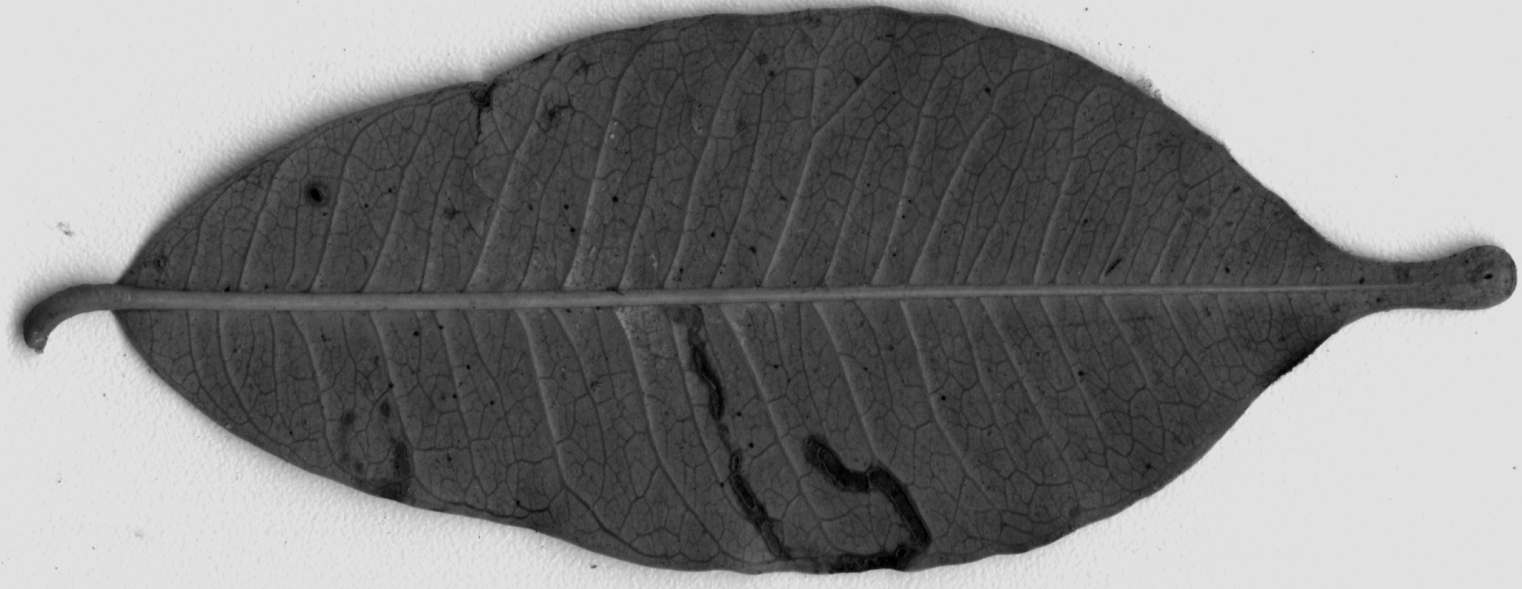
Preliminary Morphometric Analysis of Some Leaves from Barro Colorado Island

TAG	SP	GX	GY	DBH	HA	genus	species	family	grform
192506	LAFOPU	286.6	306	137	33	Lafoensia	punicifolia	Lythraceae	T



Walton A. Green
wagreen@bricol.net
CTPA

Tupper Seminar
Tuesday, January 15, 2008
STRI

interesting correlations between structural characters and climate. Particularly significant in the consideration of certain problems of geology and climatology is the climatic distribution of two types of leaves and leaflets. Those with entire margins predominate in tropical, arctic and alpine regions, moors, steppes, deserts, saline situations, and other physiologically dry environments. (In this connection it should be noted that the leaves of tropical rainforests and other tropical plant communities that live in moist environments, although often of relatively large size, are semi-xerophilous in structure.) Leaves and leaflets with non-entire margins, on the other hand, are comparatively infrequent in such situations, and are very numerous in moist temperate regions having cold winters and warm summers.

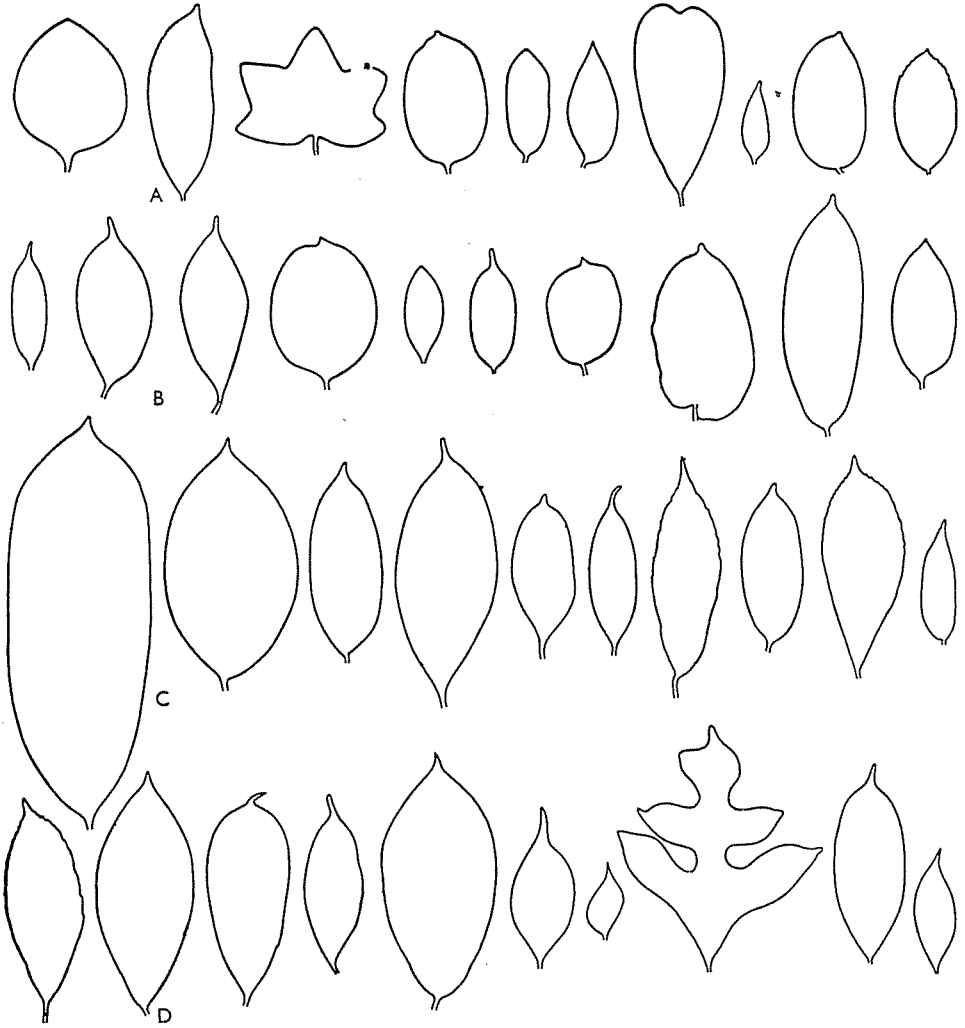
In the following table are given for a number of extensive regions in the frigid, temperate and tropical zones the percentage of entire-leaved woody plants in the Dicotyledonous flora.[1]

	Per Cent. Entire
Frigid	
Ellesmereland	100
New Zealand Alps	77
North East Siberia	65
Cold Temperate	
North East Germany	24
Central Russia	28
East Central North America	28
North Russia	30
England	32
Kamtschatka	33
Rocky Mountains	36
South East Siberia	37
West Siberia	44
France	44
Warm Temperature	
South Russia	39
East Central China	48
South East United States	49
Italy	50
Los Angeles Region	54
Spain	56
Sub-tropical and Tropical	
Hongkong	71
South West Asia	72
Bombay	72
Upper Nile Region	74
Southern Africa	74
Nicaragua	76
West Indies	76
Egypt	77
South East Central Africa	78
Brazil	79
Ceylon	80
Manila	81
West Central Africa	81
Queensland	82
New South Wales	82
West Australia	83
Florida	83
South West Central Africa	83
Mauritius-Seychelles	85
Malay States	86

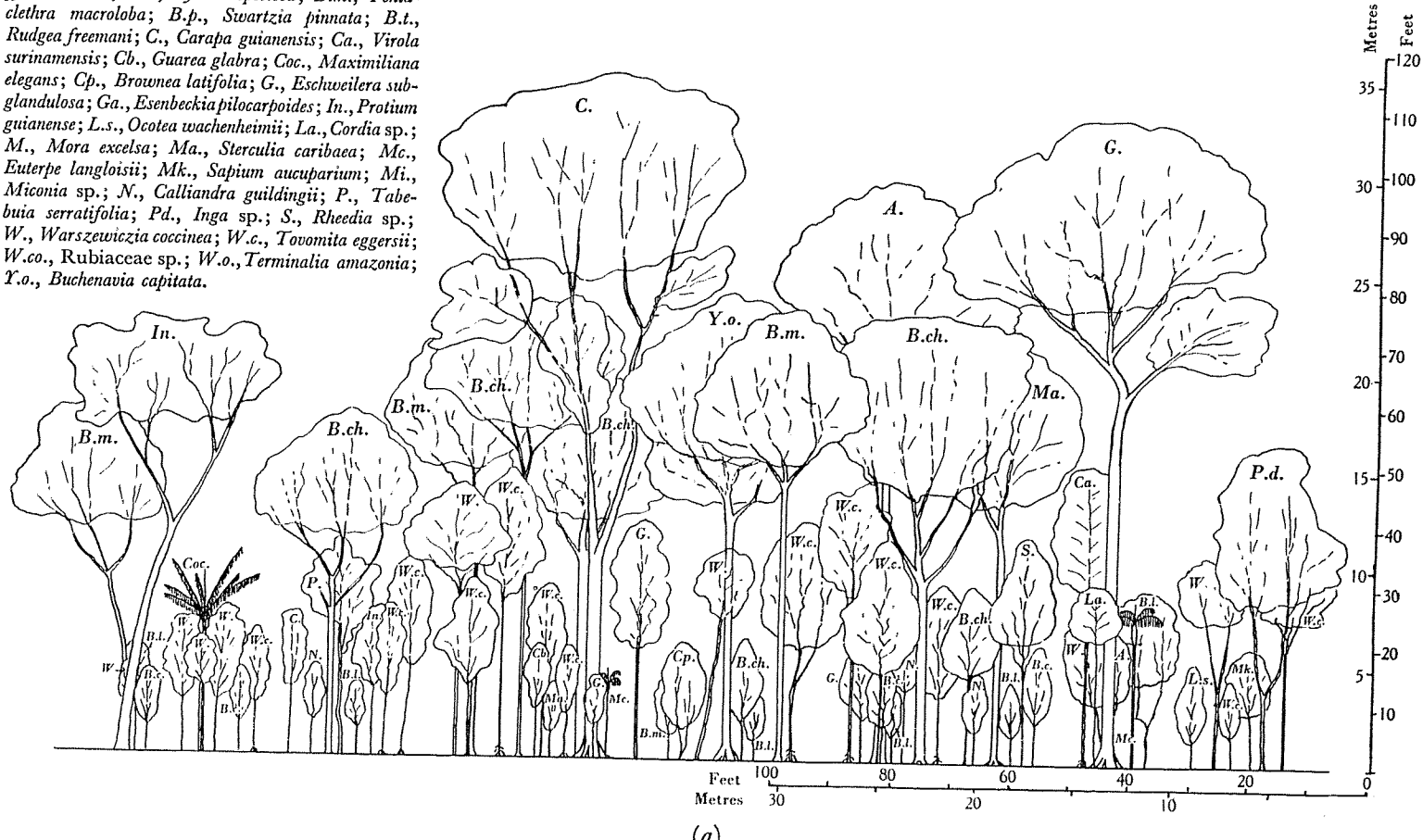
[1] In the computation of the percentages given in this table woody Dicotyledons alone were used since herbaceous forms are of very infrequent occurrence in the fossil floras of the Cretaceous and early Tertiary.

In the temperate regions given above there are more or less extensive areas of physiologically dry environments which are reflected in the floras by plants with relatively small entire leaves. In the tropical regions, on the other hand, there are cool uplands and shady comparatively temperate habitats which possess many plants with non-entire leaves and leaflets. The effect of these cool uplands upon the character of the foliage is well illustrated by comparing the percentage of entire-leaved Dicotyledons in the mountainous Simla region (58 per cent.) with that of the adjacent Upper Gangetic Plain (71 per cent.), and also by contrasting lowland (76 per cent.) and upland (56 per cent.) Hawaii.

In view of these facts it seems desirable to give an analysis of two floras that are more nearly homogeneous phytogeographically. The first flora, cold-temperate mesophytic, was constructed by eliminating from the flora of east central North America (east of the 95th meridian and between the 40th and 50th parallels of latitude) all plants growing on physiologically dry environments. The second flora, tropical, was formed from the woody plants of the moist lowlands of the Amazon valley.

