AQUATIC VEGETATION OF LAKE MANTOJÄRVI IN INARI LAPLAND, FINLAND

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I. INTRODUCTION

Lake Mantojärvi is the last and also the broadest expanse of water in the chain of lakes and narrow rapids that form the central course of the Utsjoki River. As a matter of fact, all the waters of the Utsjoki River that flow into the Teno River pass through Mantojärvi. This lake is about 3 km long, its greatest breadth is about 800 m, and greatest depth 57 m (PETÄJÄ 1964). The shoreline of the area I have studied is about 8 km long.

The Utsjoki River valley runs roughly north and south at Mantojärvi. Along the eastern shore of the lake there is a fjeld called Puollamoaivioalgi, which rises steeply to a height of more than 300 m. The western shore rises much less rapidly except at the north end where there is a cliff called Kirkkopahta which is about 200 m long and some ten metres high. The Inari—Utsjoki highway, completed in 1957, runs along the shore between the precipice and the lake.

The soil in the neighbourhood of the lake is moraine. The lake lies in the Lapland birch zone and the birch heath forest extends down to the lakeshore almost everywhere. Up till now the only residence near Mantojärvi has been the parsonage of Utsjoki. Further from the lake are the church of Utsjoki and many so-called church cottages which are not regularly inhabited. In this area the birch forest does not extend to the lake as there are meadows along the shore.

Bare bed rock does not occur anywhere on the shores. On the western shore south of Kirkkopahta cliff moraine composed of heterogeneous rocks forms the eulitoral and lower sublitoral zones. The shores at the southern end of the lake are covered by sand and finer material. The eastern and northern shores are covered for the most part by gravel about 1 m thick that lies on a sand bottom.

The rock-covered lake bottoms and precipitous shores are inseparably connected with each other. For the most part the long eastern and western shores are exposed, and wave erosion has very effectively hampered the

stratification of the finest materials there. Unexposed shores are few in number. The most unexposed areas are two long bays on the eastern shore; rather unexposed are also the southernmost coves on the western shore.

According to observations made on Aug. 17, 1959, the depth of vision in Mantojärvi is 5.9—6.0 m, and the colour of the water yellowish green. The pH value is 6.9 and the specific conductivity $35.4 \cdot 10^{-6}$ ohms/cm according to measurements made in 1957.

Reverend T. SUOMINEN made accurate notes in the years 1955—1964 on the freezing and the breaking up of the ice. According to these notes the lake froze between Oct. 24 and Nov. 26 and the ice broke up between the 12th of May and 13th of June. The lake is free from ice about 153 days a year (140—166 days).

Investigation methods

My investigation involved chiefly a topographic analysis of the higher vegetation of Mantojärvi. For this I chose 49 places for making observations in the area under study and marked on a map the stands and their depths. I attempted to make as detailed observations as possible of the species in the areas between the observation sites. In the main I worked from a boat. In addition to making visual observations, the bottom was dragged. The Secchi scale method was used in determining the depth of vision and the colour of water.

II. AQUATIC VEGETATION

1. *General features*

The sublitoral zone where water plants grow is only about 17 m wide. The maximum breadth is 40—50 m in a few places on the western shore. The upper sublitoral zone down to the depth of about 70 cm is almost bare. Thus the sublitoral zone comprises two subzones: a bare upper zone and the deeper main zone where water plants are found. The average maximum depths and horizontal breadths of these subzones are given in the following table.

