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Trunk utilisation as a factor affecting harvester productivity

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Innovating the competitive edge:from research to impact in the forest value chain
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Introduction

Wood sales in the State Forests National Forest Holding (2015)

TOTAL 37 778 tys. m³							
	TIMBER				SLASH		
	35 853 in thous. m³ = 95%				1 925 in thous. m³ = 5%		
	coniferous		non-coniferous				
	27 095,4 in thous. m³ = 72%		8 757,9 in thous. m³ = 23%				
	in thous. m³	average price per 1 m³	in thous. m³	average prize per 1 m³		in thous. m³	average price per 1 m³
large-size general purpose wood	12117	254,61	2295	292,17	*slash for industrial uses*	408	119,84
large-size special wood – venner	0,4	758,52	6,9	1866,32	*slash for fuel*	1517	34,49
large-size special wood – plywood	79	407,57	273	284,87			
medium-size log wood	302	205,36					
medium-size wood for industrial uses (pulpwood)	13183	160,74	4459	143,76			
fuelwood	1414	101,23	1724	128,71			
average per 1 m3		**314,67**		**543,17**			**77,17**
income in milon zlotys		**5441804,2**		**1624099,1**			**101216,1**
% of income		**76**		**23**			**1**

Source: General Directorate of the State Forests

Hypothesis

1. Harvesters do not maximaly utilise a birch trunk for logs.
2. Lower trunk utilisation (only from bottom) could increase productivity.
3. Harvester productivity depends on diameter at breast height (dbh) and the thinnest diameter of the top log (dtl).

