

Sveriges lantbruksuniversitet Swedish University of Agricultural Sciences

Institutionen för skogens biomaterial och teknologi

Effects of harvested tree size and density of undergrowth on the operational efficiency of a bundle-harvester system in early fuel wood thinnings

Dan Bergström (SLU), Fulvio Di Fulvio (IIASA), Yrjö Nuutinen (Luke) Department of Forest Biomaterials and Technology, SLU dan.bergstrom@slu.se





Demand for biomasses for biorefining will rise....

-Use of bundle-harvesting systems for young dense thinnings could significantly reduce supply costs for small diameter trees (Bergström & Di Fulvio 2014, SJFR)....

-A 3rd version of the Fixteri bundle-harvester has shown increases in efficiency of 90-160%. Bundles increases forwarders' and trucks' payloads by ca 50% (Björheden & Nuutinen 2014, Skogforsk report...).

-System's productivity has not been extensively studied in stands < 30 dm³, in which there may be significant proportions of disturbing under-growth trees (cf. Kärhä 2006 For. Stud.).

Objectives

- The objective of the study presented here was to <u>evaluate effects of</u>:
- a) harvested tree size
- b) and density of undergrowth

<u>on the operational efficiency</u> of the third prototype of the bundle-harvester in early fuel wood thinnings.

Study design

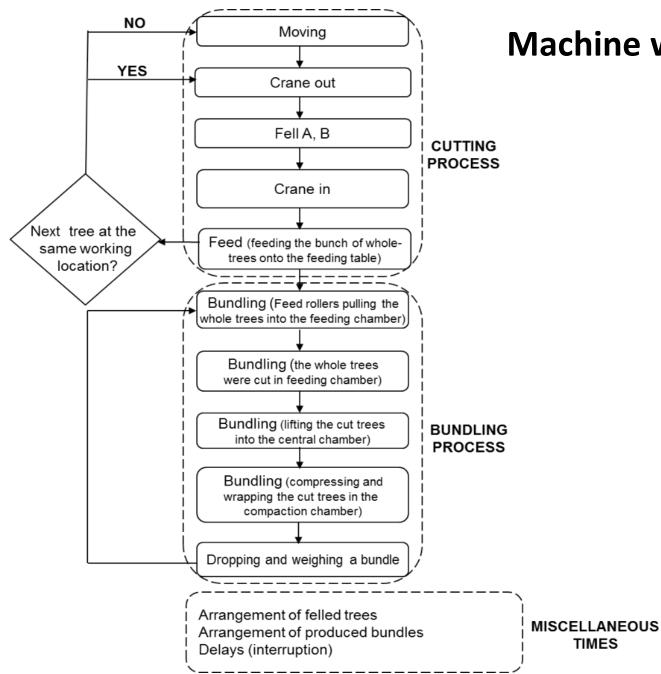
- Scots pine dominated stands (by volume)
- 26 harvesting units where inventoried
- Time studies
- Measures of:
 - bundle mass
 - MC
 - Thinning quality etc...
- Analysis of time consumption, productivity....

Stand characteristics

	DBH	Stem	Density	Height	Tot	Density
	basal	volume			volume	trees
						<2.5 cm
Stats	(cm)	(dm³)	(trees/ha)	(m)	(m ³ /ha)	(n/ha)
Mean	8.0	26.5	5406	8.2	189.2	4523
Min	6.3	15.0	2765	7.0	124.0	134
Max	9.9	43.0	9302	9.7	302.0	11951
Median	8.0	24.5	5200	8.1	173.5	3648
SD	1.0	8.1	1583	0.7	48.7	3509



- 8-wheeled Logman 811FC harwarder (Logman, Oy)
- Logfit FT100 crane (Logfit AB), rotating cabin with endless turning.
- Nisula 280E+ (Nisula Forest Oy) accumulating felling, cutting diam. 28 cm.
- Fixteri FX15a bundleing unit (mass ca. 6,500 kg, width 240 cm, length 410 cm, height 280 cm; www.fixteri.fi).



