

App. 1-6. Internet supplement to: Mäkipää, R. & Heikkinen, J. 2003. Large-scale changes in abundance of terricolous bryophytes and macrolichens in Finland. *J. Veg. Sci.* 14: 497-508.

App. 1. Variance and covariance estimators.

Our estimators of relative abundance (eq. 1) have a general form

$$R = \frac{\sum_{l=1}^L x_l}{\sum_{l=1}^L y_l}, \quad (1)$$

where, for brevity, the taxon and province indicators have been omitted, l denotes the intersection of either a line transect (1950s data) or a cluster of sample plots (1980s and 1990s data) with the province, $x_l = \sum_{i \in l} w_i P_{s,i}$, and $y_l = \sum_{i \in l} w_i P_{g,i}$. To estimate the variance of R , we applied the usual approximation (e.g., Cochran 1977)

$$V(R) \approx \frac{V(\sum_{l=1}^L z_l)}{(\sum_{l=1}^L y_l)^2}, \quad (2)$$

where $z_l = x_l - R y_l$, and estimated $V(\sum z_l)$ by the sum $\sum T_l$ of L local quadratic forms indexed by line transects or clusters.

From the permanent sample plot clusters we formed Matérn's (1960) quadruplets

$$\begin{array}{ccc} l_3 & l_4 & \\ l_1 & l_2 & \end{array} \text{ in southern Finland and } \begin{array}{ccc} & l_4 & \\ l_3 & & l_2 \\ & l_1 & \end{array} \text{ in the north,}$$

and defined

$$T_l = (z_{l1} - z_{l2} - z_{l3} + z_{l4})^2/4. \quad (3)$$

with $l = l_1$, say. Note that T_l can be interpreted as the squared difference between two local linear predictors, $(z_{l1} + z_{l4})/2$ and $(z_{l2} + z_{l3})/2$, of the value of z in the centre of the quadruplet. Accordingly, we have chosen to use second order differencing

$$T_l = (z_{l+1} - 2z_l + z_{l-1})^2/6 \quad (4)$$

with the 1950s line survey data: It also filters out locally linear trends. Following Matérn (1960), we deal with the province boundaries by setting $z_{l'} = 0$ for those line transects or clusters l' in T_l , which fall outside the province.

Quadratic forms are known to overestimate the variance if the correlation between the values of z in two locations is a decreasing function of their distance (Matérn 1960). The edge correction applied here is also safely conservative.

The covariances, $\text{cov}(R^{t_2}, R^{t_3})$, of the estimators of relative abundance at $t_2=1985-1986$ and $t_3=1995$, based on data from the remeasured plots, were estimated analogously, defining

$$T_l = (z_{l1}^{t_2} - z_{l2}^{t_2} - z_{l3}^{t_2} + z_{l4}^{t_2})(z_{l1}^{t_3} - z_{l2}^{t_3} - z_{l3}^{t_3} + z_{l4}^{t_3})/4. \quad (5)$$

References

- Cochran, W. G. 1977. *Sampling techniques*. 3rd ed. Wiley, New York, NY, US.
- Matérn, B. 1960. Spatial variation. *Medd. Statens Skogsforskningsinst.* 49-5: 1-144. Also *Lecture Notes in Statistics* 36, 1986. Springer-Verlag, New York, NY, US.

App. 2. Relative abundance of dominant terricolous bryophyte and macrolichen species by biogeographical provinces in 1951-1953 presented as percentages of the total cover of forest-floor vegetation.

