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CHANGES IN THE USE OF WETLANDS IN TWO DRAINAGE BASINS AND THE EFFECTS E.G. ON WATERFOWL POPULATIONS

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Foreword

Since their beginning in 1948 »Finnish Game Research» and its predecessor »Papers on Game Research» have concentrated on problems concerning different aspects of wildlife biology. Essential objects of study have been the occurrence, feeding and breeding biology and behavior of game animals as well as the age and sex composition and fluctuations in numbers of their populations. Some of the reports have also referred to genetic characteristics, diseases, marking, census methods and censusing of game populations. In the 1970s, however, coverage was extended to more practical aspects of hunting economy, such as the occupational status of hunters and rationalization of shooting.

»Finnish Game Research» is now about to take another step to extend its traditional sphere of interest. Game populations are, of course, only a part of the ecosystem in the same way as hunting and game management represent only one form of land use. Though it is often practical or even compulsory to confine research activities to a limited wildlife problem alone, this should not be a common rule or a deliberate aim. On the other hand it is important to put each part in its proper place in the whole.

The authors apply this new approach in their article. They put different pieces together and scrutinize the way and extent to which waterfowl populations and their environment have changed, due to types of land use other than shooting and game management. The authors have been fortunate enough to carry out their study in an area where detailed information is available for a period of a hundred years. Similar developments have obviously taken place in many other areas which were once good for waterfowl but have since deteriorated or been completely spoiled but where it is impossible to make a study on these changes. Thus, instead of a single case, we have here an example of developments which have taken place in a number of other areas as well.

The new approach requires knowledge not only of game research and ornithology but also of environmental studies and different types of land use. In this respect the study is a pioneering work, as it gives valuable information on changes which have taken place recently in land use practices in Finland. The article is thus of interest not only to game biologists and sportsmen but also to much wider circles of society. With regard to sportsmen, the article offers new scope for planning the management and utilization of game populations in the long term. As ducks are the main object of the study, its findings are evidently of international interest, too.

TEPPO LAMPIO
Editor

Tauno Waaramäki in Memoriam

Finland's eutrophic lakes and sea bays have been studied for the last 50 years and some of the results have been published. Most observations and manuscripts have, however, been left forgotten in the drawers of desks or, at best, in files of university libraries. The detailed studies on waterfowl in Åland's inland waters are in this respect a positive exception (Palmgren 1936).

One reason for lacking detailed scientific studies is, I suppose, the fact that a thorough inventory of a large eutrophic lake is a difficult and demanding task; even movement within the area may be very difficult. In Finnish we call a person with a firm type of character »sisukas», which cannot be translated exactly into other languages. Tauno Waaramäki was »sisukas» when he studied the waterfowl of Lake Valkojärvi in 1926—1930 when there was no team-work and very little technical equipment was available. I had a good opportunity to experience his »sisu» and tenacity myself while we were trudging through reed jungles or punting a flat boat when visiting the nest of the marsh harrier (*Circus aeruginosus*) or looking for the very rare water rail (*Rallus aquaticus*), etc. The same difficulties had to be overcome during the duckhunting season, too.

Tauno Waaramäki was a very good observer who was capable of making important observations even when he was hurrying through difficult habitats. He was always on the go, and it came as no surprise when a physician ordered him to take an absolute rest for a couple of months after one extremely busy spring on Lake Valkojärvi.

After taking his Master of Science degree, Tauno Waaramäki was a teacher for almost two decades in Kuusamo in NE Finland and he spent at least part of his summers there throughout his life. The northern bird fauna and the wild and rugged landscape of Kuusamo took him there. In the parishes of Kuusamo and Salla Tauno Waaramäki made the studies of the State Game Research Institute and the State Nature Conservation Office on e.g. the velvet scoter (*Melanitta fusca*), the bean goose (*Anser fabalis*) and on the bird fauna of Oulanka National Park (Waaramäki 1965, 1966, 1968 and 1970). At the end of the 1960's we decided to visit the areas of Lake Valkojärvi in Laitila, the countryside of his youth. The plan wasn't carried out until the end of April 1973. Both the authors of this paper and myself visited the area in order to see great ecological changes which had taken place there. The authors planned to produce a paper on these changes and decided on the division of labour. Two days later relatives informed us that Tauno Waaramäki had died after a surgical operation.

Tauno Waaramäki was a man of many skills as well as an active, practical, firm, 'sisukas' man. He was one of the best bird taxidermists in this country — maybe the best in his time. An exellent field knowledge of birds, an esthetic view and harmonic co-operation between eye and hand were the prerequisites for this successful taxidermist.

For Tauno Waaramäki the essence of life had always been hunting and bird watching. His family, however, was above everything else.

PEKKA GRENQUIST

Abstract

HAAPANEN, ANTTI and WAARAMÄKI, TAUNO (†) 1977: Changes in the use of wetlands in two drainage basins and the effects e.g. on waterfowl populations. — *Finnish Game Research 36: 19—48.*

This paper deals with the land use changes in two drainage basins covering 645 km^2 from 1883 to 1972. The study is based on surveys of maps available from 1883, the 1920's and 1960's and surveys of aerial photographs taken in 1946 and 1972. The development of agricultural and forestry drainage was followed. This drainage has adversely affected many waterfowl breeding and resting sites including one big important one; it has also caused the acidification of impoundment water. The wetland area has decreased by 43 per cent. The waterfowl capacity of the area is at present apparently 55 per cent of what it was a hundred years ago. The construction of summer cottages on the shores of otherwise preserved lakes has greatly changed their nature. The poor integration of the management of land and water resources is also discussed.

1. Introduction

The aim of this paper is to study the changes in land use and their ecological effects in two small river systems, Ihodejoki and Sirppujoki (approximately 61° N, 21° 30′ E; Fig. 1).

It has been possible to follow fairly exactly the changes in land use over the last 100 years in this area. The area is particularly suitable for this type of study since detailed maps or aerial photographs are available from the last ten decades. Special attention has been paid to the wetlands because it has been possible to analyse these from old maps and because they are of special ecological interest.

The exact map analysis of the changes in the areas of woodland and fields is, however, impossible. Actually the types of land use were not so clearly divided between woodland and field in earlier times. Open and woodland pastures were formerly the major land use types covering most of the land (Osara 1938, Jäntti 1945).

Land upheaval in the area is about 6 mm per year (the Atlas of Finland 1960), which means observable changes in land area within one hundred years in this area of shallow shores. These are, however, outside the scope of this study. Of the authors, Tauno Waaramäki made field studies in the area in the late 1920's and the early 1930's. His unpublished theses on the bird fauna of Valkojärvi (Waaramäki 1930) and on the landscapes of Otajärvi (Waaramäki 1932) form the basis for detailed comparisons. One nontechnical paper has been published on these studies (Waaramäki 1928). The other author, Antti Haapanen, was responsible for the map surveys, the editing of old reports and the final conclusions.

Surprisingly little attention has been paid to the changes in land use in Finland. The dramatic changes in the water levels of some bigger lakes are well known, but the overall effects of draining small water bodies may have been of greater importance especially in coastal areas, where waters are not so numerous as in the Finnish Lake District. If this study stimulates similar ones giving information on larger areas, then it has fulfilled one of its main tasks.

Wolf's study (1956) is a classical example of the effects of drainage in the Nordic countries. Recently, perhaps because of the European wetland conservation years 1976—1977, several authors have given their attention to the problem (see e.g. Meisel & Hübschmann 1975, Ringler 1976). Although these studies, including ours, are case studies, they do contribute to the overall picture of the wetland situation both now and earlier.

Wetlands are biologically highly productive biotopes and are an important habitat for several plant and animal species e.g. waterfowl. The importance of wetlands is, however, often neglected and they are regarded as wastelands.

2. Material and methods

Important material for this study is found in the umpublished works of Waaramäki (1930 and 1932). Waaramäki used mapping methods to describe vegetation and to census bird fauna.

The following maps and aerial photographs were used in the analysis of land use:

- Russian topographic maps (1: 42 000) from 1883—1903 (The field work was done in 1883);
- Economic map (1: 20 000) from the 1920's;
- Land use maps from the central parts of the study area made by Waaramäki in the early 1930's;
- Aerial photographs (1: 20 000) from 1946;
- Basic map (1: 20 000) from the early 1960's;
- Aerial photographs (1: 60 000) from 1972.

Wetland areas have been calculated in these maps by using a planimeter. The land use mapping around Lake Valkojärvi and the vegetation and bird fauna mapping of the lake itself were carried out by Waaramäki in 1927—1930. An analysis of the landscape was also performed in 1931 by the author. The Helsinki Forest Improvement District provided us with its own data on peatland drainage for these two river drainage basins. The local water district of the National Board of Waters provided information on the water quality of these two drainage basins. Information on summer cottages by the lakes was supplied by local building inspectors.

3. The geographical features of the area

The size of the study area is about 645 km². The area is located on the border between a

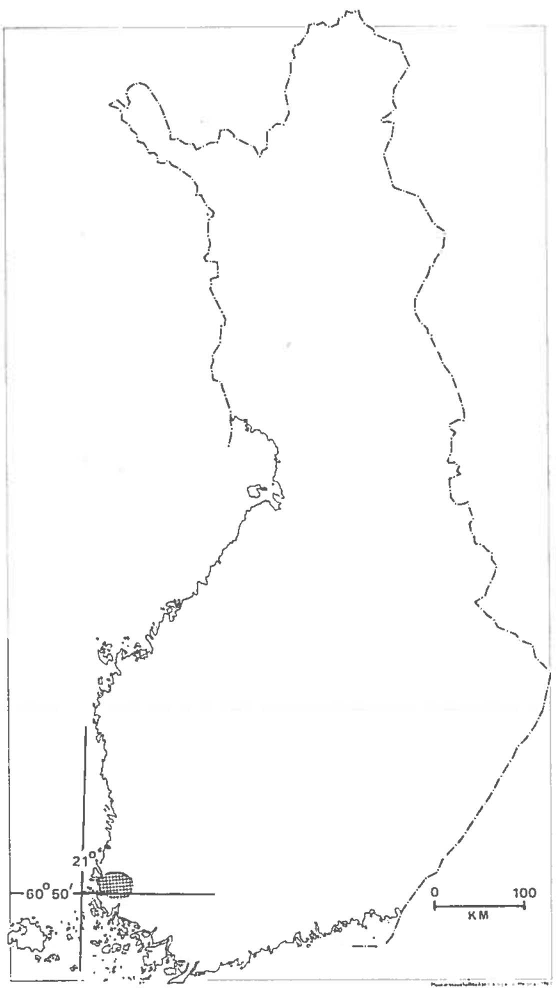

Fig. 1. The study area.

hemiboreal and a boreal zone (cf. Ahti et al. 1968, Fig. 1). The peatland complexes raised are bogs (cf. Eurola 1962).

