Work report ForestBIOTA:
Assessment and evaluation of stand structure data

April 2006
P. Meyer
Northwest-German Forestry Research Station

1 Introduction

The ForestBIOTA project aims at the further development of biodiversity monitoring activities specifically at Level II plots of the EU and ICP Forests monitoring programme. Recommendations shall be given for an optimized

a) indicator system of forest biodiversity and

b) a suitable methodology for the assessment of biodiversity at Level II plots in European forests.

This will facilitate recommendations for assessment methods applicable within different surveys (e.g. Intensive Monitoring, Level I, National Forest Inventories).

In a test-phase assessments of forest biodiversity in different fields of interest have been carried out in 11 European countries taking part in ForestBIOTA. As key attributes of forest biodiversity dead wood, epiphytic lichens, ground vegetation, forest classification and stand structure were selected. Results were submitted to the PCC (BFH, Hamburg) which checked data quality and created a database. Afterwards experts evaluated the gathered data. In a final step correlative studies were carried out in order to detect relationships between indices within and/or between fields of interest.

The presented work report summarizes the methodology of field assessment and data analysis concerning stand structure within ForestBIOTA.

2 Selected indices and simple estimates

The ForestBIOTA partners agreed on a list of stand structural indices to be computed by the experts and a methodology for the assessment of stand structure and dead wood, which is layed down in Anonymus (2004) based on Fischer and Pommerening (2003), Chirici et al. (2003) and Meyer (2004). Following, the agreements on indices are described and contrasted with the delivered data.

<u>Approach</u>

Different indices characterizing stand structure shall be tested. Suitable indices shall reveal valid results and react sensitive to structural differences between sites and stands as well as structural dynamics. Furthermore it is advantageous if necessary data can efficientely be assessed and computation is simple. The parameters can be divided into two groups: spatially explicit indices and indices without spatial relationships (s. Tab. 1).

Tab. 1: List of selected structural indices

Name	Formula	Short description	Source
Spatially explicit indices			
Clark Evans Index	$CE = \frac{\frac{1}{n}\sum_{i=1}^{n} r_i}{0{,}5\sqrt{10000/N}}$ with r_i = distance of tree $_i$ to next neighbour N = number of trees per ha n = number of sample trees	measure for regular or clustered horizontal distribution	Clark and Evans 1954
Contagion Index	$W_i = \frac{1}{4}\sum_{1}^{4} w_j$ with w_i = 1 if α angle j < 90° w_i = 0 otherwise	defines the degree of regularity of the distribution of tree positions	Gadow et al. 1998
Mingling Index	$MI_i = \frac{1}{4}\sum_{j=1}^{4} v_{ij}$ with v_{ij} = 0 in case that neighbour $_j$ belongs to same species and v_{ij} = 1 in case that neighbour $_j$ belongs to same species	describes the probability that none of the three nearest trees belongs to the tree species of the centre tree	Gadow and Füldner 1995
Diameter differentiation	$T = \frac{1}{n}\sum_{i=1}^{n}(1 - r_i)$ with r_i = (thinner dbh)/(thicker dbh) of tree pair $_i$ n = number of measured tree pairs	Quantifies the degree of diameter differentiation	Gadow and Füldner 1995
Indices without spatial relation			
Shannon Index of diversity	$H' = -\sum_{i}^{N} \log p_i \cdot p_i$ with p_i = relative abundance of the *i*th species N = number of species (log = natural logarithm (base = e))	ecological standard measure for diversity	Shannon 1948
Evenness	$E = \frac{H'}{H'_{Max.}}$ with H' = Shannon-Index $H'_{Max.}$= Potential maximum value (= log N [species number])	ecological standard measure for diversity	Pielou (1975)
Simpson index of diversity	$SI = \sum_{i}^{N}(1 - p_i)\cdot p_i$ with p_i = relative abundance of the *i*th species N = number of species	ecological standard measure for diversity	Simpson 1949
Species profile index	$A = -\sum_{i=1}^{S}\sum_{j=1}^{B} \log(p_{ij})\cdot p_{ij}$ with p_{ij} = proportion of species i in height band j S = number of different tree species B = number of height bands band 1: 100 - 80 % of maximal tree height (h_{max}) band 2: 80 - 50 % of h_{max} band 3: 50 - 0 % of h_{max}	Shannon index calculation for the proportion of tree species in different stand layers	Pretzsch 1996

Additionally the standard deviation of dbh was calculated as this measure has been shown to be a strong index for horizontal stand structure by Neumann and Starlinger (2001).

The different indices are described in detail by Anonymus (2004) and Fischer and Pommerening (2003).

In the field a list of simple estimates was recorded (Table 2), which are also described in detail by Anonymus (2004) and Fischer and Pommerening (2003).

Tab. 2: List of simple estimates

Parameter	**Estimation/Classes**
Tree species composition	estimated list of main tree species with percentage cover in 10% steps; list of all additional tree species occurring without percentage cover
Number of tree layers > 5m	• one layer • two layers (each min of 10 % coverage) • multilayered (each min of 10 % coverage) • irregular
Type of tree species mixture	• monoculture (>90% tree cover consists of main tree species) • single tree wise mixture • group wise mixture • mixture by layers • irregular, none of the above
Canopy closure	percentage coverage of tree layer > 5 m (5 % steps)
Ancient forest site	• forested since > 300 years • forested since > 200 years • forested since > 100 years • afforested in the past 100 years
Intensity of forest management	• no sign of management, natural development • signs of past management, abandoned to natural development • managed
Management type of forest	• high forest • coppice without standards • coppice with standards • plantation
Management method	• clear cut • clear cut with reservoirs • selective cut

Additionally stem number and basal area per ha were calculated for all trees ≥ 5 cm dbh. Volume (either total volume over 5 or 7 cm diameter or - in case of coniferous trees - stem wood) was calculated if the determination of dbh-height relations was possible.

Table 3 summarizes the scale (from single tree to tree stand) and the kind of expected results of the different indices selected.

Tab. 3: Scale and kind of results per attribute and index.

Unit of inventory	Inventoried (or derived) attribute	Computed index	Result concerning
single tree	Dbh	standard deviation	horizontal structure
	tree species	Shannon index, Simpson Index	tree species diversity
	Height + tree species	species profile index	combined vertical (height bands) and tree species diversity
	Coordinates	Clark Evans index	horizontal structure
group of trees	angle between central tree and neighbours	contagion index	small scale horizontal structure
	species of neighbours compared to central tree	Mingling index	small scale species diversity
	diameter of 1st neighbour compared to central tree	diameter differentiation	small scale diameter differentiation
stand	simple estimate of tree species composition	no computation	tree species composition and diversity
	simple estimate of the number of tree layers		vertical structure
	simple estimate of the type of tree species mixture		spatial tree species diversity
	simple estimate of canopy closure		density
	dbh, height	Stem number, basal area and volume per ha	density; standard measures for forests

Data submitted

The submitted data allowed for the computation of almost all indices. Exceptions are documented in Annex 3. Simple estimates were submitted for 82 plots.

3 Field assessments
3.1 Plot configuration

Approach
The ForestBIOTA plot for stand structure assessments must be entirely contained within the Level II plot. It must always be continuous and of 0.25 ha size. A division to disjunctive parts is not foressen. The plot is centered as far as possible in correspondence with the geometric center of the Level II plot. The plot should be shaped as far as possible as a square, with a side length of 50 m. Otherwise, it may be shaped as a moderate rectangle, preferably with a minimum width of 40 m (or a maximum length of 62.5 m). One side of the plot is oriented to the magnetic North if possible.

Delivered data
The countries guaranteed that the standard plot size of 2,500 m^2 has been observed. However, length of the plot axis and information on plot orientation have not been reported. Visualisation of spatial tree distribution (s. Fig. 2) revealed that the majority of plots are shaped in accordance with the above agreements. A deviation from the standard size was reported for the Greek plots 209 (2,624 m^2), 309 (2,733 m^2) and 409 (2,990 m^2) and the Italian plot 15 (2,100 m^2).

Some countries submitted data for trees, which are not located within the ForstBIOTA plot. These trees were marked in the dataset and left aside for computation.
From Switzerland data on two types of plots were delivered: a) plots, where all trees ≥ 5 cm dbh have been assessed, and b) plots, where only trees ≥ 12 cm have been measured. The latter were designated by Switzerland as ForestBIOTA plots, and subsequently dead wood inventories were carried out there. As meeting the criterion of a dbh limit of 5 cm is vital for comparable data analysis in the field of stand structure the Swiss ForestBIOTA plot could not be used for computation. Instead, the first plot type was selected.

3.2 Inventoried parameters

Approach
The list of necessary inventory parameters was derived from the list of calculated indices and growth and yield data. Therefore following parameters of the stand ≥ 5 cm dbh had to be assessed (s. Tab. 3):

- Dbh [cm; full survey]
- Tree species [Botanical name; full survey]
- Height [m; sample or full survey]
- Coordinates [preferable: full survey of x- and y- or polar coordinates; in stands with more than 1.000 trees per ha systematic samples of structural groups of four were foreseen s. chapter 4]

The assessment methodology is documented in Anonymus (2004).

Data submitted
Data were submitted for 95 plots from 11 countries. Data quality was high and the datasets were almost complete. Necessary corrections as well as completions are documented in Annex 2.
As a consequence of a negative pilot study (s. chapter 4) systematic samples of structural groups of four have not been assessed in the field.
Only for 6 plots tree coordinates were missing (all French plots and plot nr. 603 in Germany). Height measurements were not available for 13 plots (all French plots, 7 German plots and one Ukrainian plot).

4 Simulation study: sampling of structural group of four

The assessment of tree coordinates is time-consuming. Prior to developing the assessment methodology it therefore had to be decided whether the sampling of structual groups of four would be advisable. A simulation study was therefore conducted based on 23 Level II plots from which a full survey of tree coordinates was available.

The computation was carried out in cooperation with K. Staupendahl from the Institute of Forest Inventory and Growth of the University of Göttingen.
Sampling in a regular grid with sample size of 10, 20, 30, 40 and 50 (standard design) or 4, 8, 12, 16, 20 resp. (clustered design, 4 groups per sample, s. Hui and Albert 2004) was simulated using the software POISSSIM™ (Zitat der Quelle?). 500 replications per sample size and plot with randomized grid starting point and randomized angle were computed. Relative bias and relative root mean squared error (rRMSE) were calculated for the different plots and samples sizes (s. formula 1 and 2). A negative exponential function was fitted to analyse the relationship between rRMSE and sample size (s. formula 3).

$$rBIAS = \frac{B}{\mu} = \frac{\sum_{i=1}^{n}(\overline{x_i} - \mu)/n}{\mu} \qquad [1]$$

with
rBIAS = relative bias
$\overline{x_i}$ = sample mean of structural group of four in repetition i
n = number of repetitions
μ = true mean of the population

$$rRMSE = \frac{\sqrt{s_x^2 + B^2}}{\mu} \qquad [2]$$

with
rRMSE = relative root mean squared error
s = standard deviation
B = bias
μ = true mean of the population

$$rRMSE = a \cdot nSAMPLES^{-b} \qquad [3]$$

with
rRMSE = relative root mean squared error
a, b = parameters
nSAMPLES = number of samples

Results of the simulation study reveal a considerable bias of sampling structural group of four, especially in respect to species mingling (Fig. 1). This problem is well-known (see e. g. Hui and Albert 2004), but yet unsolved. Calculation of necessary sample size shows that the clustered design is less susceptible to bias (Tab. 4). Anyhow, the necessary sample size often is so high that a full survey would be more efficient on the comparatively small Level II plots.

Tab. 4: Necessary sample size of structural groups of four to fall below a rRMSE of 5 or 10 %. Two different sample designs are distinguished: standard design with single groups and clustered design with 4 groups respectively (for details s. Hui and Albert 2004).

