

# Population variability of *Fagus sylvatica* leaves - a preliminary study

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# Beech provenances in the Choczewo experimental site

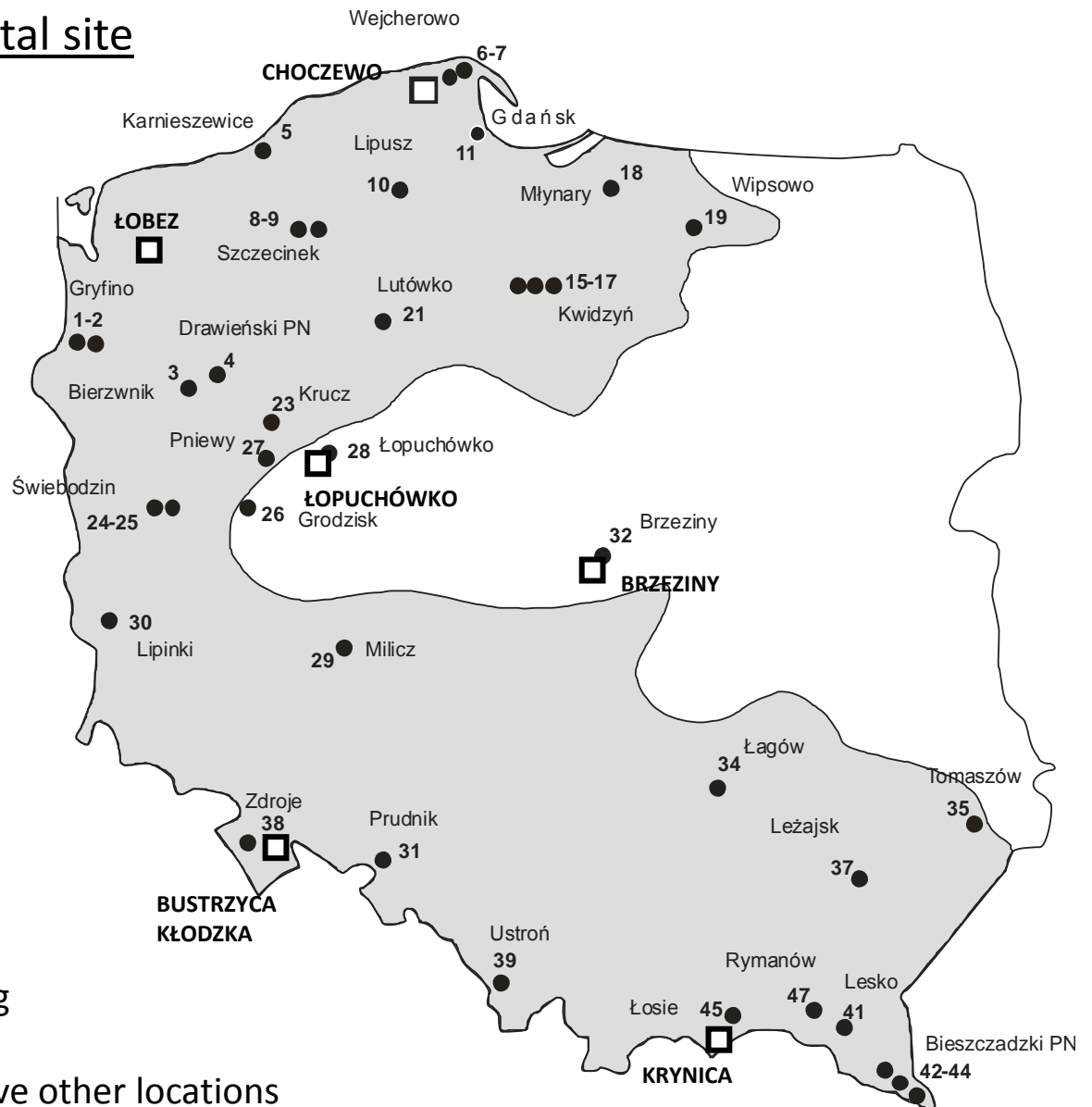
38 provenances of beech from its natural distribution range in Poland

The experiment site was established in April 1996 with three-year-old seedlings

Each provenance is represented by 100 or 50 trees (1.5×1.3 m spacings) in plots in 1 to 6 replications

This site is a part of a project testing diversity of beech in Poland.

Similar trials were planted also in five other locations (Łobez, Łopuchówko, Brzeziny, Bystrzyca Kłodzka, and Krynica)