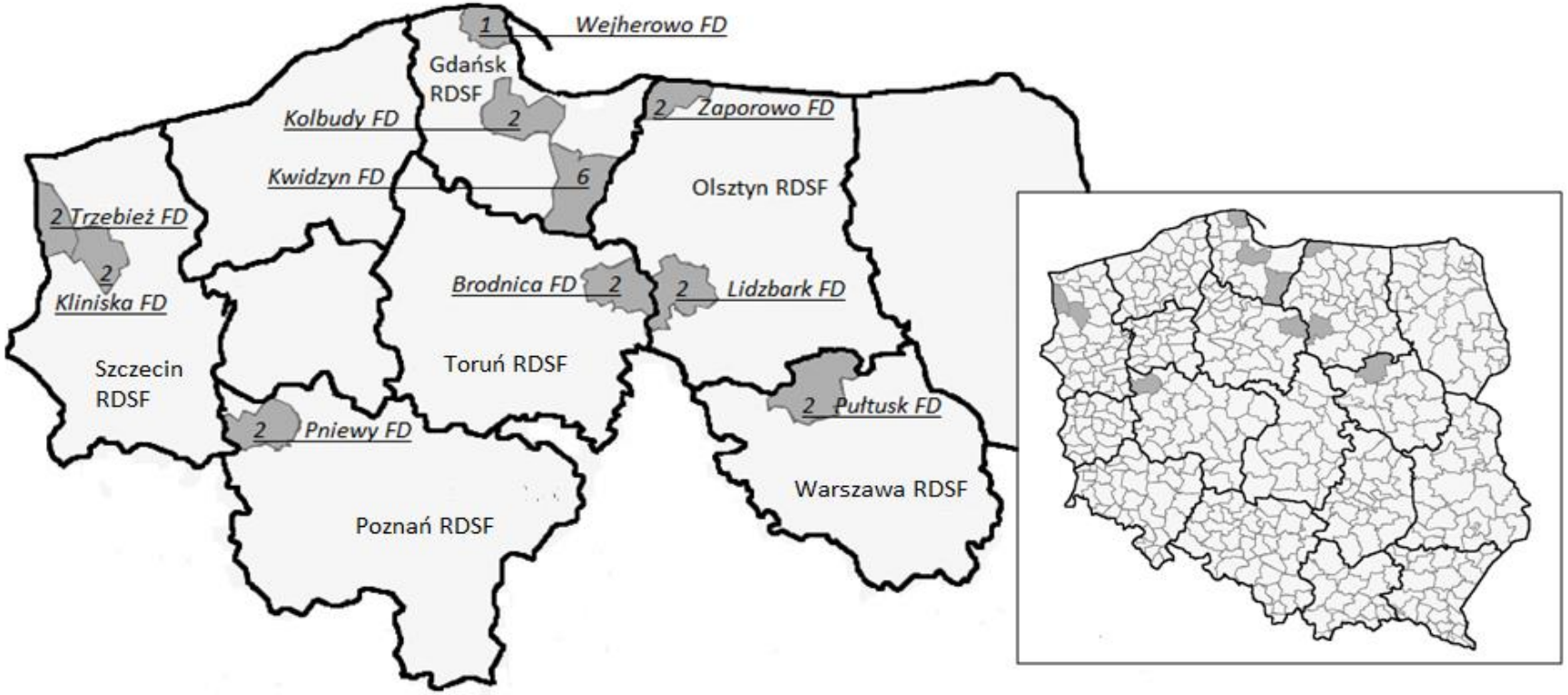
Objectives

1. What is the real trunk utilisation in birch stands?
2. Which parameters and how strong affect the productivity?

Materials and methods

Location of the research

- 23 experimental plots
- 17 experimental areas
- 10 forest districts (FD) in 6 regional directorates of the SF



3 286 trees cut during the research

Materials and methods

Tested machines

- **10 harvesters (9 models) with 10 different harvester head models**

harvester	*production year*	*harvester power (kW)*	*harvester head*	*harvester head size*	*operator experience (year)*
John Deere 1270 D	2008	160	758HD	650	10
John Deer 1270E	2013	170	H480C	710	9
Ponsse Beaver	2014	129	H6	600	0,25
Ponsse Ergo	2004	176	H73	700	3
Ponsse Ergo 6*	2011	210	H7	750	7
	2002		H73	700	4
Sampo Rosenlew 1 066	2008	129	HTH460	620	3
TBM Preus 84	2003	112	Kesla 24RHII	520	4
Timberjack 1070D	2003	136	HTH460	620	2
Valmet 901.3	2007	140	351.1	600	7

* 2 harvesters

Materials and methods

Data collection

1. Stand measurements

<-
<-
<-

2. Work time recording

3. Logs measurement

For min. 30 trees with visible numbers:
upper diameter of the top log ->
total log length ->

Materials and methods

Data analysis

Huber's volume equation (*V, m^3*)

for 3 sections of tree:

1) timber volume processed by a harvester,
2) unprocessed timber volume (until 5 cm with no bark),
3) biomass volume

$$V = \frac{\pi * (d_{1,2})^2 * l}{40000}$$

where:

$d_{1,2}$ – middle diameter with no bark(cm),

l – total wood length (m).

Operational productivity *(V, m^3h^{-1})*

$$P_{op} = \frac{V}{PMH}$$

where:

V – timber volume(m^3),

PMH – productive machine hour.

Convergence coefficient (*cm m^{-1}*)