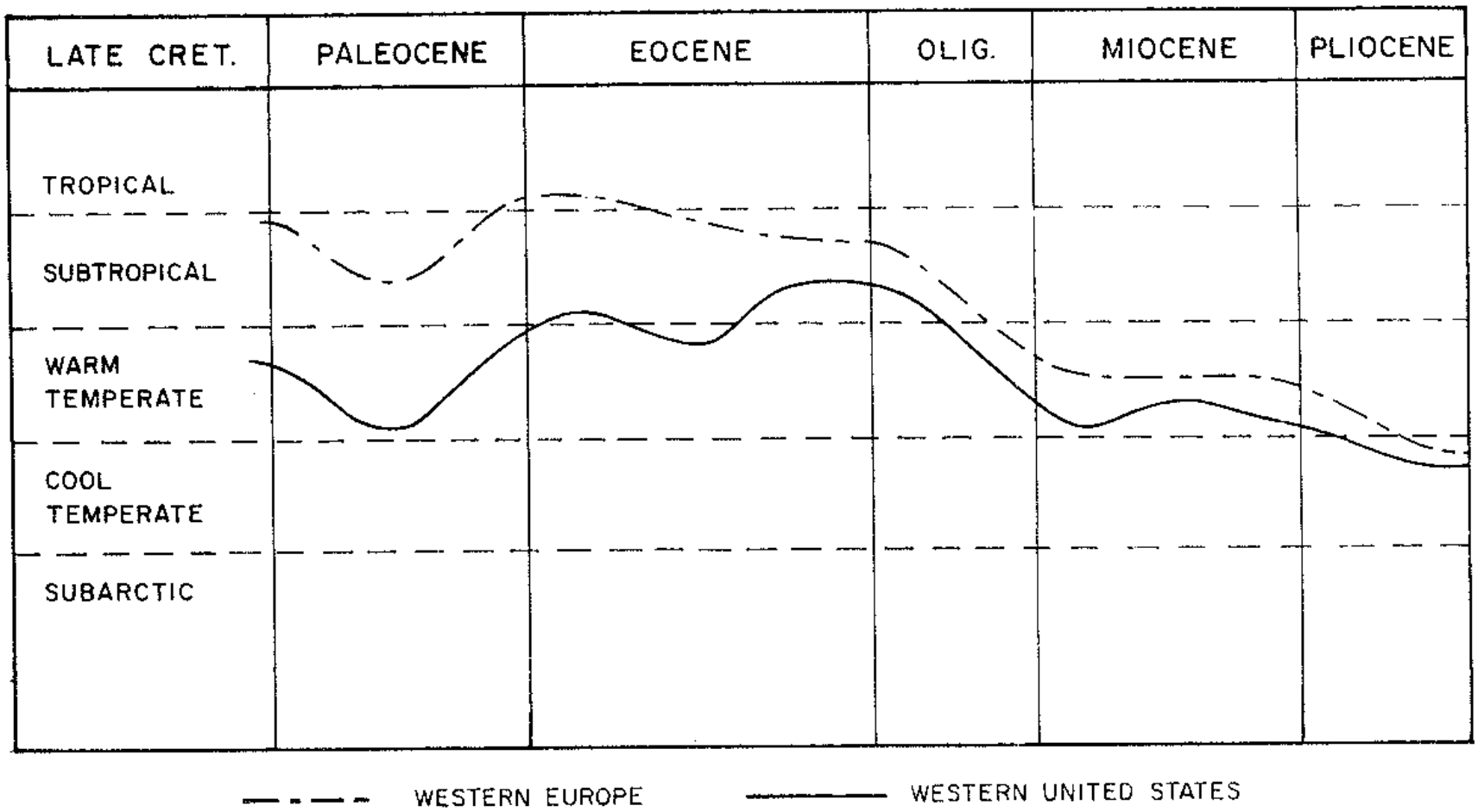

A
B
C
D

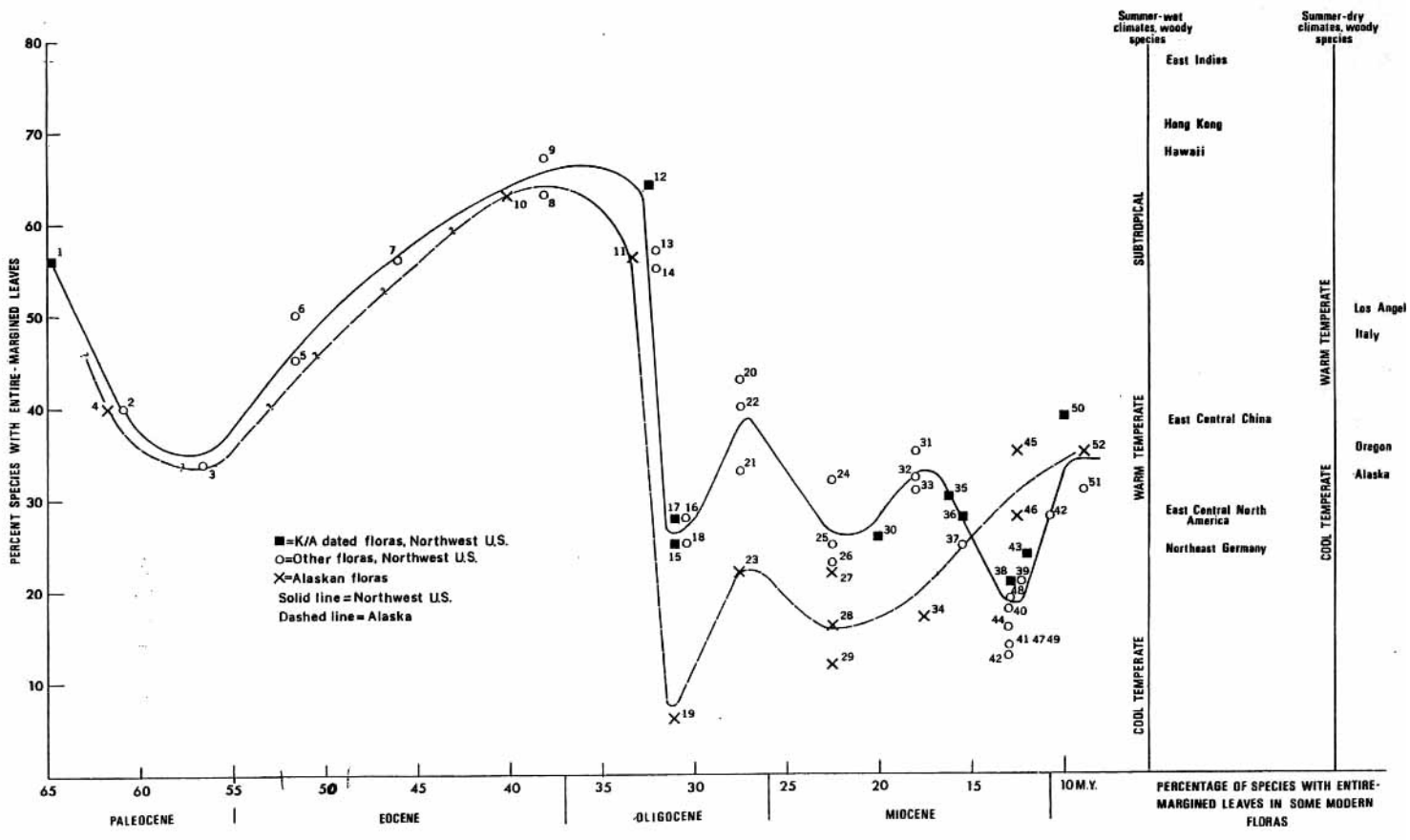
Key to symbols: *A.*, *Pera arborea*; *B.*, *Clathrotropis brachypetala*; *B.c.*, *Amaioua corymbosa*; *B.ch.*, *Diospyros ierensis*; *B.l.*, *Ryania speciosa*; *B.m.*, *Pentaclethra macroloba*; *B.p.*, *Swartzia pinnata*; *B.t.*, *Rudgea freemani*; *C.*, *Carapa guianensis*; *Ca.*, *Virola surinamensis*; *Cb.*, *Guarea glabra*; *Coc.*, *Maximiliana elegans*; *Cp.*, *Brownea latifolia*; *G.*, *Eschweilera subglandulosa*; *Ga.*, *Esenbeckia pilocarpoides*; *In.*, *Protium guianense*; *L.s.*, *Ocotea wachenheimii*; *La.*, *Cordia* sp.; *M.*, *Mora excelsa*; *Ma.*, *Sterculia caribaea*; *Mc.*, *Euterpe langloisii*; *Mk.*, *Sapium aucuparium*; *Mi.*, *Miconia* sp.; *N.*, *Calliandra guildingii*; *P.*, *Tabebuia serratifolia*; *Pd.*, *Inga* sp.; *S.*, *Rheedia* sp.; *W.*, *Warszewiczia coccinea*; *W.c.*, *Tovomita eggersii*; *W.co.*, Rubiaceae sp.; *W.o.*, *Terminalia amazonia*; *Y.o.*, *Buchenavia capitata*.