Rel. RMSE %	Parameter	N Samples Min.	Max.	Mean	UCL 95 %
Standard design					
5	Contagion	55	732.867	36.294	91.116
	Mingling	60	2.031.256	146.248	336.768
	DBH differentiation	82	2.403	286	458
10	Contagion	12	2.956	193	418
	Mingling	16	147.903	8.754	22.177
	DBH differentiation	23	233	53	68
Clustered design					
5	Contagion	10	429	42	73
	Mingling	25	55.457	4.376	9.441
	DBH differentiation	31	247	66	82
10	Contagion	3	14	5	6
	Mingling	6	7.261	670	1.352
	DBH differentiation	8	42	18	20

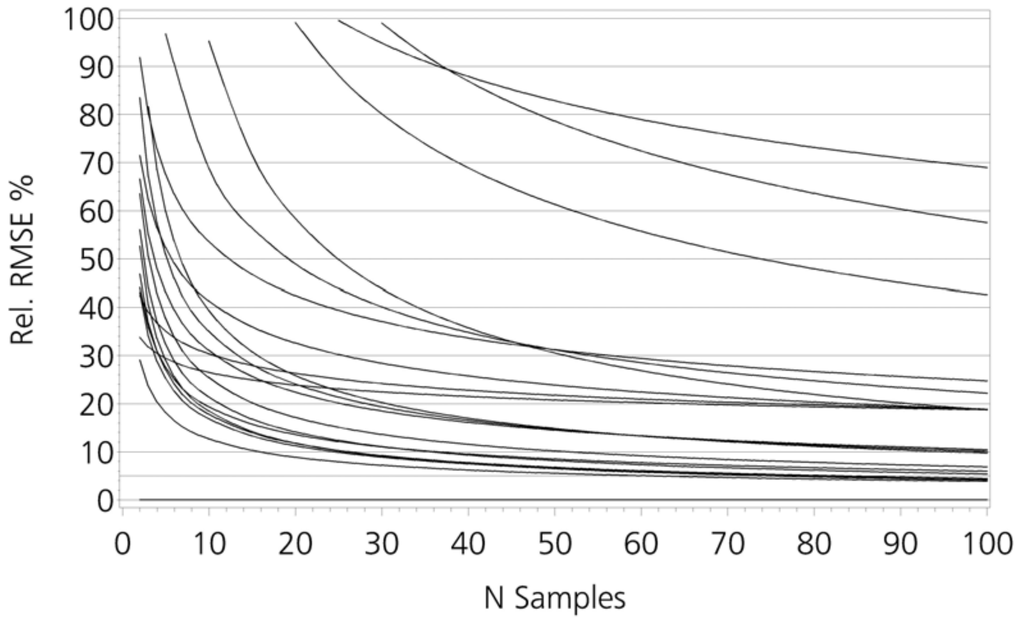

Fig. 1: Relationship between rRMSE and sample size for species mingling based on calculations for 23 Level II plots with full survey of tree coordinates. In many cases an error limit of 10 or 5 % can only be achieved with an extraordinarily high sample size.

On the basis of these results it was recommended to sample structural groups of four only in plots with high stem numbers of > 1,000 trees per ha.

5 Data processing

The Programme Coordinating Centre of ICP Forests, hosted by the Federal Researech Centre for Forestry and Forest Products in Hamburg, Germany created a database in MS Access™. Computations were carried out under SAS 8.2™. Source codes were written for data import and check of data quality and completeness. After correcting and completing, the data were analysed in following steps:

- Visualising tree positions and dbh in plot maps
- Detecting border trees
- Calculating spatially explicit indices for all trees ≥ 5 cm dbh. Border trees were only accepted as neighbors but not as central tree of a structural group or pair.
- Calculating indices without spatial relation
- Constructing height curves, if necessary
- Calculating tree and stand volume

6 Results

6.1 Visualization of tree distribution and detection of border trees

Under SAS 8.2™ a source code was written for the scalable display of the spatial tree distribution at ForestBIOTA plots. These tree distribution maps were used to check plausibility of plot size, spatial pattern and designation of border trees.
Fig. 2 shows an example of the different tree groups, which had to be distinguished prior to data analysis: trees inside the plot (green = accepted as central trees), border trees (red = only accepted as neighbours) and trees outside the plot (black = left aside for computation).

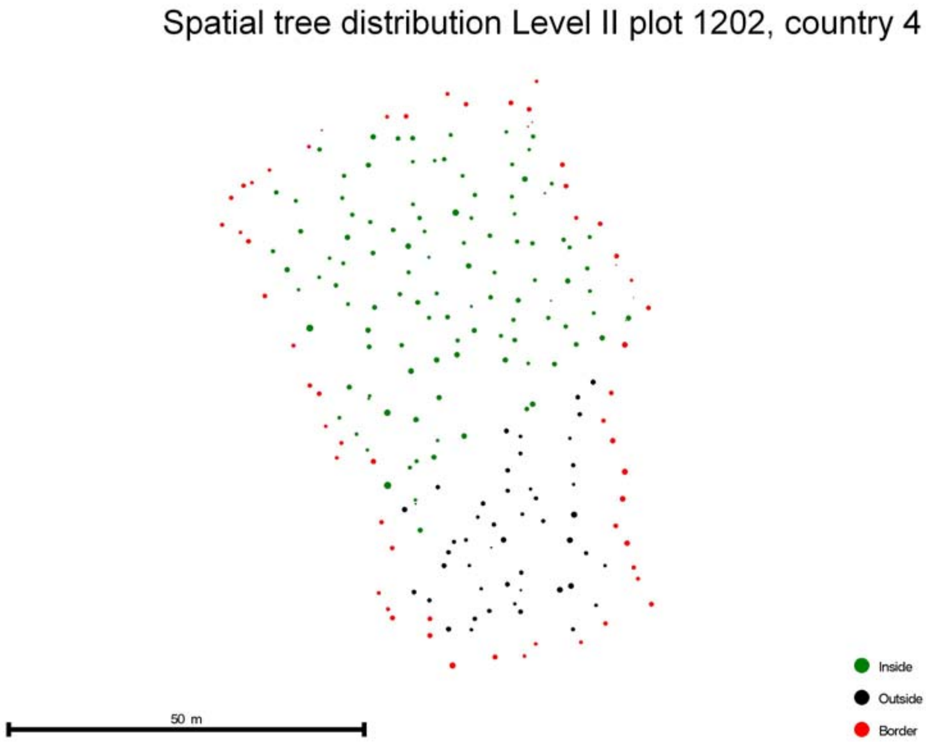

Fig. 2: Example of a tree distribution map showing trees inside the plot, border trees and trees outside the plot.

Border trees were detected as follows:

1. Each tree was defined as origin of a cartesian coordinate system and the x- and y-coordinates of all other trees in the frame of this system were calculated
2. If no trees could be found in two adjacent 45° sectors around the respective tree it was defined as border tree

As could be stated by visual check the routine worked reliable without exception.

The visual check revealed that the majority of plots is shaped rectangular and plot size did not deviate from the required 2500 m^2 except for minor deviations from the standard size in 4 cases (s. chapter 3.1).
Dbh visualisation revealed that circumference instead of diameter data had been submitted in three cases. Data were recalculated respectively.

6.2 Calculated indices

Indices characterizing stand structure were calculated according to Tab. 1. Some main results related to forest types are presented below (s. Fig. 3 - 9).

6.2.1 Tree species diversity

Tree species diversity is described by number of tree species (Fig. 3), Shannon index (Fig. 4) and mean mingling (Fig. 5).

Results are shown only for those plots, where calculation of all indices was possible and forest type information was available (n= 84). Forest types have been condensed to 8 main types in order to ensure sufficient plots per type. All other types were summarized to the group ‘Others’.

No obvious and general relationship between forest type and tree spcies diversity can be detected. Nevertheless high diversity values seem to be associated with plots of the Meso-eutrophic Oak Forests and Mountainous Mixed Beech Forests. An in-depth analysis is necessary to assure or reject possible relationships.

6.2.2 Spatial tree distribution

Spatial tree distribution is described by the Clark and Evans index (Fig 6) and the mean contagion (Fig. 7).

The visual comparison reveals that results of the two indices seem to be rather comparable. Clumped tree distributions indicated by a Clark and Evans value below 1.0 and a mean contagion above 0.5 occur mainly on plots of Mediterranean Broadleaved forests while random to regular spatial patterns seem to be typical for the plots classified as Taiga Woodlands and Coniferous Plantations. However, the range of contagion values is rather small. Thus differences between plots are not as prominent as compared to the Clark Evans Index.

6.2.3 Differentiation

Diameter differentaition is described by the mean diameter differentiation (Fig. 8) and the standard deviation of dbh (Fig. 9).

Both paramters indicate that especially the plots in Beech Forests and Fir/Spruce Woodlands are highly differentiated. The results of both indices are rather compatible.

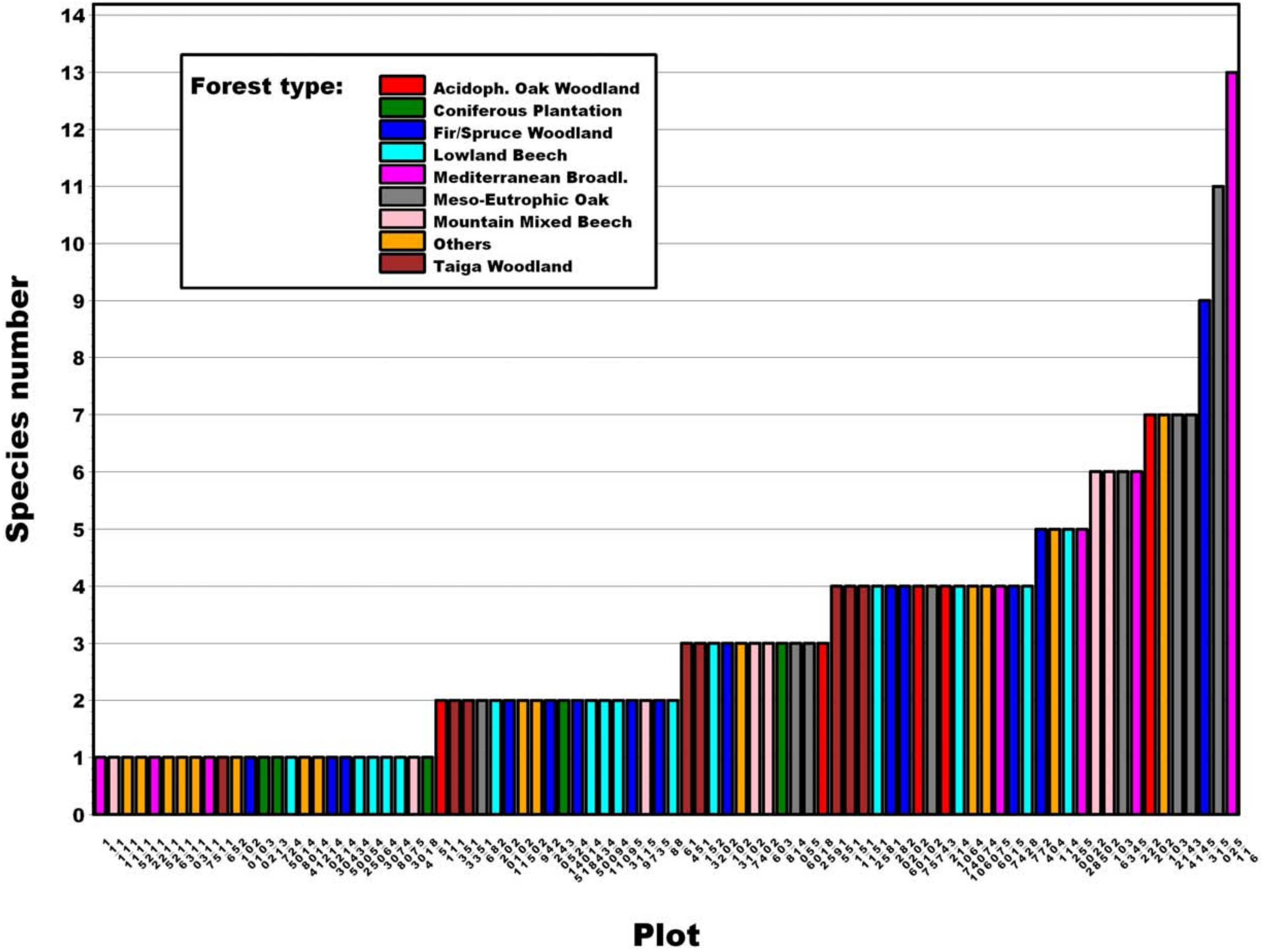

Fig. 3: Number of tree species per plot (country-plot nr.) and forest type in ascending order.