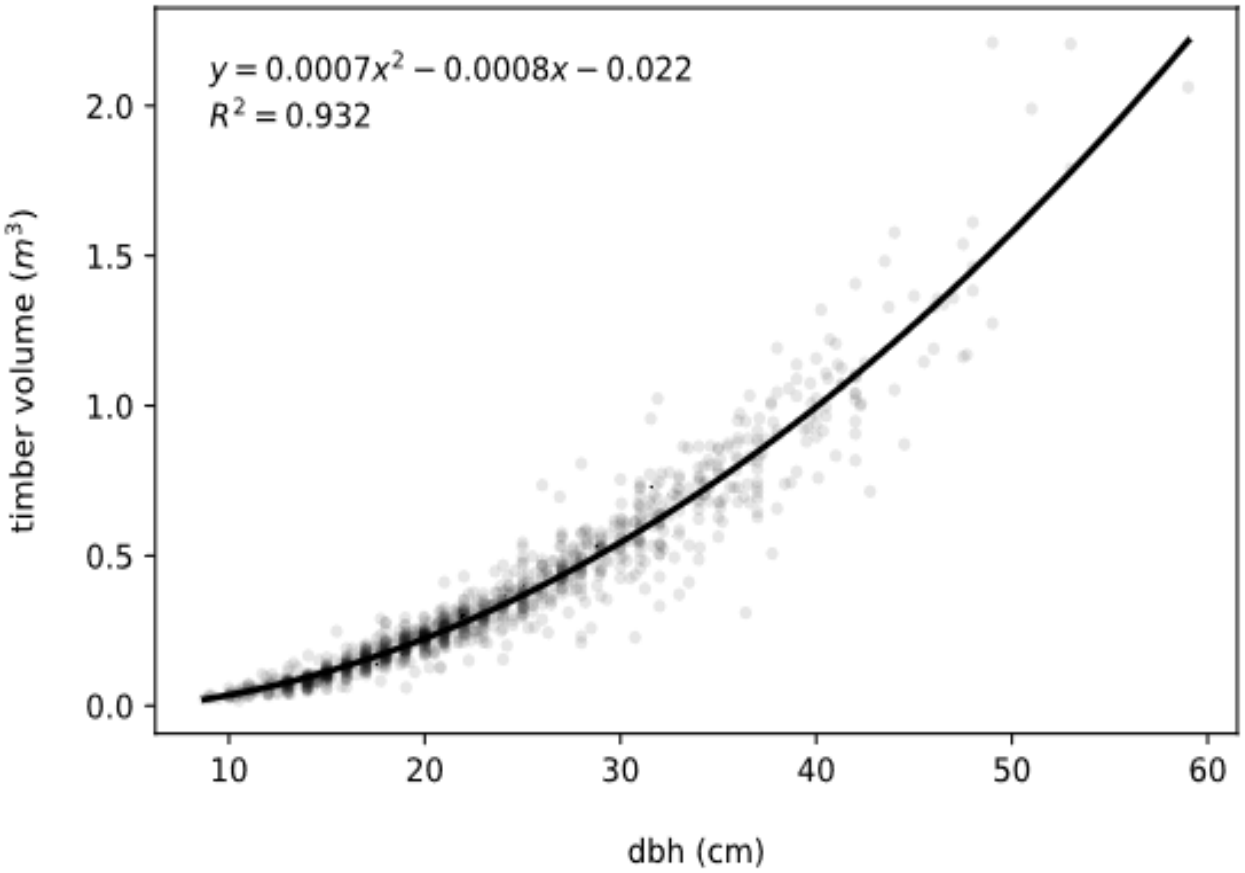
separately for:

1) timber processed by a harvester *(c_{sort})*
2) post-thinning residues *(c_{top})*

$$c_{sort} = \frac{dbh - dtl}{tll - 1{,}3} \qquad c_{top} = \frac{dtl}{utl}$$

dbh - diameter at breast height with no bark (cm),
dtl - diameter of top log (cm),
tll - total log length (m),
utl - unprocessed top length (m).

Results



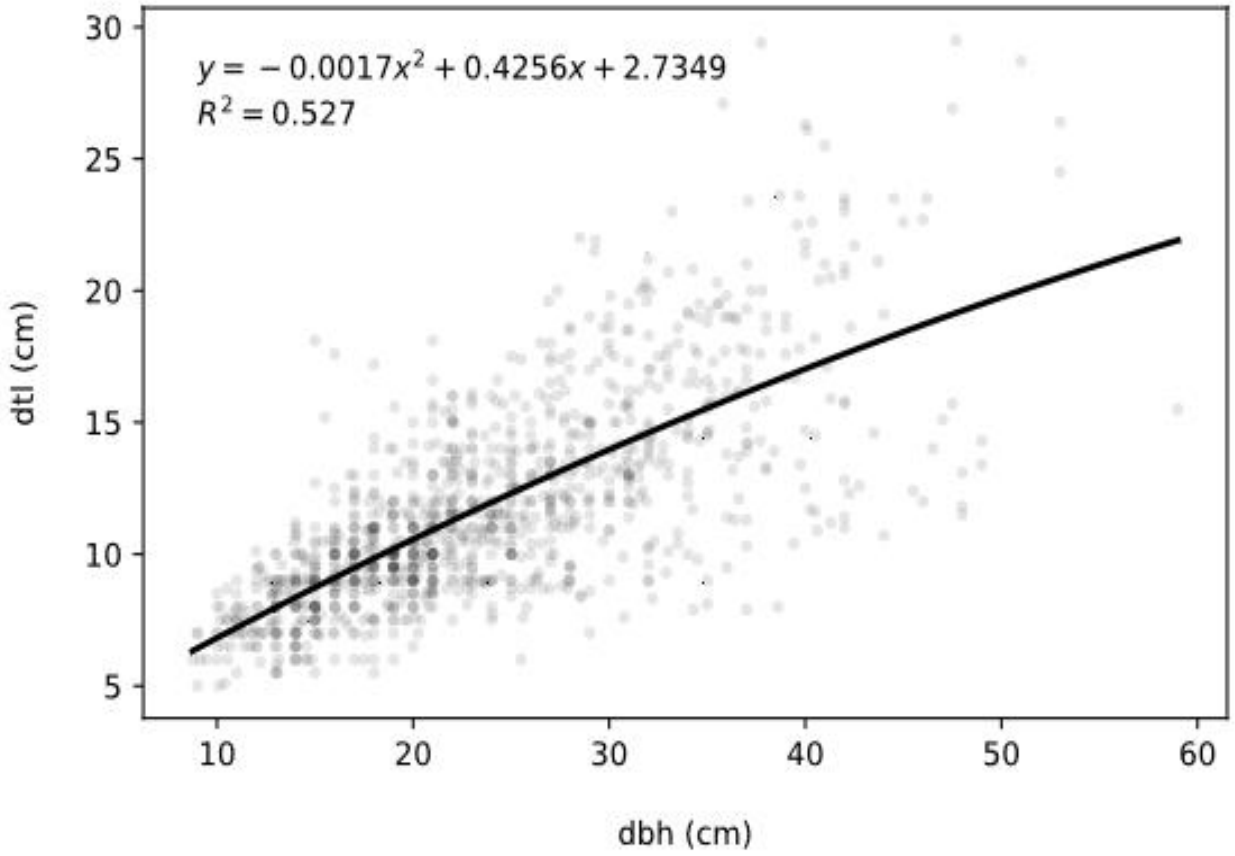
Spearman correlation coefficient
r=0.973, p<0.01