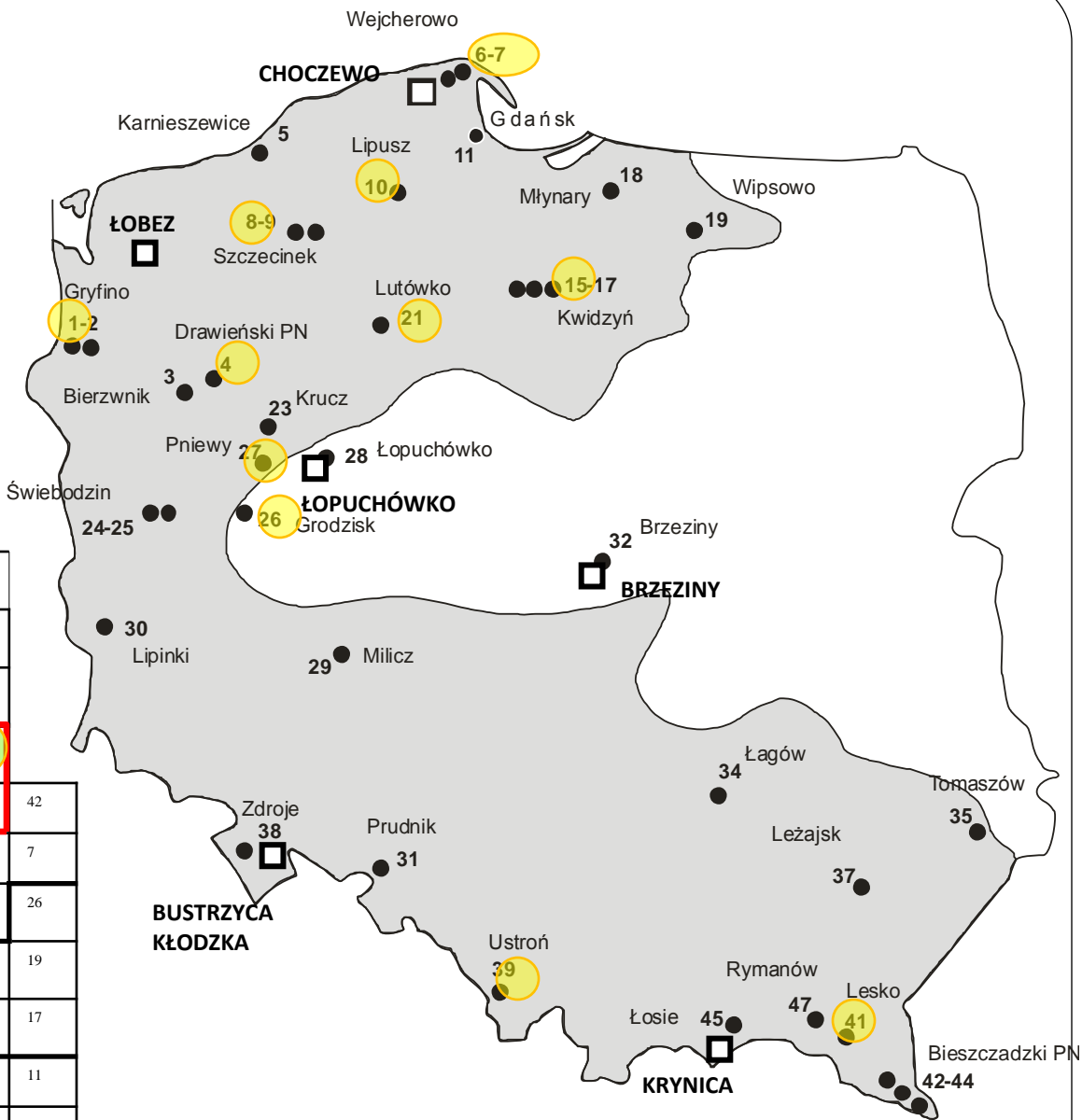


The experiment was established to investigate:

- genetic variability of common beech
- resistance of the particular populations to negative environmental factors (frost, ground frosts, drought, high temperature)
- interaction genotype  $\times$  environment
- productivity
- to create the gene bank

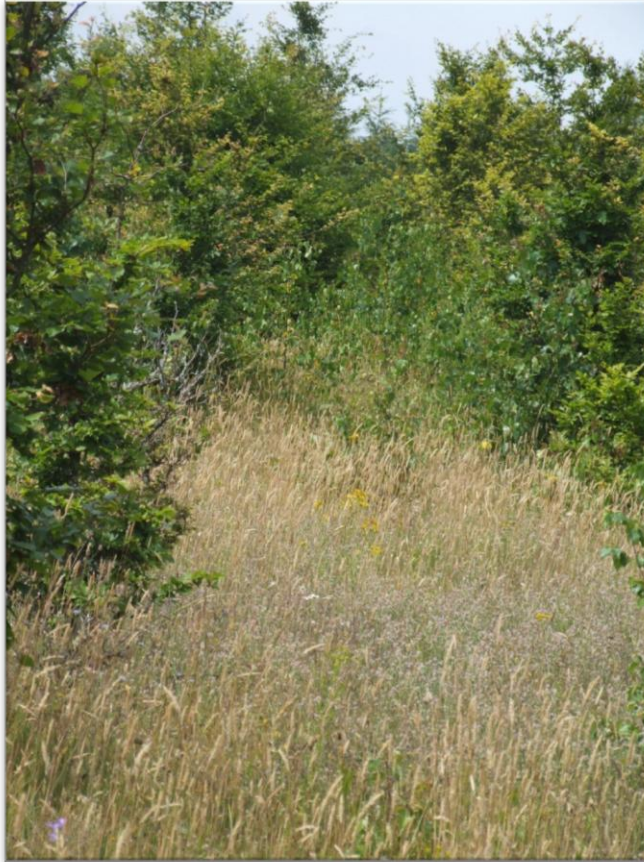


# 12 provenances for the study of variability of leaf morphology



8	11	3	29	9	17	35	19	10	39	
7	31	4	6	7	16	41	38	47	24	
18	2	25	28	37	44	43	26	1	42	
32	34	45	21	15	30/18	5	30	19	39	
10	41	31	26	32	43	18	4	23	24	42
38	37	11	30	21	15	1	17	34	25	7
3	28	2	5	6	9	27	8	47/44	16	26
15/7	4	41	5	34	8	18	32	23	27	19
28	39	38	26/21	47	10	30	6	11	31	17
2	25	42	3	1	9	34	42	18	6	11
26	41/31	8	32	47	25	9	5	3	23	39
1	10	17/27	30	2	9	8	26	10	2	11
5	6	1	18	25	30	3	34	32/39	42	23

Differences between block 1 and block 2



Morphological parameters of leaves  
were analysed using Winfolia:

Perimeter

Area

Total holes area

Leaf length

Blade length

Blade width (maximum, in 50% and 90% of length)

Mass of 10 leaves

SLA [ $\text{cm}^2/\text{g}$ ]