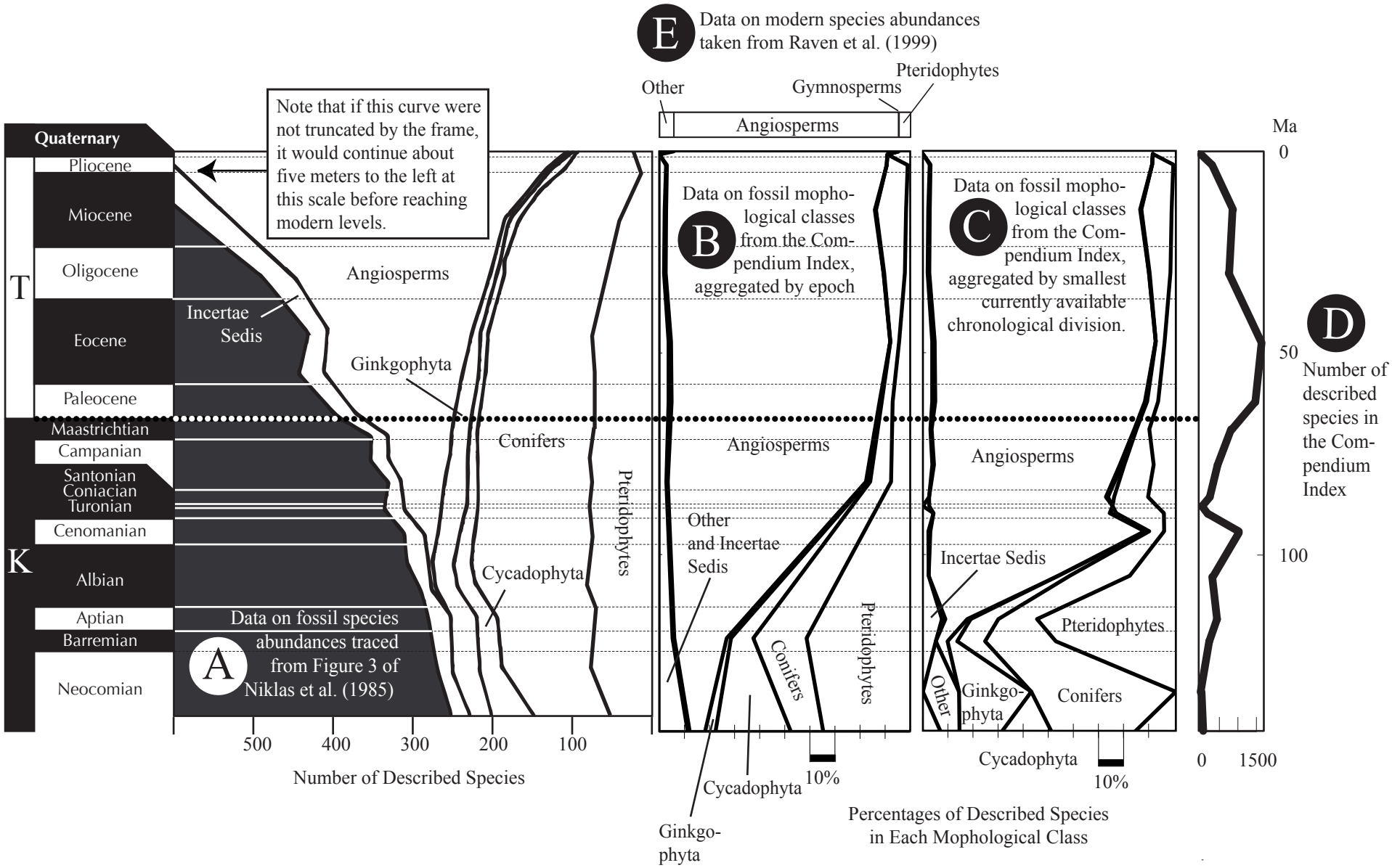


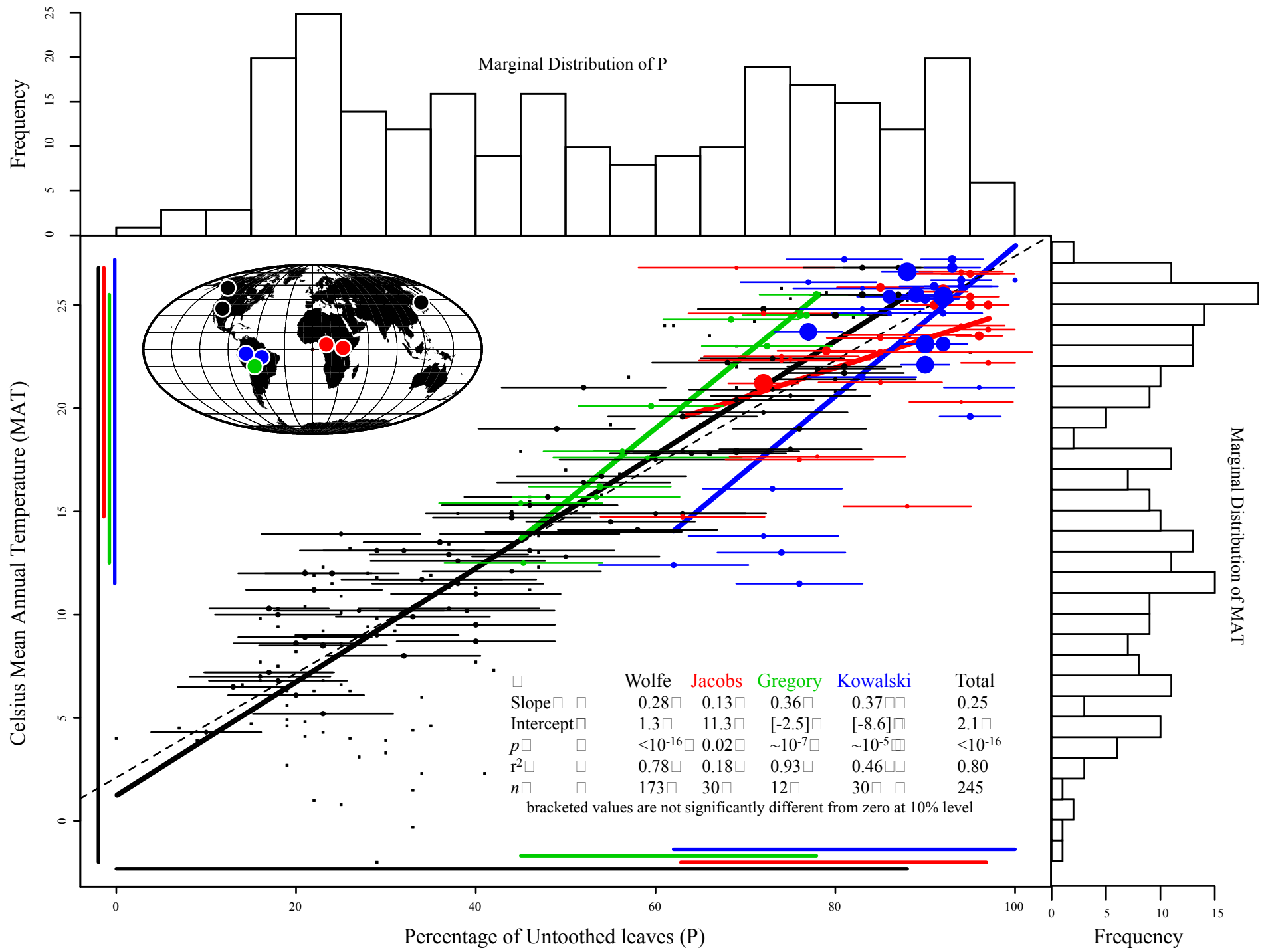
(*a*)

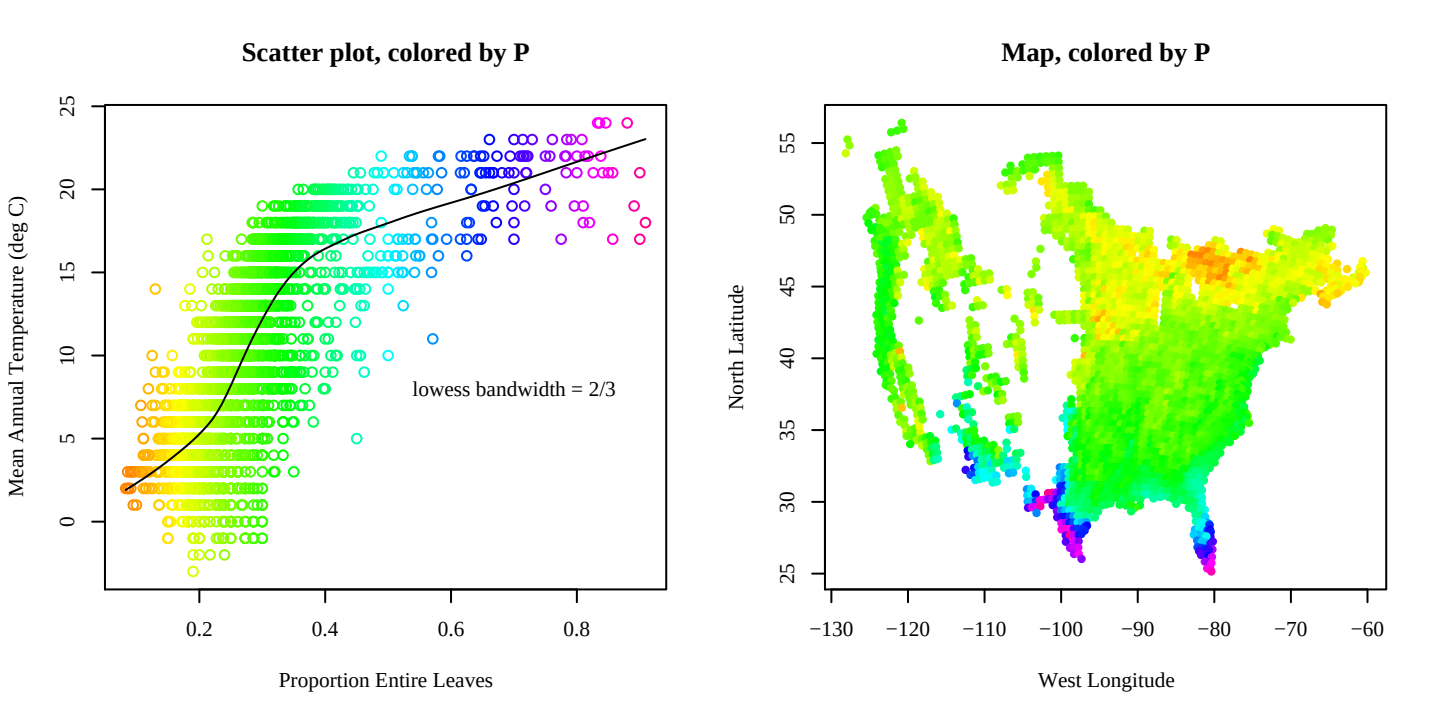
Climate Curves Based on Floral Data from Dorf (1964)

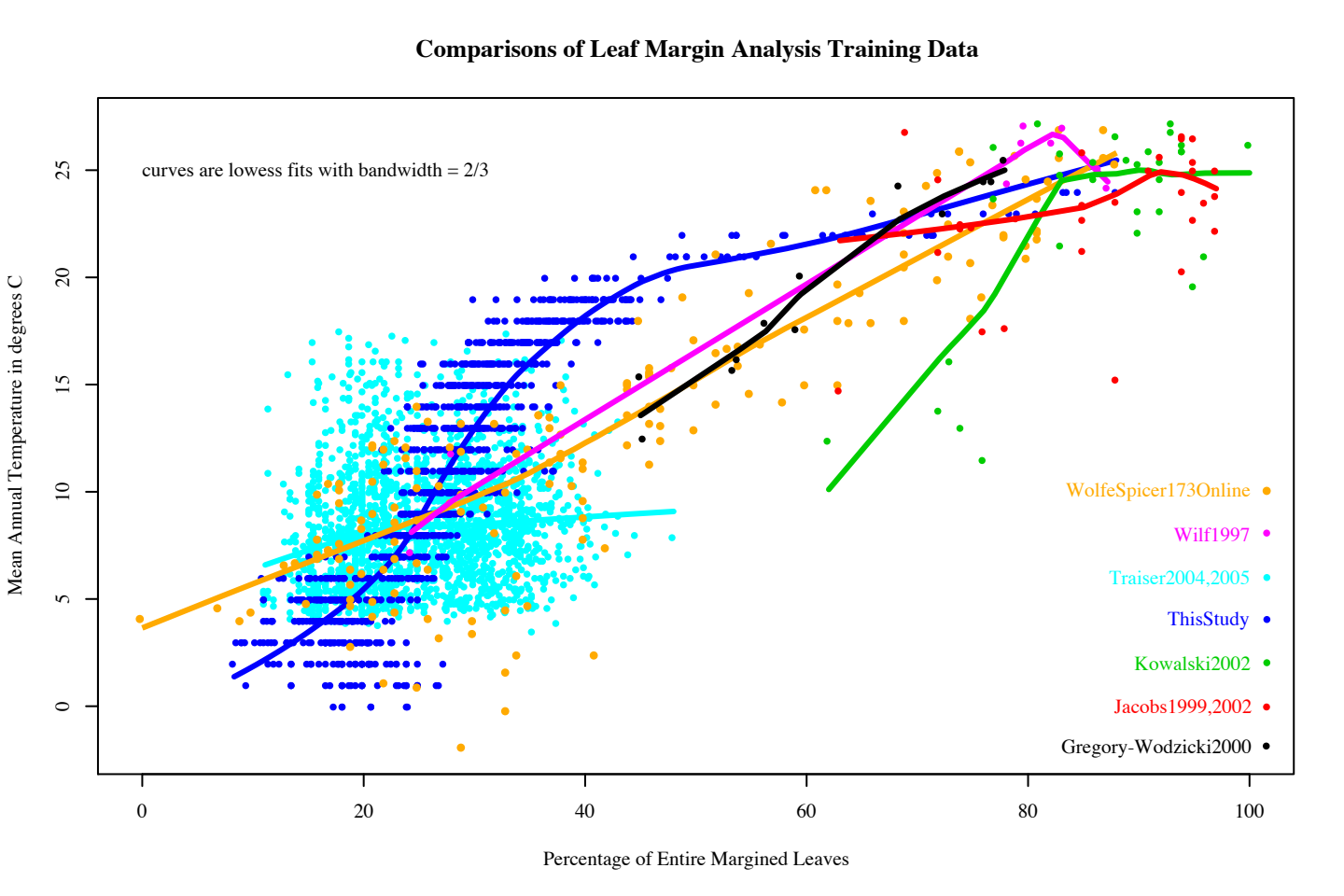



PERCENT SPECIES WITH ENTIRE-MARGINED LEAVES
80
70
60
50
40
30
20
10
■=K/A dated floras, Northwest U.S.
○=Other floras, Northwest U.S.
×=Alaskan floras
Solid line=Northwest U.S.
Dashed line=Alaska
65
60
55
50
45
40
35
30
25
20
15
10 M.Y.
PALEOCENE
EOCENE
OLIGOCENE
MIOCENE
Summer-wet climates, woody species
Summer-dry climates, woody species
SUBTROPICAL
WARM TEMPERATE
COOL TEMPERATE
WARM TEMPERATE
COOL TEMPERATE
East Indies
Hong Kong
Hawaii
East Central China
East Central North America
Northeast Germany
Los Angel
Italy
Oregon
Alaska
PERCENTAGE OF SPECIES WITH ENTIRE-MARGINED LEAVES IN SOME MODERN FLORAS


E
Data on modern species abundances taken from Raven et al. (1999)
Other
Gymnosperms
Pteridophytes
Angiosperms
Note that if this curve were not truncated by the frame, it would continue about five meters to the left at this scale before reaching modern levels.
Quaternary
Pliocene
Miocene
Oligocene
Eocene
Paleocene
Maastrichtian
Campanian
Santonian
Coniacian
Turonian
Cenomanian
Albian
Aptian
Barremian
Neocomian
T
K
Angiosperms
Incertae Sedis
Ginkgophyta
Conifers
Cycadophyta
Pteridophytes
A
Data on fossil species abundances traced from Figure 3 of Niklas et al. (1985)
500
400
300
200
100
Number of Described Species
B
Data on fossil mophological classes from the Compendium Index, aggregated by epoch
Angiosperms
Other and Incertae Sedis
Conifers
Pteridophytes
Ginkgophyta
Cycadophyta
10%
C
Data on fossil mophological classes from the Compendium Index, aggregated by smallest currently available chronological division.
Angiosperms
Incertae Sedis
Pteridophytes
Other
Ginkgophyta
Conifers
Cycadophyta
10%
Percentages of Described Species in Each Mophological Class
Ma
0
50
100
D
Number of described species in the Compendium Index
0
1500