The bedrock consists mainly of rapakivi, anorogenic granites (Gen. geological map 1958). The clay soil types made extensive field cultivation possible. Soil acidity could have been neutralized by liming (Purokoski 1959).In certain sub-areas more than 50 per cent of the area is cultivated. The average land use in the early 1960's was based on map surveys (scale 1: 20 000) according to methods developed by Hult (1969) and was as follows:

	%
woodland	60.8
fields	24.3
peatland	8.9
drained peatlands	1.2
water	4.8
settlement	+
Total	100.0

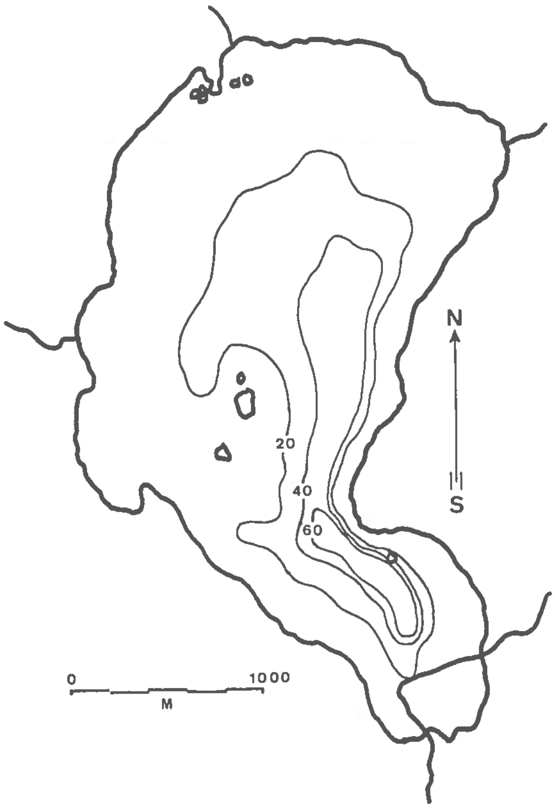

Fig. 2. The depth map of Lake Valkojärvi. Depths in centimetres.

4. Ecological studies in the 1920's

4.1. Lake Valkojärvi

The ecological state of the lake in 1928—1930 was that which followed the drainage of the lake in 1887—1905, when the surface of the lake was lowered by about 150 cm (Aimonen 1960).

The water depth map of the lake in 1928—1930 is shown in Fig. 2. The lake was very shallow with especially wide belts less than 20 cm deep. The different depth classes were as follows:

depth (cm)	%
0—20	70
21—40	21
41—60	7
61—	2
Total	100

The littoral vegetation was well developed (Fig. 3). The bottom was mostly clay and was so hard that it was possible to walk on it. In certain areas the bottom was formed from organic mud deep enough to make walking impossible. The water was generally clear. Following windy weather and heavy rains the water became turbid due to the clay. In some cases a large flock of birds also disturbed the water.

Carex sp. (apparently mostly, *C. rostrata* and *C. vesicaria*) stands were found in the dryest part of the littoral zone, usually above the summer surface of the lake. In certain places in the northern and western parts of the lake, small *Carex* stands were found in the middle of *Phragmites* and *Scirpus* stands (Fig. 3). In the *Carex* sp. belt, different high *Carex* species were found either as pure stands of one species or mixed. Mixed stands of *Carex* sp. and *Potentilla*

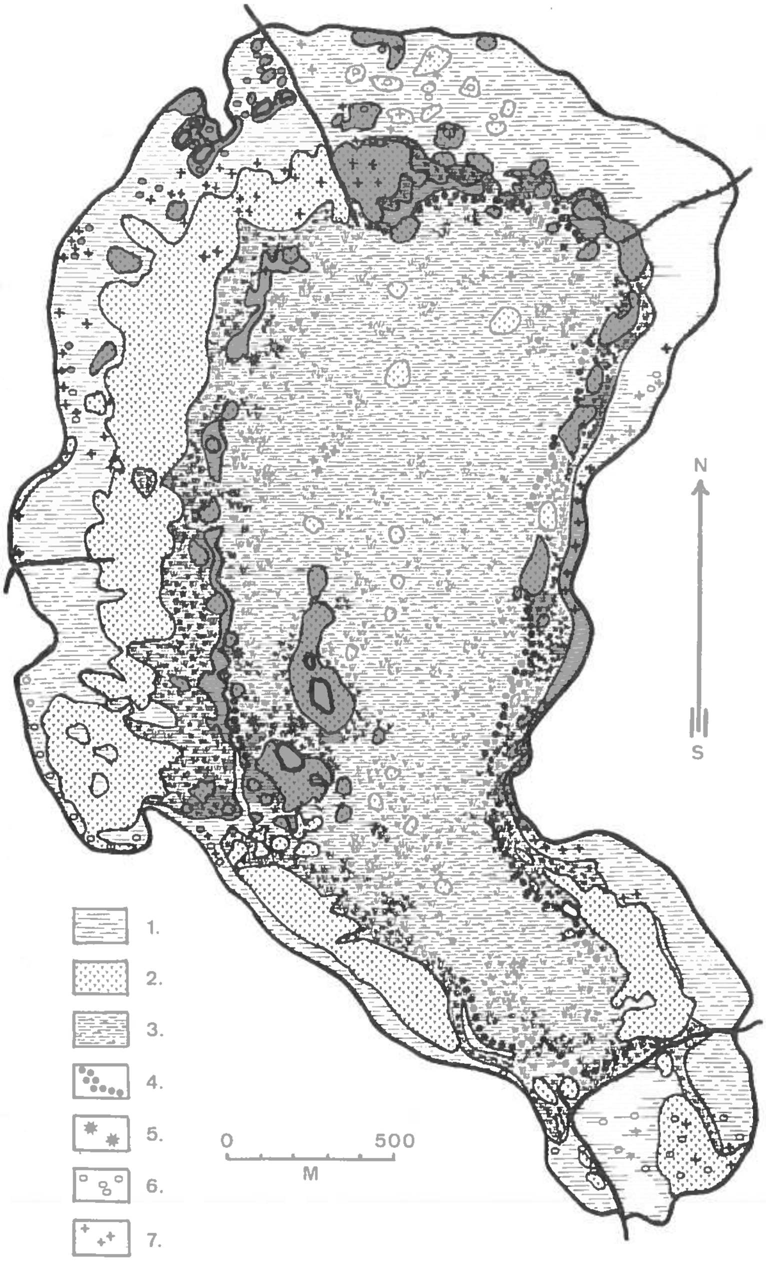

Fig. 3. The vegetation map of Lake Valkojärvi. 1. Carex sp. stands, 2. Phragmites communis stands, 3. Scirpus lacustris stands, 4. Sparganium sp. — Sagittaria sagittifolia stands, 5. Typha latifolia stands, 6. willow bushes, 7. »rapakivi» blocks.

palustris were also common in this belt. In some places, especially on the western side of the lake *Potentilla palustris* was dominant.

In those outer *Carex* stands *Iris pseudacorus, Rumex aquaticus, Cicuta virosa, Polygonum lapathifolium, P. amphibium, Lythrum salicaria, Alisma plantago-aquatica, Butomus umbellatus*, some *Juncus* species, *Lysimachia tyrsiflora, L. vulgaris* and *Bidens tripartitus* were also found. Several species of grass were also found.

The second belt was the *Phragmites communis* belt (Fig. 3). In many places the stand was formed only by this dominant species. In the eastern part of the lake the belt was poorly formed. In many places the borders of *Phragmites* stands were clear. The stands were very dense and high, in some cases over 230 cm high. In summer the *Phragmites* stands were mostly above the water level.

Scirpus lacustris stands were of two types, a belt and isolated small stands in the middle of the lake (Figs. 3—5). In the eastern part of the lake there was an ecotone between *Carex* and *Scirpus* belts. The other species of this ecotone were e.g. *Bidens tripartitus, Polygonum lapathifolium, Lythrum salicaria, Cicuta virosa* and *Rorippa islandica*. In some cases *Matricaria inodora* was also found. The ecotone between *Phragmites* and *Scirpus* stands was found only in some cases. The open spaces between the *Scirpus* stands were occupied by *Nuphar luteum* in some cases, in others by *Nymphaea* sp.

Close to the outer parts of the *Scirpus* belt, *Sparganium simplex* stands are found in areas of only a few square metres. *Amblystegium* mosses cover spaces between *Scirpus* stems. When the water is low there are only a few centrimetres of water in the *Scirpus* belt.

The central part of the lake has scattered stands (Fig. 3) comprising:

Fig. 4. Scirpus lacustris stands in the middle of Lake Valkojärvi, in front Phragmites. Photo Tauno Waaramäki.

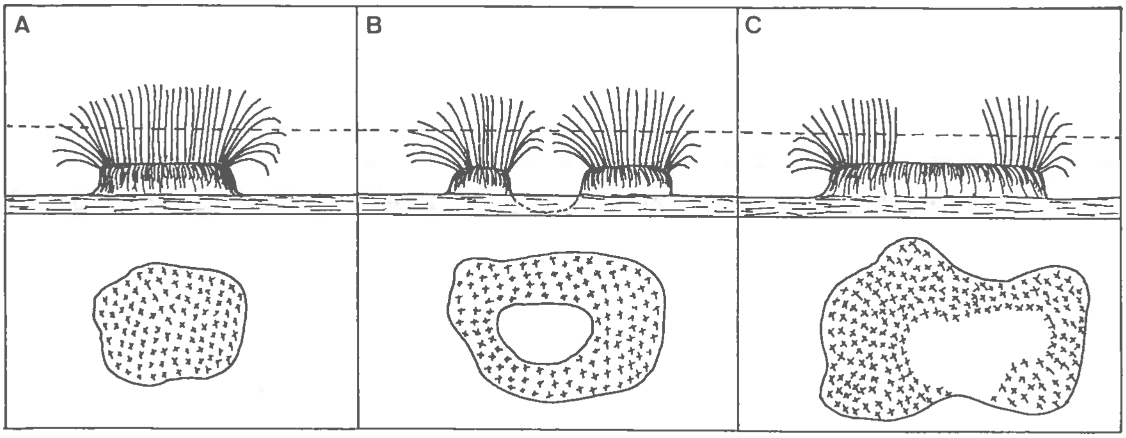

Fig. 5. The structure of different types of Scirpus lacustris stands in the middle of the lake. The water level in spring (upper line) and in summer is shown.