Species/other taxon	Province																		Finland
	2 V	3 U +4 EK	5 St	6 EH	7 ES +8 LK	9 EP	10 PH	11 PS	12 PK	13 KP	14 Kn	15 OP	16 PeP	17 Ks	18 KiL	19 SoL	20 EnL	21 InL	
Bryophytes																			
<i>Aulacomnium palustre</i>	0.31	0.32	0.24	0.41	0.28	0.19	0.25	0.57	0.63	0.35	0.49	0.51	0.48	0.51	0.74	0.21	0.42	0.15	0.40
<i>Brachythecium</i> spp.	0.06	0.02	0.05	0.08	0.19	0.03	0.09	0.52	0.28	0.05	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.08
<i>Dicranum fuscescens</i>	0.02	0.02	0.05	0.03	0.03	0.07	0.09	0.02	0.08	0.05	0.22	0.44	1.36	3.95	2.06	1.45	0.71	3.12	0.54
<i>Dicranum majus</i>	0.26	0.53	0.15	0.39	0.23	0.28	0.20	0.19	0.23	0.07	0.38	0.04	0.29	0.21	0.08	0.09	0.01	0.16	0.24
<i>Dicranum polysetum</i>	4.15	4.62	2.78	3.11	3.26	2.29	1.67	1.11	1.70	1.35	1.45	1.57	3.01	0.66	0.65	0.34	0.02	0.10	1.99
<i>Dicranum scoparium</i>	0.73	0.79	0.24	0.64	0.59	0.46	0.50	0.60	0.56	0.29	0.35	0.41	0.65	0.99	0.54	1.28	1.86	0.94	0.56
<i>Hylocomium splendens</i>	20.59	23.46	20.56	27.11	14.45	20.25	22.23	23.09	14.49	14.91	21.59	9.58	13.41	19.10	12.10	11.47	2.79	10.30	18.76
<i>Pleurozium schreberi</i>	38.56	36.76	32.40	38.74	45.23	32.08	34.42	31.83	36.81	23.65	33.70	21.90	33.11	36.33	39.29	35.71	20.72	37.48	33.69
<i>Pohlia nutans</i>	0.01	0.01	0.01	0.01	0.03	0.04	0.00	0.00	0.01	0.01	0.01	0.01	0.10	0.01	0.03	0.03	0.03	0.23	0.02
<i>Polytrichum commune</i>	4.59	3.98	6.33	5.14	8.93	13.09	7.83	10.72	7.02	15.07	6.48	10.03	6.06	5.75	5.02	3.72	4.69	1.92	7.97
<i>Polytrichum juniperinum</i>	0.65	0.48	0.42	0.38	0.42	0.24	0.33	0.28	0.21	0.70	0.24	1.00	1.01	1.06	0.93	3.00	2.50	2.19	0.65
<i>Polytrichum strictum</i>	0.46	0.10	1.30	0.35	0.37	0.60	0.58	1.07	0.81	1.08	0.64	1.35	1.42	0.99	1.01	0.47	1.59	0.23	0.77
<i>Ptilium crista-castrensis</i>	0.61	0.72	0.85	0.34	0.12	1.05	0.16	0.20	0.36	0.54	0.40	0.32	0.24	0.45	0.10	0.08	0.00	0.01	0.42
<i>Rhytidiadelphus triquetrus</i>	1.08	3.09	1.82	3.11	1.30	0.12	0.29	1.05	0.48	0.19	0.44	0.02	0.16	0.07	0.00	0.03	0.00	0.00	0.97
<i>Sphagnum capillifolium</i>	0.81	0.71	0.51	0.46	0.28	1.08	0.88	0.43	0.80	1.51	0.81	2.70	1.07	0.57	1.67	0.99	0.17	0.82	0.91
<i>Sphagnum fuscum</i>	1.34	0.92	4.59	1.62	1.58	4.11	3.69	1.45	5.98	5.28	4.73	6.78	5.72	5.48	5.84	4.42	2.23	2.06	3.92
<i>Sphagnum girgensohnii</i>	5.41	4.21	5.71	4.61	2.77	5.27	3.85	5.26	4.11	4.24	4.27	3.59	2.88	1.50	2.29	1.07	0.00	0.10	3.90
<i>Sphagnum magellanicum</i>	0.46	0.56	1.33	0.89	1.55	1.56	1.88	1.40	1.53	2.37	1.72	2.78	1.33	1.10	0.37	0.54	0.00	0.00	1.43
<i>Sphagnum recurvum</i> coll. ^a	2.28	2.59	8.38	4.14	6.41	8.26	11.71	9.15	7.04	13.80	9.77	16.08	8.67	3.87	2.38	3.59	0.00	0.25	7.92
<i>Sphagnum russowii</i>	0.27	1.78	1.24	0.75	2.20	1.38	2.81	4.11	4.38	3.68	2.99	4.68	3.76	2.55	2.35	1.02	0.13	0.18	2.47
<i>Hepaticophytina</i> (liverworts)	0.03	0.05	0.04	0.01	0.07	0.01	0.02	0.04	0.03	0.02	0.10	0.02	0.15	1.04	0.05	0.07	0.30	0.12	0.10
Macrolichens																			
<i>Cladina arbuscula</i> ^b	5.75	2.09	2.91	1.99	1.44	1.89	1.84	1.03	3.84	1.73	1.89	2.91	4.01	2.54	4.47	7.60	6.02	9.21	2.71
<i>Cladina rangiferina</i>	5.62	5.12	3.44	2.39	3.17	1.82	1.75	1.43	5.12	2.28	2.51	3.05	3.23	3.08	4.47	7.35	5.09	7.84	3.15
<i>Cladina stellaris</i>	0.50	0.54	0.58	0.12	0.17	0.75	0.17	0.03	0.16	0.64	0.37	0.99	0.11	0.45	2.36	7.11	17.21	13.93	1.04
<i>Cladonia</i> spp.	1.95	0.61	0.65	0.51	0.35	0.53	0.09	0.06	0.26	0.62	0.19	0.25	1.07	2.00	2.16	1.66	9.72	5.27	0.78
<i>Nephroma arcticum</i>	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.02	0.02	0.44	0.49	1.56	1.40	0.35	1.17	0.17
<i>Peltigera aphthosa</i>	0.11	0.22	0.22	0.18	0.46	0.20	0.29	0.24	0.43	0.36	0.23	0.33	0.56	0.34	0.46	0.25	2.53	0.29	0.30
Total	96.61	94.31	96.81	97.51	95.88	97.63	97.62	95.84	97.35	94.80	96.01	91.36	94.32	95.10	93.00	94.97	79.05	98.08	95.86
<i>Dicranum</i> spp.	5.37	6.12	3.34	4.28	4.24	3.17	2.57	2.00	2.68	1.79	2.56	2.81	6.80	6.25	4.40	3.94	5.82	4.80	3.60
<i>Sphagnum</i> spp.	11.91	12.22	23.91	13.77	16.40	23.40	26.56	24.85	25.28	35.23	27.71	43.81	26.29	18.11	18.03	13.85	6.20	3.87	23.15
<i>Cladina</i> spp.	11.86	7.76	6.93	4.49	4.79	4.46	3.76	2.50	9.12	4.65	4.78	6.95	7.35	6.07	11.30	22.07	28.32	30.98	6.90

^aIncluding *S. angustifolium*, *S. fallax* and *S. flexuosum*.