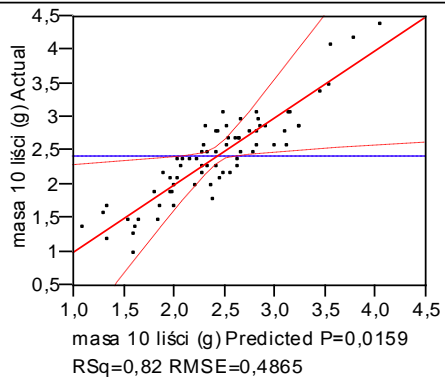


# Response mass of 10 leaves

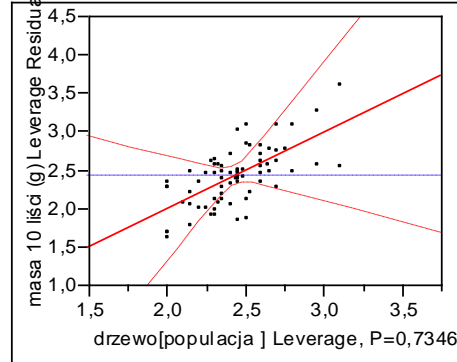
## Whole Model

## drzewo[populacja ]

### Actual by Predicted Plot



### Leverage Plot



### Summary of Fit

RSquare	0,817101
RSquare Adj	0,458924
Root Mean Square Error	0,486545
Mean of Response	2,434722
Observations (or Sum Wgts)	72

### Analysis of Variance

Source	DF	Sum of Square	Mean Square	F Ratio	Prob > F
Model	47	25,381766	0,540038	2,2813	
Error	24	5,681429	0,236729		
C. Total	71	31,063194			0,0159

### Lack Of Fit

Source	DF	Sum of Square	Mean Square	F Ratio	Prob > F
Lack Of Fit	23	5,5564286	0,241584	1,9327	
Pure Error	1	0,1250000	0,125000		
Total Error	24	5,6814286		0,5208	

Max RSQ  
0,9960

### Effect Tests

Source	Nparm	DF	Sum of Square	F Ratio	Prob > F
Tree [population]	24	24	4,385238	0,7719	0,7346
Block	1	1	0,005606	0,0237	0,8790
Population	11	11	13,094248	5,0285	0,0005
Population x block	11	11	7,477015	2,8714	0,0149

### LSMeans Differences Tukey HSD

Alpha=0,050 Q=3,60563

Level	Least Sq Mean
7 A	3,1333333
15 A	3,1333333
4 A B	2,6833333
6 A B	2,6833333
8 A B	2,5833333
10 A B	2,5761905
21 A B	2,3333333
26 A B	2,2333333
41 B	2,0333333
1 B	2,0333333
27 B	1,9833333
39 B	1,7500000

Levels not connected by same letter are significantly different

## Response Perimeter

### Whole Model

#### Summary of Fit

RSquare	0,392045
RSquare Adj	0,34822
Root Mean Square Error	2,297212
Mean of Response	19,86891
Observations (or Sum Wgts)	700

#### Analysis of Variance

Source	DF	Sum of Square	Mean Square	F Ratio
Model	47	2218,7811	47,2081	8,9457
Error	652	3440,7246	5,2772	Prob > F
C. Total	699	5659,5057		<.0001

#### Lack Of Fit

Source	DF	Sum of Square	Mean Square	F Ratio
Lack Of Fit	22	707,0715	32,1396	7,4069
Pure Error	630	2733,6531	4,3391	Prob > F
Total Error	652	3440,7246		<.0001
			Max RSq	0,5170

#### Effect Tests

Source	Nparm	DF	Sum of Square	F Ratio	Prob > F
Block	1	1	7,9997	1,5159	0,2187
Tree [population]	24	24	365,2190	2,8836	<.0001
Population	11	11	1015,2992	17,4904	<.0001
Population x block	11	11	743,8378	12,8140	<.0001

### Blok

#### Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
1	19,964965	0,12601753	19,9473
2	19,745543	0,12601753	19,7905

### Popul

### Popul\*Blok

#### LSMeans Differences Tukey HSD

Alpha=0,050 Q= 3,28

Level		Least Sq Mean
7	A	21,678022
6	A	21,081770
10	A B	20,877100
15	A B	20,752503
4	A B C	20,552096
8	A B C	20,447772
1	B C D	19,379006
21	C D	19,370258
41	C D	19,138223
27	D	19,013683
26	D	18,685078
39	E	17,287538

Levels not connected by same letter are significantly different

## Response Area

### Whole Model

#### Summary of Fit

RSquare	0,506156
RSquare Adj	0,470556
Root Mean Square Error	4,899515
Mean of Response	24,26817
Observations (or Sum Wgts)	700

#### Analysis of Variance

Source	DF	Sum of Square	Mean Square	F Ratio
Model	47	16041,594	341,311	14,2182
Error	652	15651,421	24,005	Prob > F
C. Total	699	31693,014		<.0001

#### Lack Of Fit

Source	DF	Sum of Square	Mean Square	F Ratio
Lack Of Fit	22	3500,861	159,130	8,2508
Pure Error	630	12150,559	19,287	Prob > F
Total Error	652	15651,421		<.0001

Max RSq  
0,6166

#### Effect Tests

Source	Nparm	DF	Sum of Square	F Ratio	Prob > F
Block	1	1	2,2657	0,0944	0,7588
Tree [population]	24	24	2195,5204	3,8108	<.0001
Population	11	11	7373,2684	27,9229	<.0001
Population x block	11	11	5529,4453	20,9403	<.0001

### Blok

#### Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
1	24,211232	0,26877130	24,1178
2	24,328006	0,26877130	24,4185

### Popul

#### LSMeans Differences Tukey HSD

Alpha=0,050 Q= 3,28

Level		Least Sq Mean
7	A	29,679330
6	A B	27,768410
15	A B C	26,788745
10	B C	26,483043
4	B C	26,163196
8	B C D	25,016915
21	C D E	24,298873
1	D E	22,448657
41	E	21,944640
26	E	21,663980
27	E	21,372357
39	F	17,607280

