

# Working Report ForestBIOTA - Epiphytic Lichen Monitoring

S. Stofer, Swiss Federal Research Institute WSL, CH-8903 Birmensdorf, Switzerland  
April 2006

## 1. Introduction

ForestBIOTA is conducting a monitoring test phase following Art 6(2) of the Regulation (EC) No 2152/2003 and aims at further development of monitoring methods of forest biodiversity aspects. Specifically it aims to contribute to forest biodiversity assessments by further development and test wise implementation of monitoring methods for 1) forest type classification, 2) stand structure assessments, 3) deadwood assessments, 4) extended ground vegetation surveys and 5) epiphytic lichen monitoring.

### *Epiphytic lichen monitoring*

Lichens are long-living organisms with a high sensibility to environmental influences and past regional ecological disturbances. They depend on a range of climatic parameters and are related to forest stand structure and history. The main objective of this part of the project is the development and implementation of a method to monitor the epiphytic lichen diversity on Intensive Monitoring Plots in Europe as well as assistance in developing the data base format. Furthermore the plot wise calculation of different lichen biodiversity indices based on the assessments carried out on Intensive Monitoring Plots. Based on the experience of the National Focal Centres and the results of the lichen diversity analyses we will improve the method.

## 2. Material and Methods

### *Study area*

Each participating countries made a selection of Level II plots where lichen assessment was carried out. In total 83 plots over 10 European countries were processed. Attending countries and number of evaluated plots are listed in Table 1. For the geographical distribution of the plots over Europe see Figure 1.

Country	Shortname	Number of plots
Czech Republic	CZ	3
Denmark	DK	4
Finland	SF	8
France	FR	5
Germany	DL	19
Italy	IT	12
Slovak Republic	SR	3
Spain	ES	7
Switzerland	CH	17
The Netherlands	NL	5

Tab.1. Number of evaluated plots per country

### Assessment method

The epiphytic lichen monitoring method adopts the main features of the BioAssess approach (Scheidegger et al. 2002, Asta et al. 2002) but modified them specifically for Level II plots. On each 0.25 ha plot all trees above 50 cm circumference were stratified into four groups differing in dimension and bark type. For each of the four pre-stratified groups a number of trees were then randomly selected proportionally to the occurrence of the four groups on the plot. In all, 12 trees were selected. Lichen species richness and frequency of all lichens at these 12 selected trees were evaluated. In order to specifically detect seldom lichen species, additional trees were sampled from those of the four tree species groups which are underrepresented within the 12 sample trees. Further details of the lichen assessment method are available under [www.forestbiota.org](http://www.forestbiota.org).

### Data

Lichen data was stored in a relational data base (Access) at the Federal Research Centre for Forestry and Forest Products (BFH) in Hamburg, Germany.

Each lichen taxa was assigned to one of the two following growth form classes: macrolichens or crustose lichens.

For each of the 83 plots we calculated species richness, Shannon index, Simpson index, Pielou and Heip's index per plot for all lichens as well as separately for the two growth form classes macrolichens and crustose lichens. Formulas of the indices are presented in Table 2.

Index	Formula
Species Richness	$S$ = number of species per plot
Shannon index	$H' = - \sum p_i \ln p_i$ $p_i$ = the proportion of individuals found in the $i$ th species
Simpson index	$D = \sum (n_i [n_i - 1] / N[N-1])$ $n_i$ = the number of individuals in the $i$ th species $N$ = the total number of individuals
Pielou	$J' = H' / H_{\max} = H' / \ln S$ $H_{\max}$ = maximum diversity
Heip's index	$E_{\text{Heip}} = (e^{H'} - 1) / (S-1)$

Tab. 2. Applied indices of diversity and evenness (following Magurran 2003).

### 3. Results

In total, 276 lichen taxa were found in the 83 plots (93 macrolichens and 183 crustose lichens). Specimens of the genus *Bacidina*, *Megalaria*, *Melaspilea*, *Mycomicrothelia* and *Thelopsis* could only be determined on genus level. Species lists per country and plot are provided in Appendix I.