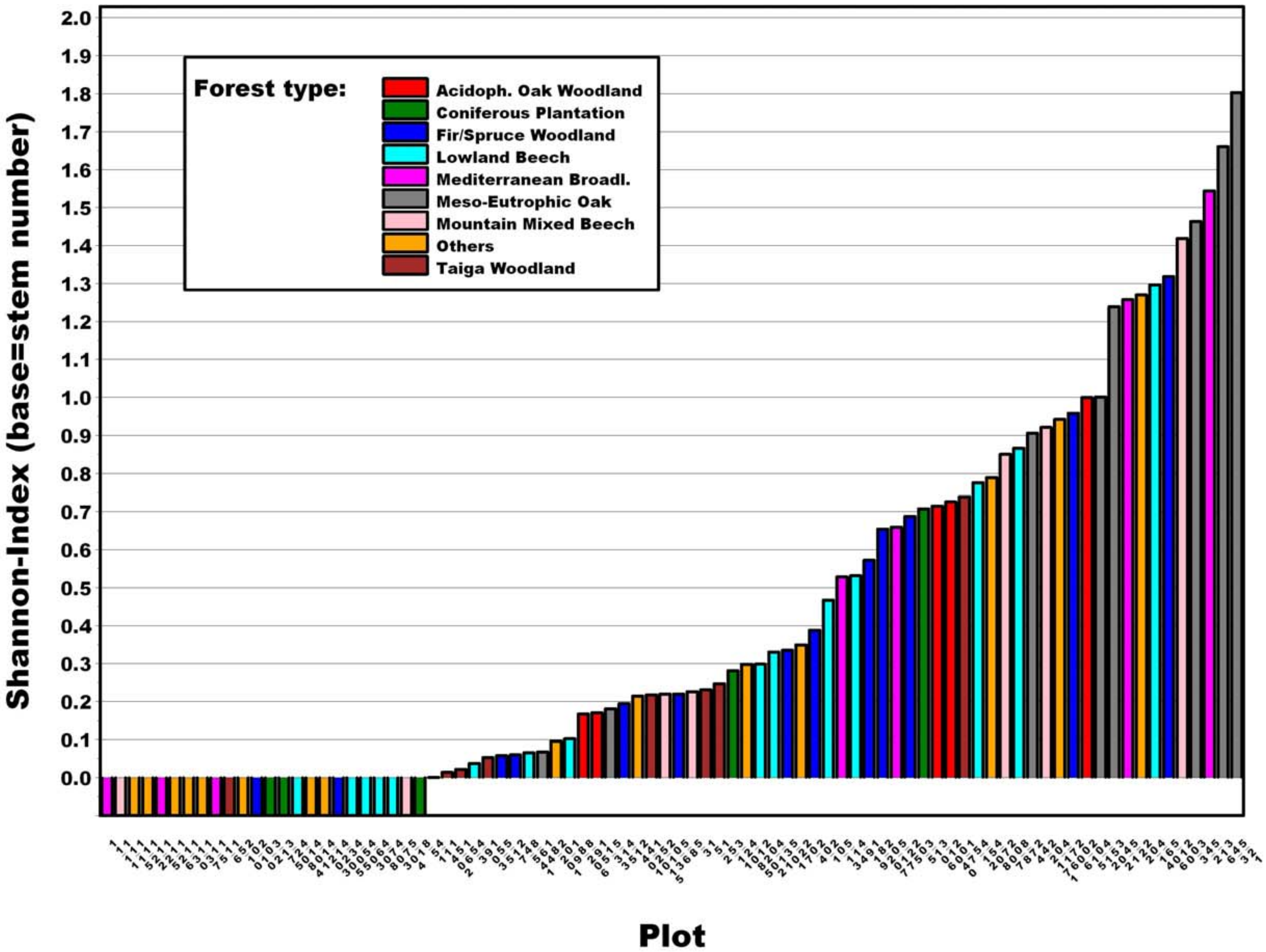

Fig. 4: Values of the Shannon index of tree species diversity per plot (country-plot nr.) and forest type in ascending order.

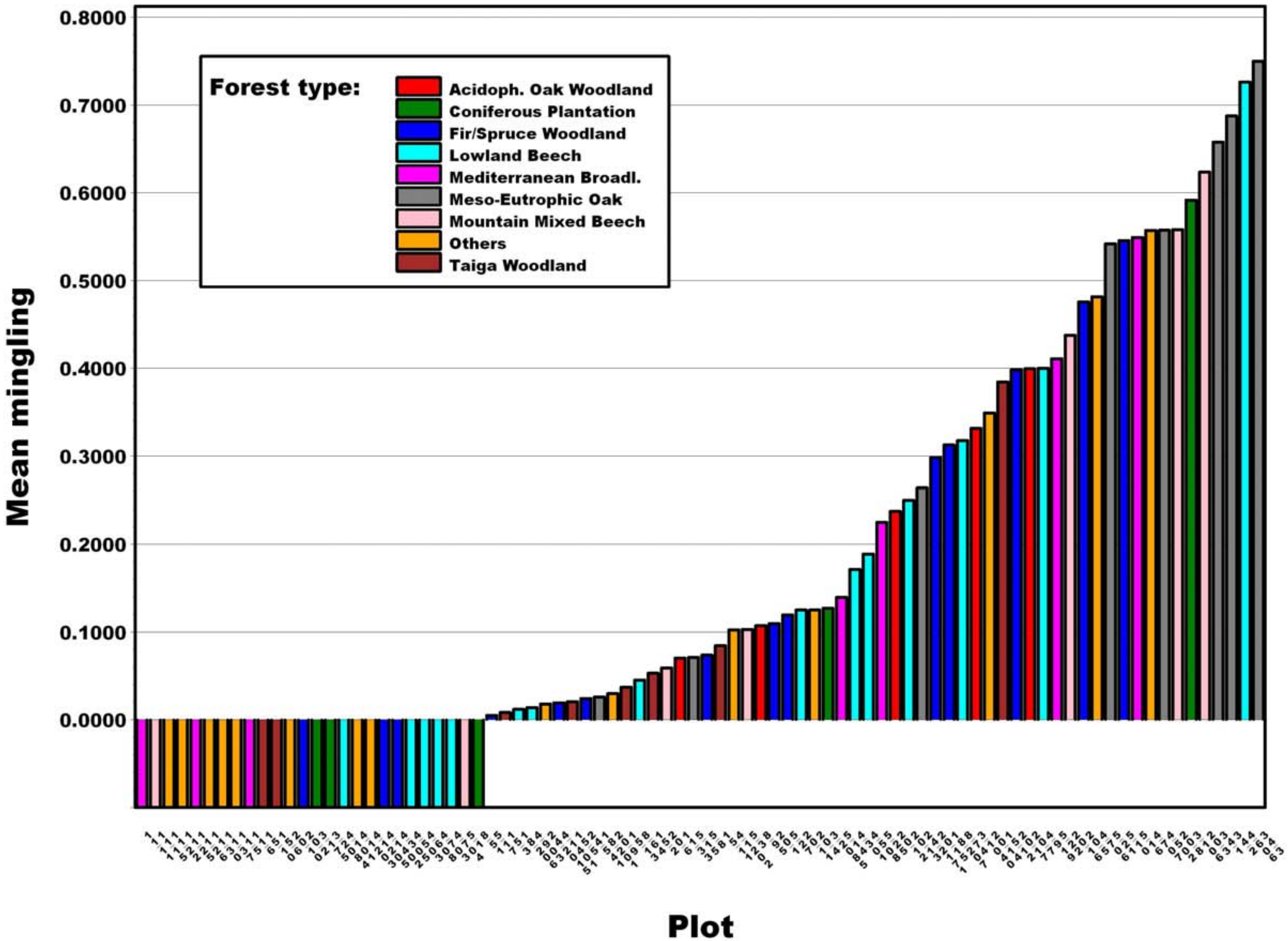

Fig. 5: Values of mean mingling per plot (country-plot nr.) and forest type in ascending order.

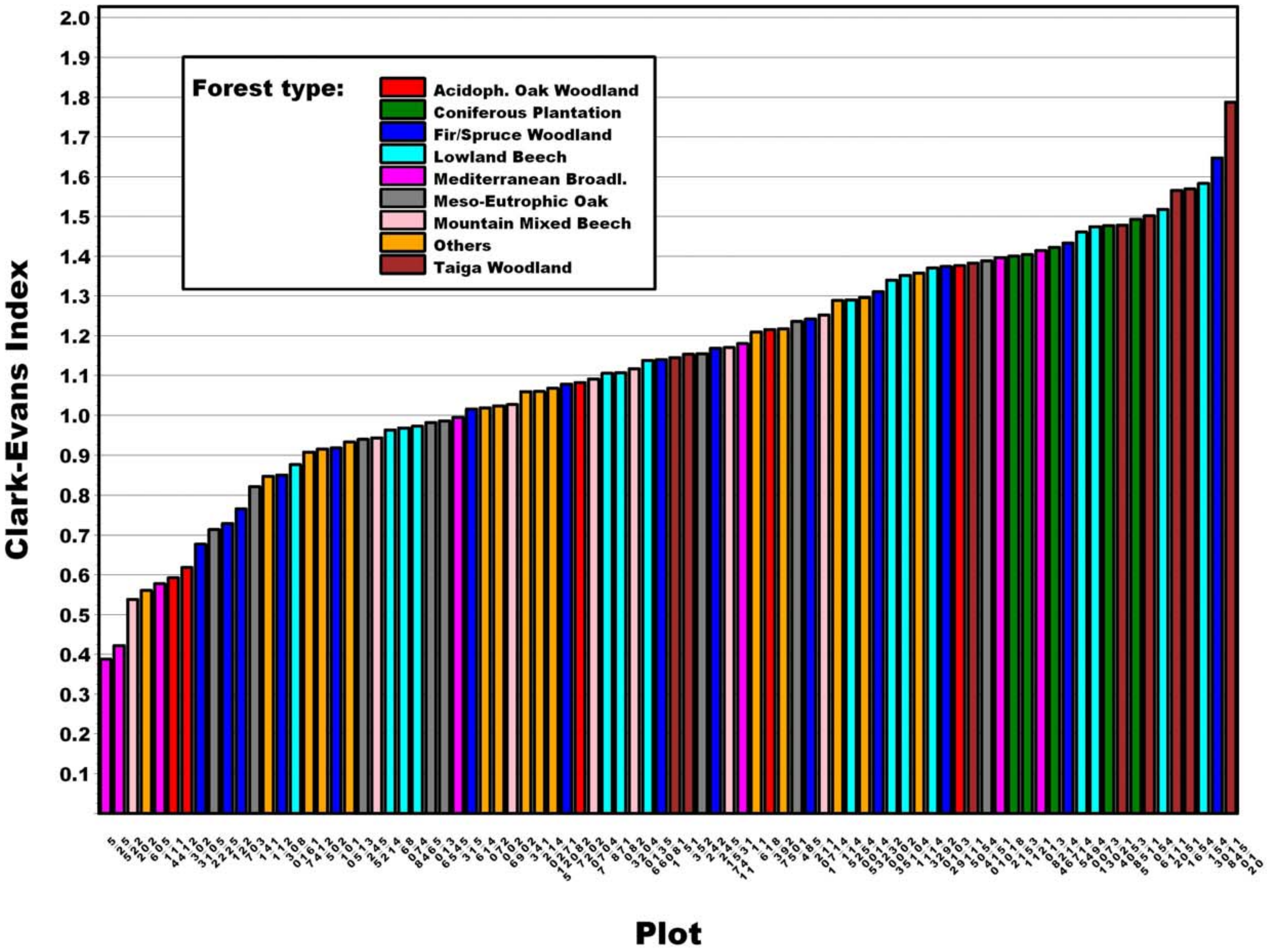

Fig. 6: Values of the Clark and Evans index per plot (country-plot nr.) and forest type in ascending order.