Marginal Distribution of P
Frequency
Celsius Mean Annual Temperature (MAT)
Percentage of Untoothed leaves (P)
Marginal Distribution of MAT
Frequency
Wolfe Jacobs Gregory Kowalski Total
Slope 0.28 0.13 0.36 0.37 0.25
Intercept 1.3 11.3 [-2.5] [-8.6] 2.1
p <10^-16 0.02 ~10^-7 ~10^-5 <10^-16
r^2 0.78 0.18 0.93 0.46 0.80
n 173 30 12 30 245
bracketed values are not significantly different from zero at 10% level


Scatter plot, colored by P
Mean Annual Temperature (deg C)
0
5
10
15
20
25
0.2
0.4
0.6
0.8
Proportion Entire Leaves
lowess bandwidth = 2/3
Map, colored by P
North Latitude
25
30
35
40
45
50
55
−130
−120
−110
−100
−90
−80
−70
−60
West Longitude


Comparisons of Leaf Margin Analysis Training Data
curves are lowess fits with bandwidth = 2/3
Mean Annual Temperature in degrees C
Percentage of Entire Margined Leaves
0
5
10
15
20
25
0
20
40
60
80
100
WolfeSpicer173Online
Wilf1997
Traiser2004,2005
ThisStudy
Kowalski2002
Jacobs1999,2002
Gregory-Wodzicki2000

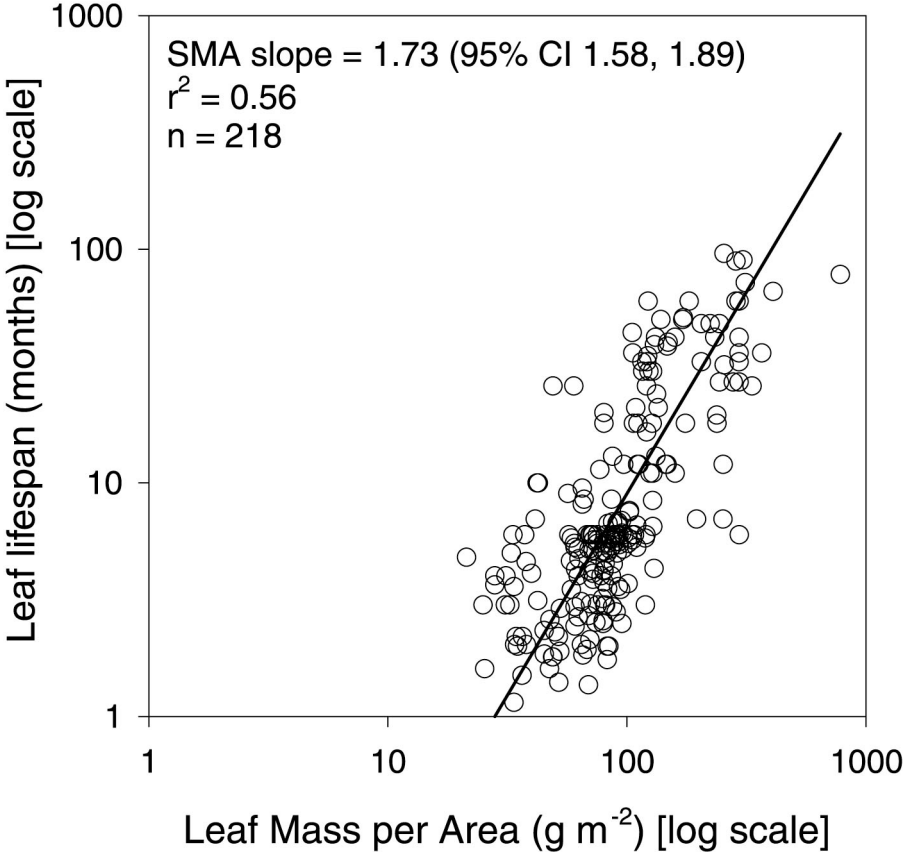


Figure 1 Correlation between leaf lifespan and leaf mass per area across 218 species from several habitats and continents. Regraphed from Reich et al. (1997); data kindly provided by the authors. SMA = Standard Major Axis; CI = confidence internal.

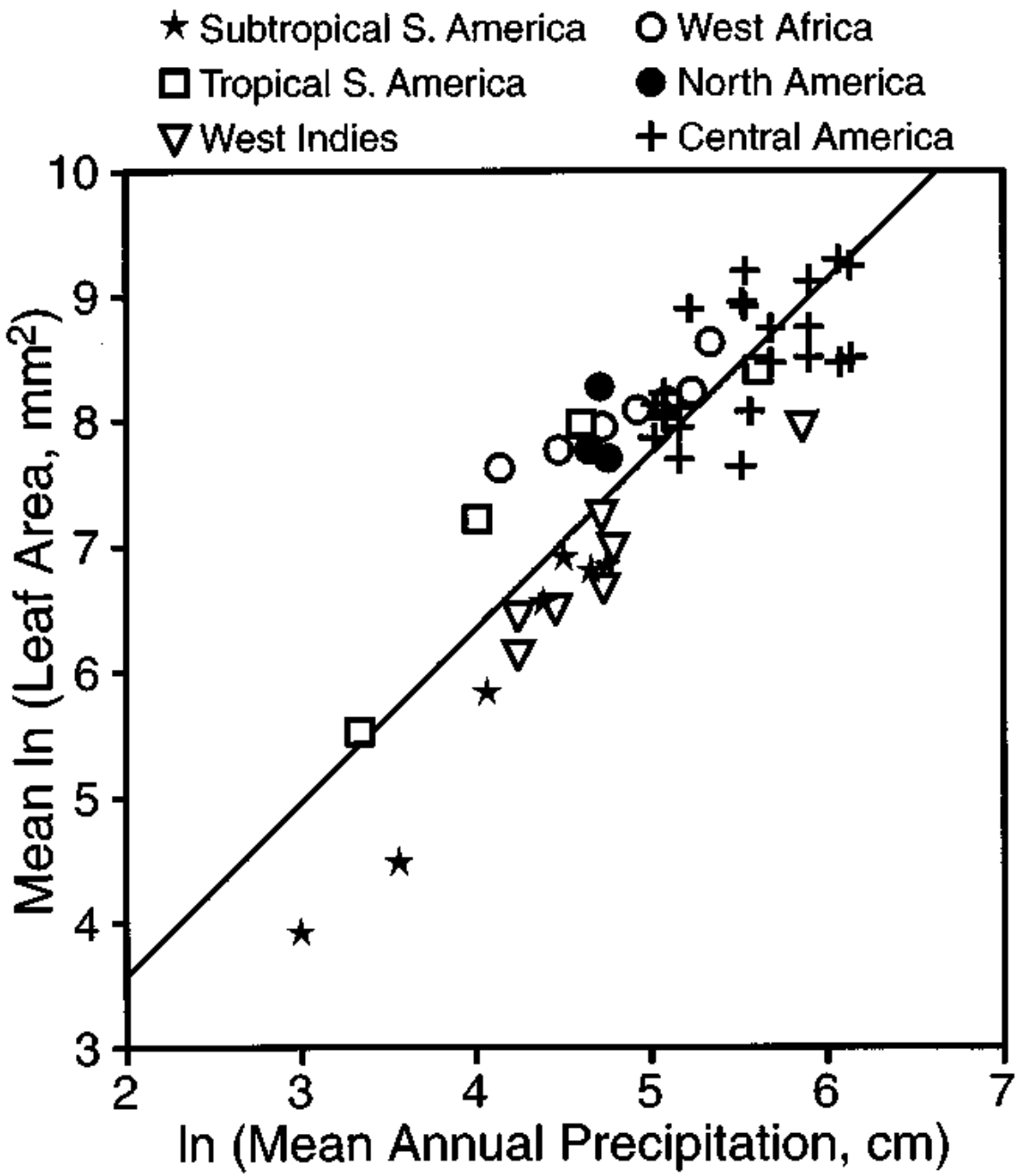
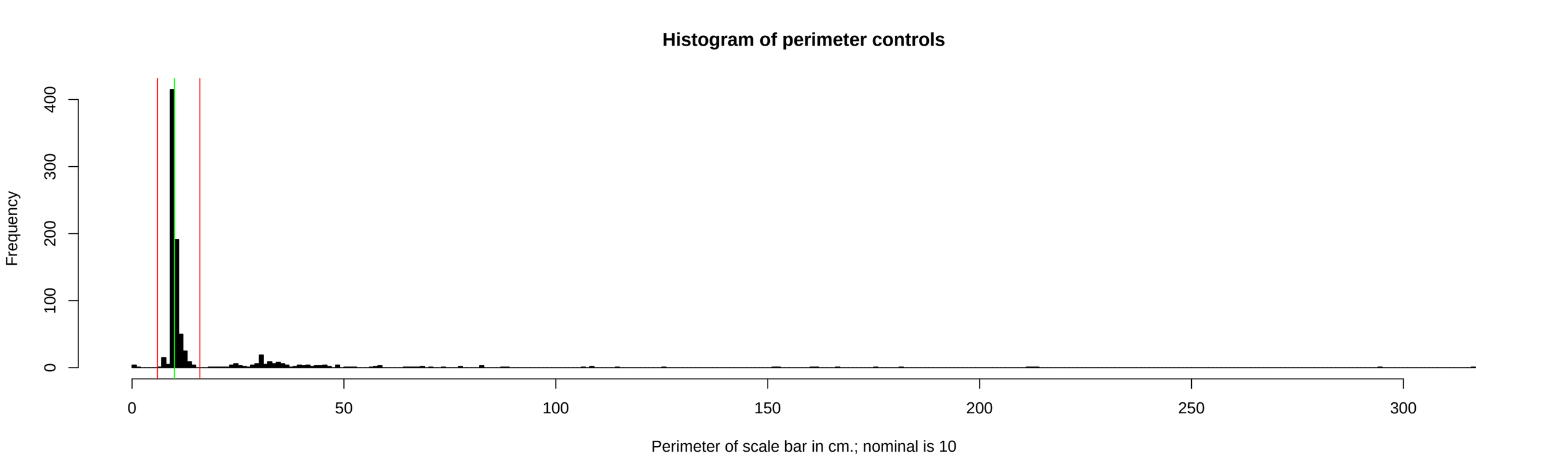
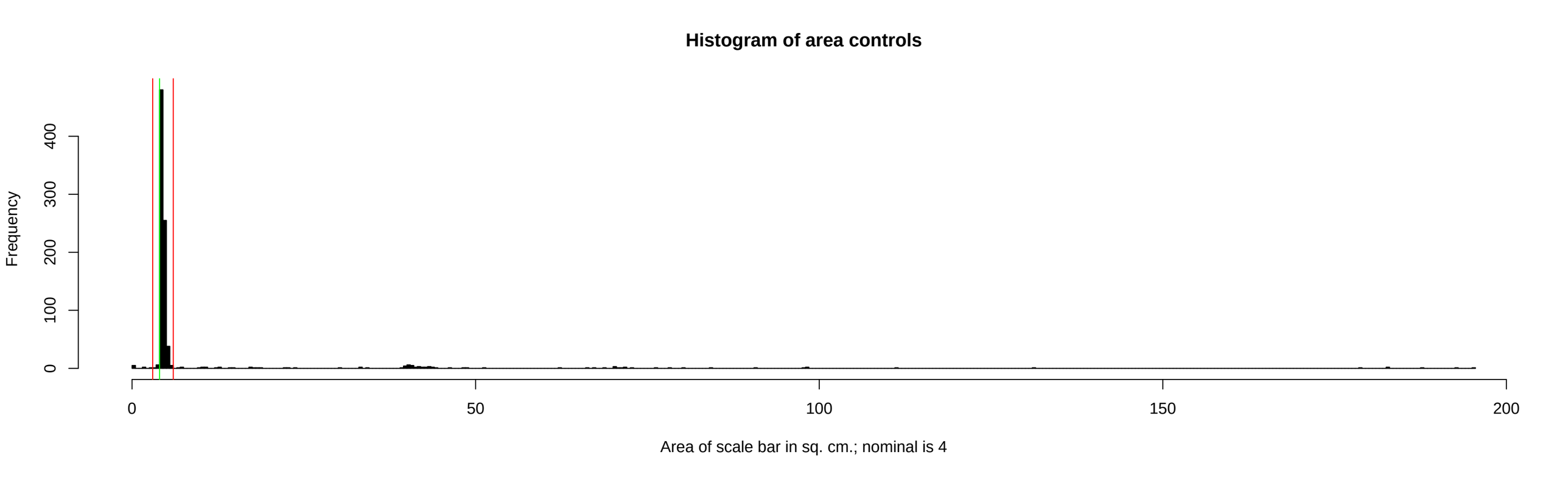
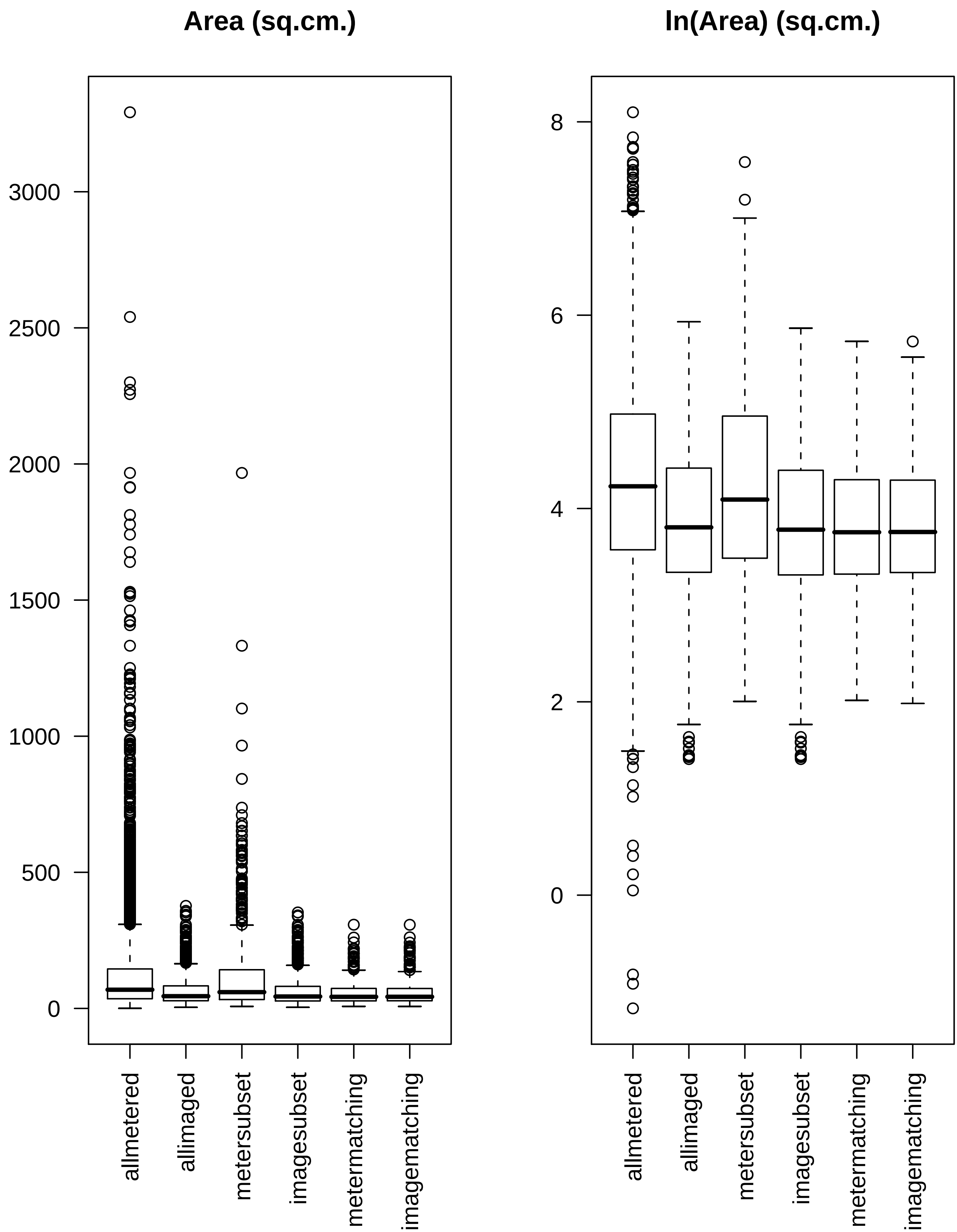


