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Changes in the flora and vegetation of 113 Finnish lakes during 40 years

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The 113 Finnish lakes studied by Lauri Maristo in the 1930's were reinvestigated in 1980–1985. The pH values of those lakes had not clearly altered, but transparency had, as a rule, diminished. The number of aquatics had generally increased, but some clearwater aquatics, such as *Potamogeton praelongus* Wulfen and *Myriophyllum alterniflorum* DC. had become rarer. Two species had disappeared, 17 species declined, and 57 species had become more frequent. Six species were found as newcomers. These floristic changes were probably caused by eutrophication due to leaching of agricultural and forest fertilizers or effluents of industry. The greatest vegetation changes were the decline of *Schoenoplectus lacustris* (L.) Palla stands and increase of *Phragmites australis* (Cav.) Trin. ex Steudel belts. In some lakes aquatic mosses currently form dense carpets. The succession caused by eutrophication can be seen as a development from oligotrophic lake types towards eutrophic ones. The most remarkable changes had taken place in *Potamogeton*-type, *Potamogeton filiformis-Chara*-type and *Typha-Alisma*-type lakes. Presently six lakes can be assigned to different botanical lake types than in Maristo's classification.

Key words: Aquatic macrophytes, botanical lake types, floristic changes, vegetation dynamics

INTRODUCTION

In 1941 the late Dr. Lauri Maristo published a botanical lake type classification for Finnish lakes, based on 135 lakes studied in 1936–1939 (Fig. 1). Twenty-two of these lakes are now situated in Russia. I studied the current Finnish lakes in 1980–1985.

Maristo (1941) emphasized in his typology the significance of zonation and helophytes. Floristically his types are not clearly distinct (Pesonen & Rintanen 1980). Another way to classify the lakes is e.g. the differential ordination of life forms of the lake (Jensén 1979).

Maristo's classification was completed by Tikkanen (1972). She gave a detailed definition of the *Nuphar*-type, primarily described by Renkonen (1935) and Metso (1936). Perttula (1954, according to Ilmavirta & Toivonen 1986: 188) treated some new, preliminary lake types for small lakes in western Central Finland. Lakes in northern Finland have been studied in detail by Rintanen (1982), and some new types and variants were described. Lampolahti (1991a) preliminarily described, besides Maristo's two southern eutrophic types, three new ones from Satakunta, SW Finland.

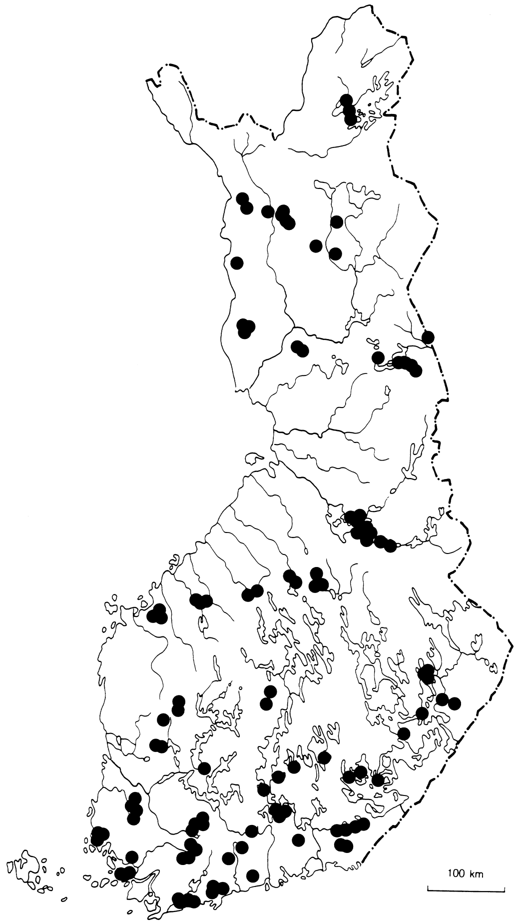

Fig. 1. Geographic distribution of Maristo's (1941: 287) sample lakes.

In Sweden Wallstén (1981) has re-studied 23 lakes from Lohammar's (1938) extensive study. Andersson (1980) treated the northern lakes of Lohammar's material, but his reinvestigation concentrated solely on physico-chemical properties of the water. In southern and Central Finland Meriläinen and Toivonen (1976), Toivonen and Ranta (1976), Toivonen (1980, 1985), Helminen (1983) and Ihantola (1987) have reanalyzed the lake flora and vegetation. Such surveys have been lacking in northern Finland.

Forty years after Maristo's (1941) study the agriculture and forestry in Finland had undergone great changes. Use of fertilizers increased, extensive pasturing on shores decreased and municipal sewer systems greatly increased the amount of sewage.

The aim of the present study was to investigate the current status of Maristo's (1941) typology by evaluating the temporal trends of vegetation and flora changes in the lakes.

METHODS

Maristo (1941: 23) measured the pH of lake water in the field using an indicator method. The measurements were conducted at noon in full sunshine and the samples were taken 2–3 m off the outermost dense helophyte stands. In the present work pH was measured in the field with a pH meter (Radiometer 24 E). The water samples were taken in the same manner as Maristo took them. The measurements were made as soon as possible and always within 24 hours from sampling.

The transparency measurements were made in both studies with a Secchi disc of 20 cm diameter. Maristo provided verbal descriptions of water colour, but he did not apply a numerical scale. In the present study this factor was measured with a Hellige-Neokomparator.

Maristo could not analyze the electric conductivity of the water, so that comparison with the present data is impossible. I employed a conductivity meter of Normameter RW 1 type.

Some currently recognized taxa were not distinguished in Maristo's time: *Eleocharis palustris* included *E. mamillata* and *Elatine hydropiper* included *E. orthosperma*. Also, Maristo did not mention hybrids like *Sparganium angustifolium* x *friesii* or *Nuphar lutea* x *pumila*. The additions caused by these discordancies were not included in the comparison of the studies.

Maristo described the vegetation with an approximate percentage frequency and abundance scale (Maristo 1945: 14–20). The scale is as follows (cf. Niemi 1990: 13–14).

1. frequency and abundance % 0–1.5
2. –"– 1.5–3
3. –"– 3–6
4. –"– 6–12
5. –"– 12–25
6. –"– 25–50
7. –"– 50–100

The frequency values are the relation of the sum of the lengths of the stands formed by individual species to the whole shore length. The abundance is the mean of the abundance values of the stands of the species. It is possible to reach this accuracy level in this reinvestigation. In some cases Maristo's lake report text allows estimating the development of some specific stands.

The reinvestigation of flora and vegetation of the lakes was made, whenever possible, by the same methods Maristo used in the 1930's (Maristo 1941: 13–23). He studied the lakes from boat and from shore, walking around them. Maristo investigated small lakes fully, but in larger ones a bay or other smaller part of the lake was chosen. I used the same method when possible. The duration of the study per lake was approximately same as in Maristo's study, in most cases one day. Complete results were presented by Rintanen (1992).

The nomenclature of phanerogams follows Hämet-Ahti *et al*. (1986) and that of bryophytes follows Koponen *et al*. (1995).

RESULTS

Water chemistry

Synopsis of the results concerning the lake types is presented in Tables 1 and 2. Complete list of the parameters for separate lakes is given in Table 3. Student's test has been used in the evalution of the significance of the differences in all comparisons that follow.

Water pH

Changes of pH values during 40 years were not very remarkable (Fig. 2). The mean of Maristo's whole material (excluding the lakes presently situated in Russia) was 6.88 (*S.D.* 0.50) and that of the reinvestigated lakes is 6.98 (*S.D.* 0.54). These values do not differ significantly. It is, however, possible that the pH level produced by Maristo's method was ca. 0.2 degrees too low. As for the botanical lake types the lowest pH values were encountered in both surveys in *Equisetum*-type lakes. The highest values were in 1930's in *Stratiotes*-type and in 1980's in *Potamogeton*-type lakes (Table 1). The greatest changes in separate lakes are the 0.7 pH

Table 1. pH and transparency in various botanical lake types.

Botanical lake type/	pH				Transparency			
Number of lakes	M ± *S.D.*	Md	min.	max.	M ± *S.D.*	Md	min.	max.
Equisetum/12								
1930´s	6.3 ± 0.23	6.4	5.9	6.5	1.3 ± 0.47	1.3	0.2	1.9
1980´s	6.4 ± 0.37	6.5	5.9	7.2	1.9 ± 0.81	1.8	0.9	3.4
Equisetum–Phragmites/21								
1930´s	6.6 ± 0.17	6.6	6.3	6.9	2.8 ± 0.78	2.7	1.2	3.9
1980´s	6.8 ± 0.32	6.8	6.0	7.3	2.5 ± 0.73	2.4	0.9	3.6
Phragmites/19								
1930´s	6.7 ± 0.14	6.7	6.5	7.1	3.7 ± 0.86	3.6	2.5	5.4
1980´s	6.9 ± 0.34	6.9	6.2	7.6	3.2 ± 1.0	3.4	1.6	4.8
Lobelia/15								
1930´s	6.6 ± 0.23	6.7	6.2	6.9	7.2 ± 2.06	6.4	4.0	12.5
1980´s	6.9 ± 0.29	7.0	6.3	7.2	6.6 ± 2.3	5.0	1.5	11.0
Potamogeton filiformis–Chara/7								
1930´s	7.5 ± 0.21	7.5	7.3	7.9	5.2 ± 0.71	5.0	4.5	6.5
1980´s	7.6 ± 0.45	7.8	6.8	8.0	4.8 ± 1.04	5.0	3.3	6.1
Carex/3								
1930´s	6.8 ± 0.06	6.8	6.8	6.9	6.5 ± 0.70	6.2	6.0	7.3
1980´s	6.7 ± 0.25	6.7	6.4	6.9	4.9 ± 0.59	4.7	4.5	5.6
Elodeid/12								
1930´s	7.1 ± 0.24	7.2	6.7	7.5	2.3 ± 0.70	2.1	1.0	3.3
1980´s	7.1 ± 0.44	7.2	6.1	7.6	2.4 ± 1.19	2.1	0.7	4.6
Scirpus lacuster/9								
1930´s	6.9 ± 0.29	6.8	6.6	7.5	1.0 ± 0.31	1.0	0.4	1.4
1980´s	6.8 ± 0.55	6.8	6.0	7.7	0.8 ± 0.29	0.8	0.5	1.3
Typha-Alisma/8								
1930´s	7.2 ± 0.27	7.1	6.8	7.7	1.4 ± 0.87	1.7	0.2	2.2
1980´s	7.3 ± 0.43	7.3	6.9	8.1	1.4 ± 0.75	1.1	0.5	2.6
Potamogeton/3								
1930´s	8.1 ± 0.10	8.1	8.0	8.2	2.5	2.5	2.5	2.5
1980´s	8.4 ± 1.01	8.3	7.5	9.5	1.2	1.2	1.2	1.2
Stratiotes/4								
1930´s	8.3 ± 0.05	8.3	8.2	8.3	2.4 ± 0.63	2.5	1.5	3.0
1980´s	7.7 ± 0.14	7.7	7.6	7.9	2.6 ± 0.98	3.2	1.5	3.2

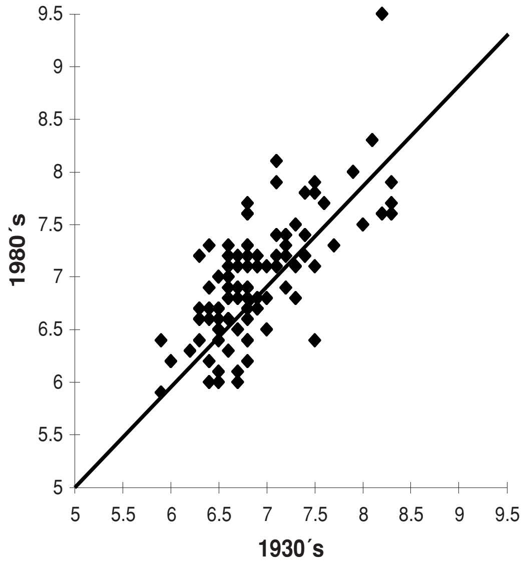

Fig. 2. pH values of all lakes.