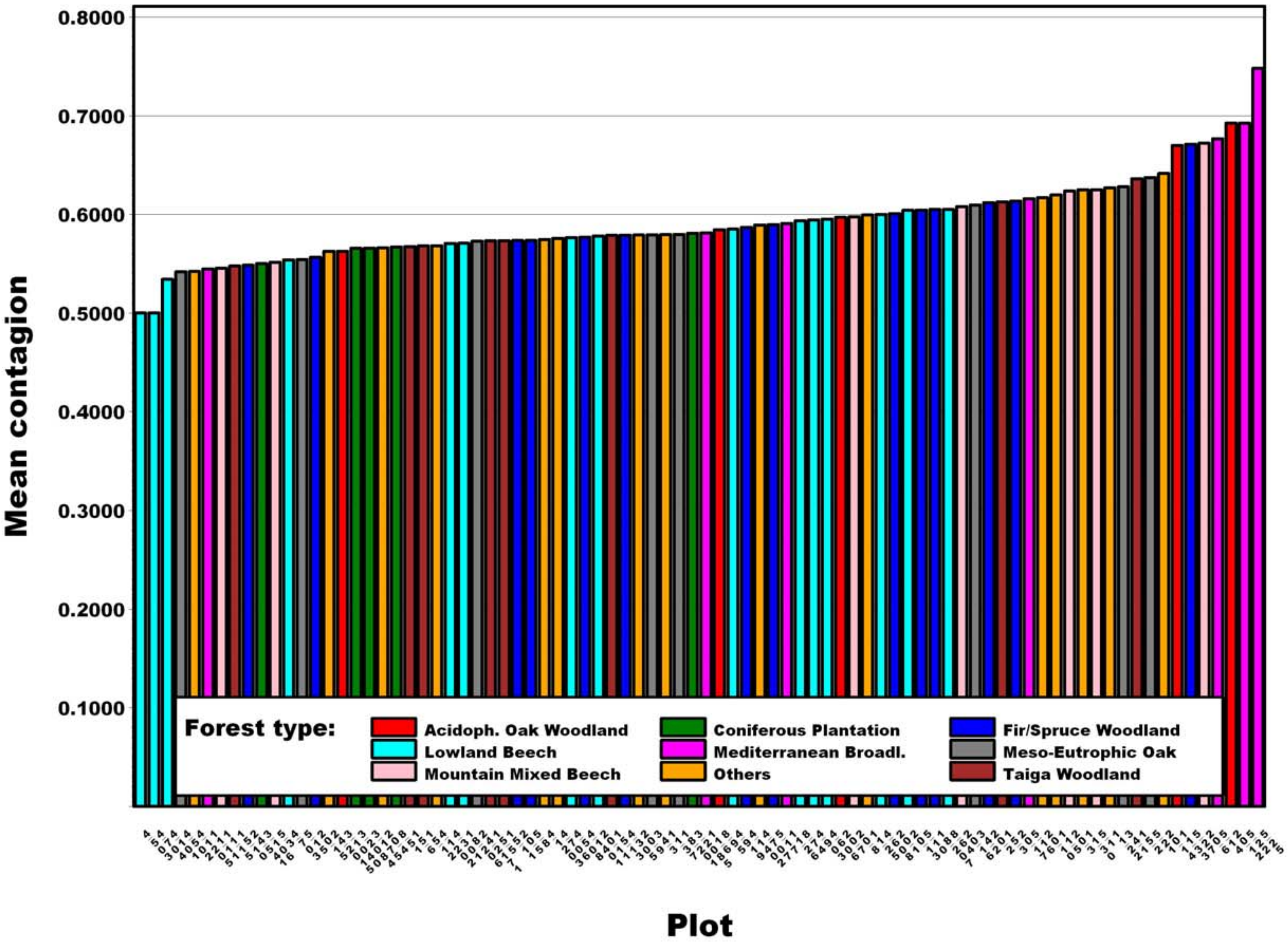

Fig. 7: Values of the mean contagion per plot (country-plot nr.) and forest type in ascending order.

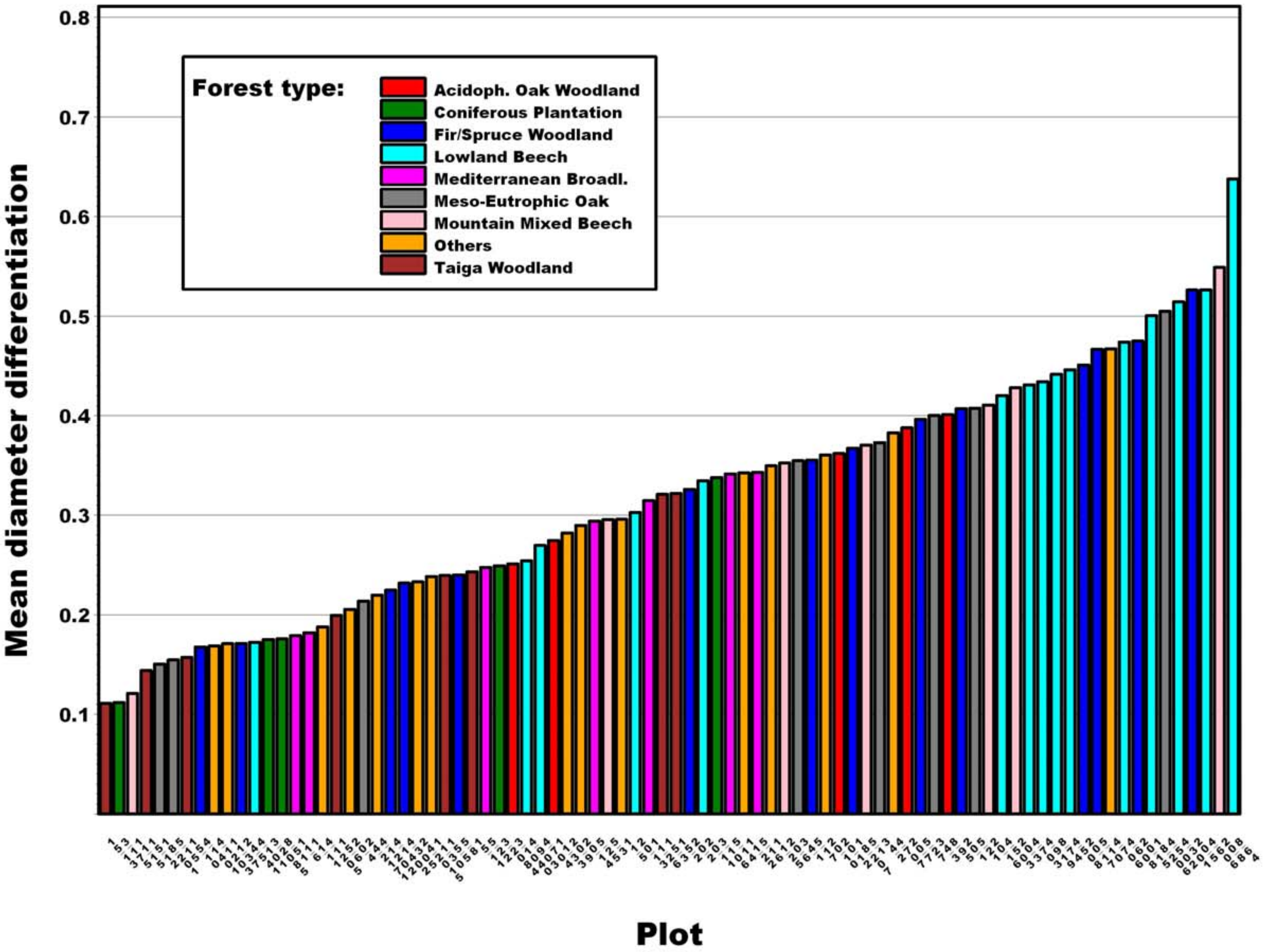

Fig. 8: Values of the mean diamter differentiation per plot (country-plot nr.) and forest type in ascending order.

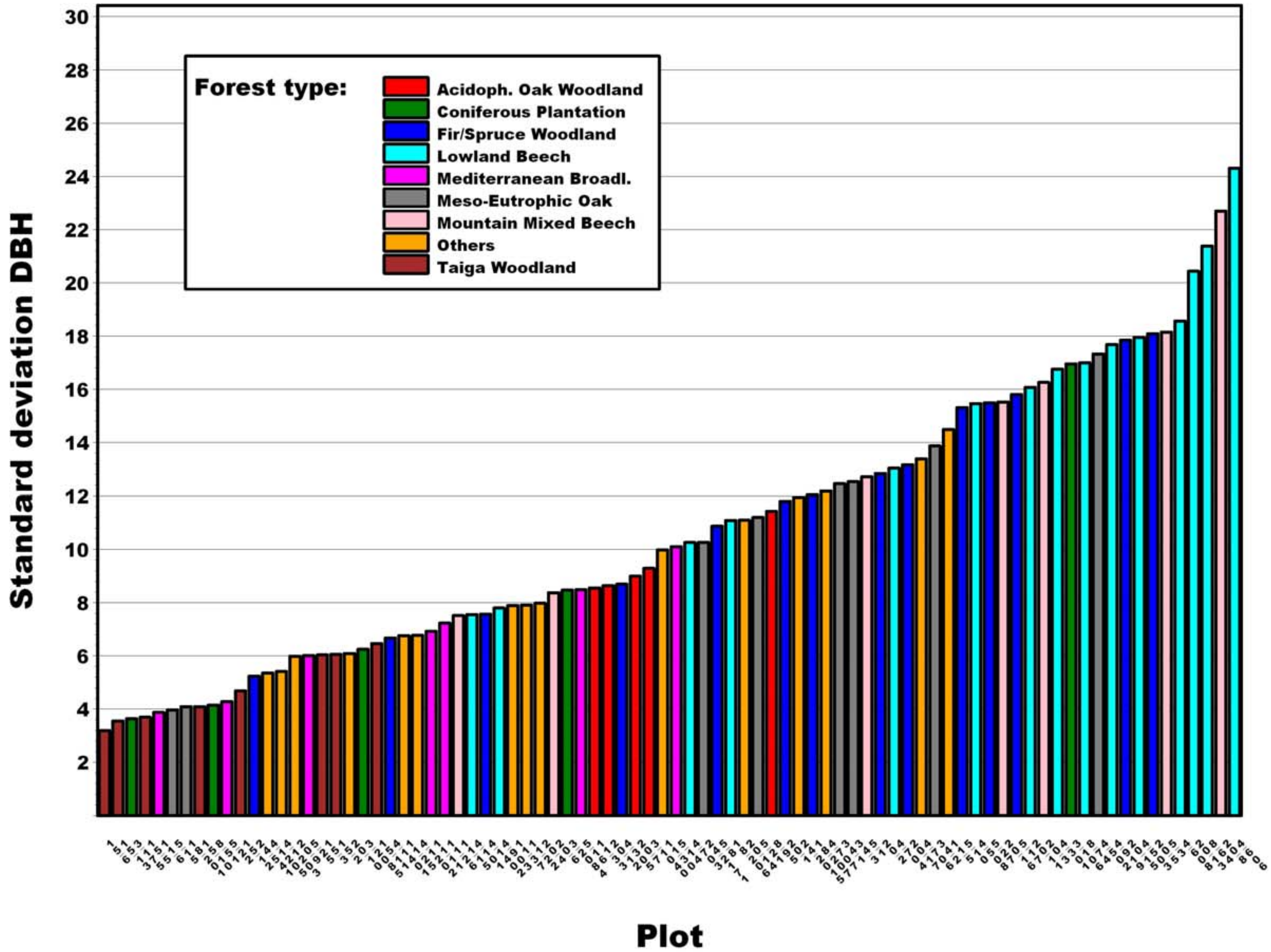

Fig. 9: Standard deviation of dbh per plot (country-plot nr.) and forest type in ascending order.

6.3 Significance of simple estimates

Simple estimates can be assessed easier than the attributes necessary to derive calculated indices. They might therefore be considered an alternative.

As can be shown by non-parametric test statistics calculated indices differ significantly between classes of simple estimates (Tab. 5). Thus simple estimates can reflect differences in stand structure to a certain degree. Nevertheless it is questionable whether they are sufficiently exact to substitute calculated indices.
Furthermore comparison between calculated indices and simple estimates is limited because they do not correspond directly to one another (e. g. Type of species mixture estimates species diversity as well as spatial distribution)
Another aspect is that that classes of simple estimates had to be condensed in order to increase and balance sample size: concerning the parameter ‘number of tree layers’ the classes ‘multilayered’ and ‘irregular’ were fused, concerning ‘type of tree species mixture’ in contrast to ‘monocultures’ (50 samples) all other ‘mixed stands’ were fused to one class. This shows the difficulties of the statistical analysis of simple estimates in case that plots are selected without pre-stratification. Simple estimates could well be used as stratification criterion for plot selection in order to gain a balanced dataset.

Tab. 5: Results of Kruskal-Wallis tests on significant differences between classes of simple estimates in respect of calculated indices (propability of a higher Chi-square value, n. s. = not significant). Simple estimates had to be condensed in order to increase and balance sample size per class (s. text).