^bIncluding *C. mitis* in our study.

App. 3. Relative abundance of dominant terricolous bryophyte and macrolichen species by biogeographical provinces in 1985-1986 presented as percentages of the total cover of forest-floor vegetation.

Species/other taxon	Province																		Finland
	2 V	3 U +4 EK	5 St	6 EH	7 ES +8 LK	9 EP	10 PH	11 PS	12 PK	13 KP	14 Kn	15 OP	16 PeP	17 Ks	18 KiL	19 SoL	20 EnL	21 InL	
Bryophytes																			
<i>Aulacomnium palustre</i>	0.42	0.31	0.16	0.25	0.41	0.51	0.42	0.56	0.90	1.00	0.95	0.95	0.84	0.74	0.33	0.90	1.19	0.05	0.66
<i>Brachythecium</i> spp.	3.86	4.52	4.96	4.30	3.63	1.69	2.17	2.68	1.93	1.18	0.47	0.29	0.02	0.06	0.00	0.00	0.00	0.00	1.35
<i>Dicranum fuscescens</i>	0.01	0.23	0.05	0.17	0.10	0.00	0.02	0.09	0.02	0.01	0.03	0.02	0.00	0.02	0.85	0.04	0.03	1.49	0.17
<i>Dicranum majus</i>	0.73	2.29	0.46	0.89	0.61	0.63	0.55	1.29	0.80	0.09	0.98	0.35	0.29	0.18	0.16	0.07	0.00	0.05	0.50
<i>Dicranum polysetum</i>	16.87	23.89	7.62	9.23	11.31	3.13	3.94	3.96	4.13	2.87	1.99	2.61	1.47	0.68	1.13	0.41	0.14	0.02	3.80
<i>Dicranum scoparium</i>	5.15	4.83	2.70	3.55	4.80	2.74	2.77	2.75	1.29	1.05	2.47	1.48	3.92	7.28	9.91	6.98	8.46	7.76	4.25
<i>Hylocomium splendens</i>	6.57	3.70	7.84	8.45	5.39	9.60	10.36	9.92	4.54	8.68	7.63	6.73	7.05	8.93	4.99	7.51	7.21	12.44	7.86
<i>Pleurozium schreberi</i>	28.27	34.11	43.27	45.36	45.86	35.44	44.25	38.34	44.98	34.52	35.01	35.09	34.70	28.47	46.71	34.37	37.47	30.97	37.15
<i>Pohlia nutans</i>	0.43	0.88	0.38	0.46	0.61	0.37	0.27	0.13	0.19	0.22	0.21	0.15	0.24	0.31	0.63	0.18	1.37	0.27	0.32
<i>Polytrichum commune</i>	3.55	3.67	5.24	4.45	4.81	9.56	7.39	9.48	7.33	11.06	9.13	8.37	5.00	7.16	3.92	2.93	10.25	4.98	6.63
<i>Polytrichum juniperinum</i>	0.58	1.30	0.63	0.91	0.72	0.40	1.68	1.11	1.71	0.59	1.13	0.99	1.56	3.08	1.52	1.20	5.36	1.42	1.37
<i>Polytrichum strictum</i>	0.66	0.14	0.81	0.28	0.35	1.40	1.55	0.69	1.81	2.58	1.89	2.76	3.27	3.76	0.83	1.42	1.00	1.04	1.75
<i>Ptilium crista-castrensis</i>	0.30	0.52	0.81	0.32	0.12	0.75	0.08	0.14	0.17	0.17	0.29	0.42	0.10	0.83	0.27	0.00	0.00	0.02	0.27
<i>Rhytidiadelphus triquetrus</i>	0.41	0.08	0.15	0.40	0.07	0.04	0.08	0.10	0.14	0.00	0.01	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.07