Levels not connected by same letter are significantly c

## Response BladeLength

### Whole Model

#### Summary of Fit

RSquare	0,462218
RSquare Adj	0,423451
Root Mean Square Error	0,621688
Mean of Response	6,93801
Observations (or Sum Wgts)	700

#### Analysis of Variance

Source	DF	Sum of Square	Mean Square	F Ratio
Model	47	216,58739	4,60824	11,9231
Error	652	251,99574	0,38650	Prob > F
C. Total	699	468,58313		<.0001

#### Lack Of Fit

Source	DF	Sum of Square	Mean Square	F Ratio
Lack Of Fit	22	65,44910	2,97496	10,0469
Pure Error	630	186,54665	0,29611	Prob > F
Total Error	652	251,99574		<.0001
				Max RSq
				0,6019

#### Effect Tests

Source	Nparm	DF	Sum of Square	F Ratio	Prob > F
Block	1	1	2,824512	7,3080	0,0070
Tree [population]	24	24	46,822947	5,0478	<.0001
Population	11	11	80,316506	18,8915	<.0001
Population x block	11	11	79,380450	18,6713	<.0001

### Blok

#### Least Squares Means Table

Level	Least Sq Mean	Std Error	Mean
1	6,9951857	0,03410379	6,99810
2	6,8648040	0,03410379	6,87792

### Popul

#### LSMeans Differences Tukey HSD

Alpha=0,050 Q= 3,28

Level		Least Sq Mean
7	A	7,4774400
6	A	7,3469933
15	A B	7,2049017
4	A B C	7,1570342
10	A B C	7,1084067
8	B C D	6,9520083
41	B C D	6,9510233
21	C D E	6,8023867
1	C D E	6,7258358
27	D E F	6,6603017
26	E F	6,4745933
39	F	6,2990133

Levels not connected by same letter are significantly different

## Response LSA

### Whole Model

#### Summary of Fit

RSquare	0,675544
RSquare Adj	-0,01761
Root Mean Square Error	16,70258
Mean of Response	101,3328
Observations (or Sum Wgts)	70

#### Analysis of Variance

Source	DF	Sum of Square	Mean Square	F Ratio
Model	47	12778,722	271,888	0,9746
Error	22	6137,479	278,976	Prob > F
C. Total	69	18916,200		0,5455