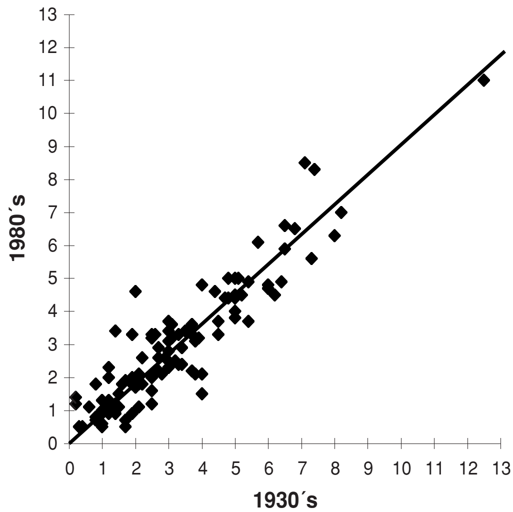

Fig. 3. Transparency values of all lakes.

unit degrees' lowering in Sulkuenjärvi (Kihniö, *Scirpus lacuster*-type, from 6.7 to 6.0) and Hautajärvi (Kittilä, *Stratiotes*-type, from 8.3 to 7.6). The strongest rise in pH value, 1.3 degrees from 8.2 to 9.5, took place in Mustfinnträsk in Parainen.

Water transparency

The transparency values are given in Fig. 3. The mean of Maristo's whole material was 3.2 m (*S.D.* 2.05), and that of the present material is 3.0 m (*S.D.* 1.86). These values are not significantly different. The corresponding median values are 3.0 and 2.6 m. The lowest values were found in both surveys in *Scirpus lacuster*-type and the highest ones in *Lobelia*-type lakes (Table 1). The greatest rises in separate lakes took place in Särkijärvi (Muonio, Maristo's Elodeid-type, from 2.0 to 4.6 m) and in Lommträsk (Karjaa, *Equisetum*-type, from 1.4 to 3.4 m). On the other hand, in Valkiajärvi (Kankaanpää, *Lobelia*-type) the transparency diminished from 4.0 to 1.5 m.

Water colour

The mean of the whole material is 39.8 mg Pt (*S.D.* 33.5). The median value is 30 mg Pt. *Lobelia*-type

Table 2. Water colour and conductivity in various botanical lake types in the 1980's. *Typha–Alisma*-type without the conductivity value of lake Ahmasvesi, effected by brackish water.

Botanical lake type	Colour of water				Conductivity			
	M ± *S.D.*	Md	min.	max.	M ± *S.D.*	Md	min.	max.
Equisetum	68.8 ± 42.1	65	20	150	58.4 ± 30.3	49.0	25.4	126.5
Equisetum-Phragmites	39.5 ± 22.0	35	5	80	67.3 ± 35.3	59.8	26.3	173.9
Phragmites	31.8 ± 17.2	25	15	60	57.2 ± 30.1	52.4	90.0	154.6
Lobelia	8.60 ± 8.40	10	5	35	50.0 ± 18.6	49.0	21.6	82.8
Potamogeton filiformis–Chara	11.4 ± 6.9	10	5	20	94.5 ± 75.6	64.6	33.8	245.4
Carex	15.0 ± 5.0	15	10	20	30.5 ± 6.2	26.9	26.9	37.6
Elodeid	51.3 ± 26.8	55	10	90	37.1 ± 13.1	34.3	23.3	69.8
Scirpus lacuster	95.6 ± 48.8	100	35	150	78.3 ± 32.4	71.0	44.9	129.1
Typha–Alisma	32.5 ± 11.0	35	15	40	150.3 ± 87.5	135.6	54.3	329.4
Potamogeton	30.0 ± 10.0	30	20	40	167.1 ± 27.4	156.7	146.5	198.2
Stratiotes	26.3 ± 2.0	25	25	30	92.4 ± 17.8	86.2	78.9	118.4

has the lowest and *Scirpus lacuster*-type the highest values in both surveys (Table 2).

Electric conductivity

The mean of the whole material is 99.4 (*S.D.* 327) and the median value 54.6 µS/cm. As to the lake types the lowest values are in northern *Carex*-type and highest in southern *Typha–Alisma*-type (Table 2).

Floristic changes

Two species, *Potamogeton lucens* and *Montia fontana*, found by Maristo were not refound in the precent study. Seven aquatic phanerogams have clearly declined (Table 4), 40 species have no essential changes (Table 5) and 35 have gained several new occurrences (Table 6). Six plants are newcomers in the lakes (Table 7).

Maristo (1941) listed 18 bryophyte species. In the present study the number is 26.

Changes in phanerogam vegetation

The most remarkable change in the helophyte vegetation is the decline of stands of *Schoenoplectus lacustris*. *Phragmites australis* has increased especially in eutrophic lakes in southern Finland. Toivonen and Ranta (1976) described a similar trend in the highly eutrophicated Iidesjärvi in Tampere, and Helminen (1983) in eutrophic lakes of Åland. In oligotrophic, southern lakes this tendency is less clear. As Toivonen (1983) noted, in small lakes near Tampere the stands of *P. australis* were usually about the same quantity as 30 years earlier. In northern Finland *Phragmites* stands have retreated.

In floating-leaved vegetation *Nuphar* stands have increased, but those of *Nymphaea* have slightly decreased. No clear trend can be seen in elodeid vegetation. Isoetids have declined especially in regulated lakes. Most of the lakes of *Phragmites*-type are currently regulated, so e.g. in lakes 51–56, belonging to the Saimaa watercourse, the isoetid vegetation has clearly diminished. Especially the stands of *Isoetes lacustris*, suffering from ice damage during low water stage in winter, have strongly deteriorated (cf. Quennerstedt 1958: 904). The trend is similar also in the other parts of this big lake system (Granberg & Ruohonen 1985: 64).

Changes in bryophyte vegetation

The estimation of the development of bryophyte vegetation can be done only indirectly, for Maristo did not give frequency and abundance values for bryophytes.

In many studied lakes stands of aquatic mosses, especially those of *Warnstorfia trichophylla* and *Calliergon megalophyllum*, have increased and partly filled the waterbodies. This development is true particularly for small lakes and sheltered bays or coves of larger lakes. Most of the partly moss-covered lakes are meso- to polyhumic.

A bryophyte vegetation type not mentioned by Maristo (1941) was found in the present study. In the middle open areas of a lake, on stony shoals in the depth of ca. 0.5–1.5 m, sparse moss stands occur. They consist of *Fissidens fontanus*, *F. adianthoides* and/or *Blindia acuta*. The bottom may be enriched by mussel shells carried by muskrats (*Ondatra zibethica*), or it can be nutrified by droppings of water fowl. This type of vegetation favours places where wave action prevents sedimentation and it occurs in 6 lakes (numbers 20, 24, 37, 41, 105, 108). Shoal moss stands are lacking in stony bottoms beside the shoreline.

Changes in charophyte vegetation

Chara stands were found in the 1930's in 17 and in 1980's the also in 17 lakes, but 1980's this vegetation was persisted only in 9 lakes. *Nitella* spp. do not, as a rule, form clear and dense stands. Members of Charales seem to be quite an unstable vegetation component, performing annual fluctuation in their stands.

Changes in the botanical lake types

Equisetum-type

According to Maristo (1941), characteristic features of this type are (1) small size of the lakes (mean 1.8 km^2), (2) muddy bottom and lack of elodeids, lemnids and Charales, (3) scarcity of isoetids and mosses and (4) sparse stands of helophytes and

Table 3. Synopsis of the physico-chemical parameters and changes in flora and vegetation of the studied lakes. Symbols + = stands clearly increased; (+) = stands slightly increased; – = stands clearly decreased; (–) = stands slightly decreased; 0 = no changes observed.

Number and name of lake	Commune	Study years	pH in 1930's	pH in 1980's	Transparency in 1930's	Transparency in 1980's	Colour in 1980's	Conductivity in 1980's
Equisetum type								
1. Lommträsk	Pohja	36–85	5.9	5.9	1.4	3.4	20	35.5
5. Svedjaträsk	Karjaa	36–85	6.0	6.2	1.2	2.3	25	25.8
6. Virojärvi	Vehkalahti	38–83	5.9	6.4	1.6	1.8	80	76.2
7. Vainolanjärvi	Luumäki	38–83	6.3	6.6	1.9	1.8	70	39.3
8. Ruostejärvi	Tammela	36–83	6.4	6.7	1.9	3.3	25	47.0
9. Finnb. Lillsjö	Karjaa	36–85	6.3	6.6	1.2	>2	30	88.8
10. Vuorijärvi	Parkano	36–84	6.4	6.2	1.4	1.2	150	25.4
11. Korhosjärvi	Kihniö	36–84	6.5	6.1	1.2	1.3	60	50.7
12. Jämijärvi	Jämijärvi	36–84	6.3	7.2	1.3	1.2	100	47.3
13. Köyhäinjärvi	Reisjärvi	36–85	6.5	6.7	1.0	0.9	125	51.5
14. Keskisträsk	Oravainen	36–85	6.5	6.0	0.2	1.2	90	87.0
15. Röykästräsk	Oravainen	36–85	6.5	6.5	0.8	1.8	50	126.5
Equisetum-Phragmites type								
17. Kalapääträsk	Vöyri	36–85	6.4	6.0	2.5	2.0	60	173.9
18. Salkolanjärvi	Somero	36–83	6.7	6.5	2.5	3.3	30	48.7
19. Evijärvi I	Evijärvi	36–85	6.5	6.5	2.0	1.7	70	115.9
20. Evijärvi II	Evijärvi	36–85	6.4	6.6	1.5	1.1	80	53.5
21. Maarijärvi	Vehmaa	37–85	6.6	6.9	2.1	2.1	40	64.6
22. Taipaleenjärvi	Uusikaupunki	37–85	6.5	6.6	1.2	0.9	80	78.9
23. Oinasjärvi	Somero	36–83	6.6	7.2	1.7	1.9	40	65.8
24. Räyringinjärvi	Veteli	36–85	6.7	6.8	2.6	2.2	30	92.8
25. Sotkamojärvi	Sotkamo	36–84	6.6	7.2	2.9	2.6	35	40.6
26. Pirttijärvi	Sotkamo	36–84	6.4	6.9	2.8	2.1	60	26.3
27. Kanajärvi	Kalvola	37–83	6.8	6.7	2.7	2.9	35	56.0
28. Kivesjärvi	Paltamo	36–84	6.8	7.3	3.4	2.4	35	30.9
29. Parkkimajärvi	Pyhäjärvi	36–85	6.6	7.0	3.7	2.2	20	46.4
31. Gålisjö	Karjaa	36–85	6.3	6.4	3.0	2.3	20	101.5
32. Littoistenjärvi	Lieto	37–85	6.8	6.9	2.6	3.3	5	101.5
33. Oksjärvi	Nastola	38–83	6.8	6.8	3.4	2.9	20	83.6
34. Ala-Kintaudenj.	Petäjävesi	37–82	6.8	6.6	2.7	2.6	70	35.8
35. Uurainen	Uurainen	37–82	6.6	7.1	3.8	3.1	30	37.6
36. Kynelmyksenj.	Anjalankoski	38–83	6.5	6.7	3.9	3.2	30	36.4
37. Kotkajärvi	Kalvola	37–83	6.9	6.8	3.7	3.6	30	59.8
40. Vitträsk	Kirkkonummi	36–82	6.4	7.3	3.7	3.3	10	61.8
Phragmites type								
41. Lestijärvi	Lestijärvi	36–85	6.5	6.7	3.0	2.3	40	30.9
42. Pyhäjärvi	Pyhäjärvi	36–85	6.8	6.2	4.0	2.1	15	154.6
43. Karankolahti	Kajaani	36–84	6.6	6.8	2.6	2.2	60	32.3
44. Kuluntalahti	Kajaani	36–84	6.7	6.9	3.2	2.5	60	30.0