Calculated index	**Simple estimate**	
	Number tree layers	**Type species mixture**
Clark Evans index	<0.01	<0.05
Contagion index	<0.05	n. s.
Mingling index	n. s.	n. s.
Diameter differentiation	<0.001	<0.001
Standard deviation dbh	<0.01	<0.001
Shannon index (stem number)	n. s.	<0.001
Evenness (stem number)	<0.01	<0.001
Shannon index (basal area)	n. s.	<0.001
Evenness (basal area)	<0.01	<0.001
Simpson index (stem number)	n. s.	<0.001
Simpson index (basal area)	n. s.	<0.001
Species profile index	n. s.	<0.001
Evenness species profile index	n. s.	<0.001

6. 4 Calculation of volume

Exact volume calculation requires dbh and height values for all trees on a Level II plot. These values are input parameters for volume functions. For 82 out of 95 plots sampled height values were available. Dbh-height relations were derived on the basis of formula 4 (Petterson-function s. Kramer and Akça 1995). Subsequently volume per ha was computed by the PCC and the expert on the basis of volume functions specific for country and tree species.

$$h = 1.3 + \left(\frac{dbh}{a + b \cdot dbh} \right)^3 \qquad [4]$$

where
h = tree height [m]
dbh = diameter at breast height [cm]
a, b = parameters

7 Recommendations

Based on the outcomes of the data analysis the following recommendations can be given:

In order to guarantee comparable results plot shape and not only plot size should be harmonized. Irregular or transect-like shape increases border effects and reduces the proportion of central trees (s. chapter 6.1). It must therefore be recommended to observe the plot configuration rules (s. chapter 3.1) strictly.

On a first glance the calculated indices show comparable results. Nevertheless reliable conclusions about correlations between indices as well as their validity can only be drawn after in-depth data analysis. Considering the variability between plots, almost all indices reflect differences of stand structure seemingly well. An exception might be the mean contagion. After these first evaluations, the calculated indices fulfilled the requirements with respect to sensitivity, comparability and validity.

The inventory of the attributes dbh, tree species, height and coordinates allows for a multitude of subsequent calculations. Therefore the applied inventory design can be recommended without restrictions.

The full survey of coordinates is recommended because of the high potential of spatially explicit indices for data analysis. In addition, coordinates help to re-identify trees in the course of repeated surveys.

Full survey of tree heights might on the one hand be too labour intensive. On the other hand it is a prerequisite for exact results concerning vertical structure. As an alternative, trees can be assigned to height bands (s. Tab. 1). In any case, height values are needed for volume calculations. A final recommendation concerning the number of necessary height measurements can therefore not be given.

Concerning simple estimates the results of future in-depth data analysis must be taken in consideration. Yet no recommendations can be given. However it becomes apparent that they can not serve as an equivalent substitute of calculated indices., Estimating height bands might Probably be an alternative to the full survey of tree heights.

Literature cited

Albert, M.; Gadow, K. von (1998). Assessing biodiversity with new neighbourhood-based parameters. in: *Data Management and Modelling Using Remote Sensing and GIS for Tropical Forest Land Inventory. Y. Iaumonier, B. King, C. Legg and K. Renolls (eds.) Proceedings of the FIMP-INTAG International Conference, October 26-29, 1998, Jakarta, Indonesia*, pp. 433-445.

Anonymus (2004): Stand structure assessments including deadwood within the EU/ICP Forests Biodiversity Test-Phase (ForestBIOTA). Working paper, ForestBiota, s. http://www.forestbiota.org/docs/

Chirici, C.; Marchetti, M. (2003): Proposal of deadwood monitoring protocol in ForestBiota. Working paper, ForestBiota, s. http://www.forestbiota.org/docs/struct1.doc.

Clark, P.J.; Evans, F.C. (1954). Distance to nearest neighbour as a measure of spatial relationships in populations. *Ecology,* 35, pp. 445-453.

Fisher, R.; Pommerening, A. (2003): Methodology for stand structure assessments in the biodiversity test phase 2003 - 2005 of EU/ICP Forests. Working paper, ForestBiota, s. http://www.forestbiota.org/docs/.

Gadow von, K.; Füldner, K. (1995). Zur Beschreibung forstlicher Eingriffe. *Forstw. Cbl.* 114, pp. 151-159.

Gadow. K. von; Hui, G.Y.; Albert, M. (1998). The neighbouhood pattern - a new parameter for describing forest structures. *Centralblatt. Gesamtes Forstwesen,* 115, pp. 1-10.

Hui, G.Y.; Albert, M (2004): Stichprobensimulationen zur Schätzung nachbarschaftsbezogener Strukturparameter in Waldbeständen. *Allg. Forst- und Jagdzeitung*, 175 (10/11), pp. 199-209.

Kramer, H.; Akça, A. (1995). Leitfaden für Dendrometrie udn bestandesinventur. J. D. Sauerländer’s verlag, Frankfurt a. M., 266 p.

Meyer, P. (2004): ForestBiota: Work package 1.1. Proposal for the assessment of stand structure. Working paper, ForestBiota, s. http://www.forestbiota.org/docs/.

Neumann, M.; Starlinger, F. (2001). The significance of different indices fo stand structure and diversity in forests in: *Forest Ecology and Management* 145, pp. 91-106.

Pielou, E.C. (1959). The use of point to plant distances in the study of the pattern of plant populations. *J. Ecol.,* 47, pp. 607-613.

Pielou, E.C. (1975). Ecological diversity. Wiley, New York, London, Sidney, Toronto, 165 p.

Pommerening, A. (2002). Approaches to quantifying forest structures. *Forestr,y* 75, pp. 305-324.

Pretzsch, H. (1996). Strukturvielfalt als Ergebnis waldbaulichen Handels. *Allg. Forst u. J.-Zeitung,* 166, pp. 213-221.

Shannon, C.E. (1948). The mathematical theory of communication in: *Shannon, C.E.; Weaver, W. (Eds.). The Mathematical Theory of Communication. University of Illinois Press, Urbana*, pp. 29-125.

Simpson, E.H. (1949). Measurement of diversity. *Nature,* 163, pp. 688.

Annex 1: Plausibility SAS 8.2 dataset [edited version of ForestBIOTA_treedata_07_02_06.mdb]

Number of observations

Country	Plot Nr.	Total	Within plot	Within plot				
				DBH	Height	Species	x	y
1	36	12	12	12	0	12	0	0
1	37	6	6	6	0	6	0	0
1	42	12	12	12	0	12	0	0
1	53	6	6	6	0	6	0	0
1	76	12	12	12	0	12	0	0
3	106	59	59	59	58	59	59	59
3	175	65	65	65	64	65	65	65
3	1040	91	91	91	89	91	91	91
3	2084	165	165	165	165	165	165	165
3	2085	101	101	101	100	101	101	101
4	101	42	42	42	32	42	42	42
4	301	135	135	135	0	135	129	129
4	305	112	112	112	8	112	112	112
4	502	131	63	62	33	63	63	63
4	503	159	42	42	15	42	42	42
4	508	239	64	64	17	64	64	64
4	603	15	15	15	0	15	0	0
4	606	65	65	62	0	65	65	65
4	608	135	44	44	0	44	43	43
4	703	180	180	180	180	180	180	180
4	704	48	48	48	48	48	48	48
4	706	247	247	247	247	247	246	246
4	707	103	103	103	0	103	103	103
4	903	165	165	165	165	165	165	165
4	919	85	85	85	54	85	85	85
4	1202	219	146	146	119	146	146	146
4	1203	116	79	79	79	79	79	79
4	1205	227	148	148	126	148	148	148
4	1401	118	81	81	0	81	81	81
4	1402	252	99	99	0	99	99	99
5	1	237	237	237	58	237	237	237
5	3	69	69	69	49	69	69	69
5	8	130	130	130	54	130	130	130
5	10	236	236	236	51	236	236	236
5	14	319	319	319	48	319	319	319
5	15	179	179	179	53	179	179	179
5	16	490	490	490	62	490	490	490
5	17	97	97	97	51	97	97	97
5	21	398	398	398	58	398	398	398
5	22	1060	1060	1060	78	1060	1060	1060
5	25	765	765	765	57	765	765	765
5	27	180	180	180	61	180	180	180
8	51	165	165	165	0	165	165	165
8	64	84	84	84	0	84	84	84
8	74	157	157	157	0	155	157	157
8	95	118	118	118	0	118	118	118
9	209	206	206	206	206	206	206	206
9	309	114	114	114	114	114	114	114
9	409	86	86	86	86	86	86	86
11	5	152	152	152	148	152	152	152
11	6	162	162	162	17	162	162	162

Number of observations (continued)

Country	Plot Nr.	Total	Within plot	Within plot				
				DBH	Height	Species	x	y
11	10	101	101	101	101	101	101	101
11	11	53	53	53	53	53	53	53
11	15	30	30	30	30	30	30	30
11	22	98	98	98	98	98	98	98
11	25	101	101	101	101	101	101	101
11	26	30	30	30	30	30	30	30
11	30	123	123	123	123	123	123	123
11	33	49	49	49	49	49	49	49
11	37	45	45	45	45	45	45	45
11	102	97	97	97	91	97	97	97
15	2	468	168	168	168	168	168	168
15	3	592	301	301	301	301	301	301
15	5	1147	426	426	426	426	426	426
15	6	1230	441	441	441	441	441	441
15	10	296	87	87	87	87	87	87
15	11	554	197	197	197	197	197	197
15	12	410	173	173	173	173	173	173
15	13	341	154	154	154	154	154	154
18	201	160	160	160	148	160	160	160
18	206	253	253	252	242	253	253	253
18	207	254	254	254	252	253	254	254
20	1	153	153	153	148	153	153	153
20	2	141	66	66	61	66	66	66
20	3	238	134	134	123	134	134	134
20	4	112	65	65	65	65	65	65
20	5	190	83	83	81	83	83	83
20	6	493	363	363	258	363	363	363
20	7	410	251	251	245	251	251	251
20	8	195	123	123	119	123	123	123
20	9	697	413	413	366	413	413	413
20	10	613	395	395	381	395	395	395
20	11	72	34	34	34	34	34	34
20	12	462	286	286	210	286	286	286
20	13	84	43	43	42	43	43	43
20	14	123	95	95	79	95	95	95
20	15	264	137	137	134	137	137	137
20	16	152	71	71	71	71	71	71
20	17	310	155	155	150	155	155	155
24	541	93	93	93	92	93	93	93
24	2015	54	54	54	54	54	54	54
24	2171	90	90	90	90	90	90	90
34	1	128	128	128	0	128	128	128
34	2	134	134	134	15	134	134	134
34	3	120	120	120	15	120	120	120

Coordinates

Country	Plotnr	Length				Unit
		X axis	Y axis	80 % X axis	80 % Y axis	
1	36					
1	37					
1	42					
1	53					
1	76					
3	106	84.188	58.812	61.969	38.938	m
3	175	53.969	80.594	35.719	58.125	m
3	1040	56.641	124.844	36.157	99.093	m
3	2084	86.359	52.813	58.781	31.5	m
3	2085	79.11	71	56.531	49.875	m
4	101	55.802	59.42221	35.94339	38.15718	m
4	301	49.4	50.3	39.7	40.7	m
4	305	57.57	58	37.3	38.74	m
4	502	53934	100792	40597	79185	mm
4	503	54.32065	50.69361	39.38676	38.51271	m
4	508	131462	129826	80474	81831	mm
4	603					
4	606	72.2487	53.2272	39.5772	26.1405	m
4	608	92.93819	85.45039	63.71633	58.12019	m
4	703	60.39152	38.7378	48.65598	33.460605	m
4	704	54.01339	50.07592	40.95682	40.4313	m
4	706	54.23621	58.46932	33.26497	39.25651	m
4	707	55.978	52.645	37.34	33.524	m
4	903	74.269	69.709	43.056	45.488	m
4	919	55.003	60.57	40.649	45.984	m
4	1202	60.4071	82.1261	39.1815	60.4951	m
4	1203	41.1135	82.6225	32.1528	66.4861	m
4	1205	81.2568	47.61968	63.76944	33.54875	m
4	1401	71799	72678	41175	49237	mm
4	1402	102586	98890	62978	62458	mm
5	1	49.64913	48.1701	42.33213	41.4508	m
5	3	46	47.375	43.125	42.625	m
5	8	49.82457	48.58408	42.324565	38.62832	m
5	10	49.02883	49.73684	36.90476	41.28241	m
5	14	49.73	49.46429	41.97889	37.72835	m
5	15	38.5	68.2	28.2	56.1	m
5	16	49.58621	49.07408	44.43583	38.14815	m
5	17	79.08144	37.96875	68.0303	25.9375	m
5	21	49.3	48.8	40.2	36	m
5	22	49	46.6176	37.98035	37.7589	m
5	25	49.5147	49.7827	40.0762	39.0701	m
5	27	49.25	50	40.875	40.375	m
8	51	49	48	38	38	m
8	64	48	48	41	42	m
8	74	48	49	38	40	m
8	95	48	49	40	44	m
9	209	43.995	71.918000001	30.931	54.777	m
9	309	71.016	52.682	48.899	37.640000001	m
9	409	41.0559	74.49883	30.06229	63.72917	m
11	5	65.65693	54.955060001	39.98015	38.688130001	m
11	6	54.73149	46.89516	39.74319	37.02029	m
11	10	54.46928	44.62295	38.76136	29.80303	m
11	11	56.28986	63.70401	38.45116	39.425989999	m
11	15	66.07551	52.65844	58.50125	36.465065	m
11	22	66.41508	63.51672	40.4866	37.63198	m