<i>Sphagnum capillifolium</i>	2.09	0.14	0.35	1.06	0.46	0.32	1.64	0.75	1.11	1.05	1.80	1.80	1.38	2.52	0.64	1.83	1.42	1.60	1.33
<i>Sphagnum fuscum</i>	1.28	0.00	0.60	0.34	0.11	2.05	1.27	0.34	1.44	3.38	4.64	2.62	5.89	5.00	7.08	6.46	2.56	2.08	3.19
<i>Sphagnum girgensohnii</i>	5.12	6.67	3.36	4.58	5.36	3.30	6.73	5.41	6.50	4.84	2.43	2.59	0.67	1.22	0.79	0.54	0.00	0.62	3.03
<i>Sphagnum magellanicum</i>	0.80	0.23	0.29	0.43	1.10	1.67	0.69	1.13	0.68	1.20	1.50	2.58	2.24	1.20	0.14	0.52	0.00	0.00	1.05
<i>Sphagnum recurvum</i> coll. ^a	3.79	1.50	9.21	5.46	5.53	11.75	5.13	11.81	8.04	13.76	14.44	16.12	13.21	9.14	4.10	5.98	0.87	2.52	8.98
<i>Sphagnum russowii</i>	0.71	0.06	1.81	1.26	0.68	4.57	1.66	3.34	4.10	3.57	4.86	7.12	6.57	6.78	1.64	6.93	1.96	1.10	3.95
<i>Hepaticophytina</i> (liverworts)	2.37	1.74	0.20	0.51	0.49	0.26	0.57	0.25	0.30	0.17	0.78	0.48	0.41	3.37	1.30	1.25	4.49	2.12	1.01
Macrolichens																			
<i>Cladina arbuscula</i> ^b	5.10	2.48	3.04	1.58	1.61	1.68	1.40	1.08	1.37	1.65	1.92	0.90	1.86	0.22	3.63	5.38	6.31	12.17	2.83
<i>Cladina rangiferina</i>	3.43	1.45	3.22	1.74	2.67	2.61	3.42	1.30	2.72	3.09	2.07	1.79	2.37	0.57	2.77	2.79	2.88	4.71	2.49
<i>Cladina stellaris</i>	1.57	0.06	0.41	0.02	0.17	1.08	0.22	0.00	0.09	0.23	0.22	0.38	0.00	0.00	2.92	0.84	0.58	3.85	0.64
<i>Cladonia</i> spp.	0.80	0.39	0.44	0.22	0.45	0.29	0.51	0.26	0.48	0.29	0.34	0.18	2.23	1.05	0.73	1.30	2.46	4.52	1.03
<i>Nephroma arcticum</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.30	0.60	0.69	0.79	0.48	0.17
<i>Peltigera aphthosa</i>	0.00	0.03	0.01	0.03	0.04	0.01	0.02	0.06	0.03	0.02	0.04	0.04	0.05	0.01	0.18	0.03	0.80	0.18	0.06
Total	94.87	95.22	98.02	96.25	97.46	95.85	98.79	96.97	96.80	97.27	97.23	96.81	95.49	92.88	97.93	90.55	97.60	96.46	95.91
<i>Dicranum</i> spp.	22.81	31.39	10.93	14.00	16.85	6.52	7.34	8.22	6.26	4.04	5.74	4.65	6.44	8.64	12.62	9.05	8.71	10.03	9.12
<i>Sphagnum</i> spp.	15.39	9.59	16.09	13.73	14.25	27.14	17.51	24.34	23.74	29.97	31.69	35.18	31.27	29.04	14.86	25.70	7.14	8.61	23.27
<i>Cladina</i> spp.	10.10	3.98	6.66	3.34	4.45	5.38	5.04	2.38	4.18	4.97	4.21	3.07	4.23	0.80	9.32	9.02	9.76	20.73	5.97