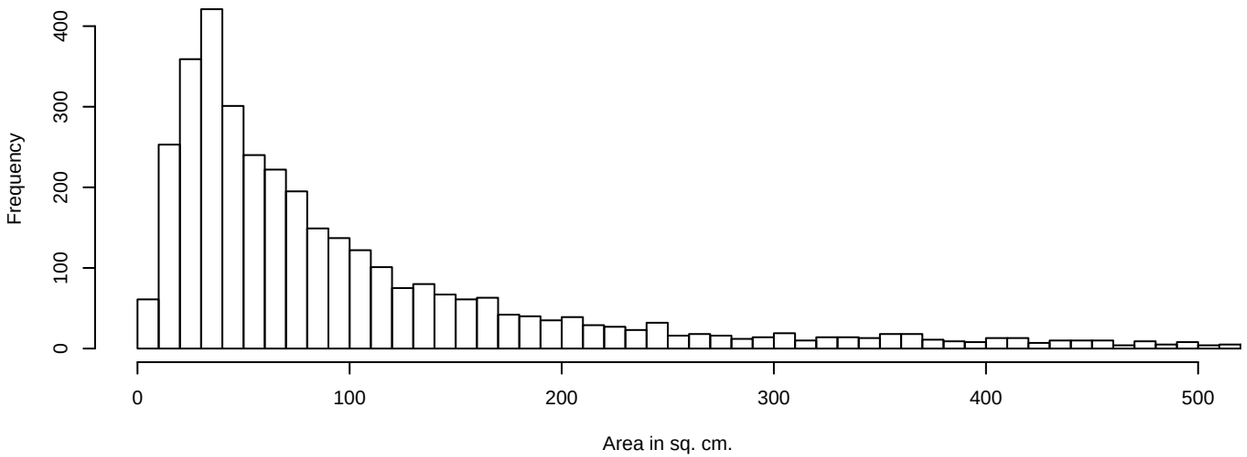
Figure 2. Mean natural log leaf area (MlnA) as a function of mean annual precipitation (MAP): MlnA = 1.39 ln(MAP) + 0.786, r^2 = 0.760, standard error = 0.572, F (1,48) = 152, $p = 10^{-15}$. Data from Table 2.


Histogram of perimeter controls
Frequency
0
100
200
300
400
0
50
100
150
200
250
300
Perimeter of scale bar in cm.; nominal is 10

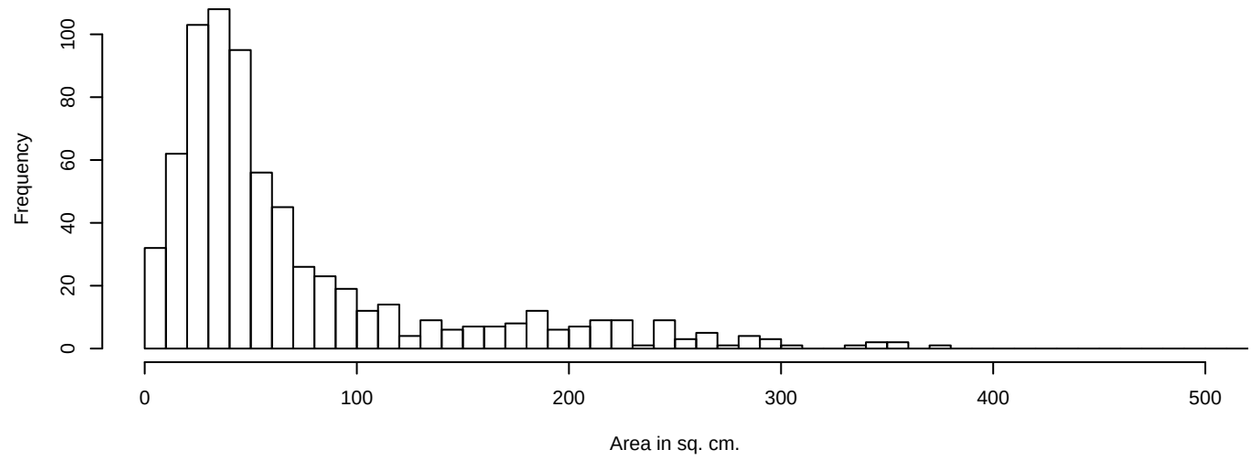

Histogram of area controls
Frequency
0
100
200
300
400
0
50
100
150
200
Area of scale bar in sq. cm.; nominal is 4


Area (sq.cm.)
ln(Area) (sq.cm.)
0
500
1000
1500
2000
2500
3000
0
2
4
6
8
allmetered
allimaged
metersubset
imagesubset
metermatching
imagematching

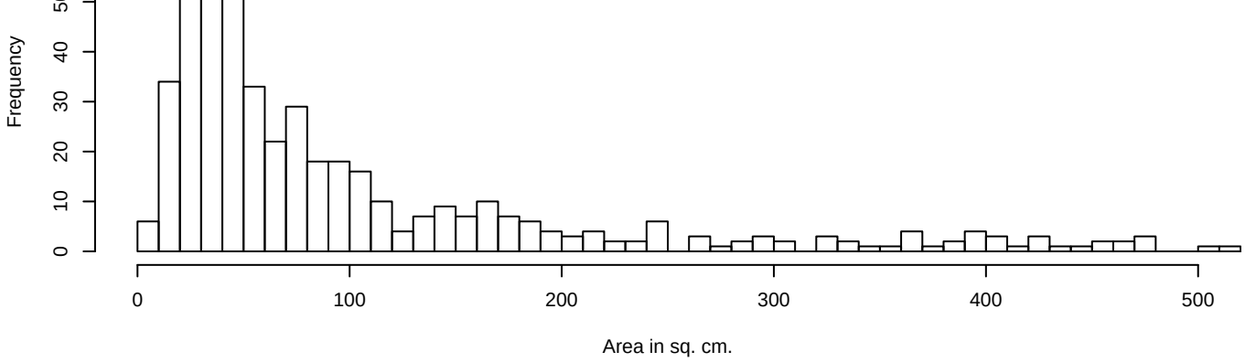
Leaf areas from area meter, n = 3662



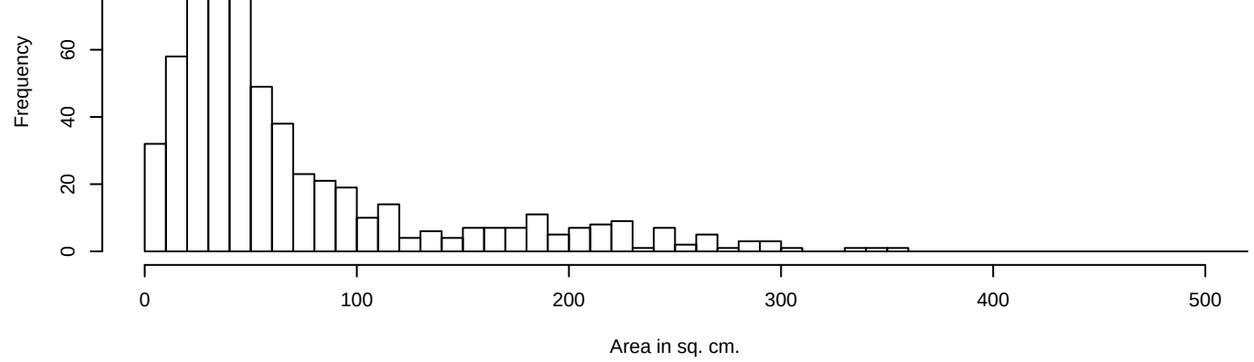
Leaf areas from processed images, n = 712



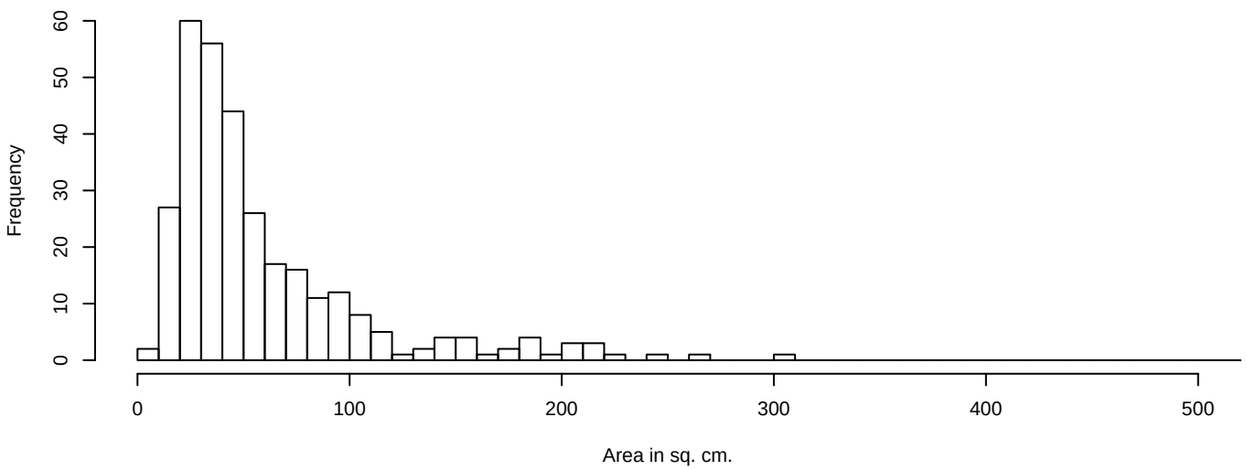
Leaf areas from area meter also imaged, n = 515