Coordinates (continued)

Country	Plotnr	Length				Unit
		X axis	Y axis	80 % X axis	80 % Y axis	
11	25	61.25278	53.60309	37.47271	36.22306	m
11	26	53.16295	47.34398	39.961985	38.9397	m
11	30	46.03138	49.7927	35.57037	39.89687	m
11	33	21.21803	32.42371	17.64785	19.16973	m
11	37	50.34806	64.78262	37.94752	44.18521	m
11	102	58.97589	65.57239	43.6623	39.929579999	m
15	2	92.76	102.71	57.2	74.86	m
15	3	79.26	93.99	53.43	62.19	m
15	5	90.9	101.08	62.08	70.25	m
15	6	88.04	150.63	54.985	90.56	m
15	10	122.8	105.88	78.65	62.529999999	m
15	11	99.35	98.68	62.83	63.21	m
15	12	121.41	93.34	82.895	60.970000001	m
15	13	97.36	85.9	58.43	56.57	m
18	201	49.295	55.111	38.9925	41.4995	m
18	206	51.23	49.952000001	37.673	40.317	m
18	207	53.92	53.382999999	36.485	36.547	m
20	1	36.232	48.713	24.493	39.691	m
20	2	95.357	63.532	70.323	46.654	m
20	3	92	119.95	69.74	100.14	m
20	4	121.37	64.018	102.003	40.823	m
20	5	60.587	95.011	41.3805	74.6205	m
20	6	77.457	105.052	49.236	76.701	m
20	7	95.426	90.493	64.9155	58.138	m
20	8	54.361	56.98	42.11	37.144	m
20	9	137.122	129.382	106.667	97.753	m
20	10	86.064	109.193	59.418	80.327	m
20	11	78.253	59.503	49.794	41.119	m
20	12	75.896	98.791	53.471	77.935	m
20	13	64.319	52.018	43.01	38.567	m
20	14	49.996	76.953	27.849	57.559	m
20	15	62.764	66.377	40.268	41.024	m
20	16	79.309	130.448	50.246	110.622	m
20	17	57.708	58.847	40.891	42.27	m
24	541	49.286	48.055	34.835	39.278	m
24	2015	46.835	45.713	38.308	32.081	m
24	2171	51.552	51.669	38.203	42.0335	m
34	1	5419.85854	6208.13967	3582.3446	4039.61453	cm
34	2	4874.88588	5020.71585	3979.10284	3766.56033	cm
34	3	5096.94804	5228.782	3975.96276	4066.709675	cm

DBH and height

Country	Plotnr	Min. DBH	Max. DBH	Min. height	Max. height	10th percentil DBH	90th percentil DBH	10th percentil height	90th percentil height
1	36	37.00	37.00			37.00	37.00		
1	37	31.00	45.00			31.00	45.00		
1	42	16.00	43.00			25.00	42.00		
1	53	32.00	58.00			32.00	58.00		
1	76	20.00	52.00			20.00	44.00		
3	106	6.70	80.40	6.60	34.20	26.80	69.00	20.10	31.90
3	175	20.70	36.60	15.20	21.80	24.90	33.50	17.20	21.00
3	1040	10.10	50.20	5.50	23.50	16.50	40.50	11.65	20.00
3	2084	12.20	59.10	2.40	31.20	18.10	39.60	21.40	27.60
3	2085	3.00	43.20	5.00	20.40	20.50	35.10	13.50	18.90
4	101	29.90	60.90	26.00	38.00	41.10	59.20	29.00	35.00
4	301	4.60	76.90			7.40	47.50		
4	305	20.60	63.10	30.70	36.40	28.70	51.90	30.70	36.40
4	502	6.40	76.15	12.59	33.30	12.15	58.95	14.80	30.68
4	503	13.85	74.81	18.00	38.72	19.90	63.63	21.00	37.80
4	508	10.70	62.98	17.46	36.89	12.70	54.39	18.36	33.25
4	603	17.00	59.00			17.20	54.60		
4	606	5.10	72.70			6.00	60.90		
4	608	12.00	70.00			15.50	60.50		
4	703	6.00	46.50	1.80	28.10	10.50	35.70	11.85	25.75
4	704	14.50	71.40	19.80	41.50	20.40	59.10	24.00	39.20
4	706	2.90	57.50	3.20	34.20	7.10	44.00	7.80	31.00
4	707	6.40	59.20			15.30	47.58		
4	903	14.48	54.23	14.50	33.20	20.50	41.60	21.80	28.90
4	919	13.92	71.74	13.30	37.30	14.82	58.62	16.70	34.70
4	1202	5.40	49.00	9.00	30.00	22.30	37.00	22.00	28.00
4	1203	24.00	53.00	18.00	29.00	27.00	40.00	21.00	26.00
4	1205	0.00	43.70	17.00	31.00	21.00	34.60	21.00	27.00
4	1401	23.00	55.00			29.00	44.00		
4	1402	21.00	54.00			25.00	45.00		
5	1	4.14	56.00	5.80	29.80	5.89	41.06	14.40	27.30
5	3	4.30	72.42	12.50	33.90	8.28	65.89	22.00	32.60
5	8	3.50	63.66	8.50	37.50	8.51	47.51	25.30	35.30
5	10	5.09	74.17	6.60	29.60	6.37	45.68	10.90	28.40
5	14	3.66	70.35	1.70	22.40	6.05	28.49	6.40	19.00
5	15	7.32	34.38	12.00	25.20	15.60	26.10	14.50	21.30
5	16	0.00	60.16	4.00	30.90	4.14	20.37	9.20	19.40
5	17	5.09	66.21	3.90	35.10	14.01	58.57	26.10	34.20
5	21	3.18	65.25	4.90	27.70	3.82	23.87	10.40	26.30
5	22	2.86	33.58	4.10	13.80	3.98	15.60	6.20	11.90
5	25	0.00	72.26	4.10	19.10	4.77	17.67	10.00	17.20
5	27	5.57	77.35	3.70	29.30	6.60	43.61	5.60	26.50
8	51	12.00	35.00			18.00	28.00		
8	64	6.00	68.00			8.00	61.00		
8	74	5.00	111.00			6.00	41.00		
8	95	5.00	50.00			8.00	40.00		
9	209	5.60	46.00	2.30	21.00	7.60	34.90	6.50	19.00
9	309	9.50	69.10	5.20	31.10	21.50	48.70	21.30	29.50
9	409	8.80	74.90	5.00	32.80	16.90	62.80	8.30	30.50
11	5	9.00	77.00	5.00	34.00	13.00	53.00	8.00	20.00
11	6	11.00	31.00	6.00	10.00	14.00	24.00	6.00	9.00
11	10	9.00	33.00	6.00	12.00	16.00	28.00	8.00	11.00
11	11	26.00	68.00	6.00	14.00	31.00	46.00	7.00	11.00
11	15	33.00	64.00	20.00	39.00	39.50	58.50	25.00	33.50

DBH and height (continued)

Country	Plotnr	Min. DBH	Max. DBH	Min. height	Max. height	10th percentil DBH	90th percentil DBH	10th percentil height	90th percentil height
11	22	11.00	47.00	1.00	17.00	14.00	35.00	6.00	15.00
11	25	8.00	33.00	5.00	13.00	10.00	29.00	7.00	11.00
11	26	9.00	43.00	4.00	10.00	16.00	33.50	6.00	9.00
11	30	7.00	56.00	0.00	23.00	16.00	41.00	13.00	21.00
11	33	8.00	46.00	4.00	27.00	11.00	33.00	8.00	22.00
11	37	16.00	62.00	8.00	21.00	30.00	49.00	11.00	18.00
11	102	9.00	57.00	6.00	28.00	14.00	49.00	11.00	25.00
15	2	2.90	32.45	2.90	14.60	5.45	23.55	5.70	12.60
15	3	1.45	35.95	1.90	18.20	4.15	18.00	3.50	11.40
15	5	4.05	27.85	1.60	15.40	7.70	17.35	6.80	13.00
15	6	5.85	23.60	5.60	17.10	9.50	17.45	11.20	15.30
15	10	0.00	34.90	0.00	27.40	21.70	31.80	20.40	24.70
15	11	8.25	40.35	7.70	29.00	15.55	31.65	15.90	25.00
15	12	0.00	33.20	0.00	25.40	15.50	28.10	16.00	22.90
15	13	0.00	36.85	0.00	23.70	18.25	26.90	19.10	21.90
18	201	45.60	127.00	9.40	30.00	63.05	94.85	20.90	26.90
18	206	11.20	151.20	4.50	32.00	20.10	110.50	10.00	31.00
18	207	18.00	218.00	2.50	35.50	45.80	140.00	14.00	29.50
20	1	5.00	62.01	3.40	28.30	6.27	31.67	4.40	18.90
20	2	9.14	59.49	3.10	30.60	14.32	47.17	6.90	27.50
20	3	5.22	73.91	3.40	27.00	6.65	48.61	6.00	23.50
20	4	26.23	62.42	16.90	27.60	30.53	50.80	20.90	25.50
20	5	7.10	81.07	3.50	35.30	12.92	57.42	8.50	33.40
20	6	5.03	49.82	3.90	19.40	6.21	24.61	7.20	15.10
20	7	5.54	49.59	7.10	27.60	8.09	30.65	11.10	24.80
20	8	5.09	93.04	3.80	42.20	5.89	57.84	4.20	37.90
20	9	5.35	35.08	2.70	16.70	9.04	24.57	7.50	13.10
20	10	5.09	31.51	3.20	17.00	6.11	22.15	4.60	14.80
20	11	7.26	78.62	6.30	38.70	33.30	72.57	24.60	36.30
20	12	5.16	40.52	2.60	21.00	6.43	28.78	6.75	17.20
20	13	6.81	82.47	3.90	44.80	12.48	70.98	6.40	41.90
20	14	5.16	92.63	3.00	9.70	5.83	19.26	4.30	8.10
20	15	5.47	78.50	5.90	36.90	11.87	59.94	16.70	33.40
20	16	6.49	73.15	4.00	40.70	12.67	60.10	7.10	38.60
20	17	5.09	51.38	2.50	26.70	6.49	40.52	3.75	20.20
24	541	15.00	38.60	5.20	17.00	20.00	35.10	11.07	15.60
24	2015	22.60	83.50	17.30	38.70	32.70	59.50	22.70	33.80
24	2171	12.30	75.80	9.00	35.90	19.60	45.85	21.20	33.80
34	1	7.10	55.90			8.00	40.70		
34	2	7.10	64.50	5.00	28.00	8.20	41.70	14.00	28.00
34	3	8.00	68.70	14.00	32.00	10.55	42.10	17.00	29.00