^aIncluding *S. angustifolium*, *S. fallax* and *S. flexuosum*.

^bIncluding *C. mitis* in our study.

App. 4. Relative abundance of dominant terricolous bryophyte and macrolichen species by biogeographical provinces in 1995 presented as percentages of the total cover of forest-floor vegetation.

Species/other taxon	Province																		Finland
	2 V	3 U +4 EK	5 St	6 EH	7 ES +8 LK	9 EP	10 PH	11 PS	12 PK	13 KP	14 Kn	15 OP	16 PeP	17 Ks	18 KiL	19 SoL	20 EnL	21 InL	
Bryophytes																			
<i>Aulacomnium palustre</i>	0.55	0.48	0.25	0.18	0.27	0.51	0.43	0.44	1.09	0.54	0.52	0.58	0.63	0.54	0.29	0.37	1.74	0.18	0.52
<i>Brachythecium</i> spp.	2.93	4.84	4.34	4.03	4.03	2.57	2.00	5.92	4.93	1.61	0.33	0.35	0.16	0.01	0.07	0.01	0.03	0.00	1.76
<i>Dicranum fuscescens</i>	0.00	0.00	0.02	0.04	0.02	0.01	0.05	0.05	0.23	0.03	0.15	0.53	3.08	0.30	5.52	5.18	6.16	6.58	1.42
<i>Dicranum majus</i>	1.66	2.37	2.02	1.75	0.51	1.61	1.18	1.12	0.94	0.35	1.26	0.31	0.18	1.70	0.25	0.28	0.00	0.00	0.90
<i>Dicranum polysetum</i>	16.24	24.96	7.64	8.44	13.51	4.09	3.94	4.21	4.87	2.27	1.39	1.35	1.34	0.18	1.14	0.41	0.46	0.01	3.76
<i>Dicranum scoparium</i>	4.53	4.88	2.42	3.49	3.10	1.05	2.67	2.85	2.10	1.11	1.34	1.52	1.51	3.19	2.99	3.67	0.96	2.18	2.32
<i>Hylocomium splendens</i>	9.49	5.32	11.97	10.97	5.92	8.02	11.08	10.97	4.09	9.22	7.63	7.74	6.29	6.87	4.62	8.36	7.19	15.00	8.21
<i>Pleurozium schreberi</i>	29.59	36.65	39.01	45.41	45.50	35.57	44.70	34.11	41.51	36.28	37.40	33.55	38.48	31.19	51.62	34.51	39.59	38.80	38.25
<i>Pohlia nutans</i>	0.31	0.73	0.38	0.46	0.46	0.55	0.37	0.21	0.27	0.24	0.28	0.25	0.11	0.37	0.31	0.20	0.65	0.19	0.31
<i>Polytrichum commune</i>	3.85	2.78	4.66	3.65	2.82	8.90	5.73	6.43	5.36	10.05	8.23	7.74	4.27	8.13	2.16	2.64	6.27	3.85	5.88
<i>Polytrichum juniperinum</i>	0.66	0.46	0.52	0.98	0.35	0.40	1.64	0.73	2.26	0.80	1.17	1.03	0.77	1.36	0.46	0.67	0.60	0.40	0.94
<i>Polytrichum strictum</i>	0.23	0.57	1.12	0.24	0.27	1.53	0.85	0.30	1.48	1.37	2.50	2.29	2.43	3.03	5.17	2.71	8.46	2.39	2.02
<i>Ptilium crista-castrensis</i>	0.46	0.27	0.75	0.90	0.21	1.28	0.10	0.39	0.23	0.10	0.21	0.28	0.23	0.98	0.31	0.00	0.00	0.05	0.37
<i>Rhytidiadelphus triquetrus</i>	0.27	0.12	0.05	0.23	0.09	0.05	0.08	0.14	0.03	0.00	0.00	0.01	0.00	0.00	0.27	0.00	0.00	0.00	0.05