Machine work sequence

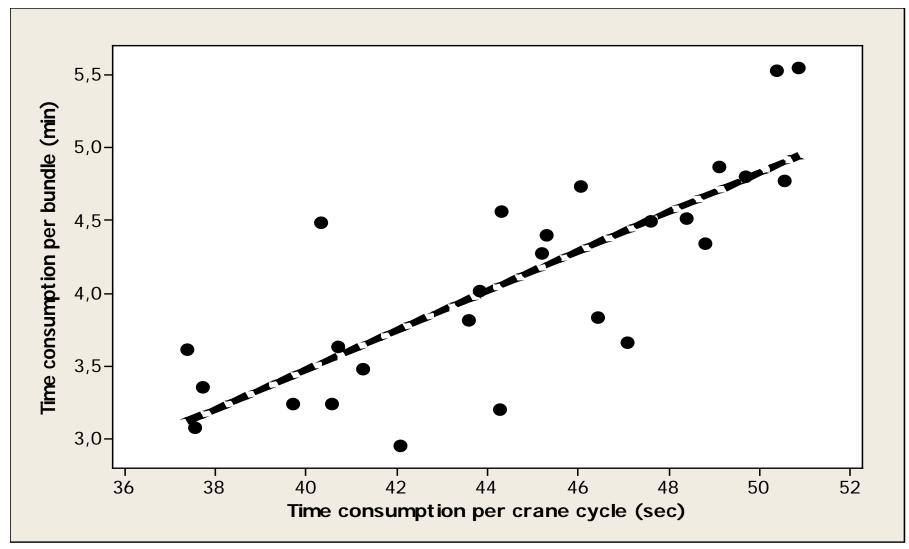
<u>A bundle</u> 2.6m length 60-70 cm diam. 0.45-0.5 m3



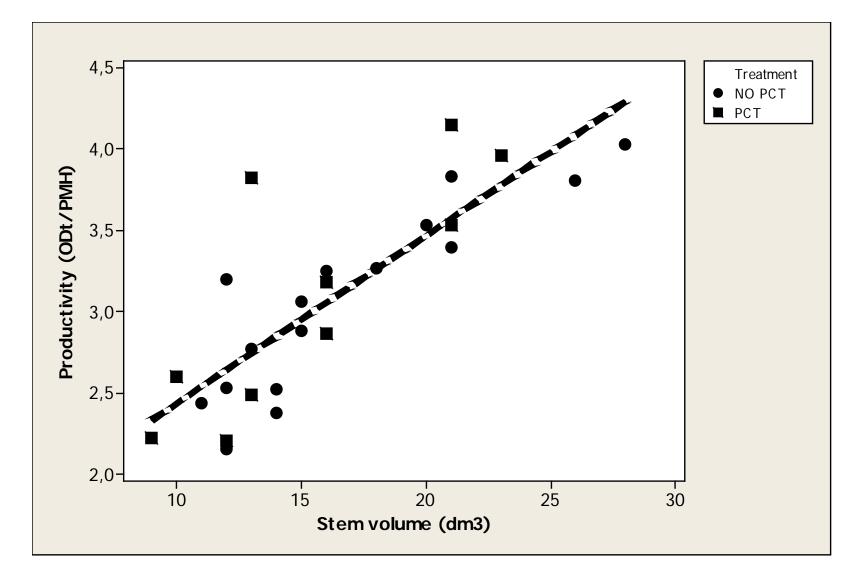
Results: Work-efficiency >> no differences between treatments!

	Stats					
Work	Mean	SD	(%)	P-value		
element	(sec/tree)					
Move	0.8	0.2	7.4	0.661		
Fell	5.8	0.5	51.6	0.229		
Crut	1.5	0.4	13.2	0.902		
Crin	2.1	0.6	18.6	0.792		
Artr	0.1	0.1	1.1	0.901		
Arbu	<0.1	0.1	0.2	0.240		
Bundle	0.5	0.3	4.5	0.848		
Drop	0.3	0.1	2.9	0.660		
Other	0.1	0.1	0.4	0.658		
Total	11.2	2.0	100	0.864		

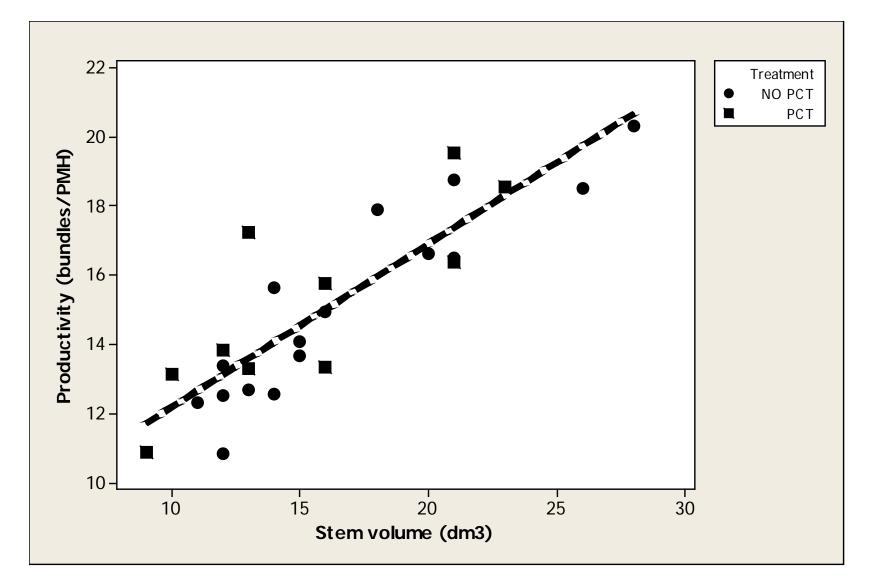
Correlation between cutting and bundling work



Productivity, mass



Productivity, bundles



During 98.5 PM₁₅H:

- 15.87 MWh of diesel fuel were consumed
- 1392.36 MWh of biofuel were produced
 >> average energy efficiency of 172 MJ/OD t (187 MJ/OD t in PM₁₅ time) and an EROEI of 80.6 (87.7 in PM₁₅ time).