Annex 2: Problems and data correction

Country	Plotnr	Problem	Correction/Solution
1	36	Coordinates missing; height values missing	No calculation of spatial indices and volume
1	37	Coordinates missing; height values missing	No calculation of spatial indices and volume
1	42	Coordinates missing; height values missing	No calculation of spatial indices and volume
1	53	Coordinates missing; height values missing	No calculation of spatial indices and volume
1	76	Coordinates missing; height values missing	No calculation of spatial indices and volume
3	106	Extreme value coordinates treenr 22;	New coordinate x = x - 700, y = y – 330
3	175	Tree-Nr. 596 without coordinates and species classification	Deleted
3	1040	treenr 101 without species classification; 10 trees with species code = 0	species treenr 101 = 71; species code 0 left unchanged
3	2084		
3	2085		
4	101		
4	301	Height values missing	No calculation of volume
4	305		
4	502	Tree Nr. 81: dbh missing	Average dbh of species 51 inserted
4	503		
4	508		
4	603	Coordinates missing; height values missing	No calculation of spatial indices and volume
4	606	3 dbh missing; height values missing	Average dbh inserted; no calculation of volume
4	608	Height values missing	No calculation of volume
4	703		
4	704		
4	706		
4	707	Height values missing	No calculation of volume
4	903		
4	919		
4	1202		
4	1203		
4	1205		
4	1401	Mingled inside and outside trees; height values missing	In accordance with PCC: correct classification as 1) trees outside the plot or 2) trees thinned (are deleted); no calculation of volume
4	1402	Height values missing	No calculation of volume
5	1	Management type = coppice with standards: choice of volume equations unclear	Volume equations coppice applied
5	3	Management type = coppice with standards: choice of volume equations unclear	Volume equations coppice applied
5	8		
5	10		
5	14		
5	15	Plot size 2100 m^2	Deviation from standard size acceptable
5	16		
5	17	Management type = coppice with standards: choice of volume equations unclear	Volume equations coppice applied
5	21	Management type = coppice with standards: choice of volume equations unclear	Volume equations coppice applied
5	22	y-coordinate of treenr 196 und 197 to high	Y = y/10
5	25		
5	27	Management type = coppice with standards: choice of volume equations unclear	Volume equations coppice applied
8	51	Height values without treenr.	Separate calculation of height curves
8	64	Height values without treenr	Separate calculation of height curves

Annex 2: Problems and data correction (continued)

Country	Plotnr	Problem	Correction/Solution
8	74	Height values without tree nr; treenr 4 and 5 without species classification	Separate calculation of height curves; species treenr 4 and 5 = 20
8	95	Height values without tree nr	Separate calculation of height curves
9	209		
9	309	Plot too large	Identification of trees inside the FB plot ; exact plot size communicated by country representative
9	409		
11	5	Assymetric plot shape	Plot size of 2500 m^2 assured by country
11	6		
11	10		
11	11		
11	15	Assymetric plot shape	Plot size of 2500 m^2 assured by country
11	22		
11	25		
11	26		
11	30		
11	33	Plot too small	Plot size of 2500 m^2 assured by country
11	37		
11	102		
15	2	Plot too large	Identification of trees inside the FB plot
15	3	Plot too large	Identification of trees inside the FB plot
15	5	Plot too large	Identification of trees inside the FB plot
15	6	Plot too large; some trees obviously outside the plot area	Identification of trees inside the FB plot
15	10	Plot too large	Identification of trees inside the FB plot
15	11	Plot too large	Identification of trees inside the FB plot
15	12	Plot too large	Identification of trees inside the FB plot
15	13	Plot too large	Identification of trees inside the FB plot
18	201	Some DBH values > 100 cm; volume and basal area too high	Circumference delivered instead of dbh; values recalculated
18	206	Some DBH values > 100 cm; 1 dbh missing; volume and basal area too high	Circumference delivered instead of dbh; values recalculated; Average dbh inserted for missing value
18	207	Some DBH values > 100 cm; volume and basal area too high; treenr 209 without species classification	Circumference delivered instead of dbh; values recalculated; species = 118
20	1	Plot too large	Identification of trees inside the FB plot
20	2	Plot too large	Trees classified as 1) inside a plot where all trees with dbh ≥ 5 cm were measured and 2) trees inside the FB plot (measured ≥ 12 cm); calculation of structural indices only for 1)
20	3	Plot too large	Trees classified as 1) inside a plot where all trees with dbh ≥ 5 cm were measured and 2) trees inside the FB plot (measured ≥ 12 cm); calculation of structural indices only for 1)
20	4	Plot too large	Trees classified as 1) inside a plot where all trees with dbh ≥ 5 cm were measured and 2) trees inside the FB plot (measured ≥ 12 cm); calculation of structural indices only for 1)
20	5	Plot too large	Trees classified as 1) inside a plot where all trees with dbh ≥ 5 cm were measured and 2) trees inside the FB plot (measured ≥ 12 cm); calculation of structural indices only for 1)
20	6	Plot too large	Trees classified as 1) inside a plot where all trees with dbh ≥ 5 cm were measured and 2) trees inside the FB plot (measured ≥ 12 cm); calculation of structural indices only for 1)
20	7	Plot too large; two separated plots	Trees classified as 1) inside a plot where all trees with dbh ≥ 5 cm were measured and 2) trees inside the FB plot (measured ≥ 12 cm); calculation of structural indices only for 1)
20	8	Plot too large	Trees classified as 1) inside a plot where all trees with dbh ≥ 5 cm were measured and 2) trees inside the FB plot (measured ≥ 12 cm); calculation of structural indices only for 1)
20	9	Plot too large	Trees classified as 1) inside a plot where all trees with dbh ≥ 5 cm were measured and 2) trees inside the FB plot (measured ≥ 12 cm); calculation of structural indices only for 1)
20	10	Plot too large; 4 trees without DBH	Trees classified as 1) inside a plot where all trees with dbh ≥ 5 cm were measured and 2) trees inside the FB plot (measured ≥ 12 cm); calculation of structural indices only for 1); avergage dbh inserted
20	11	Plot too large	Trees classified as 1) inside a plot where all trees with dbh ≥ 5 cm were measured and 2) trees inside the FB plot (measured ≥ 12 cm); calculation of structural indices only for 1)

Annex 2: Problems and data correction (continued)

Country	Plotnr	Problem	Correction/Solution
20	12	Plot too large	Trees classified as 1) inside a plot where all trees with dbh ≥ 5 cm were measured and 2) trees inside the FB plot (measured ≥ 12 cm); calculation of structural indices only for 1)
20	13	Plot too large	Trees classified as 1) inside a plot where all trees with dbh ≥ 5 cm were measured and 2) trees inside the FB plot (measured ≥ 12 cm); calculation of structural indices only for 1)
20	14	Plot too large; height values to low? Some very high dbh values	Trees classified as 1) inside a plot where all trees with dbh ≥ 5 cm were measured and 2) trees inside the FB plot (measured ≥ 12 cm); calculation of structural indices only for 1); DBH and height values are correct
20	15	Plot too large	Trees classified as 1) inside a plot where all trees with dbh ≥ 5 cm were measured and 2) trees inside the FB plot (measured ≥ 12 cm); calculation of structural indices only for 1)
20	16	Plot too large; 2 separated plots	Trees classified as 1) inside a plot where all trees with dbh ≥ 5 cm were measured and 2) trees inside the FB plot (measured ≥ 12 cm); calculation of structural indices only for 1)
20	17	Plot too large	Trees classified as 1) inside a plot where all trees with dbh ≥ 5 cm were measured and 2) trees inside the FB plot (measured ≥ 12 cm); calculation of structural indices only for 1)
24	541		
24	2015		
24	2171		
34	1	4 trees outside the FB plot (Nr.: 102, 105, 106, 107); height values missing	Trees excluded; no calculation of volume
34	2		
34	3		

Annex 3: Computation (- = not computable, X = computable)

Country	Plotnr	Indices			
		Volume	Spatially explicit structural indices	Shannon and Simpson-index	Species profile index
1	36	-	-	X	-
1	37	-	-	X	-
1	42	-	-	X	-
1	53	-	-	X	-
1	76	-	-	X	-
3	106	X	X	X	X
3	175	X	X	X	X
3	1040	X	X	X	X
3	2084	X	X	X	X
3	2085	X	X	X	X
4	101	X	X	X	-
4	301	-	X	X	-
4	305	X	X	X	-
4	502	X	X	X	-
4	503	X	X	X	-
4	508	X	X	X	-
4	603	-	-	X	-
4	606	-	X	X	-
4	608	-	X	X	-
4	703	X	X	X	X
4	704	X	X	X	X
4	706	X	X	X	X
4	707	-	X	X	-
4	903	X	X	X	X
4	919	X	X	X	-
4	1202	X	X	X	-
4	1203	X	X	X	-
4	1205	X	X	X	-
4	1401	-	X	X	-
4	1402	-	X	X	-
5	1	X	X	X	-
5	3	X	X	X	-
5	8	X	X	X	-
5	10	X	X	X	-
5	14	X	X	X	-
5	15	X	X	X	-
5	16	X	X	X	-
5	17	X	X	X	-
5	21	X	X	X	-
5	22	X	X	X	-
5	25	X	X	X	-
5	27	X	X	X	_
8	51	X	X	X	-
8	64	X	X	X	-

Annex 3: Computation (continued)

Country	Plotnr	Indices			
		Volume	Spatially explicit structural indices	Shannon and Simpson-index	Species profile index
8	74	X	X	X	-
8	95	X	X	X	-
9	209	X	X	X	X
9	309	X	X	X	X
9	409	X	X	X	X
11	5	X	X	X	X
11	6	X	X	X	-
11	10	X	X	X	X
11	11	X	X	X	X
11	15	X	X	X	X
11	22	X	X	X	X
11	25	X	X	X	X
11	26	X	X	X	X
11	30	X	X	X	X
11	33	X	X	X	X
11	37	X	X	X	X
11	102	X	X	X	X
15	2	X	X	X	X
15	3	X	X	X	X
15	5	X	X	X	X
15	6	X	X	X	X
15	10	X	X	X	X
15	11	X	X	X	X
15	12	X	X	X	X
15	13	X	X	X	X
18	201	X	X	X	X
18	206	X	X	X	X
18	207	X	X	X	X
20	1	X	X	X	X
20	2	X	X	X	X
20	3	X	X	X	X
20	4	X	X	X	X
20	5	X	X	X	X
20	6	X	X	X	-
20	7	X	X	X	X
20	8	X	X	X	X
20	9	X	X	X	-
20	10	X	X	X	X
20	11	X	X	X	X
20	12	X	X	X	-
20	13	X	X	X	X
20	14	X	X	X	-
20	15	X	X	X	X
20	16	X	X	X	X

Annex 3: Computation (continued)

Country	Plotnr	Indices			
		Volume	Spatially explicit structural indices	Shannon and Simpson-index	Species profile index
20	17	X	X	X	X
24	541	X	X	X	X
24	2015	X	X	X	X
24	2171	X	X	X	X
34	1	-	X	X	-
34	2	X	X	X	-
34	3	X	X	X	-
Sum		82	89	95	50

Annex 4: Main results of structural indices

Spatially explicit indices

Country	Plotnr	Mean contagion	Mean Mingling	Mean diameter differentiation	Clark and Evans index
3	106	0.55	0.591667	0.337752	1.492862
3	175	0.565789	0	0.111819	1.422065
3	1040	0.5625	0.33125	0.251064	1.376196
3	2084	0.565574	0	0.248993	1.403849
3	2085	0.580769	0.126923	0.175163	1.476978
4	101	0.534091	0	0.172407	1.517817
4	301	0.570652	0.171196	0.514221	1.138107
4	305	0.578947	0	0.231757	1.31044
4	502	0.541667	0.557292	0.504878	1.388396
4	503	0.5	0	0.420266	1.290224
4	508	0.576531	0.188776	0.446078	1.58305
4	606	0.595238	0.72619	0.526269	0.972409
4	608	0.6	0	0.473791	0.96304
4	703	0.553846	0	0.431013	1.105687
4	704	0.5	0	0.26953	1.474315
4	706	0.57582	0.481557	0.46723	1.01864
4	707	0.589286	0.557143	0.382678	1.067747
4	903	0.594488	0.01378	0.254043	1.460601
4	919	0.585	0.4	0.433994	1.370689
4	1202	0.568182	0.102273	0.219765	1.357841
4	1203	0.574561	0	0.1686	1.296058
4	1205	0.542035	0	0.187734	1.288717
4	1401	0.576923	0.019231	0.167664	1.433329
4	1402	0.586735	0	0.224692	1.647369
5	1	0.625	0	0.370347	0.943301
5	3	0.551471	0.102941	0.295563	1.170148
5	8	0.573529	0.073529	0.240027	1.140203
5	10	0.604396	0.54533	0.466525	1.015359
5	14	0.676653	0.139463	0.341406	0.577435
5	15	0.554104	0.070896	0.15456	0.981805
5	16	0.615798	0.54908	0.342979	0.99477
5	17	0.589623	0.004717	0.355375	1.241746
5	21	0.63745	0.541833	0.407494	0.713808
5	22	0.692568	0.410811	0.24753	0.422042
5	25	0.748198	0.224775	0.294053	0.387976
5	27	0.671154	0.119231	0.396274	0.728918
8	51	0.566929	0	0.175713	1.400087
8	64	0.605	0.045	0.637553	0.875826
8	74	0.593478	0.317391	0.441454	0.968177
8	95	0.584416	0.107143	0.400949	1.2154
9	209	0.584356	0	0.367297	1.154905
9	309	0.581081	0	0.25854	1.210698
9	409	0.572115	0	0.369034	1.269129
11	5	0.619658	0	0.295872	0.907413
11	6	0.581301	0	0.178915	1.180079
11	10	0.589286	0	0.204248	1.195028
11	11	0.544643	0	0.181964	1.396201