1. Emergent species:
   Scirpus lacustris
   Phragmites communis
   Typha latifolia
   Butomus umbellatus
   Sparganium simplex
   Sagittaria sagittifolia

2. Mergent species:
   Potamogeton perfoliatus
   P. obtusifolius
   Callitriche sp.
   Amblystegium sp.
   Scirpus acicularia

3. Nymphaeids:
   Potamogeton natans
   Nymphaea (*candida?*)
   Nuphar luteum

4. Floating:
   Lemna minor

The Typha latifolia stands are only few in number and small in area, 2—3 m² (Fig. 3). *Butomus umbellatus* is somewhat more abundant than the former. The stands are small, 0.5—1 m². In the southern part of the lake, in the river which flows through the lake, there was an almost continuous *Butomus* belt. *Potamogeton obtusifolius* was found fairly scattered, sometimes as a stand of 0.5 m². *P. perfoliatus* stands were larger, 2—20 m².

The *Equisetum fluviatile* stands were found only in the rivers running into or through the lake.

On the small islands rapakivi blocks were found. The vegetation consisted mainly of sedge and grass vegetation with some bushes or trees of *Sorbus aucuparia* and *Betula*.

The lake was known in the late 1880's as a good fishing area. In the 1920's and 1930's *Esox lucius*, *Perca fluviatilis*, *Leuciscus rutilus* and *Cyprinus carassius* were found, but the lake has since lost its fishing importance.

Lake Valkojärvi was known to have a rich waterfowl population. The main aim of studies in 1920's and 1930's was to census the waterfowl populations. The results are shown in Table 1. The numbers of some species varied widely during this period. Such species were *Podiceps auritus*, *Anas querquedula*, *A. acuta*, *Aythya ferina* and *Fulica atra*. The reasons for this are partly local. The low water level apparently caused many *Aythya ferina* pairs to move to the nearby lakes in summer 1930. The low numbers of *Podiceps auritus* and *Fulica atra* in the same year

Table 1. The bird fauna of Lake Valkojärvi, 1928—1930. Some species were not censused in 1929. These are marked with —. The lake area was 475 ha. The dominance of different species has been calculated for all wetland species (1.) and for waterfowl only (2.).

	1928 pairs	1929 pairs	1930 pairs	p/km²	1. (%)	2. (%)
Podiceps cristatus	27	20	5	3.6	4	7
P. auritus	16	13	0	2.0	2	4
Anas platyrhynchos	65	70	80	15.1	19	31
A. crecca	8	9	12	2.0	2	4
A. querquedula	0	0	26	1.8	2	4
A. penelope	15	16	12	3.0	4	6
A. acuta	6	10	19	2.5	3	5
Spatula clypeata	11	16	24	3.6	4	7
Aythya ferina	30	20	8	4.1	5	8
A. fuligula	45	40	23	7.6	9	15
Bucephala clangula	5	4	0	0.6	1	1
Circus aeruginosus	1	—	1	0.2	+	—
Fulica atra	30	21	1	3.6	4	7
Larus ridibundus	24	16	35	5.3	7	—
Sterna hirundo	2	—	3	0.5	1	—
Acrocephalus schoenobaenus	42	—	46	9.3	11	—
Motacilla alba	1	—	2	0.3	+	—
M. flava	28	—	32	6.3	8	—
Emberiza schoeniclus	45	—	46	9.6	12	2
Total	401	—	375	81.0	100	100
Waterfowl	258	239	210	49.5	—	—
Total p/km²	84.4	—	78.9	81.0	—	—
Waterfowl p/km²	54.3	50.3	44.2	49.5	—	—

was a more general phenomenon. In other areas e.g. close to the city of Turku these species were not at all as numerous as before. The population of *Anas querquedula* varies widely from year to year in Finland.

The small scale habitat preferences of three wetland passerines are shown in Table 2. The habitat preference of *Emberiza schoeniclus* and

Table 2. The density of three wetland species in different vegetation types in Valkojärvi. Figures indicate pairs/sq.km The area of Carex sp. stands is 1.4 sq.km and that of Phragmites stands 1.9 sq.km.

	Habitat type			
	fields	peat-lands	*Carex-Salix* stands	*Phragmites* stands
Motacilla flava	25	35	20	0
Emberiza schoeniclus	0	30	15	6
Acrocephalus schoenobaenus	0	0	11	14

Acrocephalus schoenobaenus show the same trend as that found by Fritzén and Tenovuo (1957). Table 3 shows the breeding sites of certain waterfowl species. Clear preferences are found. Before the lowering of the water level in the late 1800's, the main part of the lake was 150—200 cm deep. The shallow shores at that time covered 50 per of the total shoreline. It was 100 per cent in the late 1920's. The detailed map (scale 1: 21 000) of 1883 shows that the littoral emergent vegetation was well formed on the western shore of the lake. Apparently the populations of dabbling ducks were smaller in the 1880's than in the late 1920's, but it is probable that diving ducks and grebes were more numerous. The area of the lake was not much bigger.

The following summary shows the dominance of waterfowl populations in Valkojärvi (1.), in the eutrophic lakes of Åland (2.) according to Palmgren (1936) and in the eutrophic lakes of

Table 3. The breeding sites of some wetland species in Valkojärvi. Figures are percentages of the total.

	peatlands	other terrestrial sites	*Carex*-stands	*Phragmites* stand	*Scirpus*		Islets on min. soil	Total	
					belt	islets		%	N
Anas platyrhynchos	67	13	7	0	0	0	13	100	15
All *Anas* sp.	64	16	8	0	0	0	12	100	25
Aythya fuligula	0	0	100	0	0	0	0	100	27
Fulica atra	0	0	0	100	0	0	0	100	48
Podiceps auritus	0	0	0	100	0	0	0	100	14
P. cristatus	0	0	0	96	0	4	0	100	25
Larus ridibundus	0	0	0	69	0	31	0	100	113
Sterna hirundo	0	0	0	0	0	37	63	100	8

south-west Finland (3.) according to Haapanen & Paasivirta (1973):

	1. %	2. %	3. %
Podiceps cristatus	7	9	12
P. griseigena	0	0	1
P. auritus	4	6	2
Anas platyrhynchos	31	10	19
A. crecca	4	3	10
A. querquedula	4	0	2
A. penelope	6	0	5
A. acuta	5	0	1
Spatula clypeata	7	2	4
Aythya fuligula	15	40	14
A. ferina	8	9	12
Bucephala clangula	1	7	6
Cygnus olor	0	0	+
Fulica atra	7	11	11
Total	100	100	100

The results from Valkojärvi (1.) and Åland (2.) are from the same time. The results from south-west Finland (3.) are from about 40 years later. Apparently there have not been any major changes in the composition of waterfowl species in this period. The results from Valkojärvi and south-west Finland are perhaps more alike than those obtained during the same period. The population of *Larus ridibundus* has grown enormously during the last few decades, especially since the 1940's (cf. e.g. v. Haartman et al. 1963). The population in Valkojärvi would probably now be 100 times greater than it was in 1928—1930.

As seen from the above table in the late 1920's the composition of the waterfowl species of Lake Valkojärvi was not unusual. Valkojärvi was, however, exceptionally large by Finnish standards. Of the 183 eutrophic sites censused in south-west Finland only 8 were larger than 4 sq. km (Haapanen & Paasivirta 1973). Of these eight sites four are sea bays. Of the four lakes only one, Lake Puurijärvi can be regarded as a typical waterfowl lake. Siikalahti in south-east Finland is also of this type (see e.g. Blomqvist 1968, Haapanen et al. 1969) and Ainali in the Suomenselkä region a slightly poorer site, area 7.7 sq. km (Merikallio 1952). Although the information on rich waterfowl sites is not quite exact from all parts of the country (cf. Haapanen 1973), it is very difficult to find many new areas belonging to this category, although there may be some. Some are found in the national wetland inventory (P. Rassi, oral information). Eutrophication creates these, too. (See section 8.2 and 8.3.).

Lake Valkojärvi was also an important resting site for migratory waterfowl. The bean goose (*Anser fabalis*) in particular used the area during its spring and autumn migration. Some hundreds of birds could be seen at a time. Unfortunately no detailed information was collected. In addition to Lake Valkojärvi the fields and extensive peatlands were used by these geese as feeding and resting sites.

4.2. *The bird fauna of terrestrial sites*

Tables 4, 5 and 6 show the bird fauna of forests, peatlands and fields respectively in the late 1920's.

The forest sites censused represent small woodlots with a high edge effect in the middle of agricultural areas and do not represent the bigger forest areas of the region. Therefore the bird density, too, is especially high and some species, which are not typical forest species, are found. The areas have been partly grazed. Therefore those species with an open or semi-open habitat e.g. *Lyrurus tetrix*, *Lanius collurio* and *Carduelis cannabina* are found.

Table 4. The bird fauna of forest sites. Three areas size 10 ha, 3.5 ha and 4.5 ha were censused in 1928 and 1930, a total of 36 ha.

	pairs	%
Falco tinnunculus	2	1
Lyrurus tetrix	2	1
Perdix perdix	4	1
Columba palumbus	1	+
Asio flammeus	3	1
Apus apus	4	1
Dendrocopos major	3	1
Corvus cornix	13	4
Parus major	5	1
Turdus pilaris	33	10
T. philomelos	3	1
T. iliacus	5	1
Oenanthe oenanthe	6	2
Saxicola rubetra	1	+
Phoenicurus phoenicurus	2	1
Acrocephalus schoenoboenus	5	1
Hippolais icterina	3	1
Sylvia borin	16	5
S. communis	25	7
S. curruca	2	1
Phylloscopus trochilus	21	6
Muscicapa striata	26	8
Anthus trivialis	2	1
Motacilla alba	6	2
Lanius collurio	12	3
Sturnus vulgaris	10	3
Carduelis chloris	21	6
C. cannabina	3	1
Fringilla coelebs	80	23
Emberiza citrinella	17	5
E. hortulana	6	2
E. schoeniclus	4	1
Total	346	100
Pairs/sq.km	960	

Table 5. The bird fauna of peatlands. The area censused 37.5 ha in 1928 and 1930, a total of 75 ha.

	pairs	pairs/km²	%
Lagopus lagopus	2	3	1
Vanellus vanellus	5	7	3
Capella gallinago	13	17	8
Numenius arquata	18	24	10
Asio flammeus	2	3	1
Corvus cornix	6	8	3
Saxicola rubetra	21	28	12
Sylvia communis	12	16	7
Phylloscopus trochilus	6	8	3
Anthus pratensis	25	33	14
Motacilla flava	25	33	14
Fringilla coelebs	8	11	5
Emberiza citrinella	9	12	5
E. schoeniclus	22	29	13
Total	174	232	100