Results

Average values of the stands description and the effects of wood harvesting

sample	*stand age*	*dbh*	*tree height*	*crown height*	*dtl*	*crown utilisation (%)*	*unprocessed timber volume in total timber volume (%)*	*post-thinning residues volume (timber+biomass) in whole trunk (%)*
1	28	12,7	16,7	10,2	7,3	34,14	10,94	14,81
2	70	19,0	21,1	15,0	10,2	18,26	7,89	8,77
3	53	19,2	19,2	11,4	10,5	29,56	10,92	12,28
4	59	20,4	19,6	12,0	10,0	33,40	10,18	11,46
5	63	20,8	19,5	11,2	9,8	39,72	6,27	7,07
6	70	20,9	22,0	14,6	11,3	16,02	14,44	15,57
7	52	21,0	19,8	12,2	8,6	48,18	5,98	7,92
8	48	21,2	22,3	13,1	10,8	29,63	7,98	8,68
9	69	21,3	20,5	12,5	11,5	29,28	11,17	12,33
10	48	21,9	23,4	14,2	13,4	17,00	15,62	16,27
11	71	22,0	20,7	12,5	10,8	34,57	7,10	7,78
12	50	22,2	21,2	12,4	13,8	23,88	11,97	12,53
13	73	23,9	22,0	14,7	10,6	18,46	11,20	12,35
14	50	23,9	21,3	13,2	12,9	41,12	6,97	7,34
15	58	25,7	22,1	14,0	12,0	27,86	11,83	12,90
16	56	27,0	23,9	14,3	12,3	34,66	8,35	8,91
17	64	28,9	23,9	14,1	13,0	12,65	9,25	9,92
18	64	30,2	23,8	13,4	13,8	25,18	8,91	9,40
19	58	30,3	23,9	15,6	13,3	36,20	11,02	11,66
20	68	31,6	31,5	16,6	13,4	19,74	9,11	9,50
21	66	32,1	23,2	13,9	14,2	31,35	7,06	7,24
22	79	33,5	25,4	16,5	14,7	34,79	5,82	6,06
23	68	35,0	32,6	18,6	15,7	21,62	11,39	11,70
average	**60**	**24,6**	**22,6**	**13,7**	**11,9**	**28,58**	**9,62**	**10,54**
min	**28**	**12,7**	**16,7**	**10,2**	**7,3**	**12,65**	**5,82**	**6,06**
max	**79**	**35,0**	**32,6**	**18,6**	**15,7**	**48,18**	**15,62**	**16,27**
stdev	**11**	**5,6**	**3,6**	**1,9**	**2,1**	**9,08**	**2,61**	**2,85**