Vascular plants in 1930's	Vascular plants in 1980's	Disappeared vascular plants	New vascular plants	Disappeared mosses	New mosses	Changes in *Equisetum fluviatile* stands	Changes in *Phragmites* stands	Changes in *Schoenoplectus lacustris* stands	Changes in *Nuphar* spp. stands	Changes in *Nymphaea* spp. stands	Changes in submerged plant stands	Changes in isoetid stands	Changes in moss stands	Changes in *Chara* spp. stands
8	11	0	3	0	0	0	0	0	0	0	0	(+)	0	0
14	18	3	7	1	2	–	–	0	0	–	0	(–)	?	0
21	27	2	8	0	2	0	0	+	+	–	0	+	(+)	0
14	25	0	11	1	1	(–)	–	(–)	–	+	(+)	0	0	0
16	25	2	11	0	2	–	0	0	(–)	–	+	+	+	0
9	21	1	13	0	0	–	–	0	(–)	–	0	0	0	0
22	22	6	5	0	0	+	–	–	(–)	+	(+)	–	?	0
20	28	2	9	1	2	+	(–)	–	0	0	+	–	+	0
18	28	5	15	0	0	(+)	–	–	0	(–)	(+)	–	0	0
18	19	2	3	0	0	(–)	–	0	(–)	0	(+)	(–)	0	0
10	36	2	24	0	4	0	0	0	+	0	(+)	(+)	+	0
21	28	4	11	0	1	+	+	0	+	+	0	–	+	0
21	23	6	8	0	0	0	0	0	(–)	(–)	–	–	?	–
17	22	3	8	0	0	0	–	(–)	+	0	+	+	0	0
19	37	0	18	1	5	+	+	+	+	+	+	+	+	0
25	41	4	19	0	8	0	(+)	–	(–)	+	+	+	+	0
22	24	4	5	1	0	(–)	0	–	0	–	0	–	–	0
28	33	1	5	0	1	0	–	(–)	0	–	0	–	+	0
21	35	3	17	1	1	–	–	–	0	–	0	+	?	0
17	34	2	20	0	7	(+)	0	+	+	+	+	0	+	0
28	44	1	16	0	4	+	(–)	–	0	+	–	–	+	0
26	35	1	10	1	4	(–)	–	0	0	+	–	–	+	0
19	32	2	15	4	2	(–)	–	–	(–)	–	0	+	–	–
23	26	3	6	1	1	0	–	0	+	0	–	–	?	0
18	27	0	9	0	6	+	(+)	0	+	0	+	0	+	0
18	29	2	13	4	0	0	–	–	0	0	–	+	–	0
27	25	7	5	1	0	0	(–)	–	0	–	+	+	–	0
27	39	1	13	0	0	–	(+)	0	0	–	+	+	0	0
24	26	4	6	0	2	0	0	0	0	(–)	–	0	+	0
28	37	1	9	1	4	(–)	–	0	0	–	0	+	+	0
19	24	3	8	1	0	0	0	+	+	+	+	(+)	?	0
17	31	2	15	0	2	+	(–)	–	+	+	(–)	0	(+)	–
26	28	5	7	0	1	0	+	–	+	0	0	+	(+)	+
25	39	2	16	1	6	0	0	(–)	+	0	0	–	+	0
24	37	2	15	0	5	0	(+)	0	+	+	0	–	+	0
16	23	2	9	2	2	(–)	–	0	+	0	0	–	?	0
24	30	3	9	0	4	0	0	0	+	0	0	0	?	0

(Continues)

Table 3 continued.

Number and name of lake	Commune	Study years	pH in 1930's	pH in 1980's	Transparency in 1930's	Transparency in 1980's	Colour in 1980's	Conductivity in 1980's
45. Sokajärvi	Kajaani	36–84	6.6	6.9	2.5	1.6	50	35.6
46. Melalahti	Paltamo	36–84	6.8	7.6	3.3	2.4	40	32.3
47. Pyhäjärvi I	Yläne	36–85	6.8	7.3	3.0	2.8	15	88.8
48. Pyhäjärvi II	Säkylä	36–85	6.8	7.1	–	–	15	78.9
49. Pyhäjärvi III	Eura	36–85	6.9	7.1	3.0	3.4	15	78.9
50. Jääsjärvi	Hartola	38–82	6.7	7.1	3.0	3.7	20	52.4
51. Jänisselkä	Rääkkylä	38–85	6.6	6.6	3.5	3.4	50	37.6
52. Paasivesi	Savonranta	38–81	6.6	6.3	3.7	3.3	40	32.6
53. Haukivesi	Savonlinna	38–85	6.8	6.8	4.4	4.6	25	73.2
54. Lehmäinselkä	Puumala	38–82	6.6	7.1	4.7	4.4	25	45.8
55. Harvionselkä	Anttola	38–82	6.7	6.9	5.4	3.7	20	63.7
56. Louhivesi	Ristiina	38–85	7.1	7.2	4.0	4.8	15	63.2
57. Aitolahti	Tampere	32–84	6.6	6.8	3.8	2.1	60	59.2
58. Päijänne	Padasjoki	38–83	6.8	6.7	4.8	4.4	20	56.8
59. Puulavesi	Hirvensalmi	38–82	6.7	7.2	5.0	4.4	20	40.6
Lobelia type								
63. Valkiajärvi	Kankaanpää	36–84	6.8	7.1	4.0	1.5	15	49.0
64. Simuna	Uurainen	37–82	6.7	7.2	5.0	3.8	35	43.1
65. Pieni Uurainen	Uurainen	37–82	6.8	6.9	5.4	4.9	20	27.1
66. Lunkinjärvi	Kalvola	37–83	6.5	6.4	5.2	4.5	20	30.6
67. Ylä-Kivijärvi I	Luumäki	38–83	6.5	7.0	6.4	4.9	15	65.5
68. Ylä-Kivijärvi II	Luumäki	38–83	6.7	6.9	5.0	4.0	15	69.3
70. Venepohja	Liperi	37–85	6.9	7.2	6.5	6.6	10	55.7
71. Urajärvi	Asikkala	38–83	6.9	6.8	6.8	6.5	5	54.6
72. Suurijärvi	Heinola	38–83	6.9	7.1	6.0	4.8	5	59.3
74. Särkijärvi	Tohmajärvi	38–80	6.8	7.2	8.0	6.3	5	82.8
75. Valkjärvi	Somero	37–83	6.4	6.7	7.1	8.5	10	21.6
76. Sääksjärvi	Nurmijärvi	39–82	6.2	6.3	4.8	5.0	15	36.6
77. Herajärvi	Luumäki	38–83	6.3	6.7	7.4	8.3	5	30.2
79. Törmäsjärvi	Ylitornio	37–78	6.8	7.2	8.2	7.0	5	20.9
80. Kuorinkajärvi	Liperi	37–85	6.6	7.0	12.5	11.0	5	53.5
Potamogeton filiformis-Chara type								
81. Yläkitkajärvi	Kuusamo	37–84	7.6	7.7	4.5	3.7	20	64.6
82. Saapunkijärvi	Kuusamo	37–80	7.3	7.1	4.5	3.3	20	58.0
84. Oivankijärvi	Kuusamo	37–80	7.5	7.9	5.0	5.0	5	67.4
85. Hyypiöjärvi	Kuusamo	37–80	7.5	7.8	5.1	5.0	15	63.0
86. Horkanlampi	Paltamo	36–84	7.4	7.8	5.0	4.5	10	245.4
87. Salmijärvi	Kajaani	38–84	7.3	6.8	5.7	6.1	5	33.8
89. Korvasjärvi	Kuusamo	37–84	7.9	8.0	6.5	5.9	5	129.1
Carex type								
90. Ukonselkä	Inari	39–82	6.8	6.9	6.0	4.7	15	37.6
91. Vastusjärvi	Inari	39–82	6.9	6.7	6.2	4.5	20	26.9

Vascular plants in 1930's	Vascular plants in 1980's	Disappeared vascular plants	New vascular plants	Disappeared mosses	New mosses	Changes in *Equisetum fluviatile* stands	Changes in *Phragmites* stands	Changes in *Schoenoplectus lacustris* stands	Changes in *Nuphar* spp. stands	Changes in *Nymphaea* spp. stands	Changes in submerged plant stands	Changes in isoetid stands	Changes in moss stands	Changes in *Chara* spp. stands
25	32	5	11	0	2	(–)	(+)	0	+	+	0	–	+	0
24	36	6	18	0	6	0	–	(–)	+	+	0	–	+	0
14	20	3	9	0	2	+	+	0	0	0	–	–	+	0
29	30	12	13	0	3	0	(–)	–	+	0	(+)	–	(+)	0
26	37	4	14	0	4	(–)	–	–	(+)	–	–	+	+	0
35	44	4	13	0	4	+	0	(–)	(+)	+	+	+	+	0
20	29	3	12	0	3	0	+	0	0	0	+	+	+	0
32	36	2	6	1	7	+	0	–	0	0	–	–	+	0
29	32	6	9	1	1	–	(+)	–	0	0	+	+	?	0
30	25	10	5	0	3	–	(–)	–	–	–	–	–	+	0
42	34	11	3	0	4	0	–	–	0	–	+	0	+	0
33	39	5	12	0	0	–	(+)	–	0	–	0	+	0	0
51	34	21	4	2	0	–	–	–	–	–	–	–	–	0
27	37	3	12	0	4	(+)	0	+	(+)	+	+	0	+	0
16	26	1	11	0	1	–	0	–	(+)	(+)	+	+	+	0
15	28	3	16	1	7	(+)	0	–	(+)	0	+	–	+	0
21	25	2	6	1	0	0	(–)	0	0	–	0	+	–	0
19	20	3	4	2	6	0	0	(+)	0	–	+	(+)	+	0
14	21	3	10	0	3	–	(–)	0	–	–	–	(+)	+	0
25	30	3	8	0	0	(–)	(–)	–	(+)	–	0	–	0	0
23	30	2	9	0	0	0	–	0	0	0	+	+	0	0
31	37	3	9	2	0	0	(–)	–	(–)	0	0	+	–	0
33	33	4	4	1	4	0	–	(+)	0	0	+	0	?	0
11	12	2	3	0	1	+	–	0	0	–	0	0	+	+
27	31	6	10	0	2	–	0	0	(+)	–	+	–	+	?
14	14	4	4	0	1	0	–	0	(+)	(–)	–	+	+	0
22	20	5	3	1	1	–	–	0	0	+	–	+	?	0
20	24	1	5	0	0	(–)	+	0	0	–	+	0	0	0
20	14	6	0	0	1	–	0	0	0	0	–	–	+	0
23	34	7	18	1	1	(–)	(+)	0	+	0	–	–	?	0
35	39	3	7	0	7	(+)	(–)	(–)	+	+	–	–	+	?
30	31	4	3	6	1	0	–	–	–	–	0	–	–	–
29	28	3	2	0	4	(–)	0	–	–	0	–	–	+	?
21	20	5	4	1	0	(–)	–	0	(–)	0	–	–	–	–
8	12	6	10	0	0	–	+	–	+	0	–	0	0	?
19	21	4	6	0	1	0	0	0	–	0	–	–	+	–
13	20	2	9	1	0	(–)	0	+	0	0	+	0	?	?
25	23	5	3	0	4	0	0	0	+	0	–	–	+	0
25	25	3	3	2	3	(–)	0	0	(–)	0	–	–	+	0

(Continues)

Table 3 continued.