Table 6. The bird fauna of fields. Four areas 8.5 ha, 9 ha, 19 ha, 16 ha in size were censused in 1928 and 1930, a total of 105 ha.

	pairs	pairs/km²	%
Vanellus vanellus	36	34	22
Numenius arquata	17	16	10
Alauda arvensis	15	14	9
Hirundo rustica	28	27	17
Oenanthe oenanthe	10	10	6
Saxicola rubetra	7	7	4
Sylvia communis	6	6	4
Motacilla alba	7	7	4
M. flava	28	27	17
Emberiza citrinella	5	5	3
E. hortulana	4	4	3
Total	163	157	100

The peatlands studied are also fairly small. The bird fauna in the larger peatland complexes is not necessarily quite the same. The occurrence of the willow grouse (*Lagopus lagopus*) is of special interest, since at present it is very rare so far to the south west, where it is found mainly in large peatland complexes (Helminen & Moilanen 1972). The willow grouse is among the species in Table 5, the only one which is restricted to peatlands in southern Finland. Seiskari (1956) regarded his observations in 1951—1953 on lapwing (*Vanellus vanellus*) nesting on a raised bog quite exceptional. The species was, however, found to nest on the bogs of the study area as early as the late 1920's. This has been a common occurrance since the 1950's (v. Haartman et al. 1963). The crane (*Grus grus*) was found nesting in the late 1920's in large peatland complexes. The peregrine falcon (*Falco peregrinus*) was also found nesting in one large peatland complex.

5. The drainage of wetlands

5.1. Lakes

At the beginning of the study period there were 122 waters, ponds or lakes in this area. The size distribution of these and the changes of their use are shown in Table 7. In 1972 46 of these were completely dry. The water area in 1972 was only 50 per cent of what it was one hundred years earlier. Only 49 lakes (40 per cent) of the original number of lakes have maintained their water area throughout the study period 1883—1972. These lakes are mostly on till soil surrounded by woodland.

Fig. 6 shows that the drainage of water bodies has not been a continuous process, since a large part (about 40 per cent) of the total area drained was drained between 1928 and 1946. The main purpose of these drainage projects was to develop new pasture-land and fields. Littoral meadows were important as grazing areas and also for hay-making for local farmers up to the 1930's. As a result of the Second World War Finland lost a considerable part of her agricultural land in South Karelia. Nearly 500 000 people from ceded areas had to be resettled in other parts of the country. The whole nation was given the job of finding new agricultural land. In this particular area the drainage of the central lake of the Sirppujoki river system, Lake Valkojärvi and some other lakes was carried out just after the war. This constituted about one half of the total drainage during this period.

The regional agricultural engineer (Aimonen 1960) described the projects as follows: »In the early 1880's Lake Valkojärvi was in its natural state. It was about two metres deep. The meadows around the lake were good pasture-land and were easy to convert into fields. Floods, however, were a problem and for this reason the

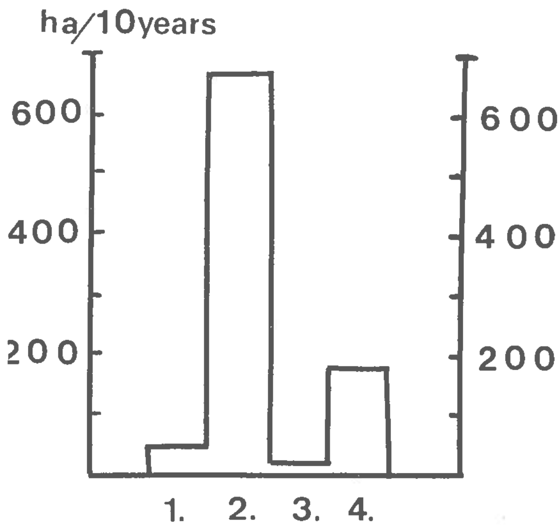

Fig. 6. The drainage of lakes measured as hectares per ten years in different periods. 1. 1883—1928, 2. 1928—1946, 3. 1946—1963, 4. 1963—1972.

Table 7. The lakes of the study area in the different study periods.

size (ha)	1—9		10—29		30—49		50—99		100—399		400—		Total		Number of dried lakes
Year	no.	ha	no.	ha	no.	ha	no.	ha	no.	ha	no.	ha	no.	ha	
1883	68	276	35	600	8	310	7	513	2	230	2	1 170	122	3 099	0
1928	69	283	27	472	7	255	7	526	2	230	2	1 148	114	2 914	8
1946	69	269	21	374	5	195	3	221	2	230	1	420	101	1 709	21
1963	68	266	18	341	5	195	3	221	2	230	1	420	97	1 673	25
1972	48	192	17	309	5	195	3	194	2	230	1	420	76	1 540	46

first proposals to lower the water level were made 150 years ago. The first drainage project took place in 1899. (The ecological state of the area in 1930 was that resulting from this drainage). The second project began in 1933 and the final one after the war, when the lake was finally drained although it had long been wasteland. Cultivation did not begin until the summer of 1960.»

Much later it was possible to cultivate the whole of Lake Valkojärvi as can be seen in aerial photographs taken in 1972. Lake Peräjärvi (50 ha) is still wasteland. Highly acidic types of soil are found in these coastal areas because of Litorina sea sediments and their cultivation without sufficient liming is often difficult (Purokoski 1959).

In 35 cases out of a total of 46 lakes drained, drainage has not resulted entirely in cultivated fields, some wasteland also being produced. The size distribution of these drained uncultivated areas is shown in Table 8. In 9 cases drainage led to cultivation of the total lake area, 719 ha altogether. However, in quite a number of cases part of the drained area was arable. It may be that in the future part of the wasteland shown above will be cultivated since it takes rather a long time for the soil acidity to drop.

Table 8 shows the area of uncultivated dried lakes in different periods. The area was largest in the 1940's when extensive work was under way. Although in 1972 the number of uncultivated drained lakes was high, the area consisted of small units. The total area was then only one third of that found in 1946. Detailed maps of the study area showing soil type are not available. To investigate the effect of the soil on lake drainage it is assumed that the number of fields and the percentage of field shores show to what extent soil types are arable, although in many cases it may not be possible to drain the lake for other reasons. Table 9 shows that in cases where the lake was drained and later cultivated fields on its shores, are quite extensive. On the other hand, when the lake maintained its original volume it was surrounded mainly by uncultivated land. The intermediate cases are also intermediate in this test (Table 9).

Table 8. The area and size distribution of uncultivated drained lakes (wasteland) 1928—1972.

Year	size (ha)				total	mean	median
	1—10	11—20	21—	n	(ha)	ha	ha
1928	3	2	5	10	258	25.8	45
1946	11	4	9	24	1 001	41.7	83
1963	10	7	7	24	539	22.5	60
1972	26	6	3	35	362	7.5	19

5.2. Peatlands

Under Finnish conditions peatlands do not always form clear units. Therefore the changes in their area are difficult to follow. Only the best formed peatland complexes are clear enough in this respect. In the study area there were 15 larger peatland complexes at the beginning of the study period. As these complexes belong to raised bogs (Eurola 1962), they are thus dependent only on rainwater. Therefore they may

Table 9. The percentage of field shores for various types of lakes. Figures indicate percentages of the total occurrence.

lakes	percentages of field shores						total	N	median (%)
	0	1—20	21—40	41—60	61—80	81—100			
Undrained	45	33	16	4	2	0	100	51	5
Partly drained	13	25	33	8	21	0	100	24	30
Uncultivated dry	8	15	15	10	38	13	100	39	60
Cultivated dry	0	0	0	38	13	50	100	8	80
Total								122	

Table 10. The drainage of 15 peatland complexes, (1880's—1972).

	size (ha)			total		mean	number totally drained
	1—50	51—100	101—	no.	ha	(ha)	
1883	7	4	4	15	1 513	100	—
1928	10	2	3	15	1 326	88	0
1946	8	2	2	12	1 008	83	3
1963	3	2	2	8	881	110	7
1972	2	2	2	6	871	145	9

be classified as peatlands even in cases when e.g. the minerotrophic parts of the complex are cultivated.

Table 10 shows the changes that had taken place in these complexes by 1972. Nine of the fifteen original areas have been drained. Later one more was drained for forestry purposes and there is also one completed drainage plan. Thus only four out of fifteen peatland complexes have been preserved in such a state that they can still be called peatlands. Fig. 7 shows that the drainage of these peatland complexes was most extensive between 1928 and 1946, apparently after 1944, as in the case of lake drainage.

The following summary shows the subsequent land use of drained peatlands:

	fields	forested	peat cutting
area (ha) .	536	35	103
%	80	5	15

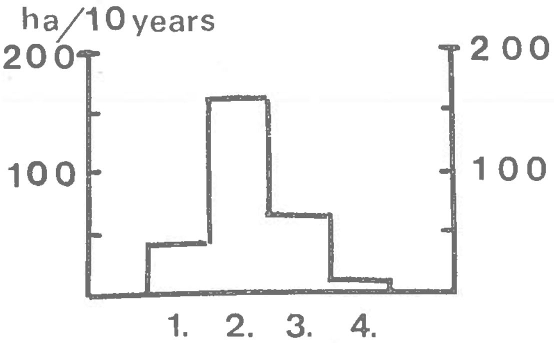

Fig. 7. The drainage of peatlands for agricultural purposes. Only fifteen peat and complexes were taken. The periods are the same as in Fig. 6.

In these cases drainage for agricultural cultivation was the most important factor. Two peatlands and parts of others have been used for peat cutting. Peat cutting for farm use has not been practised since the 1950's. Peatland reclamation for agricultural purposes may still be practised but only to a lesser degree. The government does not subsidise this any longer.