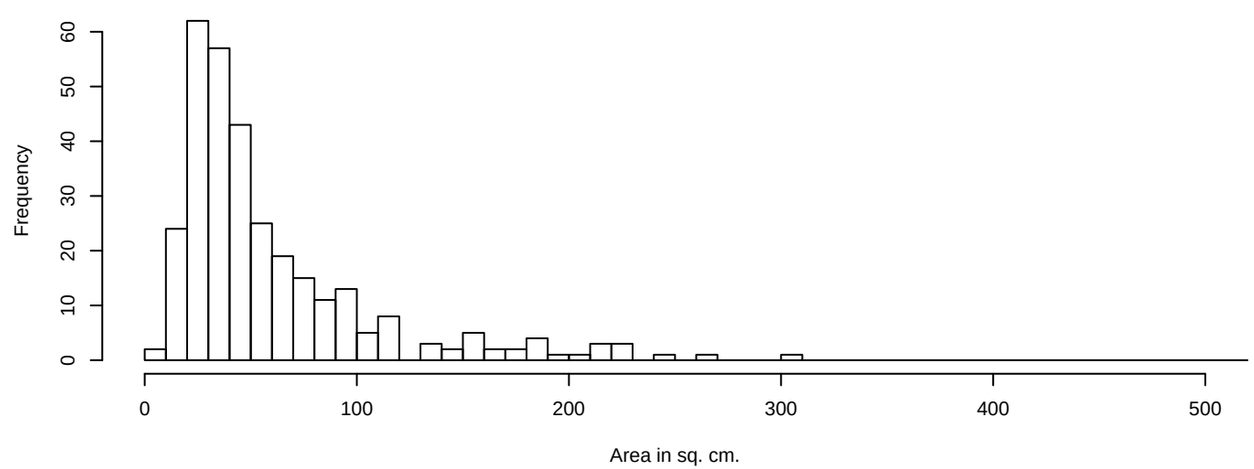
Leaf areas from images also metered, n = 651

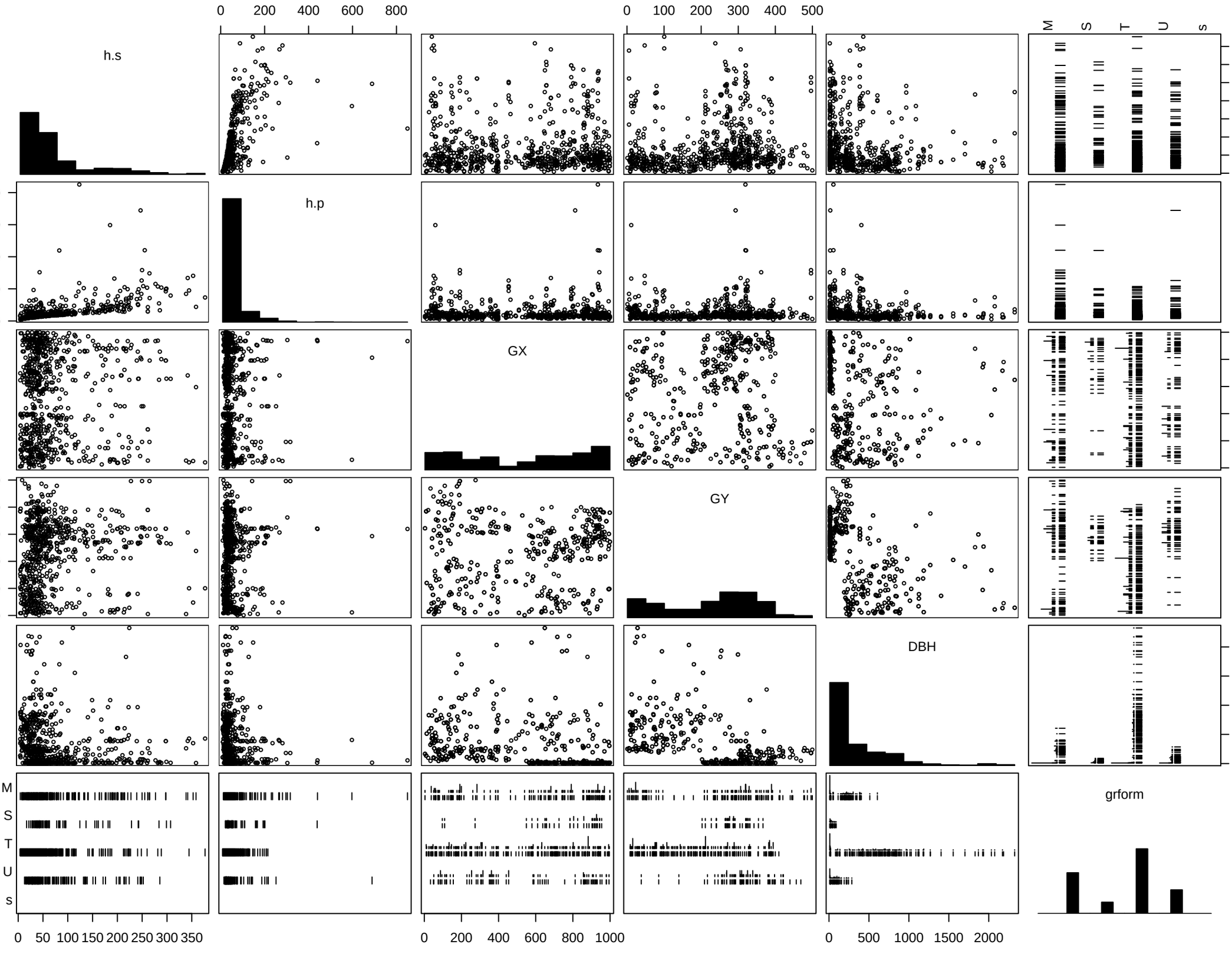


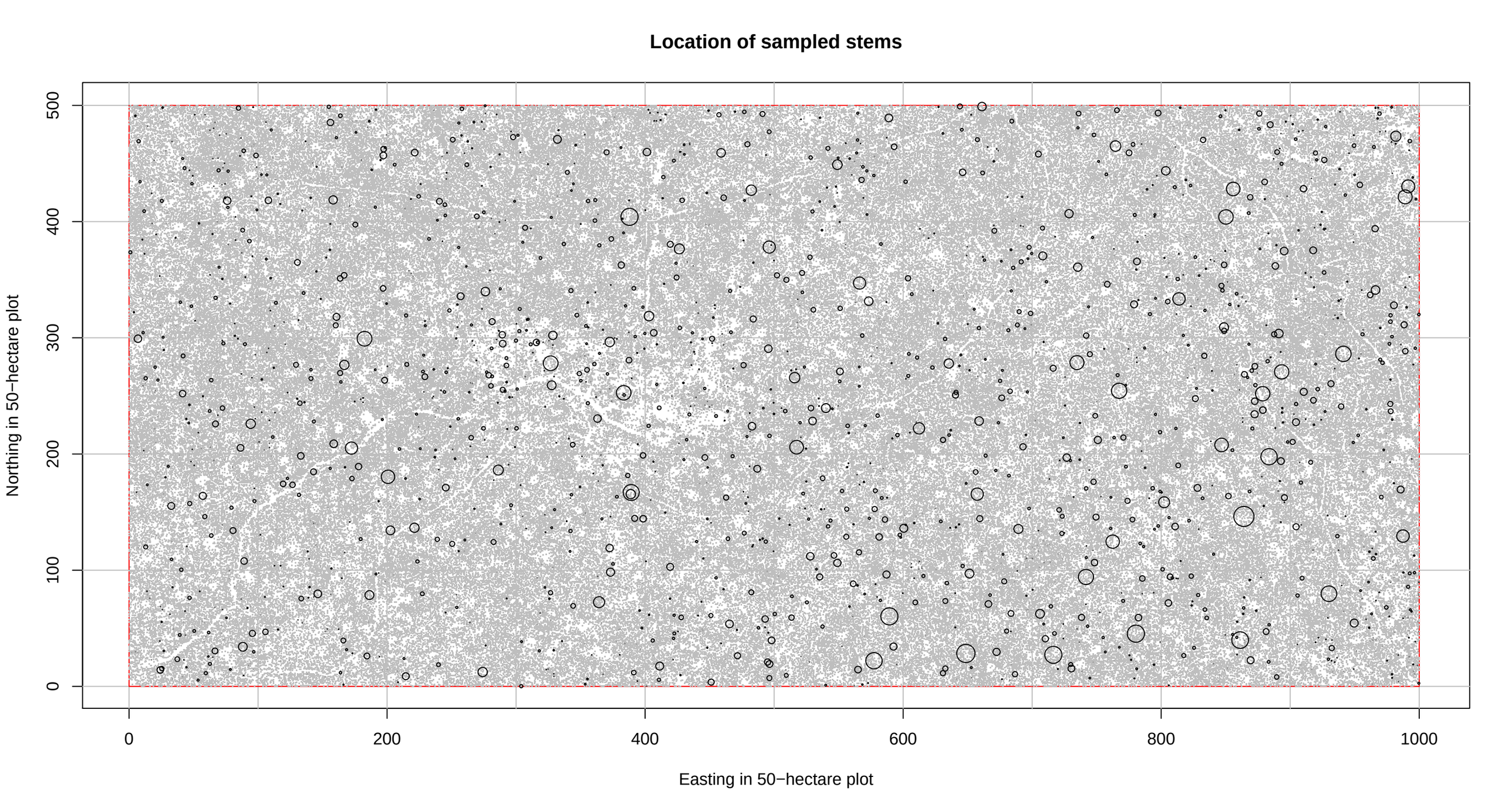
Leaf areas from metering, matching to 10%, n = 313