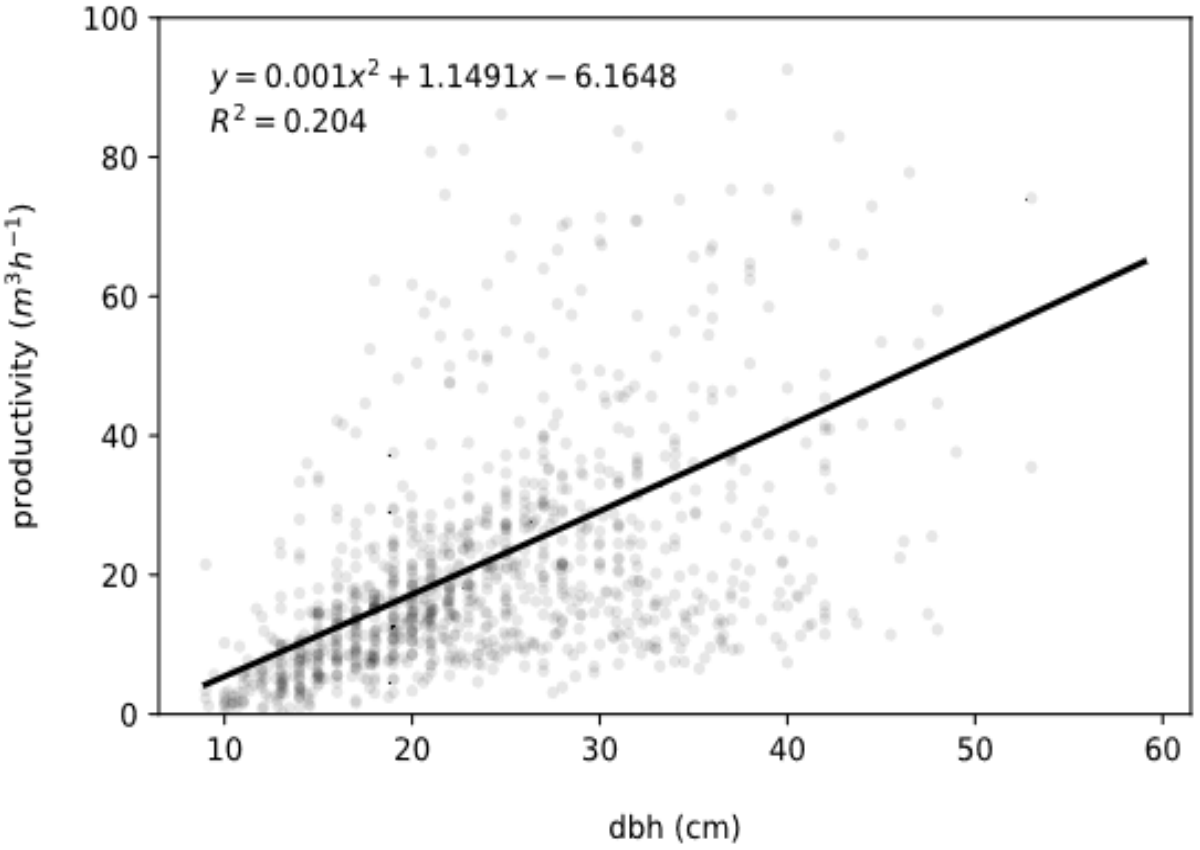
Results



Spearman correlation coefficient

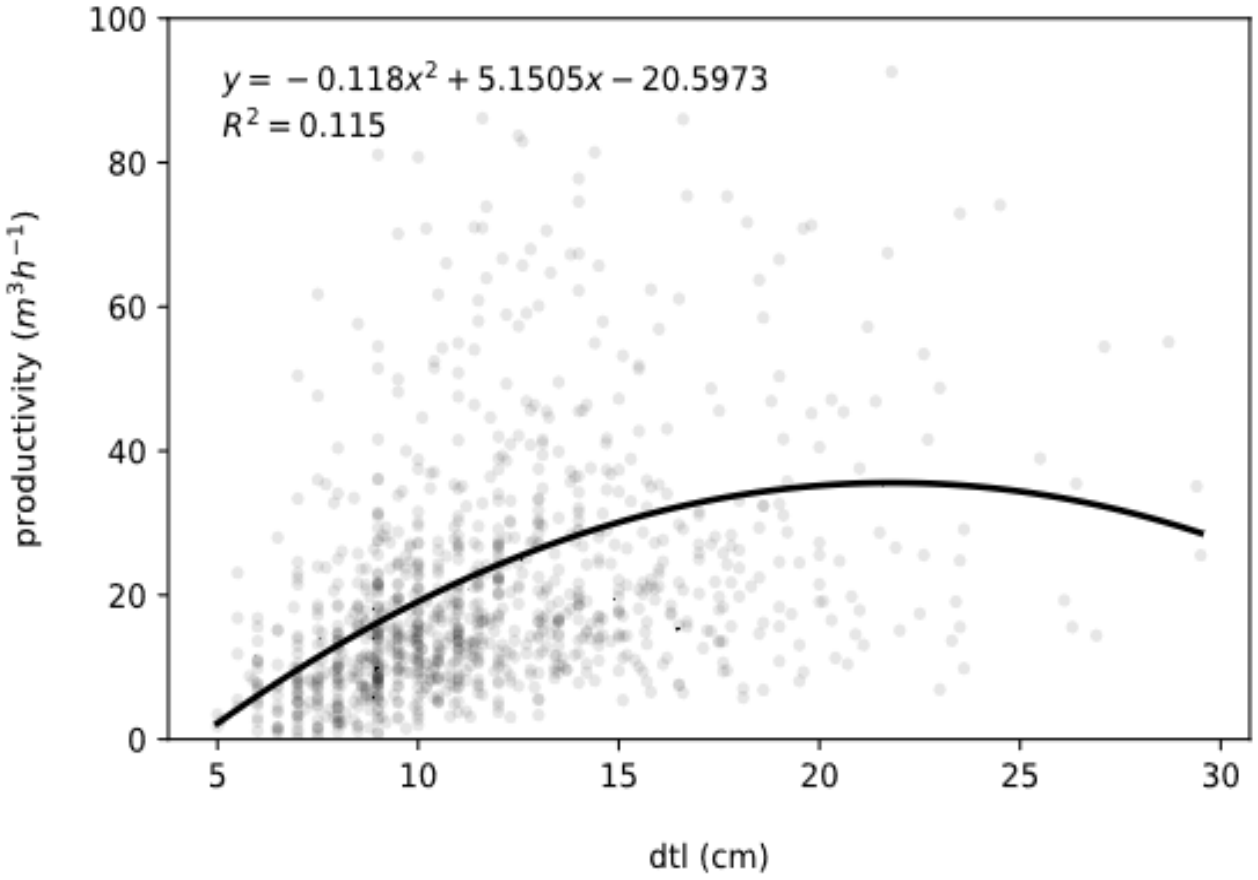