Number and name of lake	Commune	Study years	pH in 1930's	pH in 1980's	Transparency in 1930's	Transparency in 1980's	Colour in 1980's	Conductivity in 1980's
92. Talvitupajärvi	Inari	39–82	6.8	6.4	7.3	5.6	10	26.9
Elodeid type								
93. Saiveljärvi	Sodankylä	39–81	7.0	6.5	1.0	1.0	90	31.9
94. Orajärvi	Sodankylä	39–84	6.8	7.6	3.3	3.3	20	36.6
95. Vaalajärvi	Sodankylä	39–84	6.7	6.1	2.1	1.1	70	23.3
96. Posiojärvi	Posio	37–84	7.3	7.5	2.7	2.2	60	24.0
97. Narkausjärvi	Rovaniemi	38–80	7.1	7.1	3.0	3.1	40	48.0
98. Immelänjärvi	Kittilä	37–82	7.2	7.4	3.1	3.6	20	69.8
99. Äkäsjärvi	Muonio	37–82	7.2	7.4	3.1	3.2	35	47.6
100 Särkijärvi	Muonio	37–82	7.5	7.1	2.0	4.6	10	27.7
101 Ylinen Sieppij.	Kolari	37–82	7.2	7.3	1.7	0.7	70	39.6
102 Vähä-Lohijärvi	Ylitornio	37–80	7.4	7.2	1.9	1.9	50	29.6
103 Majamalompolo	Ylitornio	37–84	6.9	6.7	2.1	1.8	60	29.8
104 Perunkajärvi	Rovaniemi	37–80	7.2	7.2	1.9	2.0	90	37.3
Scirpus lacuster type								
105 Sulkuenjärvi	Kihniö	36–84	6.7	6.0	1.0	1.3	60	44.9
107 Evijärvi III	Evijärvi	36–85	6.8	6.4	1.0	0.5	150	49.7
108 Näläntöjärvi	Kiuruvesi	36–84	6.6	6.6	1.0	0.6	150	53.3
109 Kiuruvesi	Kiuruvesi	36–82	6.8	6.9	1.4	0.9	150	53.3
110 Niemisjärvi	Kiuruvesi	36–85	7.0	6.8	1.4	1.2	100	92.8
111 Tjusträsk	Siuntio	36–82	6.8	7.7	1.1	1.0	40	129.1
112 Stor Lonokträsk	Kirkkonummi	36–82	6.6	7.3	0.4	0.5	50	83.6
113 Ridasjärvi	Hyvinkää	38–82	7.5	6.4	0.8	0.7	125	71.0
114 Köyliönjärvi	Köyliö	36–85	7.1	7.4	0.8	0.8	35	126.8
Typha-Alisma type								
115 Valkjärvi	Kärkölä	38–83	7.1	7.8	1.7	0.5	40	135.6
116 Majuvesi	Sysmä	38–82	6.8	6.9	2.2	1.8	40	54.3
117 Kaukjärvi	Forssa	36–83	7.2	6.9	0.6	1.1	35	109.6
118 Savijärvi	Sipoo	40–82	7.4	7.4	1.9	0.9	30	101.5
119 Läppträsk	Karjaa	39–85	7.1	8.1	0.2	1.4	25	170.2
120 Sääskjärvi	Iitti	38–83	7.7	7.3	0.3	0.5	50	329.4
123 Särkijärvi	Liperi	37–85	7.1	7.1	2.0	2.0	25	151.2
124 Ahmasvesi	Uusikaupunki	37–83	7.0	7.1	2.2	2.6	15	3508.8
Potamogeton type								
129 Mustfinnträsk	Parainen	37–83	8.2	9.5	–	–	40	198.2
130 Gräggböleträsk	Parainen	37–83	8.1	8.3	2.5	1.2	30	156.7
131 Lampisträsk	Parainen	37–83	8.0	7.5	–	–	20	146.5
Stratiotes type								
132 Jesiöjärvi	Kittilä	37–84	8.3	7.9	2.5	3.2	25	83.6
133 Hautajärvi	Kittilä	37–84	8.3	7.6	2.5	3.2	25	78.9
134 Rastinjärvi	Kittilä	37–84	8.2	7.6	3.0	–	25	88.8
135 Sotkajärvi	Kittilä	37–84	8.3	7.7	1.5	1.5	30	118.4

Vascular plants in 1930's	Vascular plants in 1980's	Disappeared mosses	New vascular plants	Disappeared vascular plants	New mosses	Changes in *Equisetum fluviatile* stands	Changes in *Phragmites* stands	Changes in *Schoenoplectus lacustris* stands	Changes in *Nuphar* spp. stands	Changes in *Nymphaea* spp. stands	Changes in submerged plant stands	Changes in isoetid stands	Changes in moss stands	Changes in *Chara* spp. stands
13	13	2	2	0	0	–	0	0	–	0	+	+	0	0
14	15	3	4	1	1	+	0	0	+	0	–	0	?	0
25	32	4	11	0	6	+	–	0	0	(–)	+	–	+	0
27	30	3	6	0	4	(–)	(+)	+	+	0	–	–	+	–
28	35	0	6	0	2	(–)	–	0	+	0	–	–	+	0
31	28	6	3	1	3	–	–	–	–	0	(–)	–	+	+
24	24	3	3	0	0	(–)	0	0	0	0	+	–	?	0
23	21	4	2	1	2	0	0	0	0	0	–	(–)	+	0
19	20	3	4	0	4	(+)	0	0	+	0	(+)	–	+	0
28	25	6	3	0	3	(+)	0	0	0	+	+	–	+	0
40	30	11	1	2	1	0	(–)	–	–	–	–	–	?	0
41	42	4	5	0	5	0	0	(–)	+	(–)	–	–	+	0
32	36	4	8	0	7	–	–	–	–	+	–	–	+	+
21	33	2	14	0	6	+	(–)	–	0	–	–	+	+	0
12	31	0	18	0	1	0	+	0	0	+	+	0	+	0
20	29	4	13	0	5	(+)	0	(+)	+	+	+	–	+	0
24	45	1	21	0	4	(+)	+	0	–	0	+	–	+	0
25	36	3	14	0	1	–	–	–	–	–	+	–	?	0
17	28	2	13	0	0	+	–	+	(–)	–	+	0	0	0
19	27	2	10	0	0	+	+	0	+	+	0	0	0	0
23	27	5	9	0	1	(+)	–	+	0	0	+	0	+	0
34	39	6	11	0	5	+	(–)	–	0	–	+	0	+	0
29	34	5	9	0	2	+	(–)	0	0	0	–	–	+	0
44	45	6	7	0	3	0	0	0	0	+	–	–	+	0
20	30	1	11	0	0	(+)	(–)	–	(–)	0	+	+	0	0
30	26	9	5	0	0	–	(–)	–	+	–	–	0	?	–
25	61	0	36	0	3	–	(–)	–	+	+	+	+	+	0
20	28	0	8	0	0	0	(–)	(–)	+	+	(+)	0	0	0
24	24	6	6	0	4	–	0	+	(+)	0	–	–	+	+
30	46	4	19	0	3	0	0	(+)	(–)	0	+	–	+	+
38	26	15	3	3	0	–	0	–	–	–	–	0	–	?
29	30	6	6	1	1	–	0	0	0	–	0	0	?	–
26	29	7	9	0	3	–	0	0	+	–	+	+	+	?
18	25	0	7	0	0	0	+	0	+	0	+	(–)	0	+
26	29	3	8	1	8	0	+	0	0	0	0	–	+	?
20	18	5	3	0	0	(–)	–	0	0	0	–	–	0	+
18	23	0	5	0	0	0	(–)	0	+	0	–	0	0	0

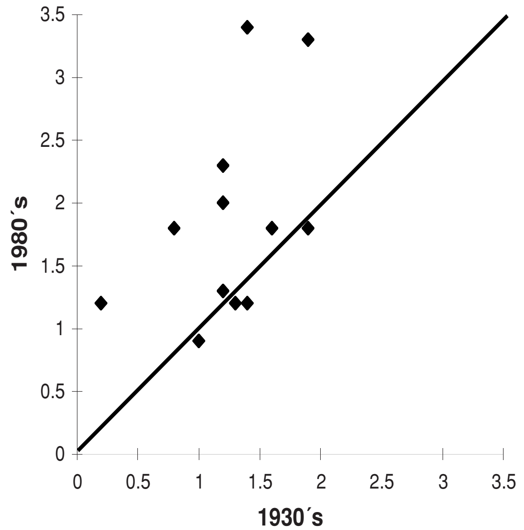

Fig. 4. Transparency values of *Equisetum*-type.

nymphaeids. The pH of this type in the 1980's was very similar to that in the 1930's (Table 1). On the other hand, the water transparency had increased from 1.3 to 1.9 m (Fig. 4).

The vascular plant flora of this type has evidently become remarkably richer, the most extreme example being lake 14 (Keskisträsk), with 24 new species and 2 disappeared ones. The trend of the vegetation changes from the 1930's to the 1980's was a diminishing of the helophyte zone and a slight deterioration of *Nymphaea* stands. By contrast, submerged plants favouring increased transparency had become more frequent: *Potamogeton berchtoldii*, *P. perfoliatus* and *Myriophyllum alterniflorum* occur in some lakes. Aquatic bryophytes similarly had appeared in many *Equisetum*-lakes. New growth forms are ceratophyllids (*Utricularia vulgaris* has appeared in five of 12 studied lakes) and lemnids (*Lemna minor* 6/12).

Table 4. Species which have retained in the study lakes (based on Maristo 1941 and the present study). The numbers refer to disappeared, persisted and new occurrences (lakes) of the species.

	Dis-appeared	Per-sisted	New occur-rences
Schoenoplectus lacustris	15	51	6
Potamogeton praelongus	11	12	6
Ranunculus flammula	10	2	1
R. confervoides	5	0	1
Crassula aquatica	8	4	2
Myriophyllum alterniflorum	12	52	6
Menyanthes trifoliata	16	42	8

Table 5. Species without essential changes (based on Maristo 1941 and the present study). The numbers refer to disappeared, persisted and new occurrences (lakes) of the species.

	Dis-appeared	Per-sisted	New occur-rences
Isoetes lacustris	7	67	4
Sagittaria natans	2	16	1
Stratiotes aloides	1	5	0
Potamogeton filiformis	1	5	0
Scolochloa festucacea	1	2	0
Carex vesicaria	18	17	13
Nymphaea alba	6	3	4
Subularia aquatica	12	33	11
Callitriche hermaphroditica	7	5	5
Lobelia dortmanna	5	55	3
Equisetum fluviatile	3	106	3
Phragmites australis	3	100	3
Sparganium gramineum	6	66	6
Polygonum amphibium	5	27	5
Nymphaea tetragona	3	2	3
Carex acuta	8	48	10
C. lasiocarpa	7	43	11
Potentilla palustris	9	91	11
Eleocharis palustris	8	76	15
Glyceria maxima	0	1	1
Alopecurus aequalis	13	11	18
Spirodela polyrrhiza	1	3	2
Potamogeton perfoliatus	6	67	13
P. compressus	2	8	3
Lemna trisulca	2	4	4
Ceratophyllum demersum	4	3	5
Myriophyllum sibiricum	3	7	6
Utricularia minor	3	0	5
Callitriche palustris	10	27	14
C. cophocarpa	3	1	4
Juncus bulbosus	7	12	9
Rumex hydrolapathum	0	1	2
Carex rostrata	5	81	17
C. pseudocyperus	0	5	2
Glyceria fluitans	10	21	16
Caltha palustris	11	33	19
Hippuris vulgaris	7	11	9
Cicuta virosa	10	29	17
Myosotis scorpioides	2	4	6
Bidens cernua	3	3	7

Equisetum–Phragmites-type

This type is characterized by the abundance of helophytes, marked zonation and a scarcity of elodeids. The mean pH in the lakes increased from the 1930's to the 1980's (Fig. 5, Table 1) so that the difference was significant. Transparency values had to some extent diminished. Values of the water colour were clearly lower than those of the preceding type, and the conductivity values were somewhat higher.