<i>Sphagnum capillifolium</i>	1.03	0.27	0.48	1.26	0.21	0.53	1.02	0.38	1.57	1.21	0.35	2.01	1.30	6.06	0.95	1.39	4.88	0.75	1.51
<i>Sphagnum fuscum</i>	2.14	0.00	0.75	0.02	0.16	2.55	1.42	0.36	1.19	2.67	4.57	3.35	7.33	5.03	4.45	4.91	3.61	1.91	3.14
<i>Sphagnum girgensohnii</i>	4.28	3.41	3.79	3.91	5.20	2.52	4.32	5.50	4.22	3.39	1.07	1.72	0.44	1.37	0.00	0.11	0.00	0.00	2.28
<i>Sphagnum magellanicum</i>	0.77	0.01	0.51	0.27	2.17	1.43	1.13	1.53	0.57	0.85	1.18	1.66	2.00	1.10	0.23	0.44	0.00	0.00	0.99
<i>Sphagnum recurvum</i> coll. ^a	2.00	1.39	7.19	3.59	4.68	13.52	4.74	10.82	8.24	12.32	11.31	17.84	10.43	3.23	4.98	9.30	0.17	0.90	8.16
<i>Sphagnum russowii</i>	3.41	2.22	1.51	2.42	2.18	3.12	4.56	5.22	6.75	7.12	12.91	6.66	6.40	11.25	2.79	8.76	5.75	4.24	6.41
<i>Hepaticophytina</i> (liverworts)	0.90	1.51	0.80	0.55	0.39	0.26	0.49	0.51	0.51	0.23	0.47	0.23	0.29	1.34	1.34	1.35	1.53	3.08	0.76
Macrolichens																			
<i>Cladina arbuscula</i> ^b	4.12	1.40	2.43	1.45	0.70	1.48	1.26	0.93	1.45	1.49	1.24	0.50	1.58	0.09	1.11	1.75	1.45	5.79	1.52
<i>Cladina rangiferina</i>	2.71	0.98	3.17	1.14	1.08	2.69	2.78	0.99	2.18	2.99	1.17	1.54	0.97	0.32	1.38	1.41	1.33	2.74	1.70
<i>Cladina stellaris</i>	0.96	0.05	0.34	0.27	0.12	0.58	0.28	0.00	0.11	0.31	0.17	0.61	0.33	0.11	1.70	1.96	0.41	2.68	0.56
<i>Cladonia</i> spp.	0.74	0.64	0.46	0.30	0.21	0.77	0.43	0.24	0.63	0.48	0.82	0.34	1.02	0.50	0.92	1.22	1.62	2.10	0.73
<i>Nephroma arcticum</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.18	0.10	0.36	0.59	1.15	0.40	0.13
<i>Peltigera aphthosa</i>	0.00	0.04	0.00	0.00	0.04	0.00	0.02	0.05	0.01	0.02	0.00	0.00	0.07	0.00	0.17	0.10	0.32	0.52	0.06
Total	93.84	96.31	96.59	95.98	94.20	95.59	97.30	94.39	96.80	97.07	97.67	94.01	91.81	88.34	95.56	92.29	94.33	94.72	94.65
<i>Dicranum</i> spp.	22.74	32.27	12.22	13.79	17.20	6.80	7.93	8.26	8.23	3.83	4.25	4.36	7.11	6.38	12.60	10.78	10.80	11.62	9.07
<i>Sphagnum</i> spp.	14.50	8.07	15.18	11.98	16.66	26.12	18.09	26.92	24.17	29.64	32.92	37.38	33.20	33.28	14.19	28.25	14.84	8.75	24.96
<i>Cladina</i> spp.	7.80	2.42	5.94	2.86	1.90	4.75	4.32	1.92	3.74	4.79	2.58	2.89	2.88	0.53	4.19	5.13	3.19	11.20	3.79

