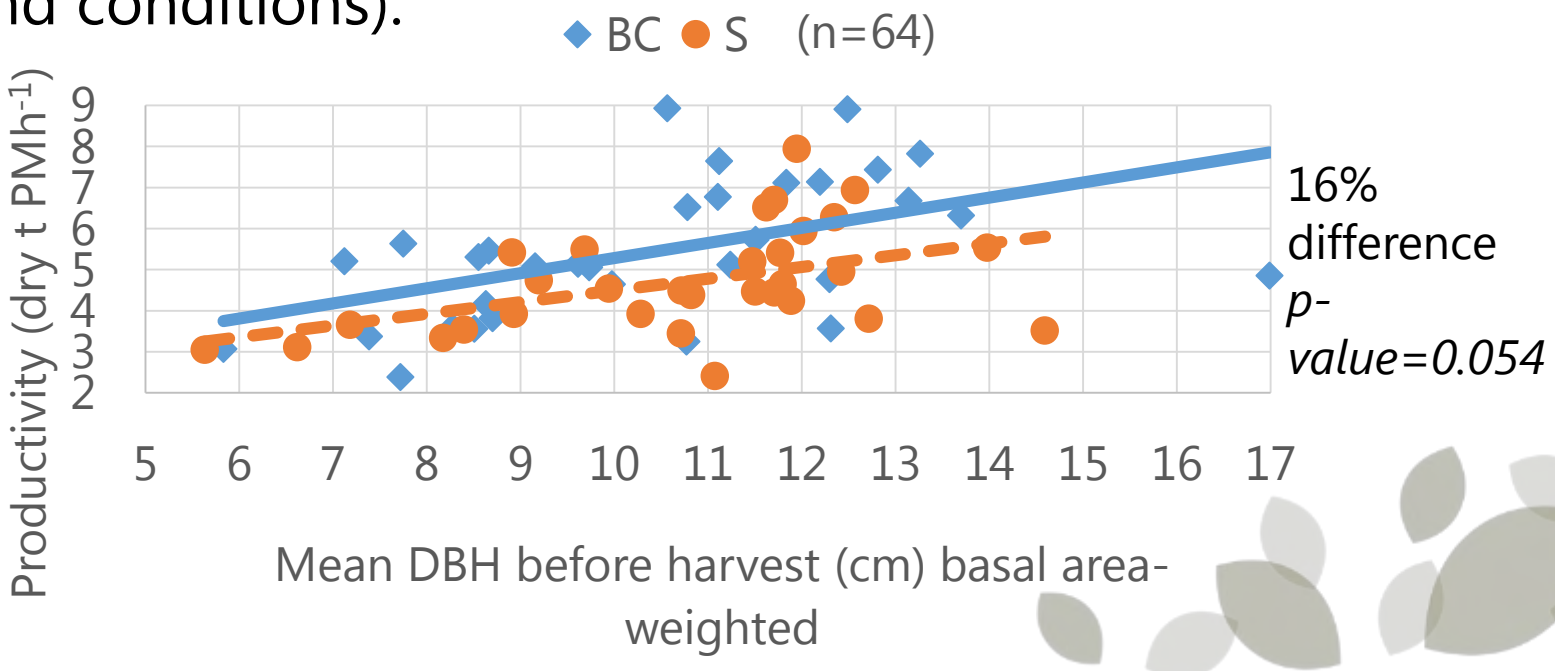
Results

The variables affecting productivity were investigated in order to model the harvester's productivity.