The number of lichens per plots varied between 0 and 47 (macrolichens: 0 – 26, crustose lichens: 0 – 33). The mean number of lichens per plot was 13.4 (macrolichens: 4.6, crustose lichens 8.8). No lichens at all were observed on two plots only (plot nr: ES10, FR36). Highest species richness was observed on plots in Italy (species richness > 40), whereas in northern parts of Europe (Northern Germany, The Netherlands, Slovak Republic, Czech Republic, Denmark and Finland) the number of lichens per plot was rather small, not exceeding 20 species (Fig. 1). Zooming in on macrolichens only or on crustose lichens a similar pattern was observed (Fig. 2 and 3).

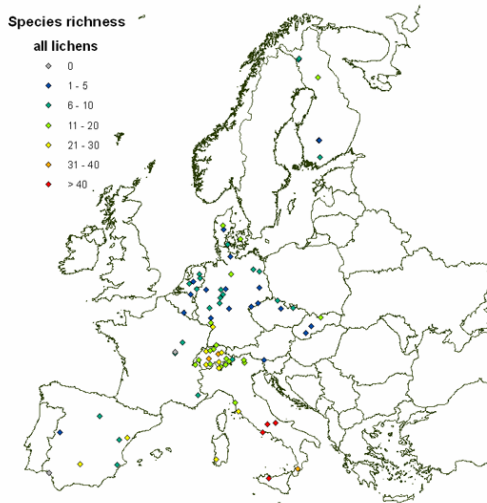


Fig. 1. Species richness per plot

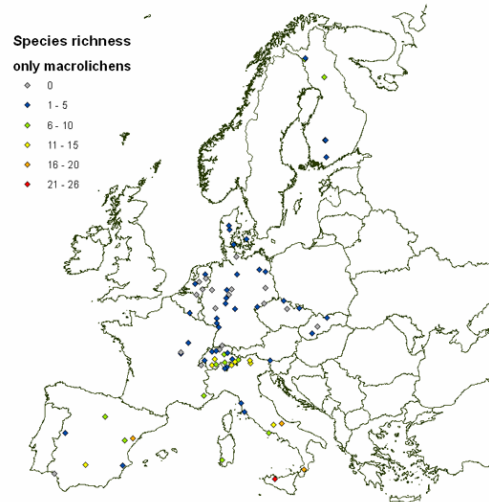


Fig. 2. Macrolichen richness per plot

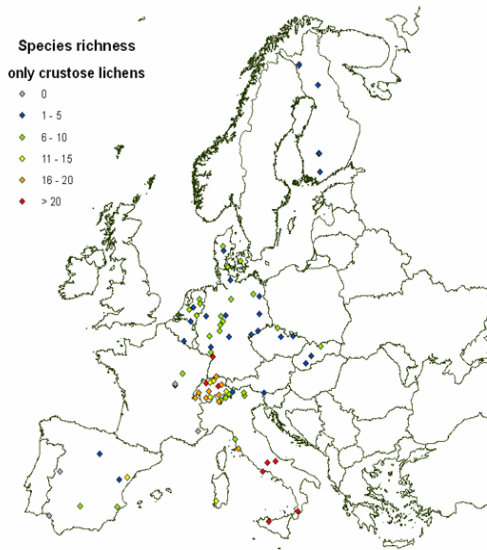


Fig. 3. Crustose lichen richness per plot

Comparing mean species richness per plot of the different countries quite a big variation was observed (all lichens: 4.8 – 27.75, macrolichens 0.79 – 11.58, crustose lichens: 2.2 – 16.06). In most countries more macrolichens than crustose lichens were found on the plots, only for the plots in Finland, France and Spain a reverse proportion was observed (Tab. 3).