Table 6. Clearly expanded species (based on Maristo 1941 and the present study). The numbers refer to disappeared, persisted and new occurrences (lakes) of the species.

	Dis-appeared	Per-sisted	New occur-rences
Typha latifolia	0	9	37
T. angustifolia	0	7	4
Potamogeton natans	5	73	15
Sparganium angustifolium	4	21	15
Nymphaea candida	9	46	19
Nuphar lutea	8	85	17
N. pumila	1	25	9
Hydrocharis morsus-ranae	1	3	6
Lemna minor	3	12	39
Elodea canadensis	1	2	13
Potamogeton obtusifolius	1	5	12
P. berchtoldii	15	18	23
Myriophyllum verticillatum	0	4	7
Utricularia vulgaris	7	25	31
U. intermedia	6	2	13
Potamogeton gramineus	2	27	13
P. alpinus	11	12	39
Isoetes echinospora	5	27	31
Elatine triandra	6	10	12
E. hydropiper	5	17	10
Littorella uniflora	0	5	7
Butomus umbellatus	0	5	4
Sparganium minimum	9	5	21
S. emersum	7	49	22
S. erectum	2	8	8
Calla palustris	2	20	36
Iris pseudacorus	0	12	33
Carex elata	1	8	12
C. aquatilis	9	1	24
Scirpus silvaticus	2	1	9
Phalaris arundinacea	1	10	14
Rumex aquaticus	0	1	10
Lythrum salicaria	3	46	19
Lysimachia thyrsiflora	4	71	32
Lycopus europaeus	0	8	9

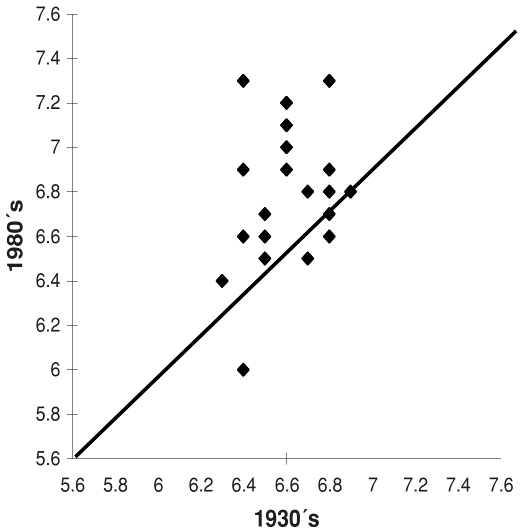

Fig. 5. pH values of *Equisetum–Phragmites*-type.

The aquatic flora of this type had clearly become richer. As to the vegetation the helophyte stands have declined, especially *Schoenoplectus lacustris* and *Phragmites* have clearly decreased. In the zone of floating-leaved plants *Nymphaea* stands have declined, but *Nuphar lutea* has enlarged its range. Submerged plants have maintained their positions, the isoetid stands have increased slightly and moss carpets have spread strongly.

Phragmites-type

The units of this type are parts of large lakes where wave action and floating ice have a greater effect

Table 7. Newcomers in the lakes (based on Maristo 1941 and the present study). The numbers refer to disappeared, persisted and new occurrences (lakes) of the species.

	Dis-appeared	Per-sisted	New occur-rences
Sparganium glomeratum	0	0	2
Potamogeton rutilus	0	0	3
P. pusillus	0	0	3
P. pectinatus	0	0	1
Zannichellia palustris	0	0	1
Najas marina	0	0	2

than in the aforementioned lake types. *Phragmites australis* forms large, yet not very dense stands; *Eleocharis palustris*, *Equisetum fluviatile* and *Schoenoplectus lacustris* are common. Submerged aquatics are abundant, especially *Ranunculus peltatus* being typical of this lake type. Isoetids, such as *Isoetes lacustris* and *Lobelia dortmanna* have large occurrences. Aquatic mosses are rather common.

The mean pH was in the 1980's a little higher than in the 1930's (Table 1); statistically the values differ significantly (95% probability).

The mean water transparency had decreased by 0.5 m. The colour values were low. Conductivity was, on the average, lower than in the two preceding lake types. The number of species had clearly increased in these lakes.

Changes in the vegetation show a clear decline of helophyte stands. Especially *Schoenoplectus lacustris* had retreated strongly. Floating-leaved plants had occupied new areas so that stands of *Nuphar lutea* had clearly increased but those of *Nymphaea* species were slightly reduced. Submerged aquatics had enlarged their stands slightly. The amount of isoetids had in most cases decreased. The aquatic moss vegetation had distinctly increased in most lakes.

Lobelia-type

This type is characterized by clear, nutrient-poor water, thin helophyte stands and abundant isoetid vegetation. *Lobelia*-type was primarily described by Samuelsson (1925) and then accepted by Almquist (1929), Cedercreutz (1934, 1937, 1947) and Maristo (1941). In northern Finland it is gradually replaced by a species poorer variant of the type (Rintanen 1982: 262).

The mean pH values had changed from the 1930's to the 1980's so that the difference is statistically significant (95% probability). Also the mean transparency had lowered, but this change is not significant statistically. Colour of water had, on the average, lowest values beside the *Potamogeton filiformis–Chara* type. Conductivity values are fairly low.

Floristically the lakes of this type have become a little richer. The greatest change (16 new and 3 disappeared vascular plants) had occurred in the little Valkiajärvi (lake 63), polluted by a military area. Similarly the amount of aquatic mosses had generally increased. The helophyte vegetation had a clearly sparser character than in the 1930's. As to the floating-leaved plants the amount of *Nymphaea* stands was smaller, but the trend of *Nuphar lutea* is not clear. Submerged plants had increased slightly, but the amount of isoetid stands has remained unchanged. Aquatic moss carpets had clearly expanded. This is partly connected with the increased humus content of waters, but there was a moss stand expansion also in one lake with an increased transparency.

Potamogeton filiformis–Chara-type

This type is characterized by clear water, but rather high pH, thin helophyte stands and occurrence of some macrophytes preferring slightly alkaline water. Geographically this type is concentrated to the Kainuu–Kuusamo schist belt. These alkaline lakes were more common in Kuusamo during the subarctic postglacial phase (Vasari 1962: 79–80, 1978: 924). Some of the southern lakes studied by Maristo (1941) (lakes 86 Horkanlampi and 87 Salmijärvi) are evidently not typical representantives of this type (Rintanen 1982: 263). The mean pH was in the 1980's very near that of the 1930's; the differences in these and the transparency are statistically not significant. Evolution of these lakes has slightly proceeded towards smaller transparency and, in some cases, increased eutrophication. The water colour values were, however, the lowest of all lake types, whereas the conductivity values vary very much in this lake type.

Floristically most of the lakes had become a little richer. The helophyte stands were thinner than in 1930's. Floating-leaved plants have no distinct trend, but submerged species and isoetids have to some extent decreased. Also stands of *Chara* spp. have diminished. In most lakes the bryophyte stands have become more numerous.

Carex-type

Characteristic features of this northern lake type are indistinct zonation (in some places a narrow *Carex* zone) and scarcity of helophyte vegetation, but often dense occurrences of elodeids. The material of Maristo (1941) was very limited, and one of the three lakes studied by him is now regulated.

The mean pH had diminished slightly and transparency more strongly, but due to the low number of the lakes both differences are statistically insignificant. The changes in aquatic flora were meagre. The number of vascular plants was slightly reduced, and that of mosses had increased. Helophytes had decreased somewhat. Nymphaeids (consisting only of *Nuphar* stands) had variable trends. Elodeids and isoetids had a similar but slightly negative tendency. Moss vegetation had to some extent expanded.

Elodeid-type

This northern lake type is characterized by abundance of elodeids. Helophytes are abundant in the southern part of the distribution area of the type. Most of the lakes are situated on a slightly basic bedrock. This type has a rather wide variation and intermediate forms towards *Nuphar*-, *Potamogeton filiformis–Chara*- and *Stratiotes*-type (Rintanen 1982). Lake 100, (Särkijärvi in Muonio) may have belonged to the *Carex*-type also in Maristo's time, but he regarded it as an elodeid lake due to the temporarily low value of transparency.

The pH and transparency values had remained very stabile in this lake type: the differences were not significant. In the Elodeid-type the changes in the vascular plant flora were in many cases negative, contrary to the situation in the other lake types. The amount of aquatic mosses had clearly increased. The helophyte zone was thinner, because of muskrats. The nymphaeid stands had mostly retained their position. The communities of submerged aquatics and isoetids had slightly diminished, but aquatic mosses had colonized new areas.

Scirpus lacuster-type

The lakes of this type are rich in helophytes, especially *Schoenoplectus lacustris* forms dense stands. Submerged plants play only a small role due to the low water transparency. pH had remained approximately at same level over the 40 years, and the transparency values had decreased somewhat. However, both differences are statistically not significant.

The floristic changes were clearly positive as to the increase of the species number of vascular plants and mosses. The helophyte vegetation was during Maristo's investigation destroyed by muskrat in many lakes. In the 1980's this zone had again developed well, especially *Equisetum fluviatile* had become more frequent. The nymphaeid stands were usually of about the same quantity as 40 years earlier. The communities of submerged plants had widely expanded since Maristo's investigation. The isoetid stands were originally scanty, and the trend seemed to be towards further diminishing. The aquatic moss communities had increased very clearly.

Typha–Alisma-type

Maristo (1941) gave the following characters for the *Typha–Alisma*-type: dense littoral plant belt, very dense helophyte zone, well-developed nymphaeid stands, abundance of elodeid and lemnid communities, and an almost total lack of isoetids. The rather high pH of the type had not changed much during the 40 years. Mean of transparency was the same in both surveys.

Floristic changes in this lake type were relatively remarkable: the number of vascular plants and aquatic mosses had increased in almost all lakes. As to the development of vegetation the helophyte stands have become slightly thinner and more discontinuous. The nymphaeid communities were denser than in the 1930's. The elodeids had an approximately similar status as 40 years before. Rare isoetid stands had still declined, whereas aquatic moss communities had strongly increased.

Potamogeton-type

Characteristic features of this lake type are relatively clear water, shallowness and a marine origin. Two lakes are nowadays so shallow that the transparency is impossible to determine. The distribution of the type is south-western; there are similar lakes in Åland (Cedercreutz 1937, Maristo 1941: 195). The lagoon lakes of the Bothnian Sea resemble this type (Rintanen 1982). In the east, on the coast of the Gulf of Finland, the lake Kirkkojärvi (Ulvinen 1958) in Hamina has evidently been close to this lake type (Rintanen 1981). However, most of these coastal lakes have developed towards more acid conditions, having paludified shores and dense reedbeds but lacking all demanding submerged plants. Evidently the *Potamogeton*-type proper demands a basic bedrock or deposits containing lime.

The flora had largely become poorer and stands of *Equisetum* and *Nymphaea* had declined. Other alterations were indistinct, and the material was very limited for general conclusions.

Stratiotes-type

This northern type is characterized by luxuriant stands of elodeids, a great number of exacting eutraphent species and a lack of isoetids. pH is high, water is clear and conductivity values are rather high, too. pH had, however, strongly lowered during 40 years; the difference is statistically highly significant. The mean transparency values increased (in the lake 134 Rastinjärvi the transparency was higher than the maximum depth), but the difference is statistically insignificant.

The number of plant species had to some extent increased in these lakes. As to the vegetation the alterations in the thin helophyte stands were indistinct. *Nuphar* communities had to some extent expanded, but the elodeid and very scanty isoetid vegetation had declined. Moss and *Characeae* stands had enlarged or appeared.

DISCUSSION

The results presented above possibly contain some errors caused by a slight discordance between these two studies. In some cases it was difficult to determine the exact location of the study lake.