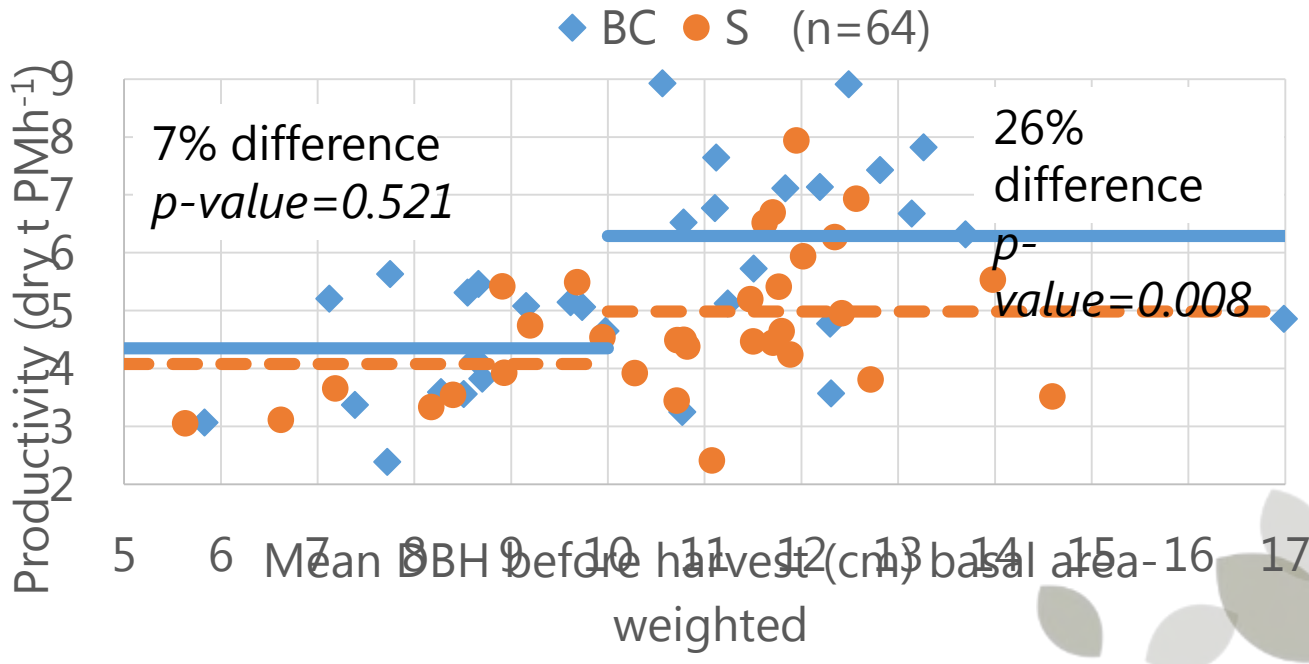
Some of the independent variables explaining productivity was the measured mean DBH, but this variable alone could not explain all the variation in productivity (large diversity in stand conditions).



Evaluation of Bracke C16c SMALLWOOD version

Results

The differences in productivity between working methods became more evident (and statistically significant) in the study units with a mean DBH above 10 cm.

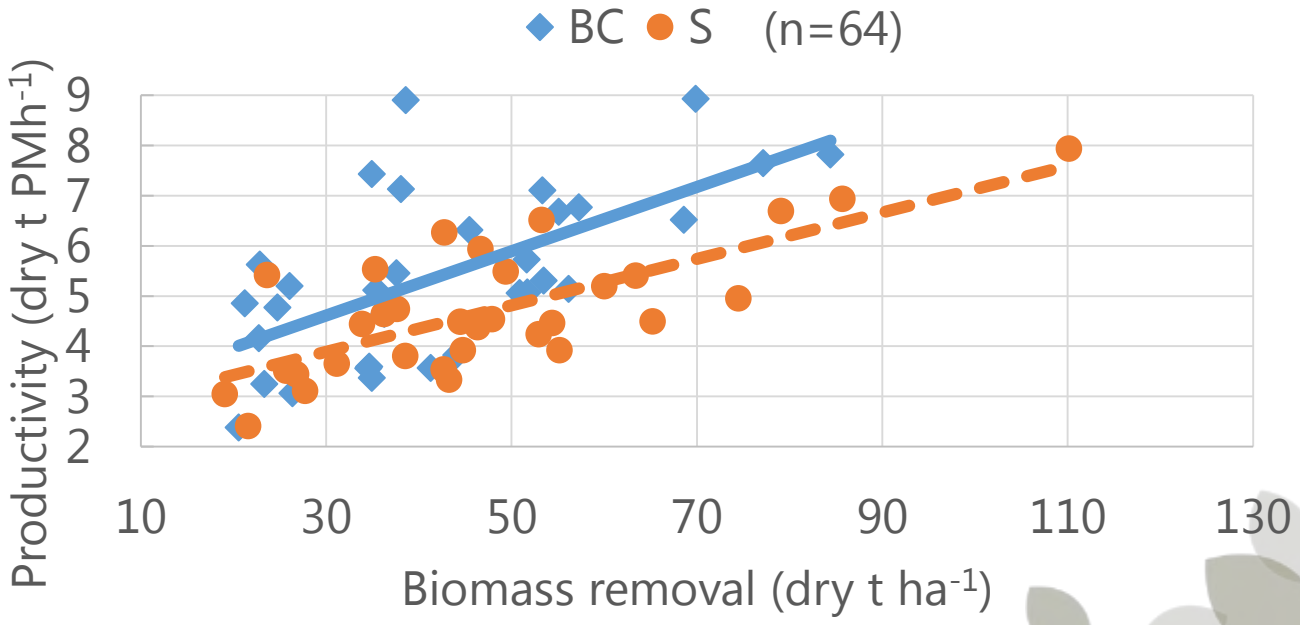


Evaluation of Bracke C16c SMALLWOOD version

Results

Large amounts of biomass were harvested in the thinnings, often between 20-60 dry t × ha^{-1}, and on average 45 dry t × ha^{-1} (108 m^3 × ha^{-1}).