(fuel consumption averaged 15.1 I/PM₀H (16.4 I/PM₁₅H))

Average a bundle mass: 454 kg, fresh = 0.96 MWh

Additional test:

Tree sections lost 37 kg (SD 29) mass during the bundling process

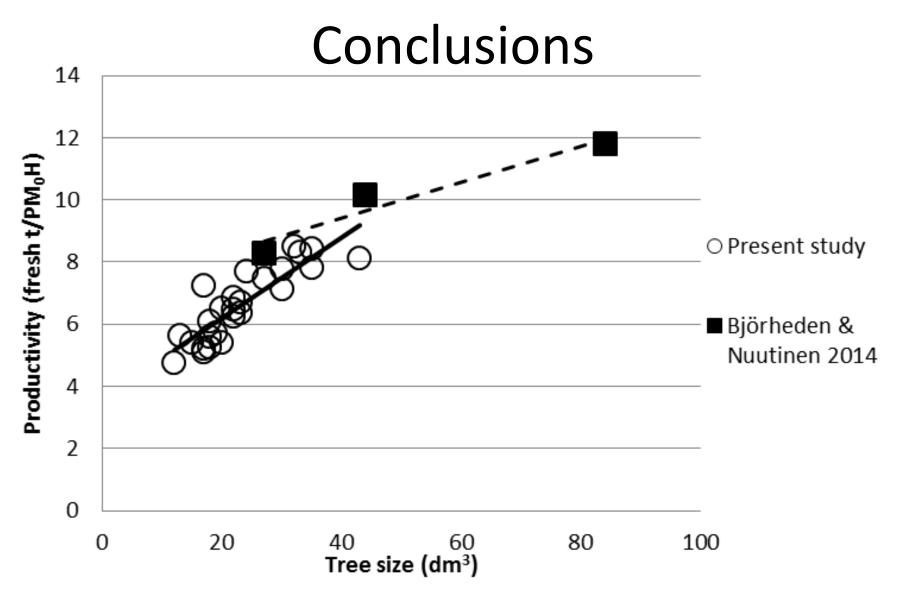
= 7.1% of mass!

By visual inspection this mass consisted mainly of fine branches and needles.

Conclusions

- Unexpectedly, the density of undergrowth trees did not significantly affect the efficiency of the cutting work, as found in previous studies (e.g. Kärhä 2006, Jonsson 2015 MSc at SLU).

- Accordingly, Jonsson (2015) found that defoliated undergrowth reduces visibility much less than fully leafed trees.
 - The undergrowth did not affect the quality of the thinning work either, which is consistent with the hypothesis that the undergrowth did not significantly impair visibility for the operator....
- Few of the harvested units in our study had dense spruce undergrowth,
 - which may be significant as spruce has greater branchiness than pine and birch (Kärhä (2006), and thus may have stronger effects....



The study provides information about the system's performance that complements earlier findings, especially when handling relatively small trees!

...additional explanation:

- the cutting work in the present study was performed with an accumulating felling head equipped with shearing knives that is less sensitive to disturbing undergrowth during cutting than the accumulating harvester heads used in the cited studies.

-Simple, robust och unsensitive for undergrowth, stones...! (but rel. slow!)

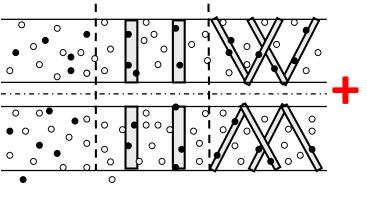


Figure 6. Felling and harvester heads used in the study. From the left the Bracke C16.a disc saw head, the Log Max 4000B harvester head and the Naarva-Grip 1500–40E guillotine head. Photo: Helmer Belbo

(Belbo, H. 2011. Efficiency of accumulating felling heads and harvesting heads in Mechanized thinning of small diameter trees. Doctoral Thesis. Linnaeus Universitetet.)

The bundling unit's maximum efficiency was not reached during the trial, but estimates indicate that it could be significantly (perhaps up to 100%) higher.