Spatially explicit indices (continued)

Country	Plotnr	Mean contagion	Mean Mingling	Mean diameter differentiation	Clark and Evans index
11	15	0.545455	0	0.120973	1.251713
11	22	0.626923	0	0.342563	1.059722
11	25	0.599315	0	0.349495	0.932525
11	26	0.590909	0	0.31461	1.414216
11	30	0.625	0	0.238257	0.846611
11	33	0.67	0.07	0.274551	0.592506
11	37	0.579545	0	0.170878	1.209281
11	102	0.560484	0.197581	0.303561	1.132906
15	2	0.636218	0.052885	0.321753	1.153453
15	3	0.612705	0.008197	0.320873	1.144982
15	5	0.573245	0.020581	0.239347	1.477863
15	6	0.56746	0	0.199177	1.565355
15	10	0.547619	0	0.157047	1.787585
15	11	0.57337	0.084239	0.243234	1.382355
15	12	0.568027	0.384354	0.143891	1.501569
15	13	0.578859	0.036913	0.111044	1.568974
18	201	0.579741	0.025862	0.150506	1.235897
18	206	0.570681	0.01178	0.500491	1.107117
18	207	0.605	0.3125	0.367137	1.078227
20	1	0.600877	0.109649	0.406915	0.765528
20	2	0.611842	0	0.325925	0.676915
20	3	0.623596	0.623596	0.428124	1.026929
20	4	0.566176	0.125	0.205422	1.217122
20	5	0.573529	0.47549	0.526139	0.917465
20	6	0.672355	0.058874	0.352314	0.538287
20	7	0.596939	0.399235	0.387762	1.08219
20	8	0.597561	0.557927	0.548806	1.091009
20	9	0.579027	0.029635	0.282075	1.023846
20	10	0.616972	0	0.360523	0.915182
20	11	0.578125	0.125	0.33461	1.340123
20	12	0.692553	0.237234	0.361935	0.618136
20	13	0.604167	0.25	0.302712	1.35195
20	14	0.641509	0.349057	0.289751	0.560663
20	15	0.556452	0.298387	0.474877	1.373996
20	16	0.607955	0.4375	0.410651	1.117035
20	17	0.613426	0.398148	0.450877	0.849749
24	541	0.548387	0.024194	0.171067	1.168398
24	2015	0.5625	0.017857	0.233028	1.059535
24	2171	0.572727	0.263636	0.213659	1.155071
34	1	0.627976	0.657738	0.354671	0.82061
34	2	0.609375	0.6875	0.37293	0.939367
34	3	0.579268	0.75	0.400111	0.985642

Indices without spatial relationship

Country	Plotnr	Shannon index (stem number)	Simpson index (stem number)	Evenness (stem number)	Shannon index (basal area)	Simpson index (basal area)	Evenness (basal area)	Species profile index	Evenness species profile index	Standard deviation dbh
3	106	0,707652	0,459063	0,644133	0,491331	0,310428	0,447228	1,424355	0,885002	16,9534
3	175	0	0		0	0		1,025565	0,93351	3,638701
3	1040	0,714693	0,369279	0,515542	0,76947	0,434833	0,555056	1,632625	0,70904	9,287679
3	2084	0	0		1,11E-16	1,11E-16		1,04089	0,947459	8,46882
3	2085	0,280739	0,148556	0,40502	0,157166	0,070624	0,226742	1,239151	0,769928	6,247476
4	101	0	0		0	0				7,548271
4	301	0,330242	0,183768	0,476439	0,674679	0,481646	0,973356			16,75517
4	305	0	0		0	0				8,69072
4	502	1,001037	0,600494	0,911183	1,061562	0,643272	0,966275			17,32485
4	503	0	0		0	0				17,94143
4	508	0,775253	0,359025	0,481692	0,949256	0,461367	0,589806			15,456
4	606	1,296449	0,703432	0,93519	0,250002	0,099623	0,180339			24,30264
4	608	0	0		0	0				18,56087
4	703	0	0		0	0		1,026733	0,934572	10,25803
4	704	0	0		0	0		1,023929	0,93202	13,03505
4	706	0,941929	0,528413	0,679458	1,019715	0,564134	0,735569	1,528011	0,663607	13,38022
4	707	0,788862	0,518993	0,569044	0,620351	0,411319	0,447488			12,17976
4	903	0,036987	0,012048	0,053361	0,039316	0,012956	0,05672	1,050627	0,757867	7,795182
4	919	0,531339	0,347128	0,76656	0,644477	0,452124	0,929783			17,67757
4	1202	0,298387	0,123595	0,185398	0,09016	0,029306	0,05602			6,768472
4	1203	0	0		0	0				5,411829
4	1205	0	0		0	0				5,355029
4	1401	0,194205	0,092374	0,280178	0,25654	0,132133	0,370108			6,666704
4	1402	1,11E-16	1,11E-16		0	0				7,563832
5	1	0	0		0	0				12,70797
5	3	0,226145	0,112274	0,326259	0,008069	0,002045	0,011642			18,14606
5	8	0,219689	0,10817	0,316944	0,015986	0,004497	0,023063			10,8697
5	10	1,3178	0,634588	0,599757	1,071767	0,543123	0,487782			15,30458
5	14	0,528398	0,240757	0,381159	0,18652	0,066984	0,134546			10,09491
5	15	0,181131	0,075528	0,164873	0,121627	0,049613	0,110709			3,970908
5	16	1,543678	0,709649	0,601836	1,640279	0,718086	0,639498			8,485305

Indices without spatial relationship (continued)

Country	Plotnr	Shannon index (stem number)	Simpson index (stem number)	Evenness (stem number)	Shannon index (basal area)	Simpson index (basal area)	Evenness (basal area)	Species profile index	Evenness species profile index	Standard deviation dbh
5	17	0,057418	0,020406	0,082837	0,0476	0,016284	0,068673			15,80183
5	21	1,803049	0,783407	0,75193	1,733729	0,779266	0,723021			11,19771
5	22	1,25707	0,644837	0,701584	0,915612	0,450056	0,511013			4,276182
5	25	0,659387	0,410169	0,4097	0,526324	0,265762	0,327023			6,013474
5	27	0,335243	0,146173	0,241827	0,553163	0,272816	0,399023			15,48438
8	51	0	0		0	0				4,151736
8	64	0,064581	0,023526	0,093171	0,003293	0,00074	0,004751			21,37958
8	74	0,865966	0,488215	0,624662	1,054085	0,60532	0,760362			16,98979
8	95	0,167104	0,065929	0,152105	0,009404	0,002259	0,00856			11,42259
9	209	0	0		0	0		1,031657	0,939055	10,17379
9	309	0	0		1,11E-16	1,11E-16		1,038047	0,944871	10,46033
9	409	0	0		0	0		1,028688	0,936352	16,29028
11	5	0	0		-2,2E-16	-2,2E-16		0,990179	0,901299	14,48543
11	6	0	0		-2,2E-16	-2,2E-16				3,871448
11	10	0	0		0	0		0,976143	0,888524	4,524861
11	11	0	0		0	0		0,991092	0,902131	6,917094
11	15	0	0		0	0		1,029653	0,937231	7,513275
11	22	0	0		0	0		0,946152	0,861224	7,910323
11	25	0	0		0	0		1,067743	0,971901	6,761226
11	26	0	0		0	0		0,801819	0,729847	7,231738
11	30	0	0		0	0		0,994188	0,904949	9,979264
11	33	0,17053	0,078301	0,246023	0,059948	0,021497	0,086486	1,176803	0,848884	8,553877
11	37	0	0		0	0		0,973076	0,885732	7,891883
11	102	0,390898	0,205078	0,355811	0,118391	0,044614	0,107764	1,322	0,821405	11,7896
15	2	0,23068	0,100914	0,209974	0,144743	0,054755	0,13175	1,232705	0,633485	6,059289
15	3	0,021259	0,00627	0,030671	0,013324	0,003641	0,019223	1,042265	0,751835	6,035507
15	5	0,052161	0,014988	0,037626	0,047769	0,014349	0,034458	1,087095	0,558656	3,692643
15	6	0,013394	0,003663	0,019324	0,002962	0,000656	0,004273	1,030244	0,937769	3,19216
15	10	0	0		0	0		1,030462	0,937967	4,092833
15	11	0,246883	0,094494	0,178089	0,219128	0,085456	0,158067	1,235903	0,594343	6,457577

Indices without spatial relationship (continued)

Country	Plotnr	Shannon index (stem number)	Simpson index (stem number)	Evenness (stem number)	Shannon index (basal area)	Simpson index (basal area)	Evenness (basal area)	Species profile index	Evenness species profile index	Standard deviation dbh
15	12	0,738849	0,384119	0,532967	0,682731	0,360789	0,492487	1,786068	0,718767	4,684791
15	13	0,217314	0,090008	0,197808	0,204583	0,083958	0,186219	1,115798	0,693284	3,556635
18	201	0,067197	0,024688	0,096945	0,02755	0,0085	0,039746	1,028221	0,741704	4,088745
18	206	0,102095	0,032951	0,073646	0,118048	0,039928	0,085153	1,076026	0,600542	11,08585
18	207	0,57231	0,31462	0,412834	0,855279	0,530384	0,616953	1,347903	0,613457	12,03873
20	1	0,387928	0,170106	0,241033	0,500822	0,297164	0,311178			11,8043
20	2	0	0		1,11E-16	1,11E-16		1,0048	0,914609	12,83463
20	3	1,41823	0,708732	0,791529	1,185771	0,63711	0,661791	2,211509	0,837992	16,25405
20	4	0,349435	0,169941	0,318069	0,463455	0,260404	0,421855	1,286416	0,717962	7,976322
20	5	0,687257	0,494121	0,991502	0,685298	0,492171	0,988676	1,617564	0,90278	18,08795
20	6	0,219639	0,094939	0,199924	0,256044	0,121276	0,233062			8,373707
20	7	0,725521	0,429517	0,523353	0,749419	0,497135	0,540592	1,464078	0,66633	8,992117
20	8	0,850034	0,541212	0,773734	0,525505	0,327658	0,478335	1,615936	0,777101	22,69199
20	9	0,095579	0,03799	0,137891	0,031104	0,00981	0,044874			5,987425
20	10	0	0		0	0		1,015413	0,924269	6,091498
20	11	0,298436	0,1609	0,430552	0,091262	0,035889	0,131663	1,264894	0,912428	16,06628
20	12	0,999318	0,509414	0,513548	0,628515	0,308156	0,322993			8,637548
20	13	0,466987	0,245538	0,42507	0,09444	0,032948	0,085963	1,380073	0,857487	20,43046
20	14	1,269679	0,62892	0,652486	1,150599	0,60056	0,591291			11,09473
20	15	0,958334	0,517662	0,691292	0,751935	0,379585	0,542406	1,852371	0,804475	17,83639
20	16	0,920843	0,425312	0,513932	0,670453	0,34855	0,374187	1,840818	0,767681	15,52183
20	17	0,653944	0,404828	0,595246	0,694962	0,493171	0,632582	1,612226	0,82852	13,16424
24	541	0,059432	0,021274	0,085743	0,061518	0,022181	0,088751			5,235962
24	2015	0,214559	0,104938	0,309543	0,391728	0,23037	0,565144			11,95635
24	2171	0,905196	0,508395	0,652961	1,121491	0,655817	0,808985			10,26665
34	1	1,238652	0,606009	0,636541	0,539588	0,25081	0,277293	1,238652	0,636541	12,44973
34	2	1,463477	0,725885	0,816782	1,119938	0,592083	0,625049	1,665528	0,723329	13,87007
34	3	1,660151	0,787361	0,853149	1,310538	0,66492	0,673483	1,866662	0,7512	12,52372