#### Lack Of Fit

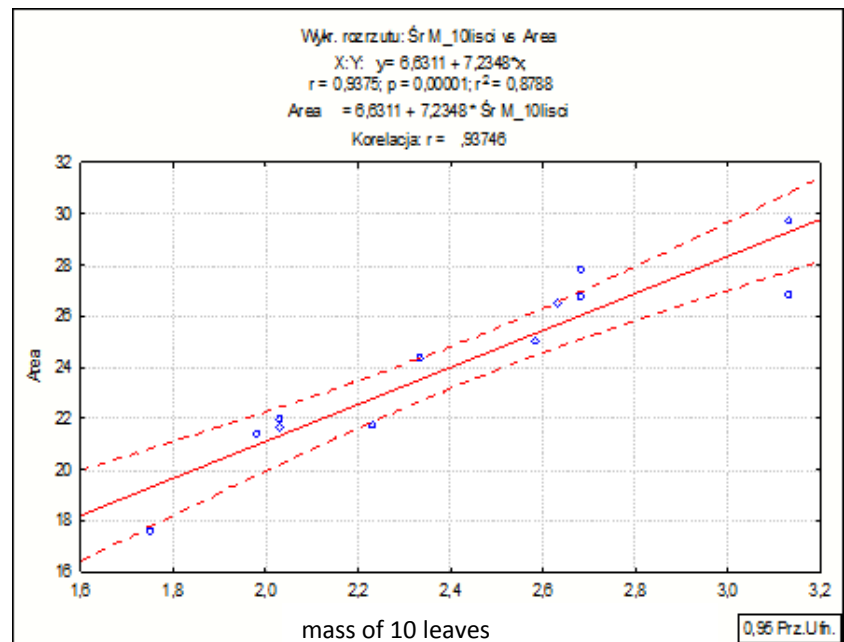
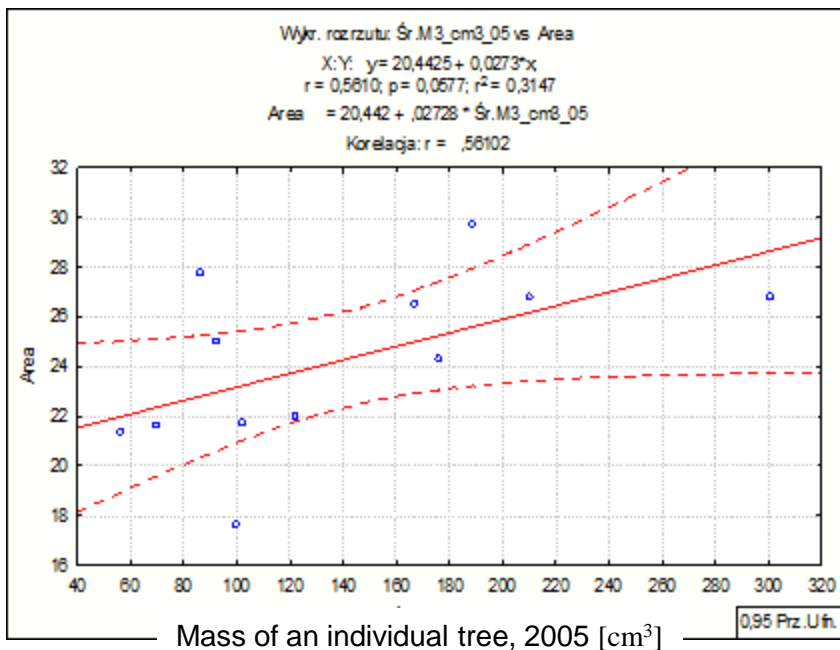
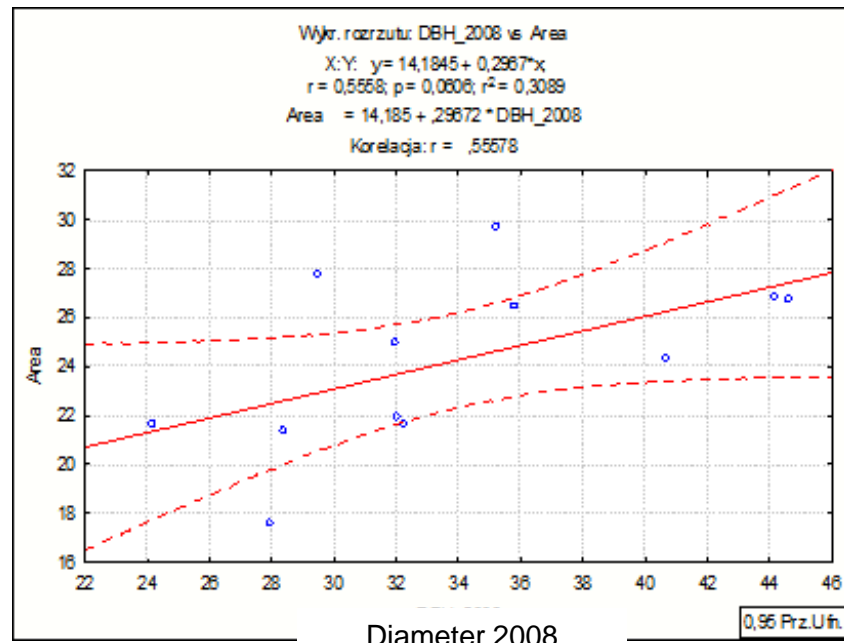
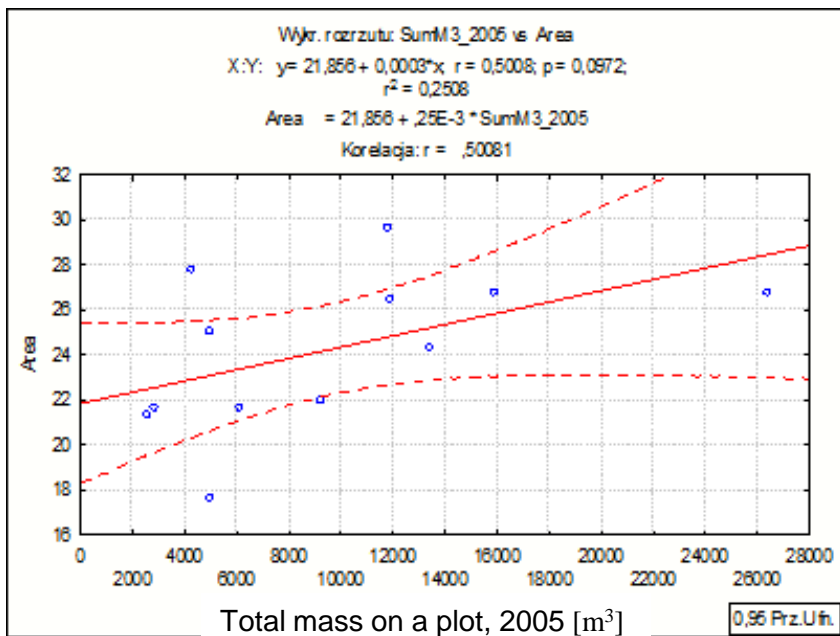
Source	DF	Sum of Square	Mean Square	F Ratio
Lack Of Fit	21	6079,1684	289,484	4,9645
Pure Error	1	58,3104	58,310	Prob > F
Total Error	22	6137,4788		0,3418