country	All lichens				Only macrolichens				Only crustose lichens				macrolichens /crustose lichens
	species richness	mean	min	max	species richness	mean	min	max	species richness	mean	min	max	
CH	137	21.12	9	40	38	5.06	0	13	99	16.06	3	30	0.38
CZ	14	6.33	4	9	4	2.33	0	4	10	4.00	2	6	0.40
DK	26	9.25	4	13	7	2.00	1	3	19	7.25	2	10	0.37
DL	46	7.32	1	24	8	0.79	0	3	38	6.53	1	21	0.21
ES	53	11.00	0	28	32	6.71	0	16	21	4.29	0	12	1.52
FR	21	4.80	0	9	12	2.60	0	7	9	2.20	0	7	1.33
IT	167	27.75	4	47	64	11.58	2	26	103	16.17	2	33	0.62
NL	18	6.20	2	10	3	0.80	0	2	15	5.40	2	8	0.20
SF	28	9.63	5	17	18	7.00	3	11	10	2.63	0	6	1.80
SR	14	5.67	2	11	5	1.67	0	4	9	4.00	2	7	0.55

Tab. 3. Species richness, mean of species richness, minimal numbers of species and maximum number of species per country for the following three data sets: all lichens, only macrolichens and only crustose lichens. Quotient macrolichens/crustose lichens per country.

### Indices per plot

Plot wise calculated diversity and evenness indices are provided in Table 4.

Plotnr	All lichens					Only macrolichens					Only crustose lichens				
	Species richness	Shannon	Simpson	Pielou	Heip	Species richness	Shannon	Simpson	Pielou	Heip	Species richness	Shannon	Simpson	Pielou	Heip
CH1	40	3.10	0.06	0.84	0.54	10	1.41	0.35	0.61	0.34	30	2.90	0.07	0.85	0.59
CH10	9	1.87	0.19	0.85	0.68	6	1.56	0.24	0.87	0.75	3	1.00	0.41	0.91	0.85
CH11	18	2.53	0.10	0.88	0.68	0	na	na	na	na	18	2.53	0.10	0.88	0.68
CH12	21	2.56	0.10	0.84	0.60	5	1.26	0.36	0.78	0.63	16	2.28	0.14	0.82	0.59
CH13	14	1.93	0.20	0.73	0.45	0	na	na	na	na	14	1.93	0.20	0.73	0.45
CH14	18	2.42	0.12	0.84	0.60	7	1.55	0.27	0.79	0.62	11	1.99	0.17	0.83	0.63
CH15	14	1.49	0.33	0.57	0.27	1	0.00	1.00	na	na	13	1.34	0.37	0.52	0.24
CH16	21	2.24	0.15	0.74	0.42	2	0.67	0.52	0.97	0.96	19	2.19	0.16	0.74	0.44
CH17	19	2.34	0.14	0.80	0.52	4	1.16	0.38	0.84	0.73	15	1.98	0.22	0.73	0.45
CH2	32	2.72	0.09	0.79	0.46	12	2.00	0.16	0.80	0.58	20	2.21	0.21	0.74	0.43
CH3	29	2.87	0.08	0.85	0.59	4	1.28	0.31	0.92	0.86	25	2.71	0.09	0.84	0.58
CH4	19	2.48	0.12	0.84	0.61	13	2.15	0.16	0.84	0.64	6	1.34	0.35	0.75	0.56
CH5	24	2.44	0.15	0.77	0.46	7	1.34	0.35	0.69	0.47	17	2.50	0.11	0.88	0.70
CH6	12	2.07	0.16	0.83	0.63	3	0.71	0.61	0.65	0.52	9	1.82	0.20	0.83	0.65