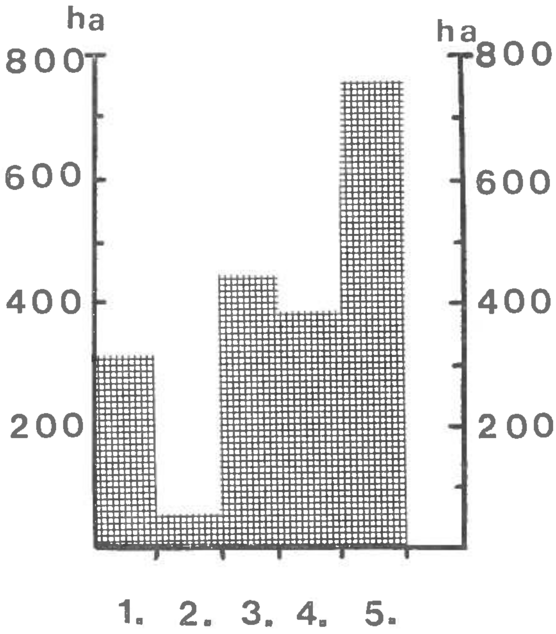

Fig. 8. The drainage of peatlands for forestry purposes. 1. 1960—62, 2. 1963—65, 3. 1966—68, 4. 1969—71, 5. 1972—74.

On the other hand peatland drainage for forestry purposes has been a very active project (cf. e.g. Heikurainen 1972). The study area is not a unit where peatland drainage statistics would be readily available. Therefore the total amount of forestry peatland drainage in the study area is not clear. According to the local Forest Improvement District in 1960 in the parish of Laitila, 939 ha of peatland were drained. Laitila covers most of the study area. Thus roughly 900 ha were drained before 1960 and 1 987 ha after that, according to the Forest Improvement District. This activity is still practised extensively as shown in Fig. 8.

In the study area all small peatland areas, especially minerothrophic spruce fens, are drainable. The central parts of large raised bogs are such poor sites that their forestation is not possible without effective fertilisation. However, this can be done. At the present time about 3 000 ha have been drained for forestry purposes, slightly less than 50 per cent of the area that existed in the early 1960's. As there are no peatland nature reserves in the study area, no peatland complexes are protected. It may be that this type of natural community will be lost in the study area in the near future. One peatland area is included in the national peatland preservation plan.

6. Shoreline utilization

The shoreline is a very important and sensitive ecotone in nature. In Finland the utilisation of this ecotone has changed greatly during the last few decades. Earlier, waterside meadows were important as grazing areas and for hay-making. Hay-making still took place in the late 1920's. This can be seen from the number of hay barns in waterside meadows (Fig. 9). This practice disappeared relatively early (cf. Jäntti 1945) but grazing of young cattle can still be found although to a lesser extent.

The drainage of lakes has affected the length of the shoreline. The following summary shows the length (km) and the percentage of the lake shoreline remaining:

	1883	1928	1946	1960	1972
km	264	249	192	188	168
%	100	94	73	71	64

Building summer cottages on sea and lake shores became more common in the 1940's and in recent years there has been a rapid growth in the number of summer cottages (Kleemola 1971). The situation in the study area was surveyed. A questionnaire on the number of summer cottages and approved permits to construct a summer cottage was sent to the local building inspectors. The results show the situation in 1972.

The recreational utilisation of these lakes is very heavy in some cases (Fig. 9). The following table shows different types of lakes without summer cottages (undisturbed lakes here are lakes which have kept their area unchanged during the last one hundred years):

	undisturbed lakes	lakes with lowered water level	eutrophic undisturbed lakes
%	36	42	100
number	17	10	6
total number .	47	24	6

Although there are quite a lot of lakes without summer cottages, these lakes are small and the length of the shoreline therefore also small. The length of the shoreline of lakes without summer cottages as a percentage of the total length of the shoreline is 13 % for undisturbed lakes and 17 % for lakes with lowered water level.

For lakes where there are summer cottages, the shoreline length per summer cottage varies greatly as can be seen from the following table (the figures indicate the shoreline in metres per summer cottage):

undisturbed lakes	lakes with lowered water level
620 ± 760 (65—3 650)	800 ± 620 (130—2 100)
18	14

There are many reasons for this great variation. One of the most important is apparently how interested the landowners have been in selling plots to city people.

If there are less than 200 metres of shoreline per summer cottage the shore ecotone can be regarded as either heavily loaded or disturbed. For undisturbed lakes 38 % of all the shoreline falls into this category. For lakes with lowered water level only 3 % of all the shoreline falls into this category. This means that 22 per cent of all shorelines in the area are heavily loaded.

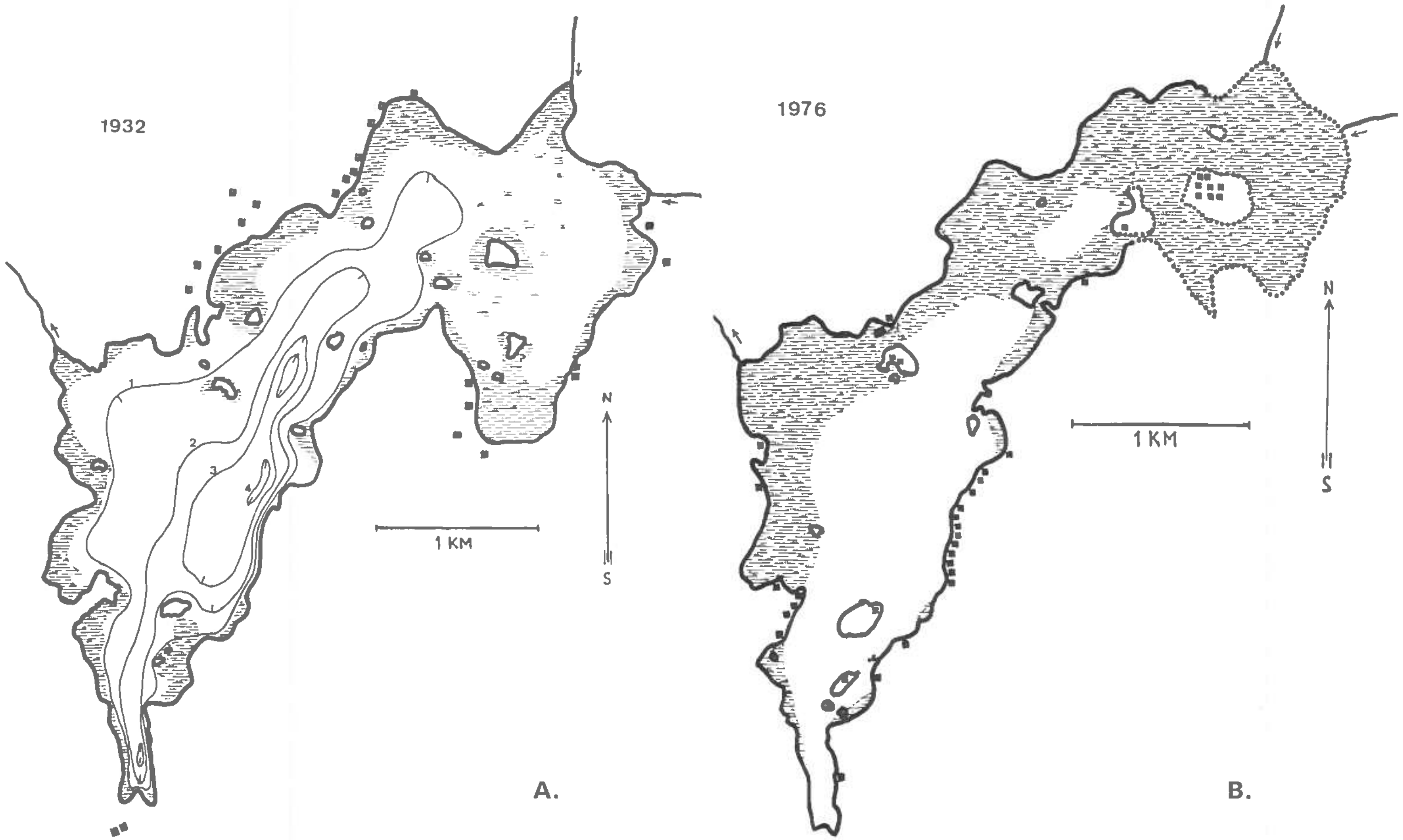

Fig. 9. The utilization of shoreline and the vegetation of Lake Otajärvi in the 1920's and in 1976 (the latter map according to Kotiranta 1976). During this period the hay barns disappeared from shallow shore and summer cottages appeared on deep shores. The vegatation belts grew much wider. The depth of the lake in metres is shown in 1932.

7. Construction of the freshwater impoundment

In 1965 the archipelago area (3 700 hectares) close to the Sirppujoki system was dammed in order to get a freshwater reservoir for the use of industry and the growing town of Uusikaupunki (see Fig. 11, cf. Isotalo 1971).

8. Ecological effects of changes in land use

It was possible to follow the history of the changes in the wetland area only. The conclusions on ecological changes are based on observations from the present time and on field studies by Waaramäki (1930, 1932).

8.1 Wetland balance

In the study area, wetland areas including peatlands cover, at present, only a small proportion of what they did one hundred years ago (Figs. 10 and 11). The main reasons for these changes have been: 1. The agricultural drainage of shallow lakes and peatlands, now seldom carried out. 2. Peatland drainage for forestry purposes, still widely practised in Finland and also in the study area. Table 11 shows the changes. The construction of the freshwater impoundment added an area of fresh water, but since this was formerly a brackish water area, it only produced an ecological loss (see chapter 8.2.).

8.2. Hydrology and the quality of water

The information given here is based on the literature and on unpublished information given by the local water district of the National Board of Waters. No permanent record of the hydrological behaviour or the quality of water has been made in these drainage basins partly because these basins have been of lesser importance and because effective water resource management has only recently evolved in Finland as in many other countries.

Isotalo (1971) presented the hydrological cycle of the Sirppujoki system in 1969—1970 (Fig. 12). The maximum flow was 53 m^3/s and the minimum in summer 0.05 m^3/s which means that the maximum flow was 1 000 times greater than the minimum. This is a typical situation for a drainage system with a small number of lakes. During the last 100 years the water area of this drainage system has diminished by 50 %. The drainage of peatlands must have had a similar effect (cf. Mustonen & Seuna 1971). The low pH of the waters caused unexpected changes in the quality of the water impoundment. The fish population died in autumn 1968 three years after the construction of the water impoundment (Isotalo 1971). Fig. 13 shows the pH values in different parts of the river system. The lowest pH values are found in waters which come from former Valkojärvi area, whereas pH can be fairly high where little or no drainage has taken place as in the waters coming from the Särkijärvi system. The low pH values are caused by sulphides in the soil. Aeration causes these sulphides to turn to sulphates. This in turn is caused by lowering the surface of the ground water. SO^{2}_{4}-ions increase the electrolytic con-

Table 11. Wetland area changes between the 1880's and the present day. The peatland complexes are clear mire units. The area of other peatlands is not known exactly. As agricultural drainage outside the 15 complexes investigated has evidently also taken place, the changes shown here are a certain minimum. Figures indicate the areas of different site types in hectares.