r=0.74, p<0.01

Results



Spearman correlation coefficient
r=0.587, p<0.01

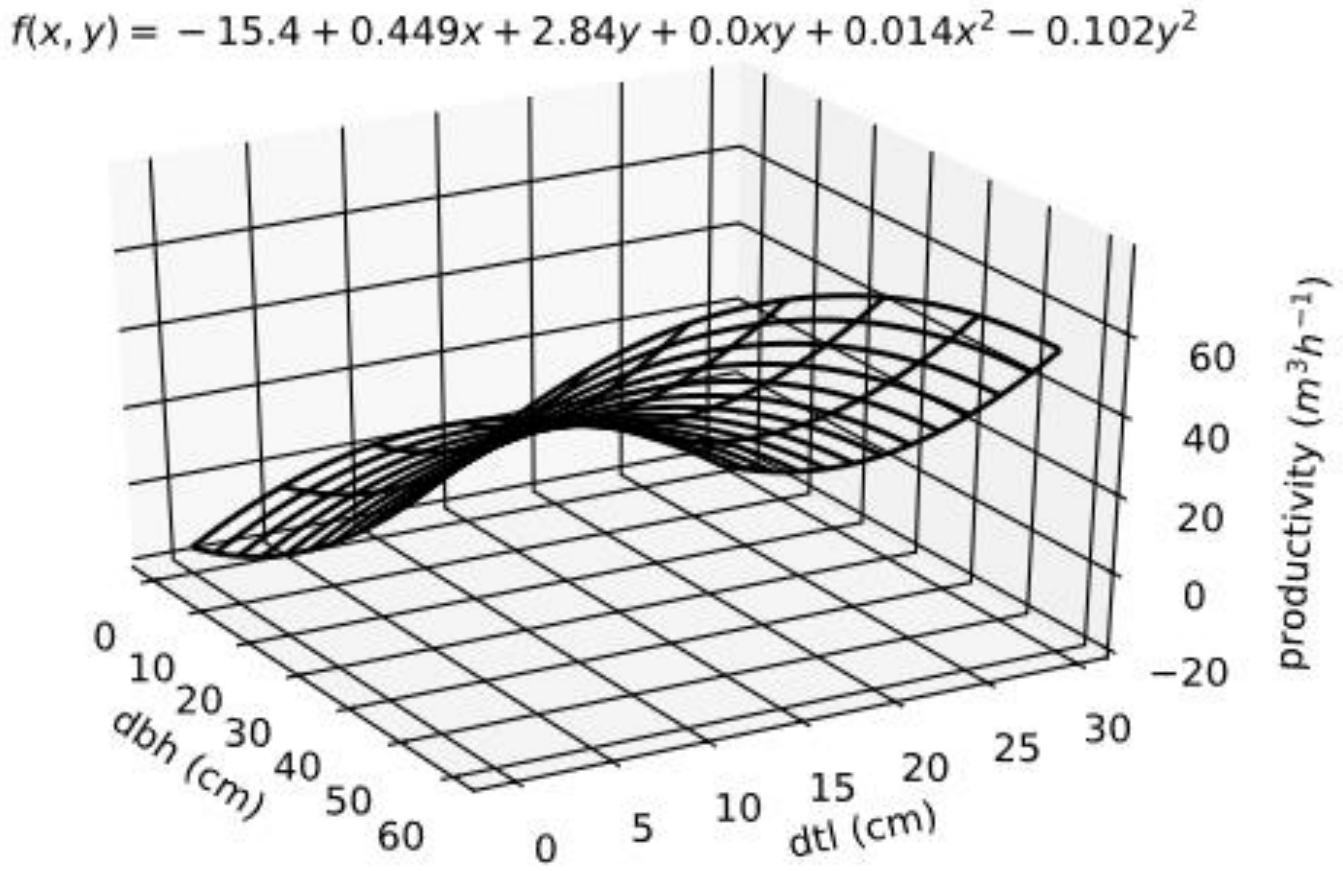