^aIncluding *S. angustifolium*, *S. fallax* and *S. flexuosum*.

^bIncluding *C. mitis* in our study.

App. 5. Statistical significance of change in relative abundance between 1951-1953 and 1985-1986: Independent *P*-values (without correction for multiple testing). Boldface *P*-values are significant according to Holm's multiple testing procedure with overall error rate $\alpha=0.05$. *P*-values are omitted for species/province-combinations with ≤ 10 observations on both occasions.

Species/other taxon	Province																		Finland
	2 V	3 U +4 EK	5 St	6 EH	7 ES +8 LK	9 EP	10 PH	11 PS	12 PK	13 KP	14 Kn	15 OP	16 PeP	17 Ks	18 KiL	19 SoL	20 EnL	21 InL	
Bryophytes																			
<i>Aulacomnium palustre</i>	0.599	0.981	0.182	0.477	0.295	0.061	0.144	0.961	0.217	0.002	0.066	0.168	0.285	0.410	0.366	0.183	—	0.357	0.001
<i>Brachythecium</i> spp.	0.000	0.002	0.042	0.000	0.000	0.005	0.001	0.002	0.001	0.013	0.011	0.120	—	—	—	—	—	—	0.000
<i>Dicranum fuscescens</i>	—	0.004	0.963	0.004	0.261	0.130	0.197	0.060	0.290	0.193	0.009	0.150	0.000	0.000	0.184	0.001	0.082	0.160	0.001
<i>Dicranum majus</i>	0.219	0.045	0.251	0.053	0.079	0.259	0.064	0.002	0.021	0.483	0.156	0.084	0.994	0.862	0.523	0.819	—	0.218	0.000
<i>Dicranum polysetum</i>	0.000	0.000	0.000	0.000	0.000	0.368	0.000	0.000	0.000	0.002	0.106	0.018	0.066	0.918	0.346	0.664	—	0.009	0.000
<i>Dicranum scoparium</i>	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.012	0.000	0.009	0.001	0.011	0.000	0.000	0.078	0.000	0.000
<i>Dicranum</i> spp.	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.018	0.846	0.361	0.006	0.004	0.487	0.022	0.000
<i>Hylacomnium splendens</i>	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.116	0.002	0.000	0.008	0.031	0.391	0.581	0.000
<i>Pleurozium schreberi</i>	0.002	0.407	0.008	0.006	0.830	0.319	0.000	0.007	0.015	0.000	0.661	0.000	0.700	0.092	0.242	0.742	0.027	0.288	0.001
<i>Pohlia nutans</i>	0.002	0.000	0.002	0.000	0.005	0.010	0.004	0.000	0.002	0.001	0.000	0.000	0.108	0.007	0.076	0.011	—	0.863	0.000
<i>Polytrichum commune</i>	0.445	0.863	0.401	0.516	0.001	0.150	0.758	0.560	0.879	0.029	0.103	0.312	0.485	0.450	0.595	0.554	0.143	0.105	0.010
<i>Polytrichum juniperinum</i>	0.773	0.054	0.495	0.089	0.276	0.243	0.004	0.006	0.000	0.761	0.001	0.992	0.253	0.082	0.446	0.013	0.168	0.296	0.000
<i>Polytrichum strictum</i>	0.762	0.695	0.497	0.689	0.901	0.019	0.040	0.473	0.054	0.002	0.000	0.083	0.047	0.113	0.722	0.117	0.421	0.229	0.000
<i>Ptilium crista-castrensis</i>	0.117	0.620	0.942	0.912	0.938	0.542	0.290	0.504	0.143	0.018	0.446	0.691	0.228	0.374	0.523	0.002	—	—	0.010
<i>Rhytidiadelphus triquetrus</i>	0.210	0.000	0.005	0.000	0.001	0.030	0.011	0.000	0.069	0.123	0.000	—	0.143	0.002	—	—	—	—	0.000
<i>Sphagnum capillifolium</i>	0.289	0.240	0.448	0.106	0.453	0.003	0.214	0.466	0.572	0.308	0.054	0.305	0.543	0.209	0.129	0.340	—	0.472	0.030
<i>Sphagnum fuscum</i>	0.967	—	0.000	0.006	0.009	0.165	0.043	0.002	0.007	0.051	0.942	0.002	0.923	0.711	0.729	0.395	—	0.987	0.075
<i>Sphagnum girgensohnii</i>	0.892	0.410	0.045	0.984	0.057	0.150	0.056	0.919	0.074	0.543	0.176	0.310	0.031	0.743	0.135	0.304	—	—	0.003
<i>Sphagnum magellanicum</i>	0.540	0.117	0.006	0.139	0.536	0.853	0.000	0.491	0.001	0.002	0.672	0.822	0.456	0.877	0.214	0.964	—	—	0.027
<i>Sphagnum recurvum</i> coll. ^a	0.365	0.201	0.760	0.273	0.701	0.109	0.000	0.307	0.598	0.985	0.040	0.989	0.159	0.017	0.433	0.288	—	—	0.082
<i>Sphagnum russowii</i>	0.327	0.000	0.505	0.230	0.000	0.001	0.237	0.535	0.774	0.905	0.095	0.065	0.113	0.084	0.643	0.013	—	—	0.000
<i>Sphagnum</i> spp.	0.417	0.504	0.036	0.984	0.524	0.382	0.000	0.875	0.680	0.047	0.237	0.025	0.371	0.002	0.619	0.029	—	0.102	0.911
<i>Hepaticophytina</i> (liverworts)	0.061	0.001	0.048	0.002	0.004	0.002	0.001	0.000	0.000	0.001	0.000	0.079	0.070	0.043	0.175	0.000	0.112	0.000	0.000
Macrolichens																			
<i>Cladina arbuscula</i> ^b	0.615	0.699	0.935	0.483	0.759	0.782	0.376	0.929	0.002	0.806	0.963	0.000	0.004	0.000	0.575	0.292	0.905	0.388	0.677
<i>Cladina rangiferina</i>	0.059	0.000	0.874	0.215	0.573	0.368	0.145	0.814	0.011	0.172	0.369	0.048	0.285	0.000	0.093	0.000	0.081	0.243	0.003
<i>Cladina stellaris</i>	0.101	0.005	0.569	0.027	0.998	0.440	0.712	0.026	0.293	0.110	0.245	0.213	0.001	0.132	0.816	0.000	0.000	0.000	0.015
<i>Cladina</i> spp.	0.533	0.002	0.931	0.275	0.808	0.566	0.429	0.912	0.004	0.746	0.586	0.000	0.026	0.000	0.570	0.000	0.001	0.067	0.054
<i>Cladonia</i> spp.	0.190	0.387	0.387	0.122	0.615	0.120	0.001	0.038	0.327	0.030	0.194	0.607	0.361	0.272	0.203	0.623	0.004	0.707	0.241
<i>Nephroma arcticum</i>	—	—	—	—	—	—	—	—	—	—	0.000	—	0.132	0.274	0.028	0.176	0.389	0.351	0.996
<i>Peltigera aphthosa</i>	0.000	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.016	0.000	0.026	0.001	0.049	0.280	0.000