Year	1883	1972	balance	%
Lakes	3 099	1 540	—1 559	— 50
Peatland complexes .	1 513	841	— 642	— 42
Other peatland	5 000	3 000	—2 000	— 40
Total	9 600	5 400	—4 200	— 43

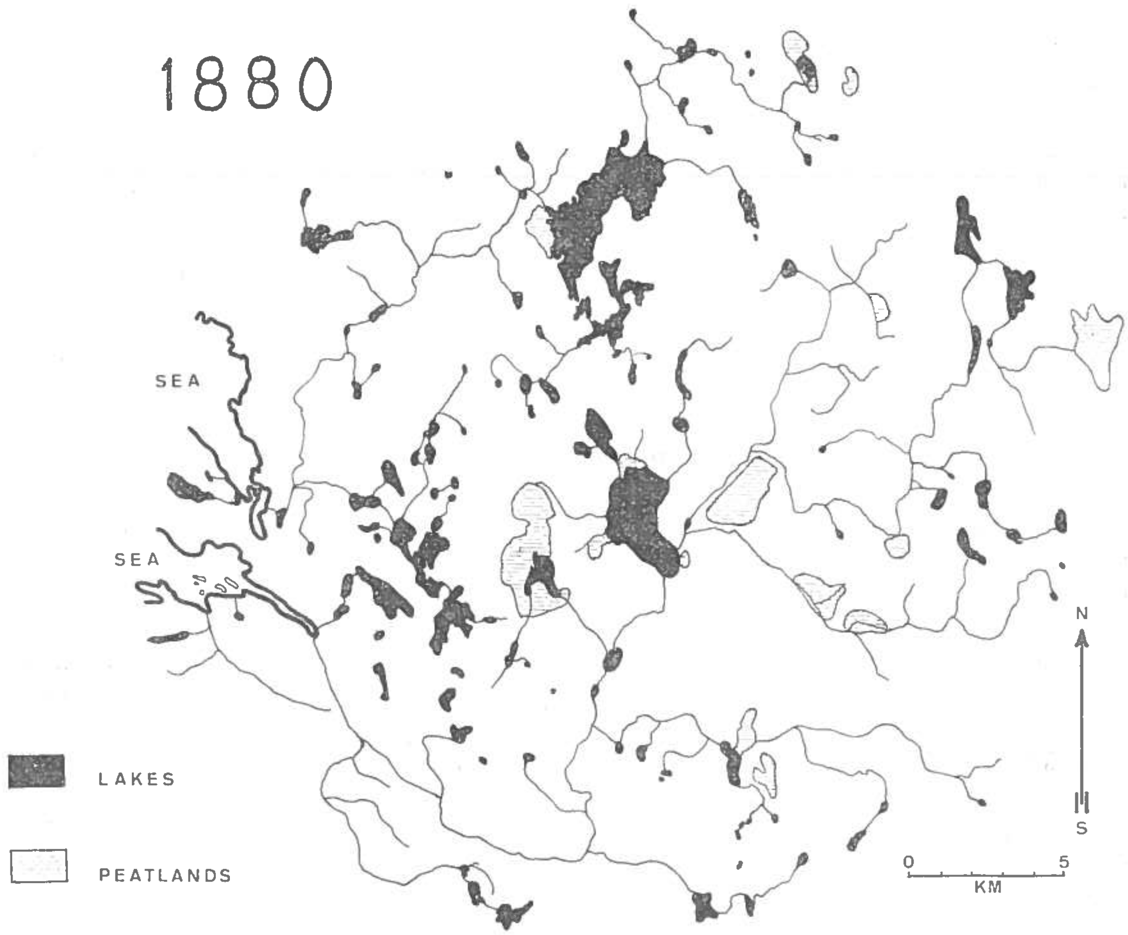

Fig. 10. The lakes and main peatlands (fifteen complexes, which were surveyed through the study period) of the study area in 1883.

ductivity of the water. This can be seen from the high values in Fig. 13.

Kivinen (1938) showed that the clay of Lake Valkojärvi has a low pH value when it is well areated. The low pH reaction of this type of soil in western coastal areas was also studied by Purokoski (1959), but apparently these studies, made for agricultural purposes, were not known or were not taken into account when plans for the freshwater impoundment were made.

Laaksonen (1970) found the mobilisation of manganese under conditions of low pH in coastal areas. This also occurred in this area (Figs. 14 and 15). This has made the use of water, for which the whole impoundment was constructed, difficult. Table 12 shows some aspects of the quality of the water from two river systems and two adjacent systems.

Hinneri (1974) made a survey on the possible sedimentation of heavy metals in the water impoundment. However, he could not find any departures from the normal situation.

The eutrophication of lakes can clearly be seen in one case. This is the case of Otajärvi, the central lake of the Ihodejoki river system. Waaramäki (1932) describes the vegetation of the lake as rich in many places. The stands consisted of *Phragmites communis*, *Scirpus lacustris*, *Sparganium*

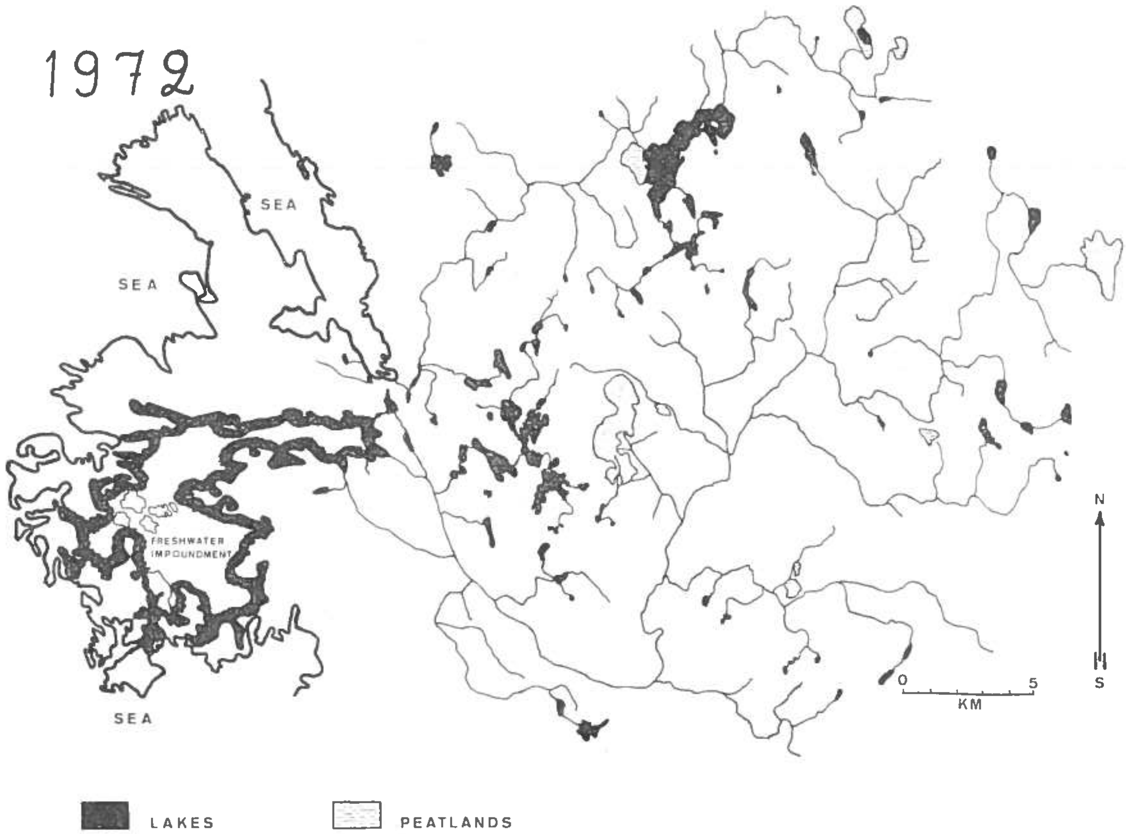

Fig. 11. The lakes and main peatlands of the study area in 1972. The freshwater impoundment is also shown.

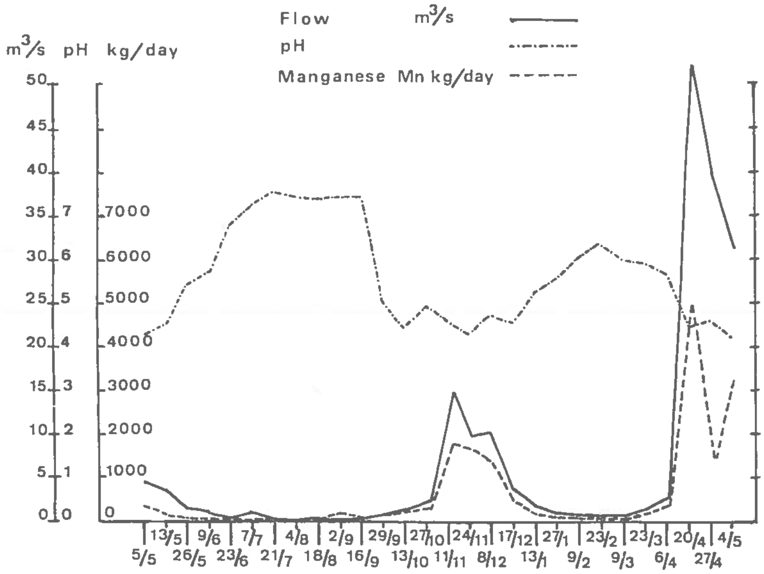

Fig. 12. The flow, pH and manganese content of the Sirppujoki river system during 1969—70, according to Isotalo (1971).