CH7	20	2.63	0.09	0.88	0.68	0	na	na	na	na	20	2.63	0.09	0.88	0.68
CH8	19	2.04	0.19	0.69	0.37	1	0.00	1.00	na	na	18	2.02	0.19	0.70	0.39
CH9	30	2.65	0.12	0.78	0.45	11	1.87	0.20	0.78	0.55	19	2.05	0.23	0.69	0.37
CZ2015	9	1.22	0.44	0.56	0.30	3	1.01	0.38	0.92	0.88	6	0.80	0.58	0.45	0.25
CZ2171	4	0.45	0.80	0.33	0.19	0	na	na	na	na	4	0.45	0.80	0.33	0.19
CZ541	6	0.81	0.63	0.45	0.25	4	0.39	0.81	0.28	0.16	2	0.69	0.50	0.99	0.99
DK51	4	0.65	0.57	0.47	0.30	2	0.05	0.98	0.08	0.06	2	0.03	0.99	0.04	0.03
DK64	9	1.57	0.27	0.71	0.48	2	0.61	0.58	0.88	0.84	7	1.42	0.29	0.73	0.52
DK74	11	1.92	0.19	0.80	0.58	1	0.00	1.00	na	na	10	1.90	0.19	0.83	0.63
DK95	13	1.62	0.29	0.63	0.34	3	0.13	0.95	0.12	0.07	10	1.37	0.41	0.60	0.33
DL101	4	0.41	0.82	0.30	0.17	0	na	na	na	na	4	0.41	0.82	0.30	0.17
DL1202	10	1.58	0.25	0.69	0.43	2	0.11	0.96	0.15	0.11	8	1.37	0.31	0.66	0.42
DL1203	6	1.03	0.41	0.57	0.36	1	0.00	1.00	na	na	5	0.95	0.43	0.59	0.39
DL1205	4	0.28	0.88	0.20	0.11	0	na	na	na	na	4	0.28	0.88	0.20	0.11
DL1401	3	0.65	0.65	0.60	0.46	1	0.00	1.00	na	na	2	0.35	0.80	0.50	0.41
DL1402	1	0.00	1.00	na	na	0	na	na	na	na	1	0.00	1.00	na	na
DL301	11	1.83	0.22	0.76	0.52	1	0.00	1.00	na	na	10	1.79	0.23	0.78	0.56
DL305	5	0.64	0.67	0.40	0.23	0	na	na	na	na	5	0.64	0.67	0.40	0.23
DL502	9	1.19	0.44	0.54	0.29	0	na	na	na	na	9	1.19	0.44	0.54	0.29
DL503	5	0.96	0.49	0.59	0.40	0	na	na	na	na	5	0.96	0.49	0.59	0.40
DL508	7	1.30	0.35	0.67	0.45	1	0.00	1.00	na	na	6	1.28	0.35	0.71	0.52
DL603	7	0.88	0.59	0.45	0.24	1	0.00	1.00	na	na	6	0.82	0.61	0.46	0.26
DL606	8	1.86	0.18	0.89	0.77	0	na	na	na	na	8	1.86	0.18	0.89	0.77
DL608	7	1.46	0.26	0.75	0.55	1	0.00	1.00	na	na	6	1.42	0.26	0.79	0.63
DL703	5	0.95	0.54	0.59	0.40	1	0.00	1.00	na	na	4	0.80	0.59	0.58	0.41
DL704	7	1.52	0.26	0.78	0.60	0	na	na	na	na	7	1.52	0.26	0.78	0.60
DL706	24	2.40	0.14	0.76	0.44	3	1.09	0.34	1.00	0.99	21	2.25	0.15	0.74	0.42
DL707	11	1.94	0.22	0.81	0.60	2	0.68	0.51	0.99	0.98	9	1.68	0.28	0.77	0.55
DL903	5	0.98	0.50	0.61	0.42	1	0.00	1.00	na	na	4	0.88	0.53	0.63	0.47
ES10	0	na	na	na	na	0	na	na	na	na	0	na	na	na	na
ES11	1	0.00	1.00	na	na	1	0.00	1.00	na	na	0	na	na	na	na