^aIncluding *S. angustifolium*, *S. fallax* and *S. flexuosum*.

^bIncluding *C. mitis* in our study.

App. 6. Statistical significance of change in relative abundance between 1985-1986 and 1995: Independent *P*-values (without correction for multiple testing). Boldface *P*-values are significant according to Holm's multiple testing procedure with overall error rate $\alpha=0.05$. *P*-values are omitted for species/province-combinations with ≤ 10 observations on both occasions.

Species/other taxon	Province																		Finland
	2 V	3 U +4 EK	5 St	6 EH	7 ES +8 LK	9 EP	10 PH	11 PS	12 PK	13 KP	14 Kn	15 OP	16 PeP	17 Ks	18 KiL	19 SoL	20 EnL	21 InL	
Bryophytes																			
<i>Aulacomnium palustre</i>	0.558	0.276	0.309	0.489	0.236	0.970	0.956	0.427	0.438	0.013	0.003	0.144	0.396	0.174	—	0.142	—	—	0.017
<i>Brachythecium</i> spp.	0.365	0.853	0.753	0.803	0.781	0.222	0.833	0.020	0.000	0.408	0.246	0.834	—	—	—	—	—	—	0.007
<i>Dicranum fuscescens</i>	—	0.001	0.258	0.021	0.299	0.791	0.157	0.344	0.018	0.269	0.008	0.036	0.015	0.084	0.000	0.013	0.011	0.067	0.000
<i>Dicranum majus</i>	0.203	0.920	0.107	0.031	0.560	0.000	0.240	0.668	0.426	0.195	0.389	0.754	0.419	0.110	—	0.219	—	—	0.000
<i>Dicranum polysetum</i>	0.756	0.599	0.985	0.339	0.116	0.107	0.978	0.808	0.319	0.126	0.014	0.000	0.705	0.028	0.978	0.979	—	—	0.756
<i>Dicranum scoparium</i>	0.523	0.968	0.734	0.923	0.044	0.000	0.853	0.737	0.001	0.743	0.006	0.934	0.005	0.057	0.000	0.004	0.062	0.000	0.000
<i>Dicranum</i> spp.	0.972	0.667	0.243	0.807	0.846	0.666	0.445	0.955	0.009	0.608	0.004	0.578	0.429	0.278	0.988	0.332	0.208	0.563	0.886
<i>Hylocomium splendens</i>	0.005	0.024	0.001	0.047	0.475	0.078	0.282	0.247	0.412	0.470	0.997	0.151	0.458	0.116	0.757	0.740	—	0.447	0.248
<i>Pleurozium schreberi</i>	0.527	0.176	0.018	0.978	0.820	0.949	0.702	0.038	0.062	0.094	0.133	0.413	0.028	0.145	0.060	0.964	0.666	0.019	0.035
<i>Pohlia nutans</i>	0.424	0.554	0.965	0.994	0.564	0.250	0.594	0.310	0.234	0.770	0.552	0.159	0.079	0.696	0.339	0.697	0.483	0.328	0.513
<i>Polytrichum commune</i>	0.682	0.110	0.335	0.153	0.006	0.319	0.103	0.013	0.028	0.169	0.346	0.662	0.328	0.524	0.103	0.563	0.075	0.033	0.003
<i>Polytrichum juniperinum</i>	0.540	0.007	0.613	0.839	0.175	0.987	0.707	0.301	0.335	0.248	0.913	0.941	0.121	0.012	0.217	0.184	0.002	0.078	0.001
<i>Polytrichum strictum</i>	—	—	0.380	0.711	0.287	0.726	0.039	0.144	0.401	0.000	0.158	0.385	0.224	0.596	0.191	0.295	0.150	0.184	0.256
<i>Ptilium crista-castrensis</i>	0.478	0.160	0.890	0.011	0.367	0.004	0.827	0.121	0.146	0.607	0.148	0.463	0.313	0.668	—	—	—	—	0.020
<i>Rhytidiadelphus triquetrus</i>	—	—	0.314	0.302	0.192	—	0.795	0.266	—	—	—	—	—	—	—	—	—	—	0.338
<i>Sphagnum capillifolium</i>	—	—	0.630	0.617	0.178	0.455	0.044	0.178	0.447	0.627	0.000	0.782	0.701	0.057	—	0.594	—	—	0.399
<i>Sphagnum fuscum</i>	—	—	0.447	—	—	0.287	—	—	0.414	0.132	0.923	0.332	0.223	0.989	—	—	—	—	0.841
<i>Sphagnum girgensohnii</i>	0.457	0.052	0.655	0.381	0.864	0.323	0.051	0.951	0.005	0.013	0.015	0.225	—	—	—	—	—	—	0.000
<i>Sphagnum magellanicum</i>	—	—	0.094	0.347	0.127	0.485	0.147	0.508	0.595	0.081	0.333	0.151	0.422	0.736	—	—	—	—	0.536
<i>Sphagnum recurvum</i> coll. ^a	0.068	0.702	0.132	0.049	0.441	0.264	0.725	0.526	0.836	0.191	0.030	0.256	0.167	0.002	—	0.030	—	—	0.040
<i>Sphagnum russowii</i>	—	—	0.692	0.044	0.086	0.079	0.003	0.179	0.001	0.000	0.000	0.700	0.896	0.002	—	0.347	—	—	0.000
<i>Sphagnum</i> spp.	0.278	0.084	0.112	0.046	0.867	0.021	0.897	0.704	0.423	0.091	0.825	0.361	0.154	0.743	0.233	0.744	—	0.684	0.125
<i>Hepaticophytina</i> (liverworts)	0.102	0.527	0.261	0.772	0.569	0.974	0.716	0.017	0.111	0.150	0.113	0.357	0.502	0.039	0.911	0.810	0.202	0.415	0.039
Macrolichens																			
<i>Cladina arbuscula</i> ^b	0.272	0.012	0.200	0.632	0.020	0.431	0.383	0.547	0.760	0.409	0.027	0.285	0.666	0.211	0.030	0.001	0.019	0.000	0.000
<i>Cladina rangiferina</i>	0.255	0.046	0.898	0.011	0.000	0.857	0.208	0.129	0.176	0.728	0.000	0.219	0.010	0.180	0.019	0.002	0.005	0.012	0.000
<i>Cladina stellaris</i>	0.067	—	0.486	0.141	—	0.019	0.464	—	0.668	0.299	0.328	0.194	—	—	—	0.081	0.142	0.342	0.469
<i>Cladina</i> spp.	0.161	0.004	0.212	0.228	0.001	0.392	0.263	0.247	0.464	0.688	0.001	0.676	0.126	0.216	0.005	0.004	0.002	0.000	0.000
<i>Cladonia</i> spp.	0.761	0.228	0.925	0.110	0.014	0.122	0.282	0.705	0.454	0.104	0.365	0.042	0.258	0.318	0.737	0.718	0.052	0.156	0.117
<i>Nephroma arcticum</i>	—	—	—	—	—	—	—	—	—	—	—	—	0.706	—	0.093	0.649	—	—	0.089
<i>Peltigera aphthosa</i>	—	—	—	—	0.881	—	0.931	0.567	0.053	0.573	0.003	0.052	—	—	0.992	—	—	0.033	0.828

^aIncluding *S. angustifolium*, *S. fallax* and *S. flexuosum*.

^bIncluding *C. mitis* in our study.