Occasional pH measurements do not give a very reliable idea of the pH fluctuation in a lake. This deficiency is, however, to some extent compensated by the large material. As a rule, the pH values had not changed very much; according to Student's test the differences in the whole material are not significant statistically. Increased values were mostly observed in low-pH lakes and decreased values in high-pH lakes. Wallstén (1981) mentioned a similar trend in Uppland, Sweden. Within the *Stratiotes*-type the decrease of pH is statistically highly significant.

The corresponding median values of pH were 6.8 and 6.9. These values are remarkably higher than the median pH of the Finnish Lake Survey (6.3 of 987 lakes selected statistically, Forsius *et al.* 1990). The difference is partly caused by the later sampling period (25.VIII.–23.XI.1987) of the last mentioned survey. In addition, the smallest and naturally most acidic *Nuphar*-lakes were not represented in the lakes Maristo (1941) studied. A disproportionally great part of his lakes were situated on basic bedrock; this was evidently caused by the advices of Dr. M. Kotilainen (Maristo 1941: IV), who was mainly interested in basic substrates.

The changes described above were evidently caused by the following factors. pH in the lakes surrounded by cultivated areas had risen due to the liming of arable lands and effect of some fertilizers in the fields. The eutrophication causes, in suitable conditions (afternoon, sunshine), a very strong plankton production. Thus consumption of carbon dioxide causes a rise of pH (Lohammar 1965: 31). The greatest rise, in Mustfinnträsk (p. 4) was evidently caused by high algal production.

The present study did not reveal the effect of acid rain. Lake acidification was found to be a common phenomenon especially in southern Finland just at the beginning of the 1980's (Forsius *et al.* 1990). Maristo (1941) dealt mostly with large lakes in lowlands or along watercourses with brown water; small lakes in rocky or esker areas, sensitive to acidification (Pätilä 1982, Forsius *et al.* 1990), were rare in his sample collection. A local case of industrial acidification is Pyhäjärvi (lake 42), where the sewage (sulphide ore) of the copper mine Pyhäsalmi had caused a slight lowering of pH: in 1936 it was 6.8, and in 1985 it was 6.2. The pH of forest lakes had possibly risen somewhat due to forest fertilizers and lowered by ditching. However, some forest ditching projects existed already in the 1930's.

The results suggest that the water in the lakes studied by Maristo had became slightly less transparent. In the whole material the differences are statistically not significant, but in some lake types the changes are quite significant. The following factors had promoted the slight diminishing in transparency, observed in re-investigation. Forest and peatland ditching increases the humus content of water. This tendency is very strong below the peat production areas (lake 7 Vainolanjärvi, 41 Lestijärvi, lakes 108–110 in Kiuruvesi). Also the regulation of a lake makes the water more brownish (e.g. lake 57 Näsijärvi, 51–56 Saimaa, 90 Ukonselkä).

The eutrophication of lakes has often caused thick planktonic suspension diminishing transparency. Sometimes it reaches its culmination as a mass occurrence of green and blue-green algae reducing transparency to a few decimetres. Such a situation occurred in lakes 15, 45 and 115, for example.

The following factors have often increased the transparency values. The shore belt was commonly pastured in the 1930's. In the 1980's pasturing had almost wholly ceased and the littoral water was less turbid. The groundwater drainage of fields had become more common, and the pipe drain system brought clearer waters than the formerly dominant open ditches. Abandoned and reforested fields had also diminished the supply of suspended clayey waters. The clearing of water caused by acidification was not yet visible in the present material.

The median value (30 mg Pt) of the water colour is drastically lower than the median value (100 mg Pt) of the Finnish Lake Survey (987 lakes selected statistically; Kortelainen & Mannio 1990: 852). In that survey the biggest lakes were lacking, whereas Maristo (1941) excluded the smallest and darkest lakes in his study. The water colour correlates very well with transparency, and it is a very useful parameter when a lake is too shallow to permit a measure of transparency. The wind sometimes disturbes water, especially in lakes with muddy or clayey bottoms. Maristo (1941: 32) mentioned his visit to Keskisträsk (lake 14); the windy weather lowered the transparency to as low as 0.15 m. In this case a measurement of water colour could give a better characterization of that lake. Its transparency in the present study was 1.2 m.

The conductivity values have positive correlation to basic rocks, clayey deposits, marine heritage of the lake and intensive agriculture. The values of *Potamogeton*-type lakes are very high. These lakes are recently separated from the sea and have marine bottom sediments. Ahmasvesi (lake 124) is like that. The outlet of the lake was dredged in the 1950's. Currently Ahmasvesi receives an occasional brackish water flooding, and has a sewage input.

The high conductivity values of *Potamogeton filiformis–Chara*-type lakes are due to the basic schistose bedrock. The lakes of *Scirpus lacuster* and *Typha–Alisma*-types are situated on fertile clayey soils and thus have rather high values increased by the fertilizers leached from the surroundings. Former discharging of sewage can also increase conductivity, e.g. Evijärvi (lake 107; Granberg *et al*. 1989), Läppträsk (119) and Ahmasvesi (124). There has not been any liming against acidification before the time of investigation in any of the studied lakes. Most lakes are surrounded by summer cottages, which have a small tendency to eutrophicate the water. The use of forest fertilizers in drainaged areas also raises the eutrophication degree of the shallower lakes. Similarly the regulation generally increases the conductivity, especially at the onset of inundation.

There are some difficulties in floristical comparison of the two surveys. It is impossible to estimate the changes in frequencies and abundances of some littoral helophytes in 42 lakes, because Maristo (1941) did not investigate those species during his first study year. Also, only presence/absence data were given in all lakes for the aquatic mosses and Charales.

There may have been some determination inaccuracies in Maristo's (1941) work. The clear increase in occurrences of *Carex elata* and *C. aquatilis* (Table 6) and weak decrease of *Carex vesicaria* (Table 5) may be explained by this fact. Likewise the apparent increase of *Isoetes echinospora* and *Littorella uniflora* (Table 6), and decrease of *Isoetes lacustris* (Table 5) are possibly caused by Maristo's errors in deep-water species identification.

In both studies the investigation of a lake lasted mostly only one day. Lake Aitolahti, a bay of the big Lake Näsijärvi, had been an object of an intensive study lasting the whole summer (Maristo 1935). In the present study the duration of field study was one day per lake. In this particular case the different duration of study causes clear differences in the floristic results.

The floral diversity is greatest in lowered lakes (cf. Rørslett 1991) and those situated on basic bedrock. The aquatic species composition has changed considerably in the last 40 years (Rintanen 1992). The proportion of clear-water plants has decreased due to diminished transparency caused by eutrophication and forest ditching. In this category belong *Potamogeton praelongus*, *P. lucens*, *P. filiformis*, *Ranunculus confervoides*, *Myriophyllum alterniflorum*, *Callitriche hermaphroditica*, *Isoetes lacustris* and *Lobelia dortmanna*. Eloranta (1970: 107–108) mentioned *Myriophyllum alterniflorum* and *Lobelia dortmanna* to be sensitive to pollution. Kurimo (1970: 252) reported *Potamogeton praelongus*, *Myriophyllum alterniflorum* and *Lobelia dortmanna* to belong to the group suffering most strongly from industrial effluents. *Myriophyllum alterniflorum* has disappeared or declined also in small lakes near Kuopio (Ihantola 1987: 47).

Spreading of eutraphent aquatics during the last decades is a common trend in Finland. In some lakes this is caused by effluents of pulp and paper mills (Eloranta 1970, Kurimo 1970). In the material of Maristo the most evident case of paper industry pollution was Sokajärvi (lake 45), a part of the big Oulujärvi. Presently Sokajärvi has great amounts of plankton and bacteria and a high primary production, but its nutrient content does not differ from the rest of Oulujärvi (Anttonen-Heikkilä 1983: 10). Five phanerogams have disappeared from this lake, and 11 new ones were found there.

The diminishing of shore pasturing caused a lack of suitable habitats for the littoral plants *Crassula aquatica*, *Montia fontana* and *Ranunculus flammula*. Possibly also *Carex vesicaria* benefited from grazing.

Many eutraphents had become more frequent. Some of those have a southern distribution pattern. Erkamo (1956: 132–143, 157–180) described the expansion of some aquatics caused by the climatic amelioration during the last decades. Such plants are represented in Tables 5 and 6 by *Typha latifolia*, *Glyceria maxima*, *Hydrocharis morsus-ranae*, *Lemna minor*, *Spirodela polyrrhiza*, *Butomus umbellatus*, *Iris pseudacorus*, *Carex pseudocyperus*, *Rumex hydrolapathum* and *Lycopus europaeus*. *Typha latifolia* and *Iris pseudacorus* have sometimes been cultivated near summer cottages whence they have invaded to natural lake habitats. *Glyceria maxima* has spread strongly in the drainage area of river Kokemäenjoki (Uotila 1971: 268). In the material of Maristo there were only a few lakes in this region and the only invasion of this plant was noted in Lake Päijänne, which is situated east of the Kokemäenjoki region. *Carex aquatilis* has in Finland a northern distribution pattern, and the changes in its occurrences may be explained by former determination mistakes; probably it has earlier quite often been totally neglected (as also *Carex elata*). In the earlier surveys these sedges were probably often included in *Carex acuta*.

The expansion of *Lemna minor* (cf. Toivonen 1985) is due to eutrophication. In addition, especially *L. trisulca* and *Ceratophyllum demersum* have a sporadic character in their occurrences.

Backman (1950) mentioned *Najas flexilis* from Särkijärvi (123; in addition many herbarium specimens in H). Meriläinen (1985) reported *Potamogeton pectinatus* from Särkijärvi (74). All above-mentioned elodeids are demanding, often rheophile species and occur in the lakes rich in nutrients or where ground water percolates from the bottom.

The most remarkable alterations in the helophyte vegetation were the vast expansion of *Phragmites* stands, and the deterioration of *Schoenoplectus lacustris* vegetation. Clearest negative changes in isoetid vegetation appeared in big, regulated lakes. Elodeid stands richer than formerly are dependent on the increased nutrients in water, but in some cases heavy eutrophication has diminished vegetation of this life form.

During Maristo's study muskrats had already invaded many lakes in southern Finland. This animal destroyed stands of *Nymphaea* spp. and helophytes to some extent and in some small lakes the dominant helophytes were in many cases changed (Meriläinen & Toivonen 1979, Toivonen & Meriläinen 1980). Currently the vegetation in Maristo's southern lakes is recovered, but in Central and northern Finland there are lakes which represent the pioneer phase after a muskrat invasion.

In the 1930's lacustrine helophyte stands were an important part of forage supply for cattle. Beds of *Equisetum fluviatile*, *Schoenoplectus lacustris* and *Phragmites australis* were cut for winter fodder. On summertime cattle pastured shore meadows and fed on landward parts of reedstands. This prevented sharp limits between the vegetation zones and favoured unstable helophyte stands with many weak competitors (Hulkkonen 1929: 12–13). Pasturing on shores has sporadically continued to the present, but it is decisively diminished and involves only young cattle. The former open shore meadows are presently occupied by dense *Phragmites* stands from deep water up to the upper littoral. Patchy mosaic-like pioneer vegetation occurs only in boat havens, in newly dug ditches and in the excavations for swimming and boat traffic, dredged by the owners of summer cottages. At present Water and Environment Districts and fishing communes have performed cutting of reeds in some eutrophic lakes. Thus e.g. in Savijärvi (lake 188), almost whole helophyte stands were cleared out before the new survey, and the character of the lake was temporarily altered.

Some of Maristo's study lakes were lowered before his study, eutrophicated and expanded by some helophytes (cf. Lillieroth 1950). Pyhäjärvi (lake 42) was lowered just two years before his study (Maristo

1941: 263–265). Drying and freezing phenomena (cf. Lohammar 1949: 266) were pronounced in the flat shores. At present the vegetation has reached a stabile phase. Greatest differences from the 1930's are the dense littoral sedge zones and more extensive stands of elodeids and aquatic mosses.