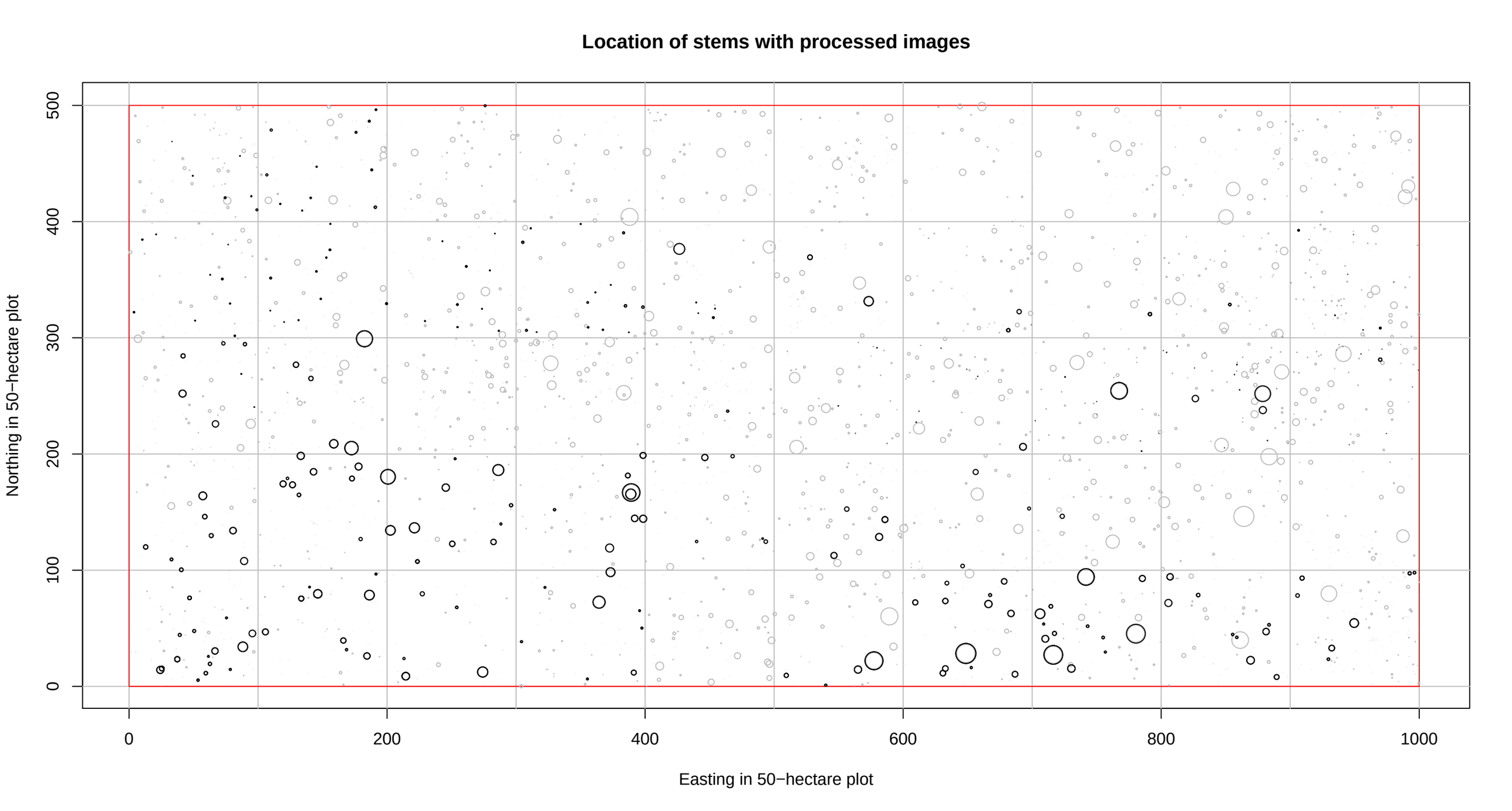


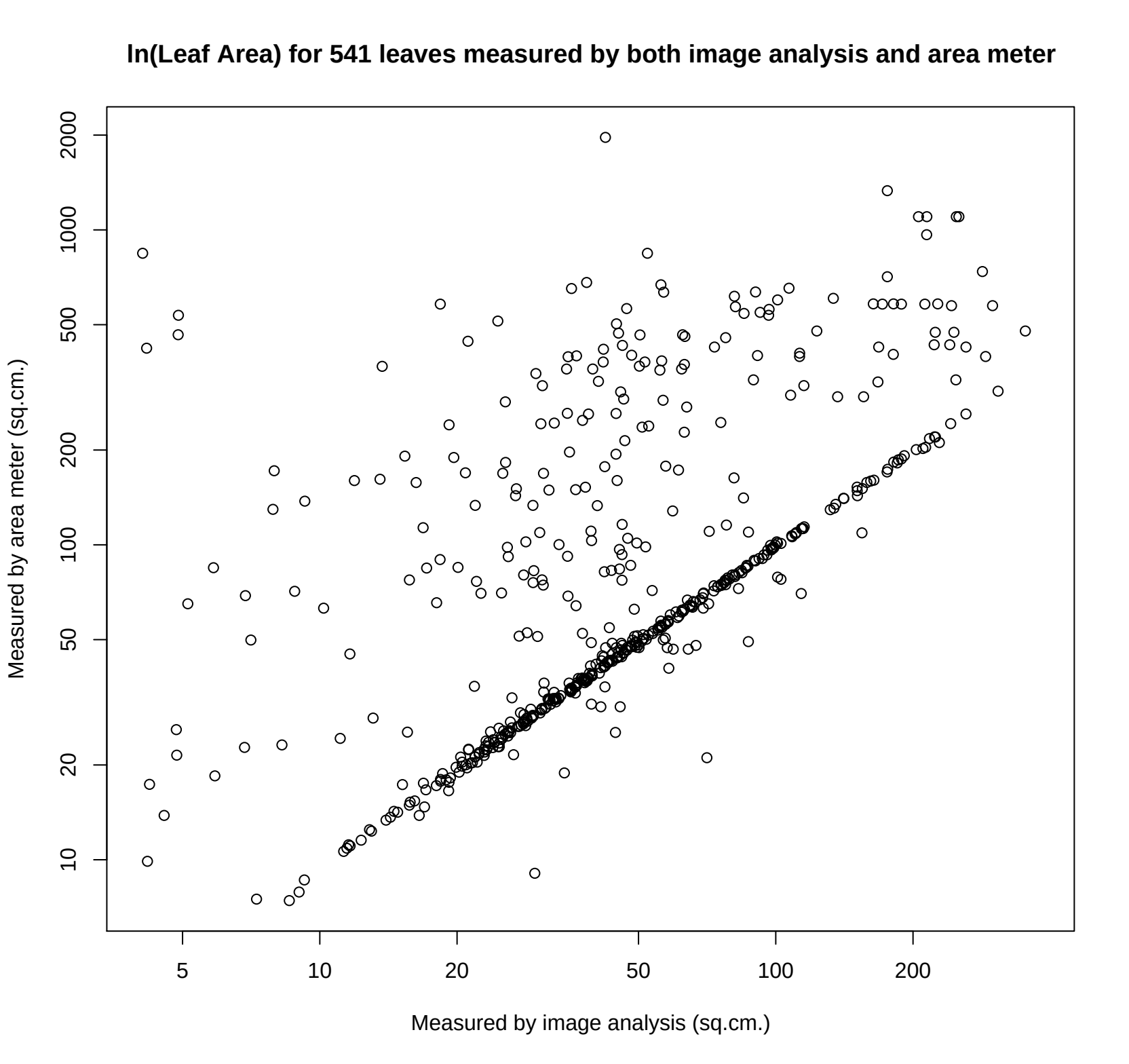
Leaf areas from imaging, matching to 10%, n = 313