Max RSq  
0,9969

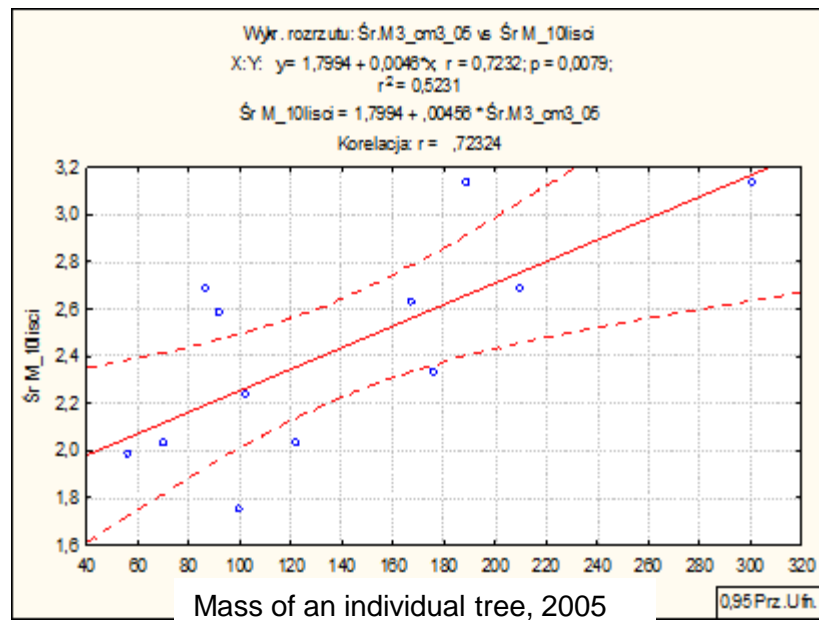
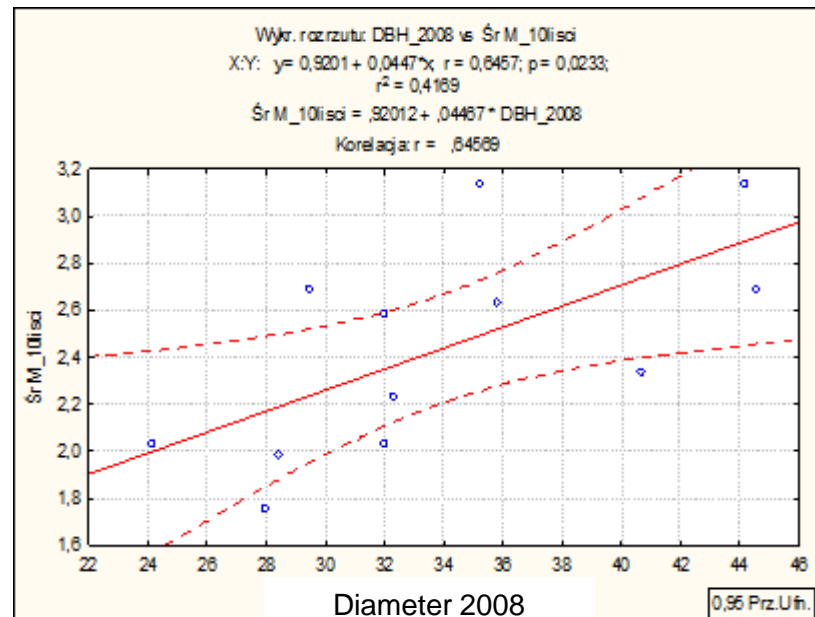
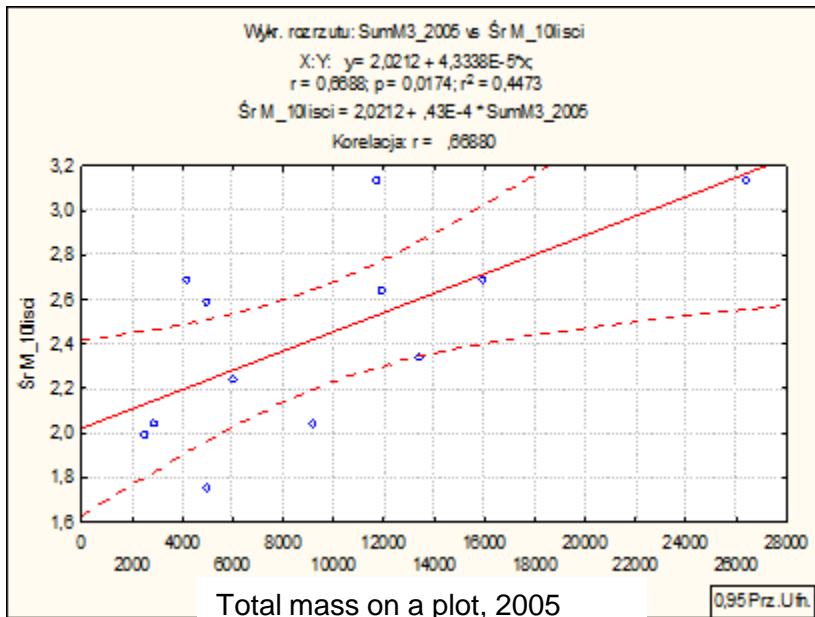
#### Effect Tests

Source	Nparm	DF	Sum of Square	F Ratio	Prob > F
Block	24	24	7766,8466	1,1600	0,3650
Tree [population]	11	11	3437,6784	1,1202	0,3921
Population	11	11	2068,2919	0,6740	0,7477
Population x block	1	1	32,2676	0,1157	0,7370

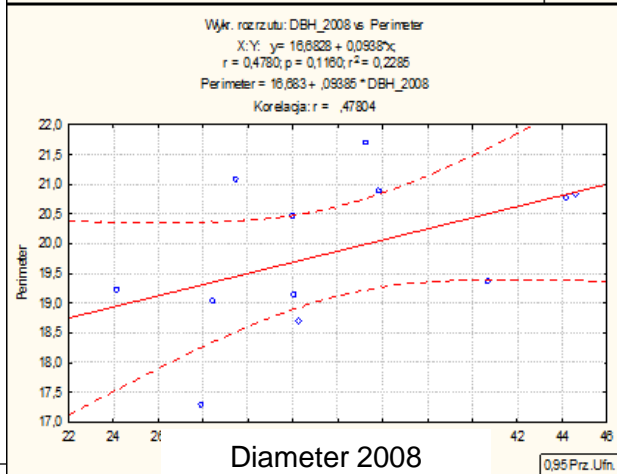
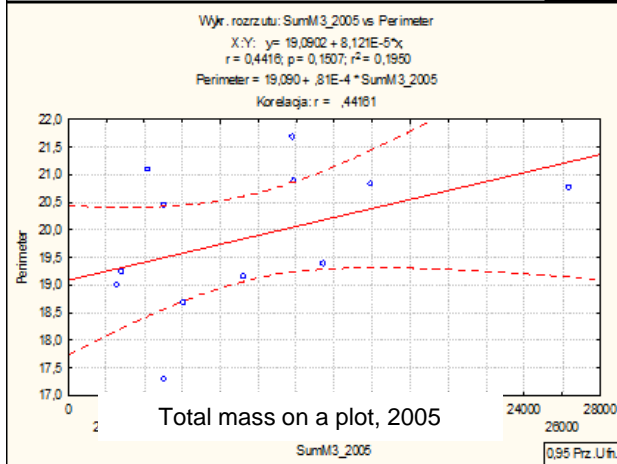
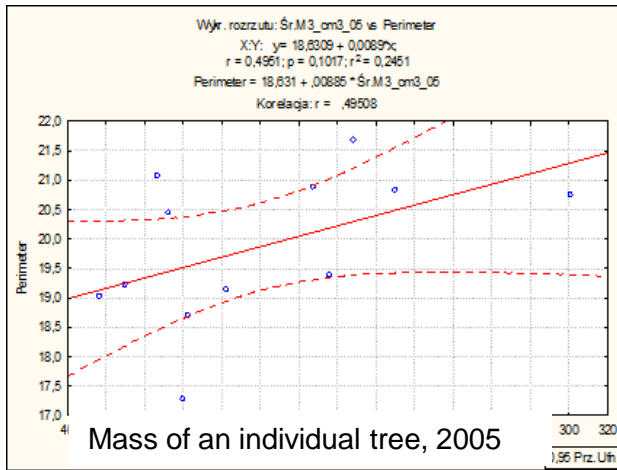
Area