ES22	10	1.44	0.32	0.63	0.36	7	1.10	0.41	0.57	0.33	3	0.78	0.51	0.71	0.59
ES25	9	1.14	0.45	0.52	0.26	2	0.14	0.94	0.20	0.15	7	1.14	0.45	0.58	0.35
ES26	21	2.50	0.11	0.82	0.56	15	2.09	0.16	0.77	0.51	6	1.40	0.34	0.78	0.61
ES30	8	1.63	0.23	0.78	0.58	6	1.41	0.29	0.79	0.62	2	0.09	0.96	0.14	0.10
ES6	28	2.60	0.11	0.78	0.46	16	2.03	0.20	0.73	0.44	12	1.79	0.26	0.72	0.45
FR36	0	na	na	na	na	0	na	na	na	na	0	na	na	na	na
FR37	2	0.38	0.78	0.54	0.46	1	0.00	1.00	na	na	1	0.00	1.00	na	na
FR42	6	1.24	0.35	0.69	0.49	3	0.75	0.53	0.68	0.56	3	0.42	0.79	0.39	0.26
FR53	9	1.96	0.16	0.89	0.76	2	0.26	0.87	0.37	0.29	7	1.77	0.19	0.91	0.81
FR76	7	1.58	0.24	0.81	0.64	7	1.58	0.24	0.81	0.64	0	na	na	na	na
IT1	43	3.13	0.06	0.83	0.52	15	2.22	0.14	0.82	0.58	28	2.62	0.11	0.79	0.47
IT10	20	2.13	0.18	0.71	0.39	13	1.61	0.29	0.63	0.33	7	1.27	0.42	0.65	0.42
IT14	21	2.48	0.11	0.81	0.54	9	1.67	0.23	0.76	0.54	12	2.03	0.16	0.82	0.60
IT15	47	3.03	0.07	0.79	0.43	26	2.50	0.10	0.77	0.45	21	2.13	0.17	0.70	0.37
IT16	14	1.69	0.30	0.64	0.34	4	1.18	0.36	0.85	0.75	10	1.49	0.34	0.65	0.38
IT17	18	2.41	0.10	0.83	0.60	11	2.00	0.15	0.84	0.64	7	1.32	0.33	0.68	0.46
IT21	46	3.03	0.07	0.79	0.44	16	2.05	0.19	0.74	0.45	30	2.57	0.11	0.76	0.42
IT22	42	3.26	0.05	0.87	0.61	9	1.67	0.23	0.76	0.54	33	3.04	0.07	0.87	0.62
IT25	21	2.32	0.13	0.76	0.46	5	1.43	0.27	0.89	0.80	16	2.01	0.17	0.72	0.43
IT27	20	2.31	0.13	0.77	0.48	13	1.88	0.20	0.73	0.46	7	1.47	0.26	0.76	0.56
IT3	37	2.83	0.09	0.78	0.44	16	2.12	0.17	0.76	0.49	21	2.22	0.15	0.73	0.41
IT8	4	0.99	0.43	0.72	0.57	2	0.46	0.71	0.67	0.59	2	0.21	0.90	0.31	0.24
NL1040	8	1.15	0.45	0.55	0.31	2	0.30	0.83	0.44	0.36	6	1.04	0.48	0.58	0.37
NL106	6	0.80	0.54	0.44	0.24	0	na	na	na	na	6	0.80	0.54	0.44	0.24
NL175	5	0.58	0.70	0.36	0.19	0	na	na	na	na	5	0.58	0.70	0.36	0.19
NL2084	2	0.10	0.96	0.15	0.11	0	na	na	na	na	2	0.10	0.96	0.15	0.11
NL2085	10	1.03	0.54	0.45	0.20	2	0.37	0.78	0.54	0.45	8	0.65	0.72	0.31	0.13
SF10	17	1.80	0.22	0.64	0.32	11	1.44	0.29	0.60	0.32	6	0.78	0.65	0.44	0.24
SF11	5	0.94	0.50	0.58	0.39	3	0.54	0.69	0.49	0.36	2	0.14	0.94	0.20	0.15