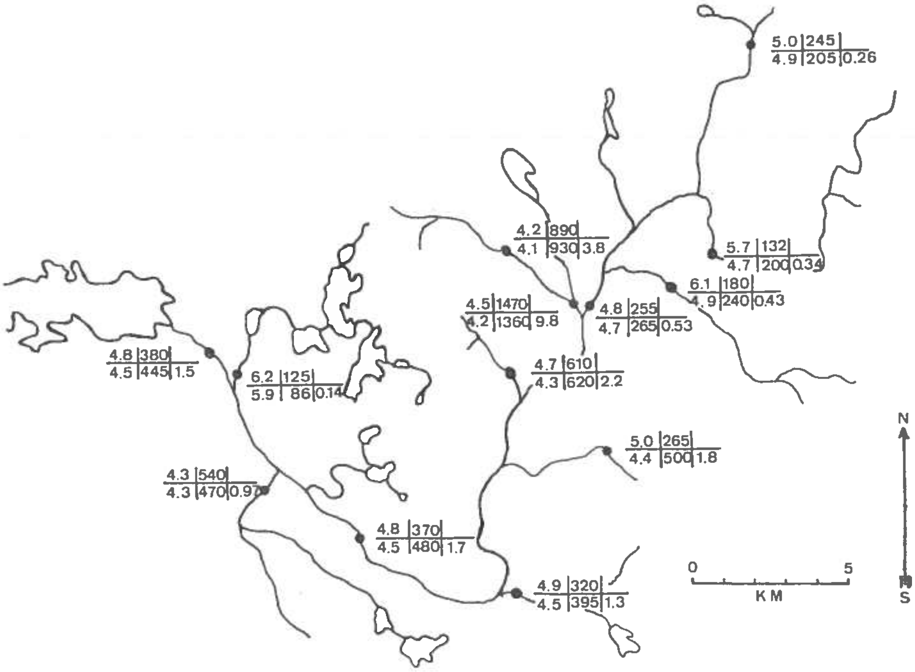

Fig. 13. The area variation of the water quality in the Sirppujoki river system according to two samples, one taken on November 14, 1968 and the second on the same day in 1969. The figures above the line indicate the pH and electrolytic conductivity ($H_{20}\mu S$) in 1968; those below the line indicate the values for 1969 plus the manganese content (mg/1), according to Isotalo (1971).

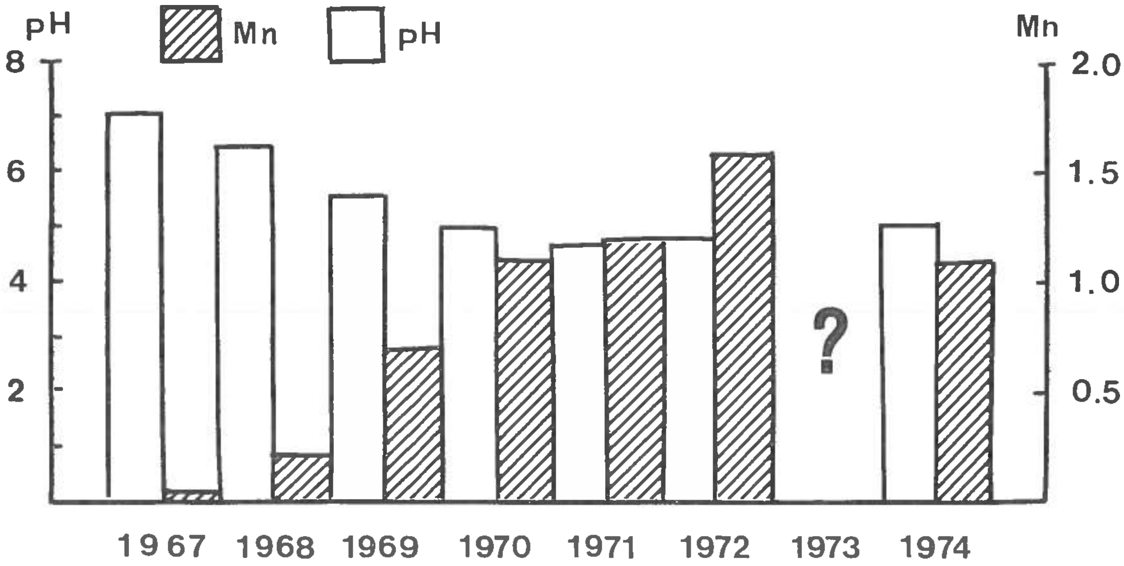

Fig. 14. The changes in pH and manganese content (mg/1) in the freshwater impoundment in 1967—74. The figures were provided by Isotalo (1971 and litt. inf.).

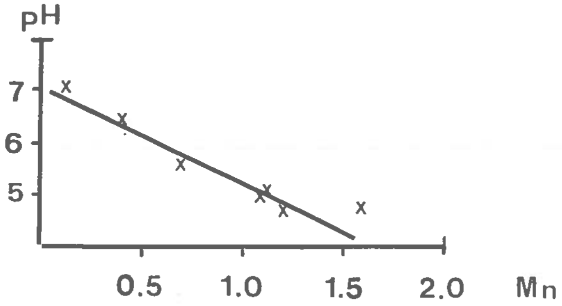

Fig. 15. The negative correlation between pH and manganese content (r = —0.8). Source of information as in Fig. 14.

simplex, different *Carex* species and *Typha angustifolia*. *Phragmites* and *Scirpus* stands in particular were extensive. The lake was fairly shallow (Fig. 9). The emergent vegetation stands are, however, now much larger than 40 years ago (Fig. 9). The water surface of the lake was lowered in the 1950's (Kotiranta 1976). This produced large areas shallow enough for emergent vegetation. Apparently the rivers flowing into the lake from field areas bring nutrients to the lake. Some lakes above Otajärvi have been drained completely.

8.3. Lake types and waterfowl populations

An attempt has been made to classify the lakes into oligotrophic and eutrophic lake types in order to show how drainage has changed the state of different types of lakes.

The lakes were divided into four groups: 1. lakes which have maintained their area, 2. lakes partly drained, 3. drained but uncultivated lakes, 4. drained and cultivated lakes. An attempt was made to show the fertility of the site through the soil fertility. Where the soil is arable, it is regarded as fertile. Thus all the lakes of the fourth group are regarded as having been eutrophic. Lakes of the second and third groups are regarded as eutrophic when more than 20 per cent of the shoreline is cultivated. Lakes of the first group were surveyed using maps. Lakes with rich emergent vegetation are regarded as eutrophic. This classification is fairly rough but the only suitable one in this case. The effects of drainage were much greater in the group of eutrophic lakes (Fig. 16). The drainage of Lake Valkojärvi forms almost 40 per cent of the drainage of all eutrophic lakes.

At the same time eutrophication has, however, caused changes in the relation between eutrophic and oligotrophic lakes. The following summary takes into account both drainage and eutrophication. It shows the areas of oligotrophic and eutrophic lakes at various periods and their relation to the original area (the first figures are hectares and the second percentages of the original area):

lake type	1883	1928	1946	1960 s	1972
eutrophic	1 393	1 254	891	857	750
	100	90	64	62	54
oligo-trophic	1 706	1 660	818	816	790
	100	97	48	48	46

Table 12. The general quality of the two drainage basins of the study area Sirppujoki and Ihodenjoki and two neighbouring drainage basins as well as the average situation in Finland. The general eutrophication of these small drainage basins of South-west Finland is clearly seen.

	pH	particles mg/l	N, mg/l	P, mg/l	O_2, %	Enterococcus ind/100 ml
Sirppujoki	5.9±1.0	14 ±14	1.8±0.7	38±19	79±13	97+260
Ihodenjoki	5.6±0.8	3.9±20	0.7±0.2	11± 6	84±21	59±120
Laajoki	6.4±0.7	19 ± 9.4	0.9±0.2	49±16	88± 4.6	160±316
Lapinjoki	6.0±0.8	9.4± 5.5	1.2±0.3	34±15	78± 8.5	33± 95
The whole country	6.6	11		50	84	611

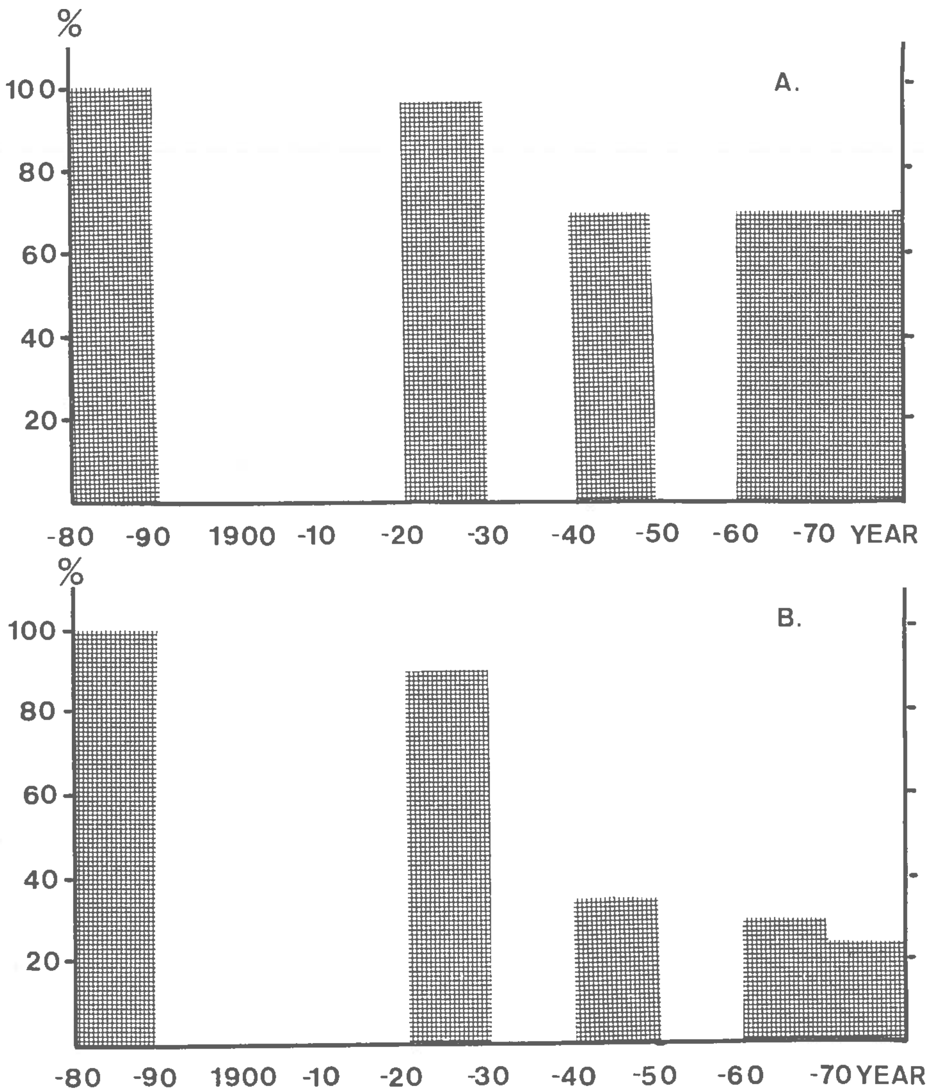

Fig. 16. The drainage of oligotrophic (A.) and eutrophic (B.) lakes. The figures show the percentage of the lake area existing in various periods between 1883 and 1972 compared with the original figures.