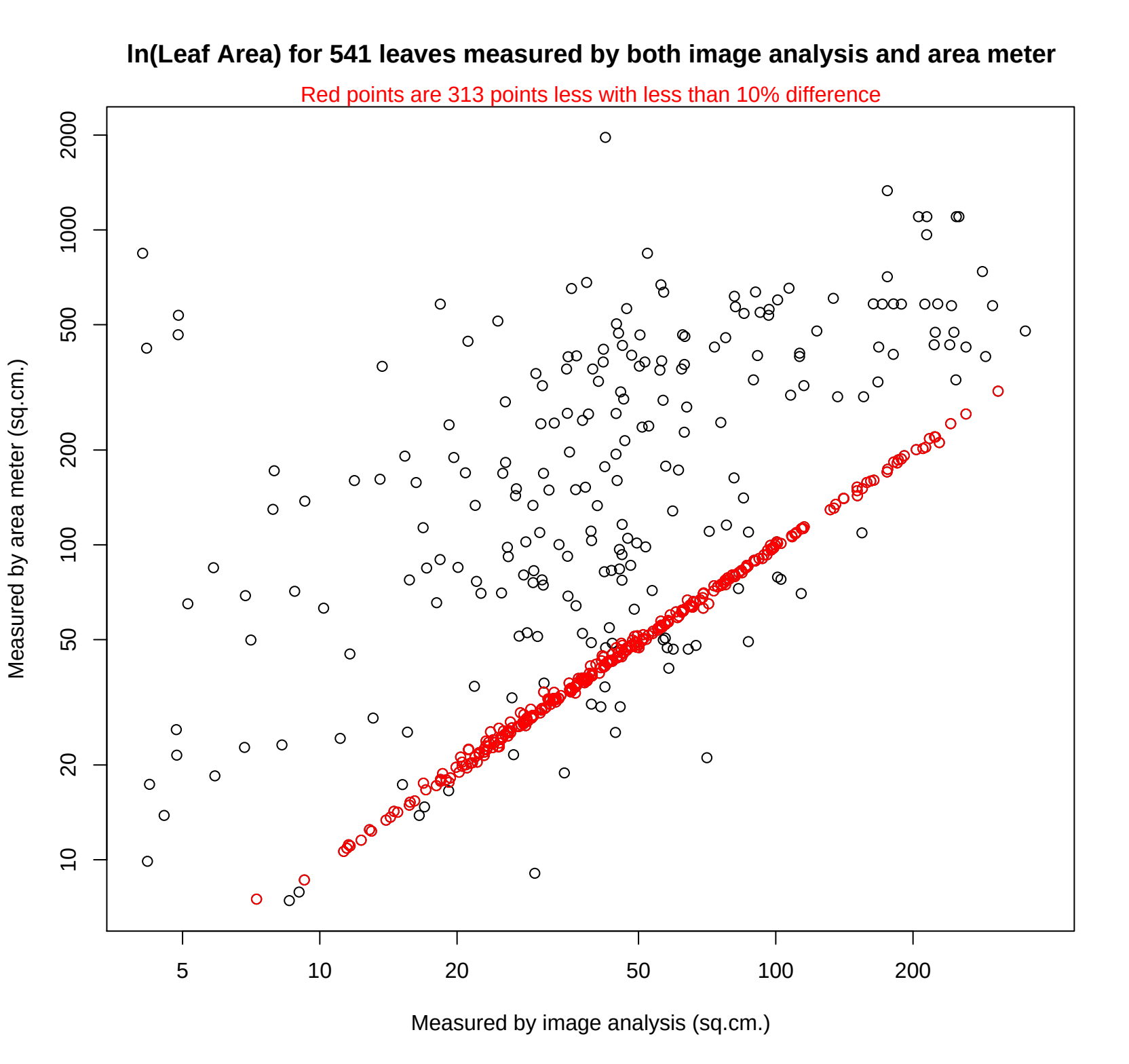


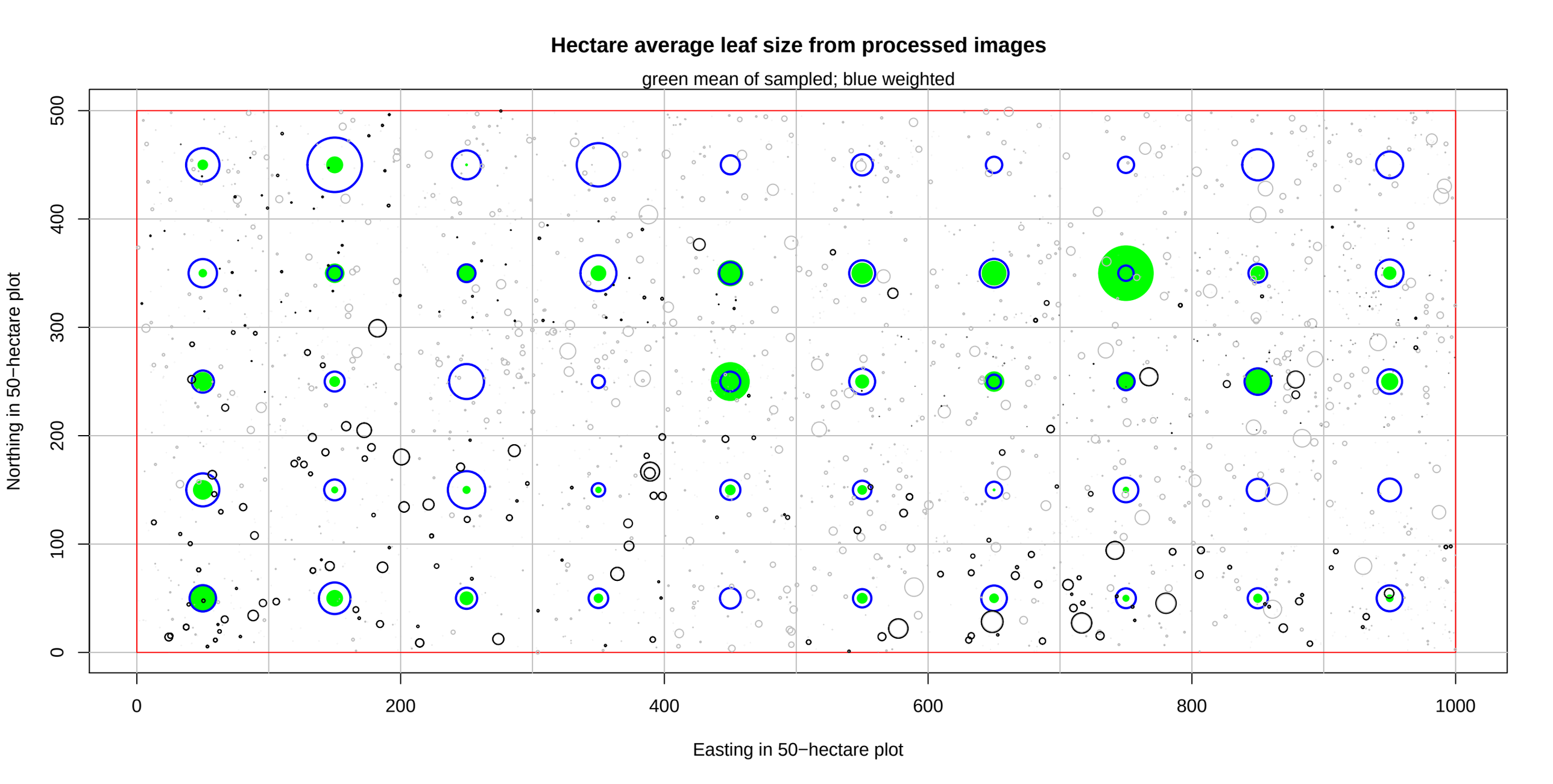

h.s
h.p
GX
GY
DBH
grform
M
S
T
U
s

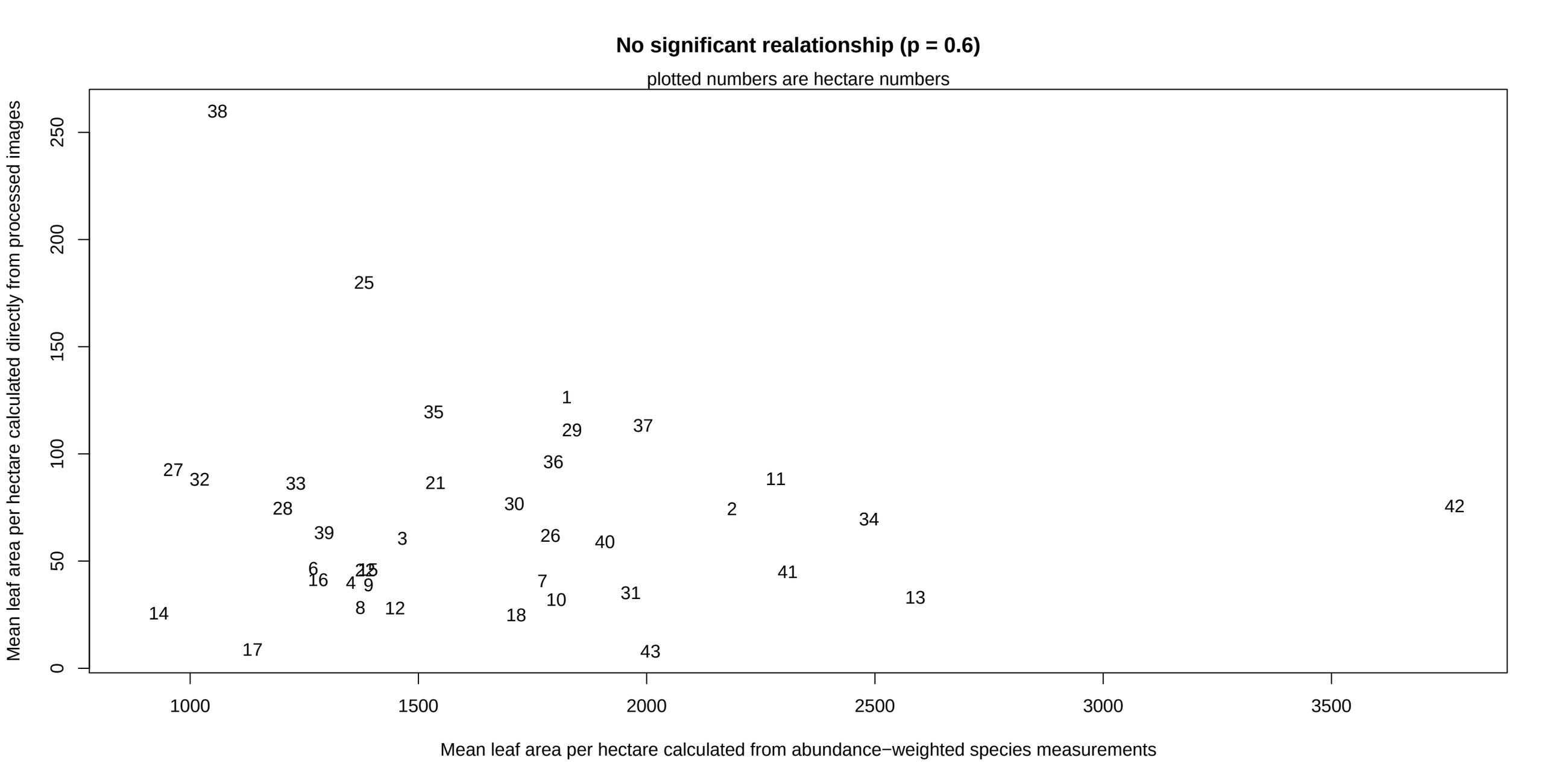

Location of sampled stems
Northing in 50−hectare plot
0
100
200
300
400
500
Easting in 50−hectare plot
0
200
400
600
800
1000

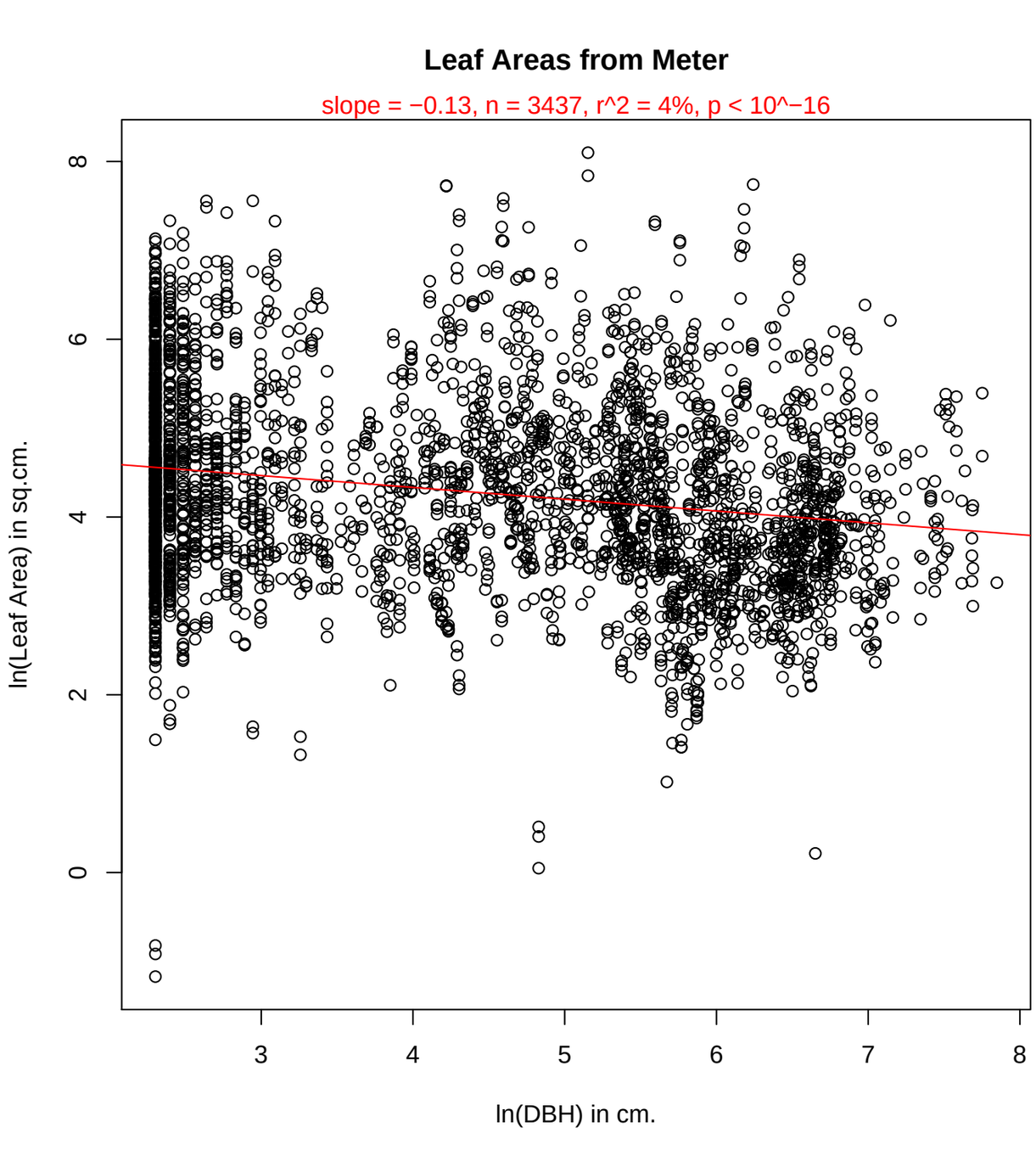

Location of stems with processed images
Northing in 50−hectare plot
0
100
200
300
400
500
Easting in 50−hectare plot
0
200
400
600
800
1000

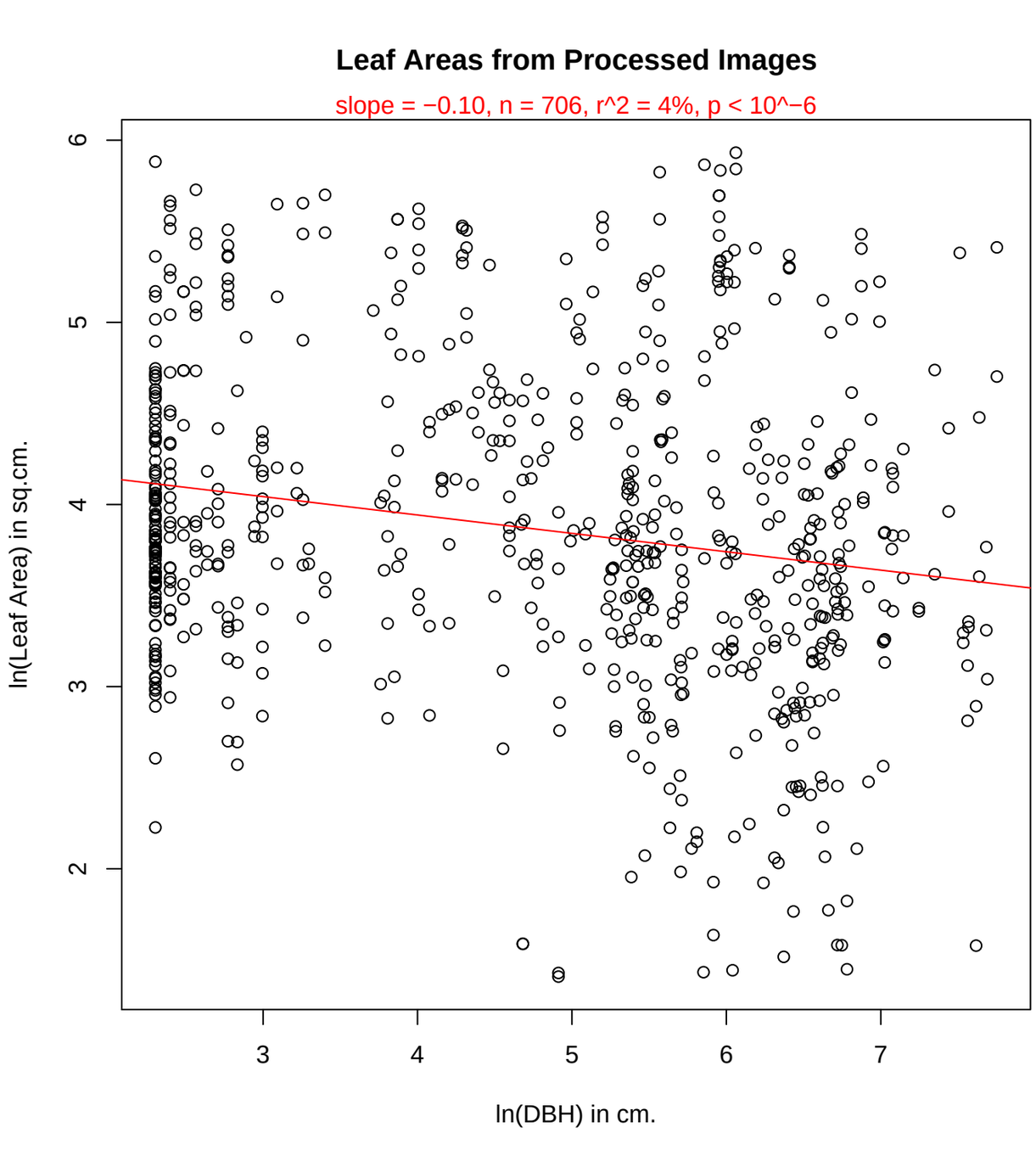

ln(Leaf Area) for 541 leaves measured by both image analysis and area meter
Measured by area meter (sq.cm.)
10
20
50
100
200
500
1000
2000
Measured by image analysis (sq.cm.)
5
10
20
50
100
200


ln(Leaf Area) for 541 leaves measured by both image analysis and area meter
Red points are 313 points less with less than 10% difference
Measured by area meter (sq.cm.)
10
20
50
100
200
500
1000
2000
Measured by image analysis (sq.cm.)
5
10
20
50
100
200


Hectare average leaf size from processed images
green mean of sampled; blue weighted
Northing in 50−hectare plot
0
100
200
300
400
500
Easting in 50−hectare plot
0
200
400
600
800
1000


No significant realationship (p = 0.6)
plotted numbers are hectare numbers
Mean leaf area per hectare calculated directly from processed images
Mean leaf area per hectare calculated from abundance−weighted species measurements
0
50
100
150
200
250
1000
1500
2000
2500
3000
3500
38
25
1
35
29
37
27
32
36
33
21
11
28
30
2
42
34
39
3
26
40
6
16
4
9
7
41
31
10
13
14
8
12
18
17
43


Leaf Areas from Meter
slope = −0.13, n = 3437, r^2 = 4%, p < 10^−16
ln(Leaf Area) in sq.cm.
ln(DBH) in cm.
0
2
4
6
8
3
4
5
6
7
8


Leaf Areas from Processed Images
slope = −0.10, n = 706, r^2 = 4%, p < 10^−6
ln(Leaf Area) in sq.cm.
ln(DBH) in cm.
2
3
4
5
6
3
4
5
6
7

```
> anova(lm(h.s ~ family + grform + DBH + HA, data = foo))
Analysis of Variance Table

Response: h.s
           Df  Sum Sq Mean Sq F value    Pr(>F)
family     50 1601083   32022 13.7097 < 2.2e-16 ***
grform      3   21223    7074  3.0288   0.02893 *
DBH         1   46392   46392 19.8624 9.893e-06 ***
HA         37  254629    6882  2.9464 3.683e-08 ***
Residuals 614 1434113    2336
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

> summary(lm(h.s ~ grform, data = foo))
Call:
lm(formula = h.s ~ grform, data = foo)

Residuals:
   Min     1Q Median     3Q    Max
-82.32 -42.94 -23.68  13.25 320.72

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
grforms       86.505      4.725  18.308  < 2e-16 ***
grformS        2.573     10.130   0.254    0.800
grformT      -30.409      6.034  -5.040 5.94e-07 ***
grformU       -9.487      7.797  -1.217    0.224
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 67.65 on 702 degrees of freedom
  (6 observations deleted due to missingness)
Multiple R-Squared: 0.04301,   Adjusted R-squared: 0.03892
F-statistic: 10.52 on 3 and 702 DF,  p-value: 8.995e-07
```