In a conventional roundwood first thinning, average removal is 50 m^3 × ha^{-1} (Eliasson *et al.* 2019).



Biomass removal was found to be a better predictor of productivity, but the models will include additional independent variables.

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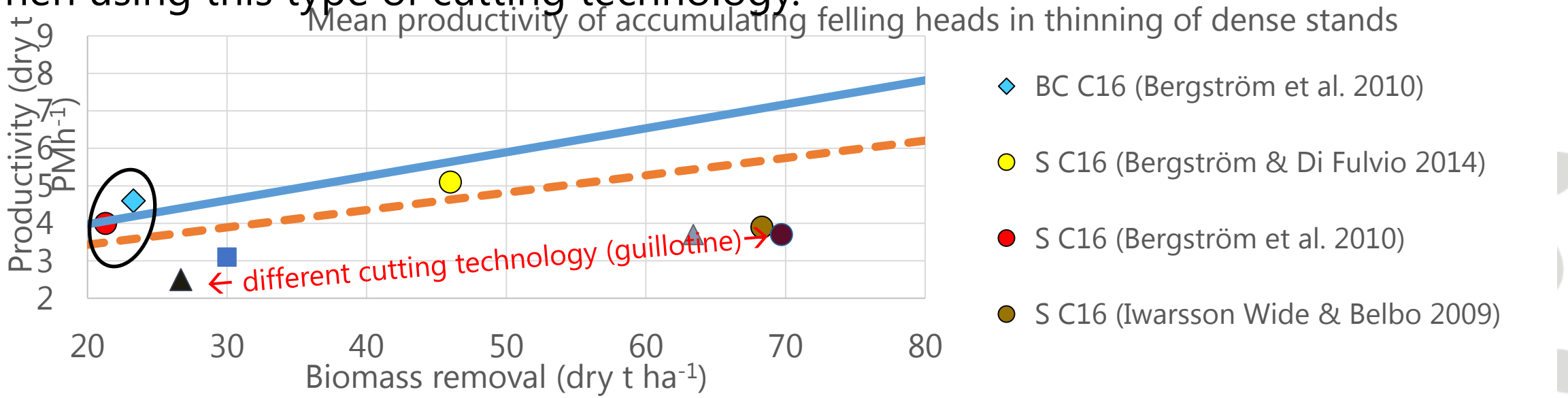
Results - Discussion

The relative differences between methods and the average productivity were in line/above the findings from previous studies in Sweden.

Bergström *et al.* (2010) showed that productivity of small tree harvest could be relatively high with the Bracke C16, despite of a relatively low biomass removal. Our trials confirmed the hypothesis that productivity increases with biomass removal when using this type of cutting technology.