Only few study lakes were lowered between Maristo's study and the present one. In Parkkimajärvi (lake 29), the water level was lowered ca. 40 cm in 1955. This has caused a clear increase of *Equisetum fluviatile* stands, and a similar trend has been seen e.g. in the lowered Koijärvi (Toivonen & Nybom 1989: 7). In Parkkimajärvi also aquatic sedges have clearly expanded. In Niemisjärvi (lake 110), the level of water was raised in 1980 by 30 cm. All helophytes and *Nymphaea candida* clearly decreased; Maristo (1941) did not give abundance data of *Carex* spp. In northern Sweden permanent flooding has caused an elimination of *Carex rostrata* and *C. aquatilis*, but *Equisetum fluviatile* was unaffected (Sjöberg & Danell 1983).

The enrichment of bryoflora is partly caused by the changes in the lakes. The hepatics *Riccia fluitans* and *Ricciocarpos natans* were not included in Maristo's floristical list and they have possibly spread to the studied lakes after the 1930's. They indicate strong eutrophy (Hinneri 1965: 66). *Ricciocarpos natans* has spread widely in Finland in recent decades (Suominen 1968, Uotila 1971, Meriläinen & Toivonen 1979: 126, Toivonen 1985: 43, Toivonen & Bäck 1989: 36, Karttunen & Toivonen 1995). The species is very unstable in its occurrence. In Scania, southernmost Sweden, its occurrence may vary in a short period of time from a dense cover to total absence (Almestrand & Lundh 1951: 136), and similar unstability was seen also in Äyräpäänjärvi, district of Vyborg (Pantsar 1933: 108–109).

The clear expansion of bryophyte vegetation is possibly caused by many factors. According to the new version of the Nordic vegetation types (Påhlsson 1994) the vegetation of *Drepanocladus (Warnstorfia)–Calliergon–Fontinalis*-type occurs in oligotrophic lakes often rich in humus and sometimes in places where ground water percolates from the bottom. In the present material abundant bryophyte vegetation occurred also in mesotrophic and eutrophic lakes. The last mentioned maintain vegetation containing *Warnstorfia trichophylla* and *W. procera*, but also *Drepanocladus tenuinervis* and *D. capillifolius*. Especially *Fontinalis antipyretica* favours ground water percolation. In oligotrophic lakes the increased bryophyte occurrences seems often to be connected to the ditching of bogs and paludified forests. In some cases this phenomenon is joined to the lowering of the water table of lakes. In Satakunta, southwest Finland, especially *Warnstorfia procera* benefits from this activity (Lampolahti 1991b).

Reinikainen (1935) studied 16 small lakes in Kuopio, Finnish Lake District. He mentioned that *Calliergon giganteum* (*C. megalophyllum* was included in *C. giganteum* then) and *Drepanocladus fluitans* coll. occurred as large stands in eutrophic sites as a part of a hydrosere succession. Ihantola (1987) re-examined these lakes, but did not mention bryophyte vegetation. Helophytes can be replaced by mosses only when the muskrat has depleted reed communities or in areas which have become open by boat traffic or fishing (Hulkkonen 1946). In western Finnish Lake District *Warnstorfia exannulata s. lato* has increased during three last decades (Karttunen & Toivonen 1995).

In western Sweden stands of *Drepanocladus* spp. (probably *Warnstorfia* spp.) belong to the vegetation of acidified lakes (Morling 1981: 34). In the present study the lakes rich in moss stands did not show any signs of acidification. Moss stands possibly have a bearing on the nutrient status of the lakes; in subarctic mire pools nitrogen fixation is carried out by blue-green algae associated with *Sphagnum* and *Drepanocladus* mosses (Granhall & Selander 1973: 12).

As for the stony shoal bryophyte vegetation (p. 5) Maristo (1941) possibly neglected those biotopes in his investigation. Fagerstén (1981: 113–114) described similar habitats of *Fissidens fontanus* from Kevätönjärvi, eastern Finland.

The unstable appearence of Charales is caused by their specific requirements and changes in water quality. In Sweden Almqvist (1929: 92) typified *Chara* lakes, partly consisting of brackish water. According to Forsberg (1965a), in the lakes where charophytes grow in abundance, the concentration of phosphorus is low. In experiments *Chara globularis* was shown to be physiologically sensitive to high phosphorus concentrations (Forsberg 1965b). In contrast, Blindow (1988) observed that phosphorus had no toxic effect in laboratory experiments to *Chara tomentosa* and *C. hispida*. Decline of large charophytes is probably caused by unfavourable light conditions (Blindow 1992).

In Finland *Chara* species have been regarded to occur in fairly eutrophic lakes (Cedercreutz 1934, Reinikainen 1935: 19–20). Charophytes are, however, very weak in competition against higher vegetation, and e.g. in Norway increased eutrophication and dense phanerogam vegetation has caused a reduction of Charales vegetation (Langangen 1974: 40–41). Charales are generally sensitive to nutrient increase, and demand unpolluted water (Lundh 1951: 12, Ihantola 1980: 4, Krause 1981: 410–413).

Maristo's (1941) lake typology was based on some earlier Nordic classifications (Samuelsson 1925, Almquist 1929, Iversen 1929, Cedercreutz 1934, 1937). He did not treat the smallest lakes, *Nuphar* lakes (Renkonen 1935, Metso 1936: 32–33, "the most acid brownwater lakes"). Later Tikkanen (1972) described vegetation of one *Nuphar* lake. Especially in northern Finland Maristo's typology is too concise and there are many intermediates between his original types, and the northernmost Finland has a type of its own, the *Nitella*-type (Rintanen 1982). The alteration process of the lake types is mostly caused by eutrophication. Also the development of agriculture and forestry causes some changes in the lakes. At present all the lakes do not very well fit the original lake typification.

In *Equisetum*-type eutrophication is shifting the floristical composition of these lakes towards *Equisetum–Phragmites*-type. In the 1930's many lakes were surrounded by ditched and newly reclaimed fen areas emptying brown waters into the lakes. For the present these fields are abandoned and they do not produce humus-rich water. This explains why the transparency values had increased (Fig. 3).

In *Equisetum-Phragmites*-type eutrophication is indicated by generally higher pH values and a richer flora (Tables 1 and 3). In addition summer cottage settlement, not yet present in the 1930's, has created many new microhabitats. Evidently the influence of muskrat is the decisive factor in the decline of *Schoenoplectus lacustris* and *Phragmites australis*.

The changes in *Phragmites*-type are to some extent caused by lake regulation, which has altered the nature of most of these large lakes, e.g. by adding the wash-out of humus. Eutrophication and elevated water-level fluctuations also have local effects, but the conductivity values reveal that at the time of the study this process did not yet have pronounced significance due to the big water mass in this lake type.

In *Potamogeton filiformis–Chara*-type the development towards a thinner helophyte zone is possibly due to the fact that muskrat has spread rather lately to northern Finland. The clear decline of *Chara* is evidently caused by the increased humus content and slight dimming of the water.

The most northern type, *Carex*-type, had very similar low conductivity values as recorded by Hinneri (1975) for the Utsjoki river and its tributaries, further north of the tree studied lakes. Northern lakes situated near the fjeld areas have generally more transparent water than those in more southern lowland regions. This phenomenon can be seen also in northern Sweden (Lundqvist 1936: 12–16, 24).

The alterations in *Scirpus*-type (small lowering of transparency and enriched flora) are caused by continuing eutrophication.

Because the coastal *Potamogeton*-type lakes are evidently in a phase of a rather fast succession caused by land upheaval, the floristic changes since Maristo's study are remarkable. In *Stratiotes*-type lowering pH and increasing transparency may reveal the initial influence of acidification, but this is not yet reflected in the flora.

Some lakes appear currently to represent a type different from that described by Maristo. Two *Potamogeton filiformis–Chara* lakes belong to this category: Salmijärvi (lake 87 in Kajaani) belongs better to *Lobelia*-type, and Horkanlampi (lake 86 in Paltamo) is an untypical elodeid lake. Maristo's elodeid Särkijärvi (lake 100 in Muonio), represents *Carex*-type. Some of Maristo's *Typha–Alisma* lakes are presently near to *Potamogeton*-type. Lakes Köyliönjärvi (114), Läppträsk (119; cf. Kurtto 1985) and Ahmasvesi (124) are most clear examples of this tendency.

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REFERENCES

Almestrand, A. & Lundh, A. 1951: Studies on the vegetation and hydrochemistry of Scanian lakes. I–II. — Bot. Notiser Suppl. 2(3): 1–174.

Almquist, E. 1929: Upplands vegetation och flora. — Acta Phytogeogr. Suecica 1: 1–624.

Anttonen-Heikkilä, K. 1983: Säännöstelyn vaikutuksista Oulujärven ranta- ja vesikasvillisuuteen. — Vesihallitus, Tie-