SF12	9	1.05	0.46	0.48	0.23	5	0.59	0.72	0.37	0.20	4	0.19	0.93	0.14	0.07
SF13	9	1.17	0.44	0.53	0.28	5	0.91	0.52	0.57	0.37	4	0.75	0.62	0.54	0.38
SF2	10	1.59	0.27	0.69	0.43	10	1.59	0.27	0.69	0.43	0	na	na	na	na
SF3	8	1.56	0.24	0.75	0.54	5	1.25	0.32	0.77	0.62	3	0.27	0.88	0.25	0.16
SF5	8	1.30	0.33	0.63	0.38	7	1.26	0.34	0.65	0.42	1	0.00	1.00	na	na
SF6	11	1.50	0.29	0.63	0.35	10	1.49	0.29	0.65	0.38	1	0.00	1.00	na	na
SR201	4	0.71	0.63	0.51	0.35	1	0.00	1.00	na	na	3	0.46	0.75	0.42	0.29
SR206	2	0.69	0.50	1.00	1.00	0	na	na	na	na	2	0.69	0.50	1.00	1.00
SR207	11	1.42	0.33	0.59	0.31	4	0.49	0.76	0.35	0.21	7	1.06	0.44	0.55	0.31

Tab. 4. Diversity and evenness indices per plot.

#### 4. Main activities

1. Development of epiphytic lichen monitoring method
2. Participation in the following meetings and workshops:
  - *Sabaudia* (February 2003)  
Contributions: BioAssess: set-up and results (talk)  
A pan-European epiphytic lichen monitoring methodology suitable for Level II (talk)
  - *Lüneburg* (May 2004)  
Contribution: Presentation of epiphytic lichen assessment methods and first Swiss results (talk)  
Training and demonstration of epiphytic lichen assessment method in the forest
  - *Ispira* (May 2005)  
Contributions: ForestBIOTA methodology for epiphytic lichen assessment (talk)
  - *Hamburg* (December 2005)  
Contribution: Planned epiphytic lichen evaluations (talk)
3. Data base
  - Assistance in the development of data base formats
  - Processing and harmonising the code list for lichens
4. Plot wise lichen biodiversity indices calculation
5. Publications:
  - *Fischer, R.; Barbosa, P.; Bastrup-Birk, A.; Becher, G.; Dobbertin, M.; Ferretti, M.; Goldammer, J.G.; Haussmann, T.; Lorenz, M.; Mayer, P.; Mues, V.; Petriccione, B.; Raspe, S.; Roskams, P.; Sase, H.; Stofer, S.; Wulff, S., 2004:*  
The Condition of Forests in Europe. 2004 Executive Report. - Geneva, UN/ECE. 48 pp.
  - *Lorenz, M.; Becher, G.; Mues, V.; Fischer, R.; Ulrich, E.; Dobbertin, M.; Stofer, S., 2004:*  
Forest Condition in Europe. 2004 Technical Report of ICP Forests. - Hamburg, Institute for World Forestry. 96 S. + Annexes.

## **5. References:**

*Asta, J.; Erhardt, W.; Ferretti, M; Fornasier, F.; Kirschbaum, U.; Nimis, P.L.; Purvis, O.W.; Pirintsos, S.; Scheidegger, C.; van Haluwyn, C.; Wirth, V., 2002:*

Mapping Lichen Diversity as an Indicator of Environmental Quality. - In: Nimis, P.L.; Scheidegger, C.; Wolseley, P.A. (eds) *Monitoring with Lichens – Monitoring Lichens*. Dordrecht, Boston, London, Kluwer Academic. 273-279.

*Scheidegger, C.; Groner, U.; Keller, C.; Stofer, S., 2002:*

Biodiversity Assessment Tools – Lichens. - In: Nimis, P.L.; Scheidegger, C.; Wolseley, P.A. (eds) *Monitoring with Lichens – Monitoring Lichens*. Dordrecht, Boston, London, Kluwer Academic. 359-365.

*Magurran, A.E., 2004:* *Measuring Biological Diversity*. Malden, Oxford, Carlton, Blackwell Publishing. 256 p.