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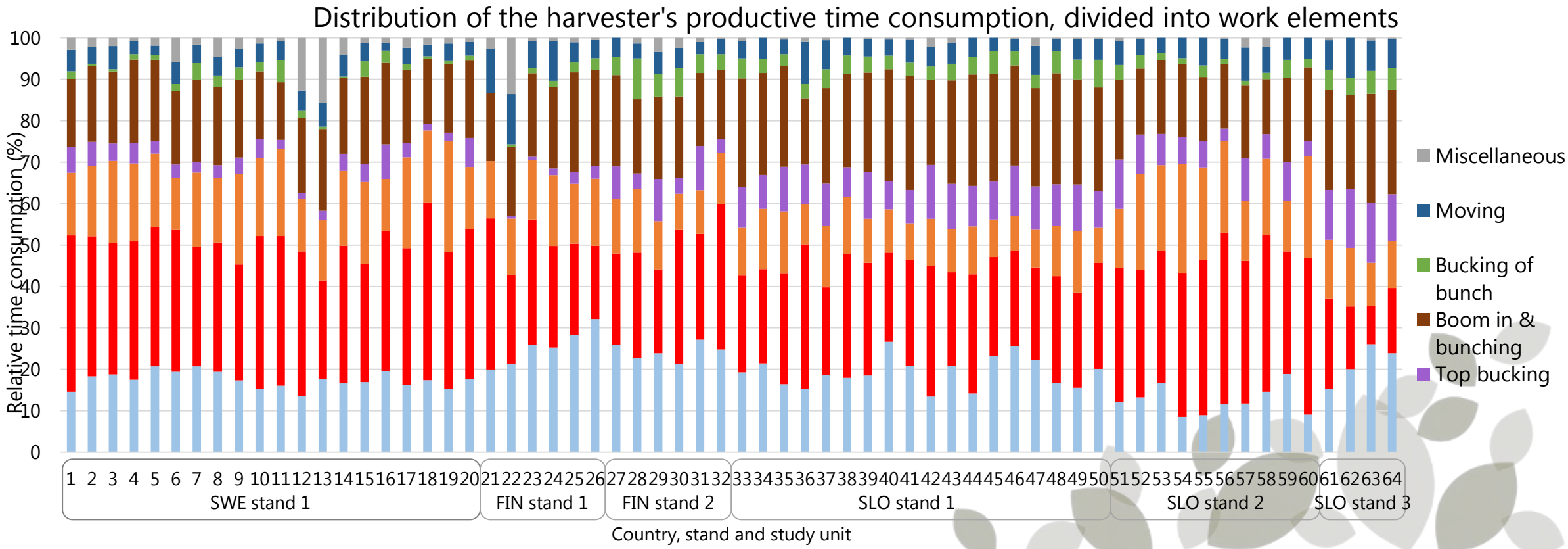
Results

Productivity and differences between thinning methods were further investigated by looking at the work elements in the work cycle of the harvester.



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Results

Time consumption (seconds) per harvested tree, pooling data from all stands:

On average, the novel BC thinning method was found to be faster in every work element!

seconds × tree^{-1} (≥4 cm DBH)			
	BC (n=32)	S (n=32)	*p-value*
Boom out	1.85	2.71	*0.002*
Felling	2.98	4.23	*0.005*
Felling in strip road	1.78	2.03	*0.320*
Top bucking	0.69	1.04	*0.032*
Boom in & bunching	2.07	2.94	*0.002*
Bucking of bunch	0.34	0.43	*0.197*

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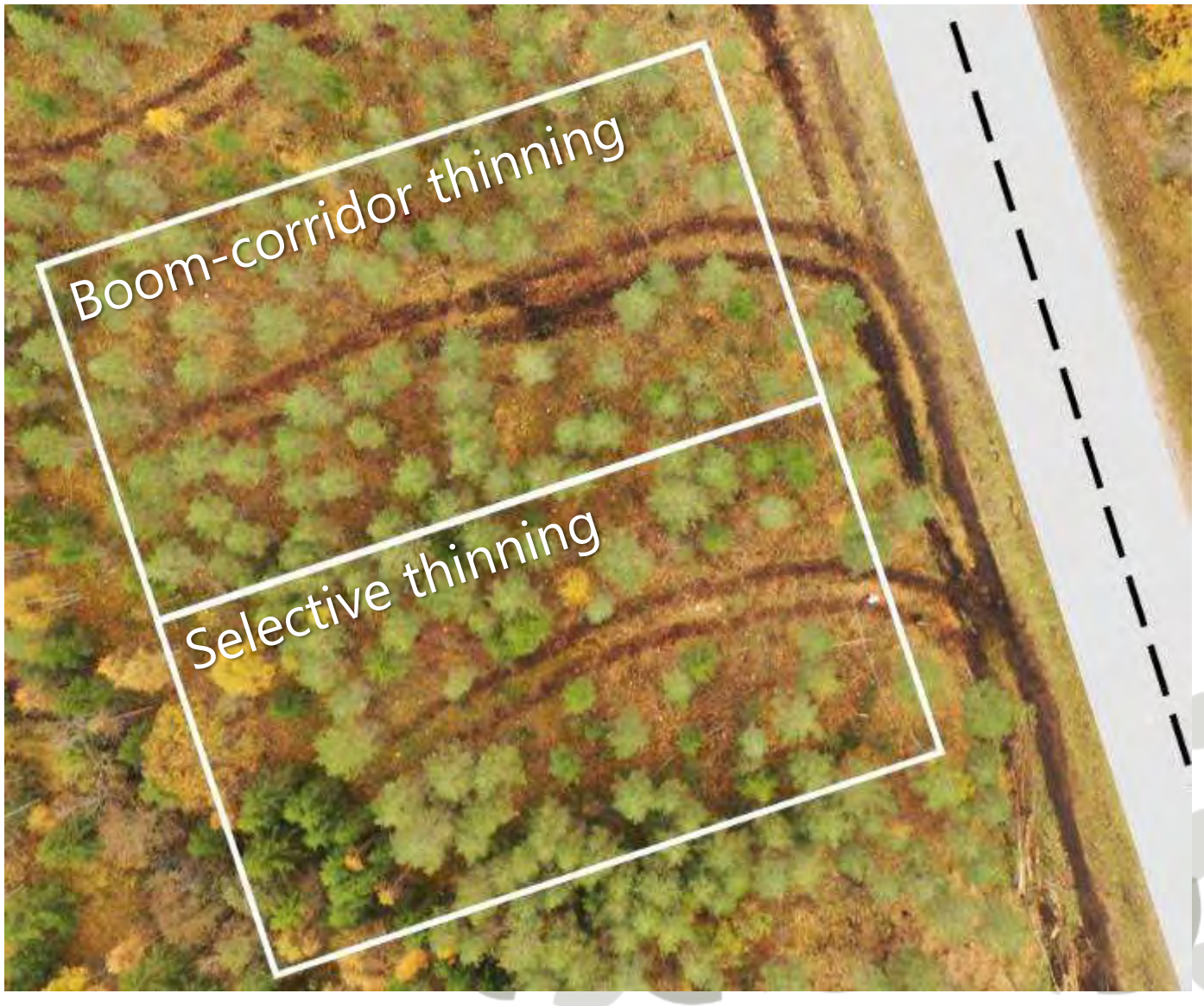
Results