dotus 231: 1–89.
Backman, A. 1950: Najas flexilis funnen i Libelits. — Mem. Soc. Fauna Flora Fennica 27: 3–8.
Blindow, I. 1988: Phosphorus toxity in Chara. — Aquatic Bot. 32: 393–395.
Blindow, I. 1992: Decline of charophytes during eutrophication: Comparison with angiosperms. — Freshwater Biol. 28: 9–14.
Cedercreutz, C. 1934: Die Algenflora und Algenvegetation auf Åland. — Acta Bot. Fennica 15: 1–120.
Cedercreutz, C. 1937: Eine Pflanzengeographische Einteilung der Seen Ålands und die Regionale Verteilung der Verschiedenen Seentypen. — Acta Soc. Fauna Flora Fennica 60: 327–338.
Cedercreutz, C. 1947: Die Gefässpflanzenvegetation der Seen auf Åland. — Acta Bot. Fennica 38: 1–77.
Danell, K. 1979: Reduction of aquatic vegetation following the colonization of a northern Swedish lake by the muskrat, Ondatra zibethica. — Oecologia (Berlin) 38: 101–106.
Eloranta, P. 1970: Pollution and aquatic flora of waters by sulphite cellulose factory at Mänttä, Finnish Lake District. — Ann. Bot. Fennici 7: 63–141.
Erkamo, V. 1956: Untersuchungen über die pflanzenbiologischen und einige andere Folgeerscheinungen der neuzeitlichen Klimaschwankung in Finnland. — Ann. Bot. Soc. Vanamo 28(3): 1–290.
Fagerstén, R. 1981: Octodiceras fontanumin (Musci, Fissidentaceae) esiintymisestä ja kasvullisesta lisääntymisestä Itä-Fennoskandiassa. — Mem. Soc. Fauna Flora Fennica 57: 113–118.
Forsberg, C. 1965a: Ecological and physiological studies of Charophytes. — Abstr. Uppsala Diss. Sci. 53: 1–10.
Forsberg, C. 1965b: Nutritional studies of Chara in axenic cultures. — Physiol. Plantarum 18: 275–290.
Forsius, M., Kämäri, J., Kortelainen, P., Mannio, J., Verta, M. & Kinnunen, K. 1990: Statistical lake survey in Finland: Regional estimates of lake acidification. — In: Kauppi, P., Anttila, P. & Kenttämies. K. (eds.), Acidification in Finland: 759–780. Springer-Verlag, Berlin-Heidelberg. 1237 pp.
Granberg, K., Anttila, M., Hakkari, L., Hyvärinen, J., Kolari, I., Kurttila, I. & Virkki, L. 1989: Säännöstelyn vaikutuksista Lappajärven, Evijärven, Välijoen ja Ähtävänjoen limnologiaan, kalastoon ja kalatalouteen. — Ympäristöntutkimuskeskuksen tiedonantoja (Reports of the Institute for Environmental Research) 134: 1–179.
Granberg, K. & Ruohonen, K. 1985: Saimaan vesikasvit ja sedimentit. — Vesihallitus, Tiedotus 255: 31–81.
Granhall, U. & Selander, H. 1973: Nitrogen fixation in a subarctic mire. — Oikos 24: 8–15.
Hämet-Ahti, L., Suominen, J., Ulvinen, T., Uotila, P. & Vuokko, S. (eds.) 1986: Retkeilykasvio, 3rd ed. (With English summary). — Suomen Luonnonsuojelun Tuki, Helsinki. 598 pp.
Heitto, L. 1990: Macrophytes in Finnish forest lakes and possible effects of airborne acidification — In: Kauppi, P., Anttila, P. & Kenttämies, K. (eds.), Acidification in Finland: 963–972. Springer-Verlag, Berlin-Heidelberg. 1237 pp.
Helminen, O. 1983: Vegetationsförändringar i åländska sjöar under 40 år. (Vegetation changes in lakes on the Åland Islands during 40 years). — Husö Biol. Stat. Medd. 24: 3–40.
Hinneri, S. 1965: Tutkimuksia Sääksmäen Saarioisjärven umpeenkasvusta. — Luonnon Tutkija 69: 64–73.
Hinneri, S. 1975: On the water chemistry of the Utsjoki River system, and its significance for the evaluation of edaphic conditions in the drainage area. — Rep. Kevo Subarctic Res. Stat. 12: 10–24.
Hulkkonen, O. 1929: Laiduntamisen vaikutuksesta kasvillisuuteen eräissä Laatokan maatuvissa lahdekkeissa. — Turun Ylioppilas 1: 1–14.
Hulkkonen, O. 1946: Kasvilajien keskinäisestä suhtautumisesta sekä tämän vaikutuksesta kasvillisuuden muodostumiseen eräissä Laatokan maatuvissa lahdekkeissa. — Ann. Bot. Soc. Vanamo 21(4): 1–76.
Ihantola, R. 1980: Porin saariston näkinpartaisten (Charophyta) levinneisyydestä. — Mem. Soc. Fauna Flora Fennica 56: 1–5.
Ihantola, R. 1987: Kuopion pikkulampien muuttuva vesikasvillisuus. — Savon Luonto 18: 46–49.
Iversen, J. 1929: Studien über die pH – Verhältnisse dänischer Gewässer und ihren Einfluss auf die Hydrophyten-Vegetation. — Bot. Tidskrift 40: 277–333.
Jansson, M., Heyman, U. & Forsberg, C. 1981: Sura sjöar och "biologisk buffring". — Vatten 3: 241–251.
Jensen, S. 1979: Classification of lakes in Southern Sweden on the bases of their macrophyte composition by means of multivariate methods. — Vegetatio 39: 129–146.
Karttunen, K. & Toivonen, H. 1995: Ecology of aquatic bryophyte assemblages in 54 small Finnish lakes, and their changes in 30 years. — Ann. Bot. Fennici 32: 75–90.
Koponen, T., Karttunen, K. & Piippo, S. 1995: Suomen vesisammalkasvio. (Summary: Aquatic bryophytes of Finland). — Bryobrothera 3: 1–86.
Kortelainen, P. & Mannio, J. 1990: Organic acidification in Finnish lakes. — In: Kauppi, P., Anttila, P. & Kenttämies, K (eds.), Acidification in Finland: 849–863. Springer-Verlag, Berlin-Heidelberg. 1237 pp.
Krause, W. 1981: Characeen als Bioindikator für den Gewässerzustand. — Limnologica (Berlin) 13(2): 399–419.
Kurimo, U. 1970: Effect of pollution on the aquatic macroflora of the Varkaus area, Finnish Lake District. — Ann. Bot. Fennici 7: 213–254.
Kurtto, A. 1985: Karjaan Lepinjärven putkilokasvistosta. (Summary: Macrophytic flora of lake Lepinjärvi, SW Finland). — Lutukka 1: 9–14.
Lampolahti, J. 1991a: Eutrofia Karvianjoen vesistöalueen järvissä. Järvien tyypittely ja vesikasvilajiston tarkastelu monimuuttujamenetelmin. — Manuscript, Dept. Biol., Univ. Turku.
Lampolahti, J. 1991b: Satakunnan lintujärvien vesisammalet. (Abstract: Aquatic mosses in the eutrophic lakes in Satakunta, SW Finland). — Luonnon Tutkija 95: 7–10.
Langangen, A. 1974: Ecology and distribution of Norwegian charophytes. — Norwegian J. Bot. 21: 31–52.
Lillieroth, S. 1950: Über Folgen kulturbedingter Wasserstandsenkungen für Makrophyten -und Planktongemeinschaften in seichten Seen des südschwedischen Oligotrophiegebietes. — Acta Limnol. 3: 1–288.

Lohammar, G. 1938: Wasserchemie und höhere Wasservegetation schwedischer Seen. — Symb. Bot. Upsaliensis 3(1): 1–252.
Lohammar, G. 1949: Über die Veränderungen der Naturverhältnisse gesenkter Seen. — Verh. Int. Ver. Limnol. 10: 266–274.
Lundh, A. 1951: Studies on the vegetation and hydrochemistry of Scanian lakes. III. Distribution of macrophytes and some algal groups. — Bot. Notiser Suppl. 3(1): 1–138.
Lundqvist, G. 1936: Sjöarnas transparens, färg och areal. — Sveriges Geologiska Undersökning Ser. C 397: 1–28.
Maristo, L. 1935: Näsijärven Aitolahden vesikasvillisuus. (Referat: Die Wasservegetation der Aitolahti-Bucht im See Näsijärvi.) — Ann. Bot. Soc. Vanamo 6(4): 1–55.
Maristo, L. 1941: Die Seetypen Finnlands auf floristischer und vegetationsphysiognomischer grundlage. — Ann. Bot. Soc. Vanamo 15(5): 1–312.
Meriläinen, J. 1985: Hapsivita Tohmajärven Särkijärvessä. — Pohjois-Karjalan Luonto 14: 37.
Meriläinen, J. & Toivonen, J. 1979: Lake Keskimmäinen, dynamics of vegetation in a small shallow lake. — Ann. Bot. Fennici 16: 123–139.
Metso, V. 1936: Kasvistosta ja kasvillisuudesta eräissä Konneveden pikku järvissä. (Referat: Über die Vegetation und Flora einiger Kleinseen im Kirchspiel Konnevesi.) — Ann. Bot. Soc. Vanamo 8(2): 1–39.
Morling, G.1981: Effects of acidification on some lakes in Western Sweden. — Vatten 81(1): 25–38.
Niemi, R. 1990: Makrofyytit vesien tilan seurannassa. (Summary: The use of aquatic macrophytes in monitoring programs.) — Vesi- ja Ympäristöhallinnon julkaisuja A 53: 1–95.
Påhlsson, L. 1994: Vegetationstyper i Norden. — Tema Nord 665: 1–627.
Pantsar, L. 1933: Äyräpäänjärven vesikasvilajien ekologiaa.(Referat: Autökologische Untersuchungen über die Wasserpflanzen des Äyräpäänjärvi-Sees). — Ann. Bot. Soc. Vanamo 3(4): 1–131.
Pätilä, A. 1982: Happamoitumisen vesikemialliset vaikutukset – havaintoja Etelä-Suomen karuista järvistä. (Summary: Changes in water chemistry due to acidification – study of 23 lakes in southern Finland.) — Luonnon Tutkija 86: 19–23.
Perttula, U. 1953: Jätevesien vaikutuksesta Valkeakosken lähivesien kasvillisuuteen ja kasvistoon. (Referat: Über die Entwicklung der Abwässer auf die Vegetation und Flora der Gewässer bei Valkeakoski in Mittelfinnland). — Arch. Soc. Vanamo 7: 106–113.
Pesonen, H. & Rintanen, T. 1980: Maristo's lake typology reanalysed by numerical taxonomy. — Manuscript, Dept. Geogr., Univ. Oulu.
Quennerstedt, N. 1958: Effect of water level fluctuation on lake vegetation. — Verh. Int. Ver. Limnol. 13: 901–906.
Rask, M., Arvola, L. & Salonen, K. 1985: A note on the acidity in 54 small lakes in Evo forest area, Southern Finland. — Aqua Fennica 15(1): 41–46.
Reinikainen, A. 1935: Kuopionniemen pikkujärvien ja lampien vesikasvistosta ja -kasvillisuudesta. — Kuopion Luonnon Ystäväin Yhdistyksen julkaisuja B1(8): 1–28.
Renkonen, O. 1935: Über das Verhalten der Wasserpflanzen zur Reaktion in einigen Gewässern Mittelfinnlands. — Ann. Univ. Turku A IV, 2: 1–44.
Rintanen, T. 1981: Vehkajoen luonto. Vehkajoen vesistöalueen järvien kasvistosta ja kasvillisuudesta. — Kymenlaakson Luonto 22: 13–16.
Rintanen, T. 1982: Botanical lake types in Finnish Lapland. — Ann. Bot. Fennici 19: 247–274.
Rintanen, T. 1992: Mariston tyyppijärvien uudelleentutkinnan havaintoaineisto. — Manuscript Bot. Arch., Bot. Mus., Univ. Helsinki.
Rørslett, B. 1991: Principal determinants of aquatic macrophyte richness in northern European lakes. — Aquatic Bot. 39: 173–193.
Samuelsson, G. 1925: Untersuchungen über die höhere Wasserflora von Dalarne. — Svenska Växtsoc. Sällskapets Handlingar 9: 1–31.
Sjöberg, K. & Danell, K. 1983: Effects of permanent flooding on Carex-Equisetum wetlands in Northern Sweden. — Aquatic Bot. 15: 275–286.
Suominen, J. 1968: Changes in the aquatic macroflora of the polluted Lake Rautavesi, SW Finland. — Ann. Bot. Fennici 5: 65–81.
Tikkanen, T. 1972: Über die höheren Wasserpflanzen des polyhumosen Sees Hakojärvi. — Mem. Soc. Fauna Flora Fennica 48: 55–61.
Toivonen, H. 1983: Changes in dominant macrophytes of 54 small Finnish lakes in 30 years. — Proc. Int. Symp. Aquatic Macrophytes, Nijmegen, 18–23 Sept. 1983: 220–224.
Toivonen, H. 1985: Changes in the pleustic macrophyte flora of 54 small Finnish lakes in 30 years. — Ann. Bot. Fennici 22: 37–44.
Toivonen, H. & Bäck, S. 1989: Changes in aquatic vegetation of a small eutrophicated and lowered lake (southern Finland). — Ann. Bot. Fennici 26: 27–38.
Toivonen, H. & Meriläinen, J. 1980: Impact of the muskrat (Ondatra zibethica L.) on aquatic vegetation in small Finnish Lakes. — Developments Hydrobiol. 3: 131–138.
Toivonen, H. & Nybom, C. 1989: Aquatic vegetation and its recent succession in the waterfowl wetland Koijärvi, S. Finland.— Ann. Bot. Fennici 26: 1–14.
Toivonen, H. & Ranta, P. 1976: Tampereen Iidesjärven vesikasvistosta ja sen muutoksista. (Abstract: Changes in the aquatic vegetation and flora of the polluted lake Iidesjärvi, SW Finland). — Luonnon Tutkija 80: 129–138.
Ulvinen, A. 1958: Haminan Kirkkojärven kasvimaailma. — Ankkapurha IV: 1–20.
Uotila, P. 1971: Distribution and ecological features of hydrophytes in the polluted Lake Vanajavesi, S Finland. — Ann. Bot. Fennici 8: 257–295.
Wallstén, M. 1981: Changes of lakes in Uppland, central Sweden, during 40 years. — Symb. Bot. Upsaliensis 23(3): 1–84.
Vasari, Y. 1962: A study of the vegetational history of the Kuusamo district (North East Finland) during the Late-quaternary period. — Ann. Bot. Soc. Vanamo 33(1): 1–140.
Vasari, Y. 1978: Kuusamon luonto ja sen kehitysvaiheet. — In: Ervasti, S. (ed.), Kuusamon historia I: 865–999. Koillissanomat OY, Kuusamo. 999 pp.