- However, to reach such efficiency the system would have to be equipped with a felling and bunching head that can cut and accumulate trees during <u>continuous boom movements.</u>







Boom-corridor thinning methods New cutting technology

Integrated bundling

Next step(s)....

Prototypes! - MAMA-head



CTAN A

- "Flowcut"!

Elow Cole 100 produces i centificat (Secondo)

6982363888

EKNI SAKERHET

Skihl i bopp. Nir Untringen Hild & Rdn Soziada sax matandigas för fetura-Bruk fick Strill MS171 flest pooling - Nend annet toppbeting for Family Barlie with mildi. Hangestma-OS blev toda. Discussive Atla Callect CS381 och lyra Batterias 14 turessay tore konar randss in haften järsfort med bergo så gan Den slop konsered (\$22385 och Enrive \$5-PE 1235. Roft Segurateds

Motionshotore. Konsers/Ferest Serienin mappgrader all skotters, Scenarios 855.1, reaching re-unay kindt, nytt stänst kostutryerme och atvechlad draving Stotanon Lanar 14 convicts biotraitaciae Librarianan Unit's somernalmendmaskers. Roll Segurited

ADDINGS WHEN IN A DOWNSTON OF

Skogsjättar intresserade av nya energiskördarna

Ett gar ran ideer for att enorgiskönfa angskogar i korridorer på att offaktivt niet is på väg att bli versifighet. Flowcast 700 är den sonaste som tittat investerare och ska bli prototyp.

Ballorit apprepatel Ekrevent 788 citit Annumuloofren Levennet Jassiete med reveraget Medizab Engineering All i Filipstial, Han berätter att uten han intoge & pit makes out at the sedan tre är tillasha te skyddod av ett världs

Fran till og for konstruknionen løgat datare kinethred) hers (CAB prograin a dataset

No Willias tiden etegen lite token für jag har fått pöngar föls Energersyn-rligherint och Sveatlag, även SCA har court intresse. Vid involution hits of hit. en jusicityp förtast, så ern 8-8 mlans-for net vi om iddema bliller eller om aggregatet frammar i skrotilalan, saner Levran't forsom lite-drastiskt.

Start intresso

this benditive act withhan med have kerntraktion te att det ska glatt ellier gall's kontinuering: i fall drift i låraga strik samtidigt solt (terreneras and fas thep ave an extrept as ackness during stittor. Statemanna somfan i en bizzi muunka kodjekapen. Haritens odst fin bit max 300 kilo modan aggregatet he rolenas vaga 600 leder.

Aggregatet burdle stimmers val mad det som hirskarns offerfrägar Sir ort få till en nationell kontidernäuting, sägst Centrary Justissee

Bara proterroritori tuckre scottintrense på en dag sen börning gall/ma er unge tits bestied som ernangetathey Here welcan av Manit annot SLU. Shegsickniska klustret och Bohad Beglob (Alasethotten

These art bearcacus from tangelongan i dapilipri micht sieselt hetiphärverg markington ar intresset for at unreck is principal solutio appendiarligen store tran skogsbruket, drugt 70 personer this Swrige och Finland delog namhgen i heldagas ministiet:

ach det fava file alternativ

ditiver Playerst prisin toyade en agrian Leiturs med effermannar Olorsion. en idd on eu maikin mod tei kenner sizer alcondar och skar af klerwerke. Ma-A rest interest presentation of the to under maiss ar. 211 annue ademanty 50 brognergh



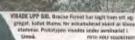
UANGA ASRADARE. Irots att scorgi felo akagan lade är jättatett på matkradan al funa det ett start ävivesse för att utvecida talenik för rattorett skärd. visade off semitarium i Uranil mod 70-talki milingara tirra veckam

Shinses alear aggregatet Plancat TOD uppiltus med ackamulatade stammer.

skand.) romöngar och gallringar är fundsalanskada Figneri FX15 som ska par 2.6 mitter thegs burner sort binds thep treet plastions och hen kirga in med skotare. Here Fitteri går reden i Brildred, kopplade till skordare reed htpp://www.com/com/ Radan i dag hur Kentlindska Bracke logit fram ett ucknowlavands apgregat med blings för skord av klens stansstar: Prototypers kalkad Murra, vitadestaniler feeristilaguna tiitviarang, daa sive Vinei demonstrende affater term through a biosload and mender

spinster, Heil Segutation 100 12 20 pt







ritaingen.

Hunstruktóren



Sveriges lantbruksuniversitet Swedish University of Agricultural Sciences

Institutionen för skogens biomaterial och teknologi

[Forest Engineers Raul Fernandez Lacruz and Mikael Öhman are acknowledged for helping out with the field work.]

• Thanks, Dan, Fulvio and Yrjö!

• dan.bergstrom@slu.se