Were there differences between methods in the remaining stands?



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Results

The analysis of post-inventory data did not reveal significant differences in the majority of variables.

However, on average, the units treated with the BC method were 23% denser after thinning than their counterparts: 1423 vs. 1158 trees (≥4 cm at DBH) × ha^{-1}.

This was also reflected in the comparatively 10% lower biomass removal in these units: 43 vs. 47 dry t × ha^{-1}, for the units treated with the BC and S method, respectively.

These differences should have favored the conventional S method, but the BC method yielded still a higher productivity.

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Discussion

Many “lights” for the evaluated felling head and novel boom-corridor thinning metho

… but let’s show some “shadows” as w

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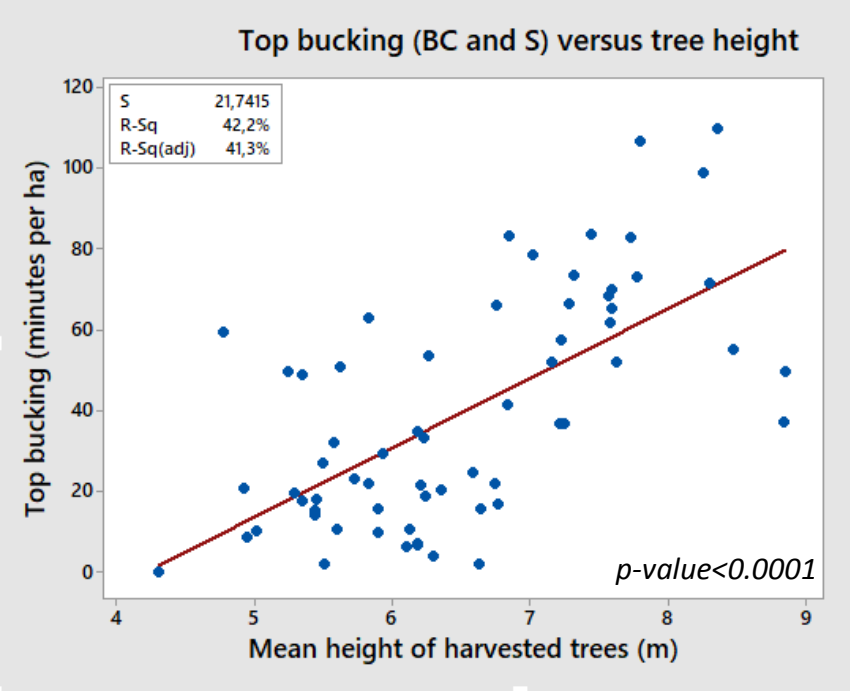
Discussion

The amount of time spent in “top bucking” increased markedly with the height of harvested trees.