Results



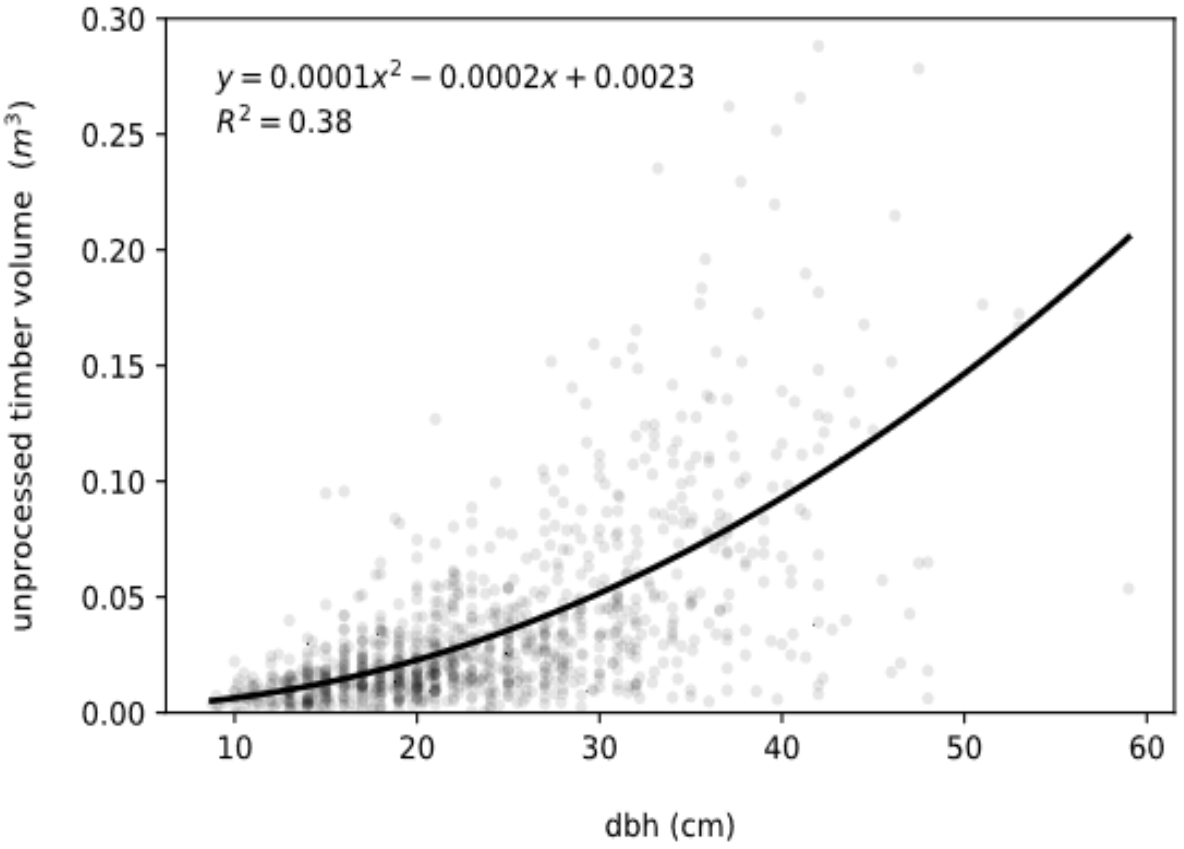
Spearman correlation coefficient
r=0.479, p<0.01