The decrease in area of these two lake types is the same, but since the two types of lake differ in size (eutrophic lakes are smaller on average) the changes in the numbers were different. Over a period of one hundred years the number of eutrophic lakes has decreased from 59 to 24 (by 60 %) and that of oligotrophic lakes from 63 to 52 (by 17 %).

A rough estimate can be made of the effects of drainage and eutrophication on the waterfowl populations. Here the average waterfowl capacity is important and short-term variations can be neglected. More detailed information on the composition and density of waterfowl species has been gained more recently. There are, however, some indications e.g. shown earlier in this paper (section 4.1.) that there have not been any radical changes. The generalizations made in the following discussion carry the risk that they may be oversimplifications. The density of waterfowl popülations on the oligotrophic lakes is low and seems to be more or less independent of the size of the lake (Haapanen 1973). The average density is about 3 pairs/km². The density on the eutrophic lakes varies within much broader limits. The size of the lake is also very important. The density figure for Valkojärvi in the 1920's was about 50 pairs/km². The other lakes are smaller, but their population density is generally higher. From the various data recorded (see also Haapanen 1973 and Haapanen & Paasivirta 1973) an average figure of 60 pairs/km² can be used here. (The surface of Lake Valkojärvi was lowered in the late 1800's. The littoral vegetation was, however, well formed in 1883 as the detailed map shows. The same density figure of 60 pairs/km² can thus be used.) The waterfowl populations of the study area are roughly as follows (figures indicate numbers of breeding pairs):

year	1883	1928	1946	1960's	1972
oligotrophic lakes ..	50	50	25	25	25
eutrophic lakes	840	750	540	510	450
Total	890	800	565	535	475
%	100	90	65	60	55

The total population is now perhaps only 55 per cent of what it was one hundred years ago. Waterfowl populations are good indicators of many other changes in wetland plant and animal life. Evidently all species of eutrophic wetlands have suffered greatly from drainage.

No detailed census of the waterfowl of Otajärvi lake was carried out in the late 1920's, but it was a fairly rich site as Waaramäki (1932) stated. A detailed population census was made in 1976. Mr. P. Rassi has kindly given these results for the purposes of this paper. The bird fauna was as follows (figures are pair numbers):

Podiceps cristatus	12
P. griseigena	15
P. auritus	13
Anas platyrhynchos	55
A. crecca	40
A. querquedula	2
A. penelope	7
A. acuta	1
Spatula clypeata	5
Aythya fuligula	20
A. ferina	47
Bucephala clangula	45
Circus aeruginosus	4
Grus grus	3
Rallus aquaticus	9
Porzana porzana	4
Fulica atra	145
Capella gallinaco	28
Tringa glareola	10
T. hypoleucos	17
T. totanus	6
Larus canus	1
L. minutus	15
L. ridibundus	320
Sterna hirundo	7
Acrocephalus arundinaceus	1
A. scirpaceus	10
A. schoenobaenus	67
Motacilla alba	22
M. flava	47
Emberiza schoeniclus	94
Total	1 092
Waterfowl total	420
Area (ha)	420
Waterfowl density (p/km²)	100

These results show that the lake is an excellent wetland habitat at the present time. Apparently there has been a great increase in the populations of different species since the 1930's as the lake is now of the same type as the now dry Lake Valkojärvi was at that time.

Disturbance caused by summer cottages has been studied surprisingly little in Finland. It is, however, known that a single house on the shore is sufficient to prevent the black throated diver (*Cavia stellata*) from nesting anywhere on the lake. In contrast *Laridae* species easily become accustomed to man and his activities. The aquatic vegetation is affected by tree cutting, trampling and boating.

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Fig. 17. Hay barns on a flooded field. March 18, 1927. Photo Tauno Waaramäki.

8.4. The bird fauna of the fields

The available material also makes it possible to make a comparison between the bird fauna of the fields in the 1920's and that at the present time.

No recent census has been performed in these fields. Surprisingly enough there are very few studies on field bird fauna in Finland. Although Salo's studies (1967) were not made in the same area they are the only studies of this type to make comparisons. No very detailed conclusions can be drawn, but some general trends seem quite clear.

The bird fauna of the fields seems to have changed since the 1920's because of agricultural methods. Our data show some aspects of this. At that time small hay barns were very numerous in the fields (Fig. 17) and provided nesting places for certain species. At that time piles of stones were, also common in the middle of fields. Nowadays these have been cleared away, so that the density of some species was higher in the late 1920's than it is today. Apparently the density of edge species was also higher. On the other hand, the density of those species living in large open areas was smaller. This can be seen from the following summary (figures indicate pairs/km^2. Data from 1965 according to Salo (1967)).

	1920's	1965	trend
Vanellus vanellus	34	19	—
Numenius arquata	16	9	—
Species nesting in constructions			
Hirundo rustica	27	0	—
Oenanthe oenanthe	10	0.5	—
Motacilla alba	7	1	—
Edge species			
Motacilla flava	27	4	—
Emberiza citrinella	5	0	—
Sylvia communis	6	4	—
Saxicola rubetra	7	7	±
Species of large open areas			
Alauda arvensis	14	24	+
Anthus pratensis	0	5	+
Emberiza hortulana	4	5	+
Other species	0	14	
Total	157	93	—

v. Haartman (1975) noticed a general decrease in the curlew populations of South Finland. The lapwing population, on the other hand, has increased. In spite of this fields may at present be less suitable as the lapwing habitat than earlier. Among the other species mentioned in the summary above are 12 species which were not found in the fairly small sample plot of the studies in the 1920's. These include e.g. *Perdix perdix* and *Crex crex* which are known to be rarer now than in the 1920's. *Phasianus colchicus*, introduced more recently is also included.

9. General remarks

Over the last few years the need to monitor slow environmental changes has been stressed in many connections. As shown here even in a country of thousands of lakes the drainage of wetlands can drastically change the nature of certain areas producing something quite different to that which existed only one hundred years previously.

In this paper waterfowl species were used as indicators of changes in wetland areas since their ecological requirements are known well enough to enable conclusions to be drawn. Since waterfowl migrate, they may be described as an »international resource» and the governments concerned should pay special attention to maintaining this resource.

The drainage projects in the study area were conducted by different governmental agencies which were active over different periods. There was little integration of these activities. Although the acid sediments of the soil in the study area were well known to agricultural scientists, the low pH in the impoundment came as a complete surprise to the impoundment constructors (cf. Isotalo 1971). In addition to financial losses caused by poorly integrated management of land and water resources much of the area's ecological value has been lost through the drainage of many lakes of special importance as breeding and resting sites for waterfowl and as the habitat of other animal and plant species of eutrophic waters. The drainage of many lakes was also unfortunate in that they never became fields. There are 35 such wasteland areas in the study area covering 362 ha, average size 7 ha.

Developers of natural resources have, until recently, had virtually no knowledge of ecological matters. It is therefore understandable if ecological factors are neglected. There are plenty of lakes almost everywhere in Finland and the study area is no exception. It is quite understandable therefore if the effects of the slow process of draining shallow lakes goes unnoticed.

All 35 drained uncultivated ponds and lakes in the present study area should be surveyed with a view to restoring the sites. Work to this end is, to some extent, already taking place (cf. Seppänen 1973). In many cases, however, the motivation for restoration is to construct a lake for recreational purposes. The aim of restoring small ponds should be to produce a shallow eutrophic pond with a rich primary and secondary production.

The fauna and flora of peatlands are endangered by extensive peatland drainage.

The main theme of the United Nations Environmental Conference in 1972 on natural resources was the integrated management of these resources. This integrated management is urgently needed at both national and local levels, and must take into account both economic plans proposed by different resources developers and ecological demands. How this should be organised is outside the scope of this study but if this study confirms the need for integration and promotes it, it has done its task.

Summary

The basis of this study was Tauno Waaramäki's field studies in the area in 1926—1930, which included a detailed survey of Valkojärvi, the central lake of the Sirppujoki system. These surveys concerned the land use around the lake and the vegetation and waterfowl of the lake.

Changes in the use of wetland in the area are based on fairly detailed maps (from 1883, the 1920's and the 1960's and on aerial photographs from 1946 and 1972).

The study area covers 645 km² which, in the late 1800's, contained 122 lakes and ponds. 47 lakes (40 %) are now completely dry and the water area has decreased by 50 %. Only 49, or 40 %, of these original 122 lakes have the same area at present as they had in the 1880's.

Eutrophic lakes were drained more often than oligotrophic lakes, although eutrophication caused approximately the same decrease in the area of both lake types. The number of eutrophic lakes decreased by 60 % and oligotrophic lakes by 17 %. The lakes were drained mainly for agricultural purposes. Much of this work was done after World War II. 35 small ponds and lakes were never turned completely into fields.

The shoreline has decreased by 96 km; in 1972 it was only 64 per cent of its 1883 length.

Those lakes still in their original condition are now utilised for recreational purposes. In many cases the density of summer cottages on the lake shores is high. For 22 per cent of all shorelines there is less than 200 m of shore per summer cottage. This means a heavy ecological load.

In the 1880's there were 15 peatland complexes (1 513 ha). Only four of these were sufficiently untouched in 1972 to be called peatlands. Formerly peatland was drained for agricultural and peat-cutting purposes, although this is no longer done. However, peatlands are still drained for forestry purposes to a large extent. By 1973 2 000 ha peatland had been drained for forestry purposes. About 40 per cent of all peatland has been drained and this drainage continues. In 1965 a freshwater impoundment (area 3 700 ha) was constructed in the archipelago outside the drainage basin of Sirppujoki. The wetland area balance shows a decrease of 43 per cent, for which the freshwater impoundment cannot compensate. The ecological function of the freshwater impoundment, which was formely a natural coastal archipelago area, has so far been poor.

The hydrological cycle of drainage basins at present is typical of areas where there is a small number of lakes causing floods, and where the flow during summer is very small. Lowering the ground-water level caused the oxidation of sulphide compounds in the soil. This causes water in rivers to become acid with accompanying manganese activation. These low pH values caused the death of fish populations in the impoundment in 1967. The high manganese values make the utilisation of the impoundment difficult as a raw water supply.

It is estimated that the waterfowl population capacity of the lakes in the study area is at present only 55 per cent of what it was in the 1880's. In the study area there was one especially good waterfowl site (Lake Valkojärvi) which was studied thoroughly in the late 1920's. This lake is now a dry field, but because of eutrophication another lake, which was only slightly better than a normal oligotrophic lake in the 1920's, has become one of the richest sites in Finland. The changes of field bird fauna are also discussed.

Also it is discussed the need to integrate various resource development plans and the need to include in these ecological considerations.

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