Excessive height can be regarded as a bottleneck in the work of the felling head (lacking of feed rollers), leading to excessive top buckings and decreasing prod



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Discussion

When working with the BC method:

→ In very dense study units: the felling head was full after harvesting a few meters corridor.

→ In less dense study units: few trees were available to be taken along the corridor.

→ If there were excessively “thick” trees, it was difficult to lay out corridors (not impossible, as the maximum capacity of the head is 26 cm).

All these made losing the advantage of

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Discussion

For both working methods:

→ If the stand was too dense/long trees, it was problematic to find a place to put the biomass down (making “top bucking” almost mandatory, not only to make the forwarder’s work easier, but just to be able to put the trees down to the ground).

→ The saw-chain in the head is sensitive to stones, which can be problematic if there is too much undergrowth or the terrain is hilly (difficult to see the stones). However, a damaged saw-chain.

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Discussion

And what about the mon 

Harvester cost= 140 € × PMh^{-1}
Harvester productivity= 5 dry t × PMh^{-1}
Cost of harvest= 28 € × dry t^{-1}

Forwarder cost= 120 € × PMh^{-1}
Forwarding productivity= 6 dry t × PMh^{-1}
Cost of forwarding= 20 € × dry t^{-1}

Biomass cost at roadside= 48 € × dry t^{-1} (20 € × m^{-3})

Who is willing to pay?

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Final remarks

Even if these thinnings are “on the edge” of profitability (or not profitable at all), they should be regarded as an investment in the future production of high-quality roundwood and other ecosystem services in these stands, also enhancing their resilience against disturbances such as wildfires.

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Final remarks

And what about the modification in the head (the “horn-shaped” support)?

According to the machine operator we had in all countries (which worked with the standard C16 for several years), the handling of the stems was notably improved.

Additional technical tests to assess the “horns” are yet to be done.

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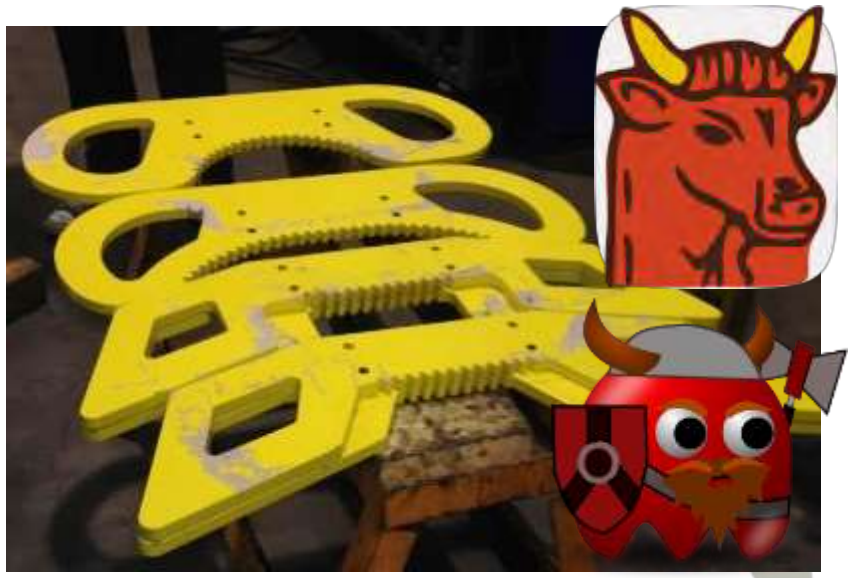

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C16 “SMALLWOOD version”

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Final remarks

The trials showed that the evaluated cutting technology can increase the cost-efficiency of thinning dense stands, especially when working with the novel boom-co

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Acknowledgements

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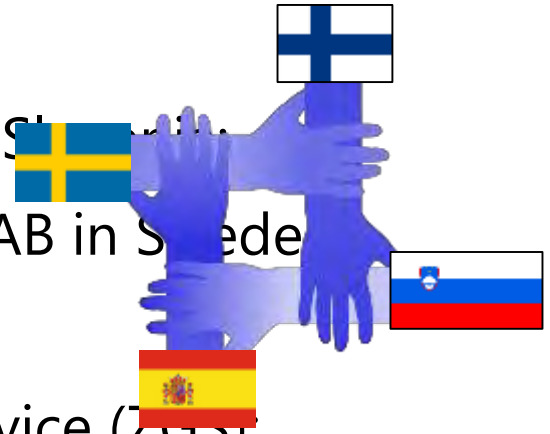

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Thanks for your attention!

Questions?

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