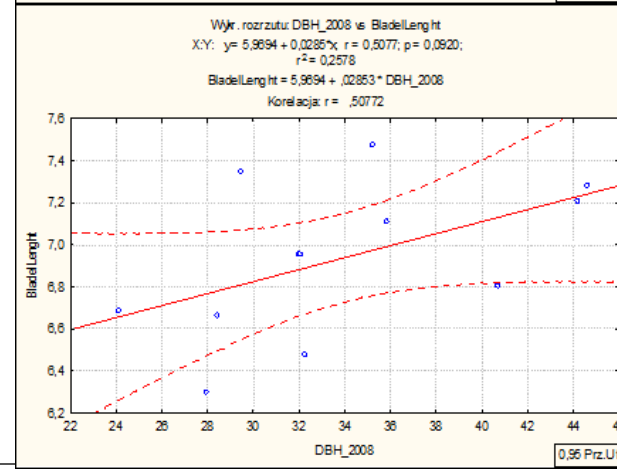
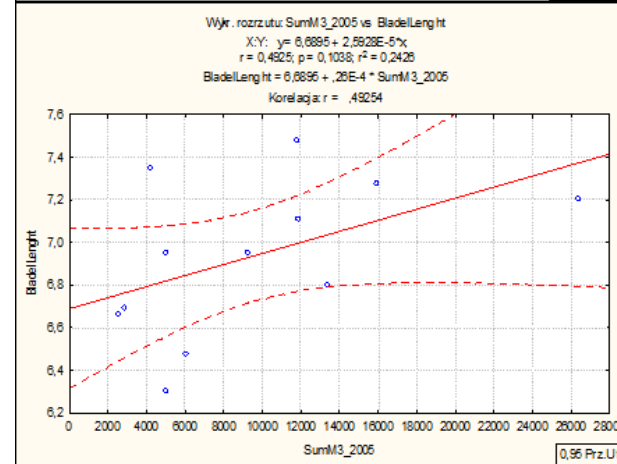
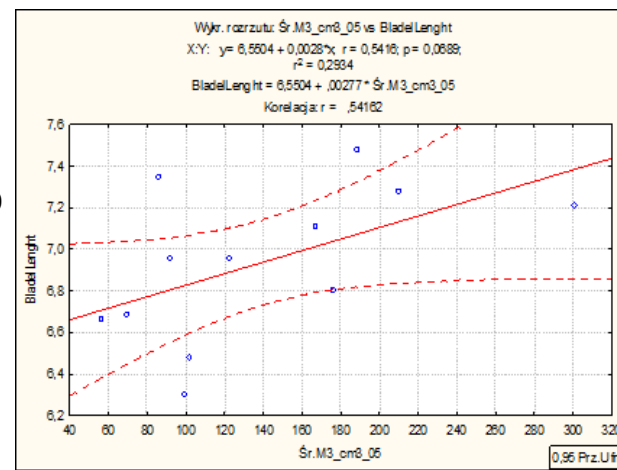
mass of 10 leaves