Results

Regresion surfaces

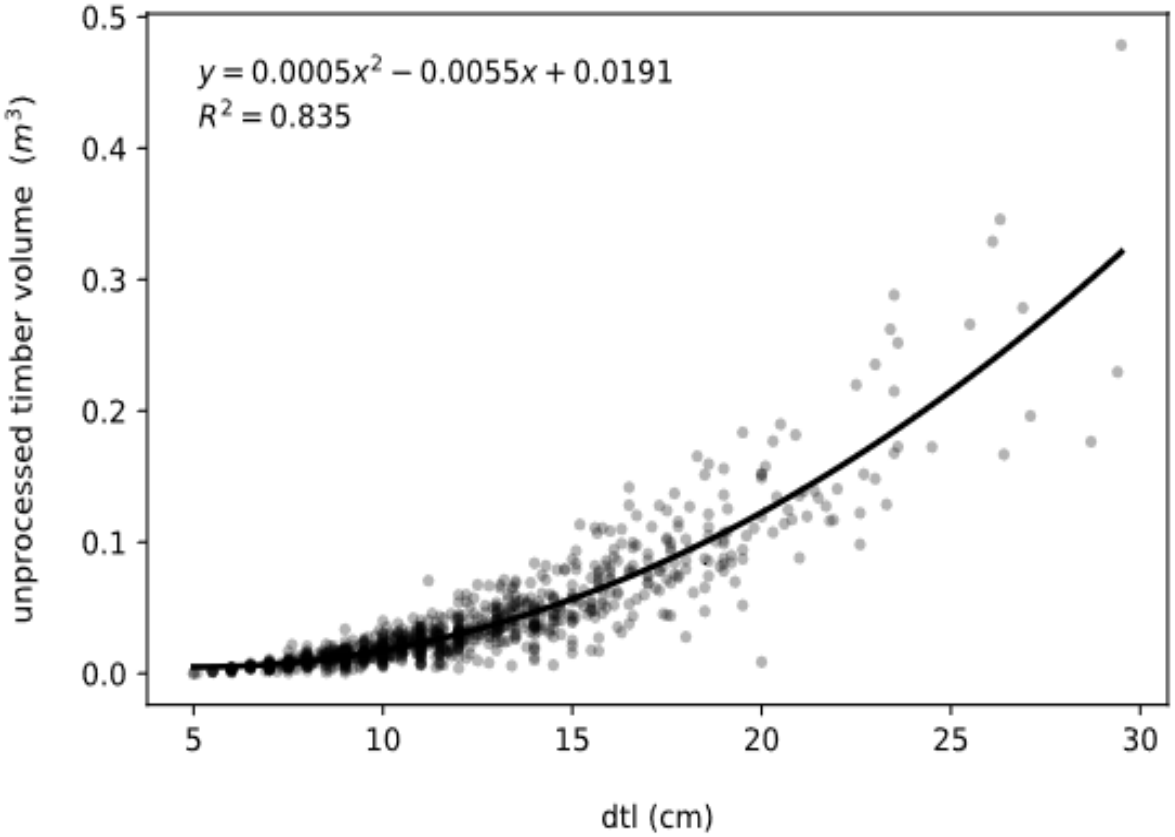


Results



Spearman correlation coefficient
r=0.635, p<0.01

Results



Spearman correlation coefficient
r=0.899, p<0.01

Summary

1) Average trunk utilisation for birch harvesting amounts to 90%.
   It means low timber losses and at the same time high possibility for harvester use in birch stands.

2) There is strong significant correlation between dbh and dtl.
   Both this factors affect productivity.

Thank you

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