# Perimeter

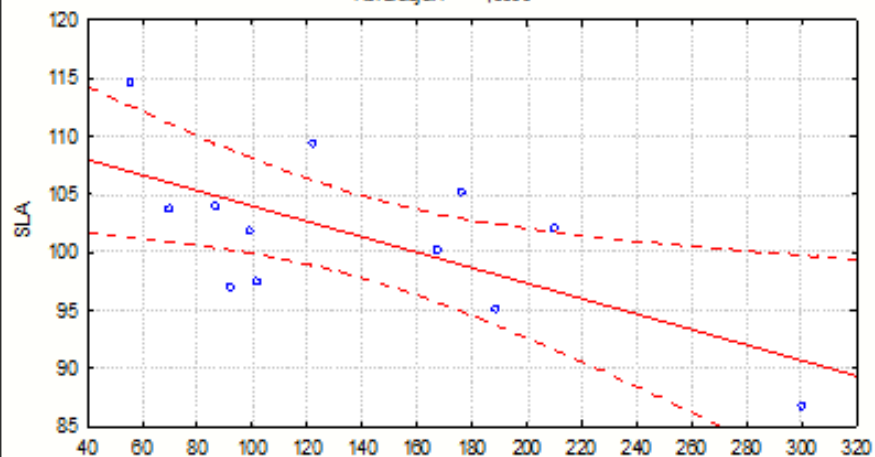


# Blade length





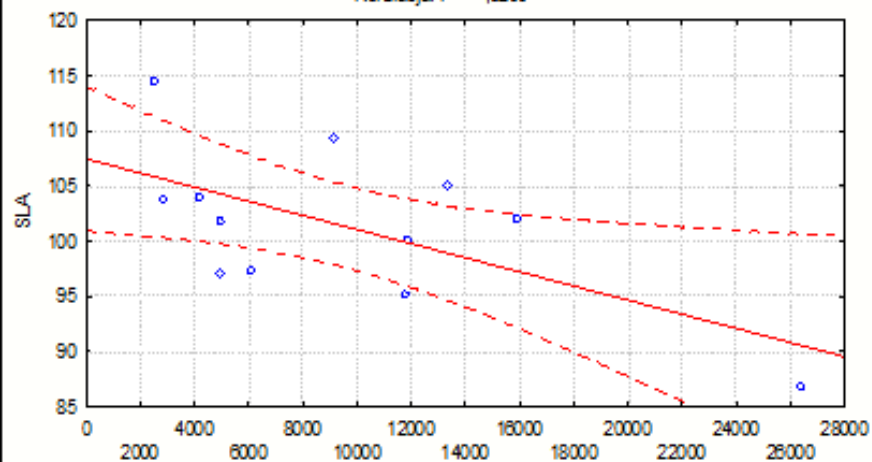
Wjtr. rozrzutu: Śr.M3\_cm3\_05 vs SLA  
 X:Y:  $y = 110,8482 - 0,0665x$   
 $r = -0,6690$ ;  $p = 0,0174$ ;  $r^2 = 0,4475$   
 $SLA = 110,85 - ,0665 * \text{Śr.M3\_cm3\_05}$   
 Korelacja:  $r = -,6690$



Mass of an individual tree, 2005

0,95 Prz.Uf.

Wjtr. rozrzutu: SumM3\_2005 vs SLA  
 X:Y:  $y = 107,4726 - 0,0006x$   
 $r = -0,6250$ ;  $p = 0,0298$ ;  $r^2 = 0,3908$   
 $SLA = 107,47 - ,06E-3 * \text{SumM3\_2005}$   
 Korelacja:  $r = -,6250$



Total mass on a plot, 2005

0,95 Prz.Uf.

our hypothesis:

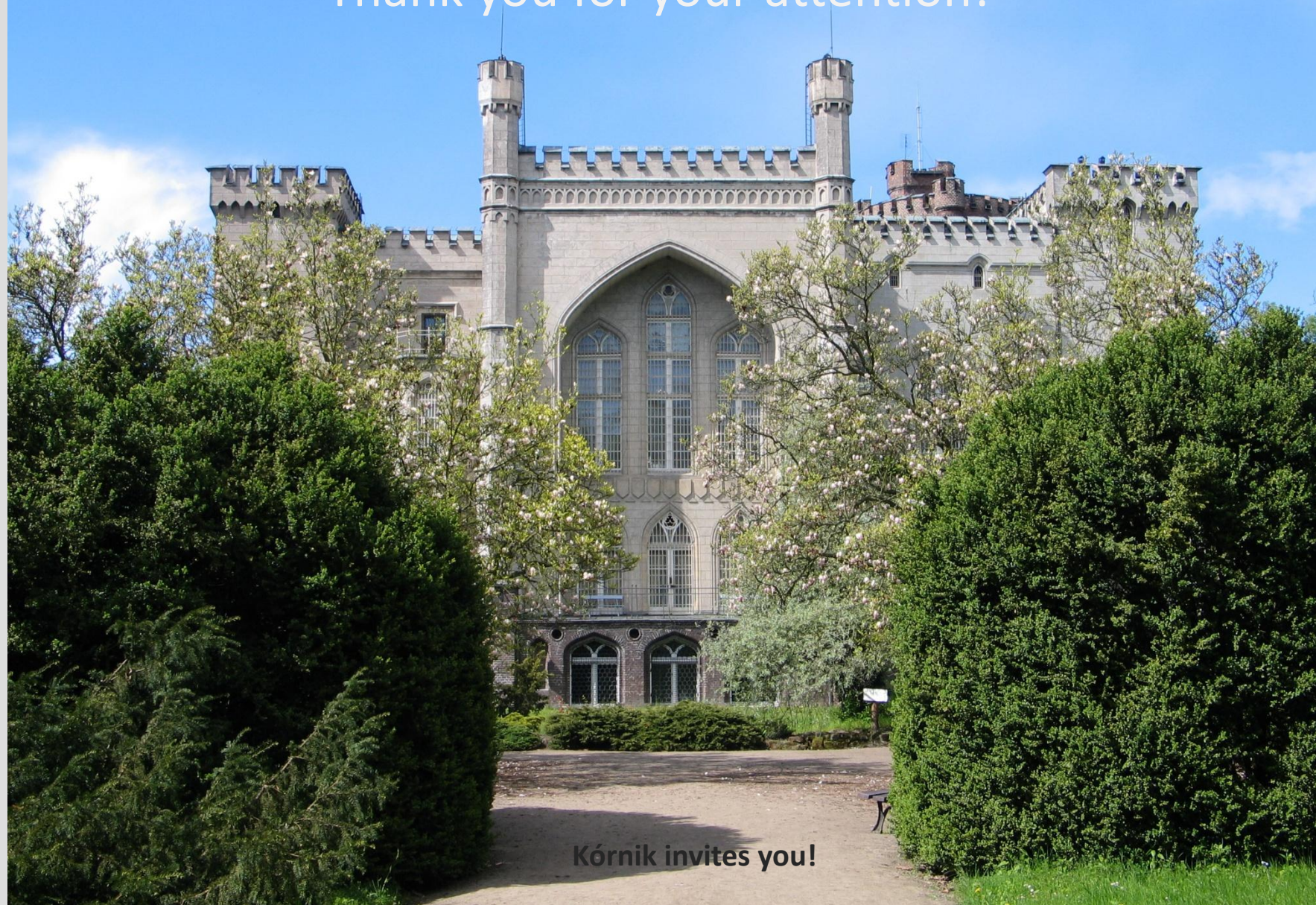
Morphological parameters of leaves can be an indicator of productivity



# Acknowledgement

- Prof. Władysław Chałupka
- Prof. Jacek Oleksyn
  
- Miss Henryka Przybył
  
- This research was financially supported by the Institute Dendrology
- and the Polish State Forests

Thank you for your attention!



**Kórník invites you!**