	Breadth			Depth	
	Bare zone	Water plant zone	Total	Bare zone	Water plant zone
Western shore ..	4.7	18.3	23.0	0.45	2.55
Eastern shore ...	5.4	9.0	14.4	0.85	2.85
Northern shore ..	5.5	8.5	14.0	0.70	2.55
The whole lake ..	5.2	11.8	17.0	0.70	2.70

The marked fluctuation of the greatest depth in the various areas of the water plant zone is obviously dependent on many interconnected factors such as the exposition and steepness of the shore and the granulation of the bottom. On the eastern and northern shores where stones often cover the whole of the eulitoral and usually a part of the sublitoral zone the water plants begin to occur where the stone bottom changes into finely granulated soil consisting of coarse or fine sand. In many places the borderline between these bottom zones can also be considered the boundary between the erosion and inerosion bottoms as proposed by THUNMARK (1931). The bare subzone of the sublitoral covers the whole of the erosion bottom in extensive areas on the eastern and northern shores, while on the western shore where the stone bottom is usually entirely missing or covers only the lowest part of the erosion bottom, the quality of the bottom favours the appearance of species that do not thrive at great depths for some reason or other. As a rule stands are found on the erosion bottom, too. In the most sheltered sites, in the innermost parts of the eastern bays, water plants are found throughout the sublitoral zone.

The water plant zone does not form a continuous belt around the lake, but is interrupted by bare areas. The longest of these bare areas is in the Kirkkopahta cliff region where the highway runs along the shore. There were no higher water plants in this area before the highway was built, because the shore was formed then by a vertical rocky wall and partly by rocks at its foot. The length of this area is about 300 m. On the eastern shore there are two bare areas 100—150 m in length. The bottom of the southern shore is covered by large blocks of stone, while on the northern side the depth conditions and the nature of the bottom are not essentially different from those in many places where *Isoëtes lacustris* forms dense stands. Strong wave erosion in this exposed basin is probably the main reason for the absence of water plants. For the same reason nothing grows at the ends of the promontories.

2. *The zonation of the vegetation*

The most striking feature of the aquatic vegetation of Mantojärvi is the nearly complete absence of helophyte stands. Four helophyte species, *Equisetum fluviatile, Carex aquatilis, C. rostrata,* and *Hippuris vulgaris* were found in the area. *Equisetum fluviatile* grows in only three sites in the lake and in very few numbers. *Carex* species form quite dense stands though they are small in area in the coves of the unexposed bays on the east shore. *Hippuris* grows in small numbers in six different sites; most of the sprouts are submerged. The shore zone which is occupied by helophytes in lakes farther south is for the most part bare.

Fig. 1. Wind-protected bay on the east shore of Mantojärvi. A stand of *Carex rostrata* as well as a few stems of *Equisetum fluviatile* grow closest to the shore, in deeper water is a belt of *Sparganium angustifolium* and farthest out *Ranunculus peltatus.*

At a depth of about 70—120 cm there is a zone where several species form stands, but these are thin as a rule and interspersed by bare areas. The various species seem to be independent of each other and there is hardly any competition anywhere. The commonest species in this zone is *Potamogeton gramineus* (which in many places extends to the lowest depth of the hydrophyte zone, although it may also grow at a very great depth), *Sparganium angustifolium, Ranunculus flammula* var. *reptans* and *Subularia aquatica.*

On going deeper from the erosion and inerosion demarcation line, the number of hydrophyte species decreases, but the stands are more uniform than in shallower water. Only three species, *Myriophyllum alterniflorum, Ranunculus peltatus* and *Isoëtes lacustris* usually grow in this zone. In addition to these there occurs in some places *Potamogeton pusillus,* less frequently *P. gramineus* and *P. perfoliatus. Myriophyllum* forms regular, often quite dense strip-like stands which in some places seem to restrict the spread of the *Isoëtes* stands. The last-mentioned species usually occurs on the deeper side of the *Myriophyllum* belt — sometimes on both sides. As a rule the *Ranunculus peltatus* stands are not dense; they usually grow on both sides of the *Myriophyllum* belt and are sometimes found in the *Isoëtes* stands. *Potamogeton pusillus* usually grows at greater depths than other vascular plants. In some places stands of *Nitella* algae are found at even greater depths.

On the basis of the above facts the general vegetation zone can be divided into two parts whose borderline runs at a depth of about 120 cm and roughly follows the erosion — inerosion demarcation line. Most of the hydrophyte species grow either entirely or chiefly in the shallower zone. The stands of this subzone are irregular and their existence is to a great degree dependent on the exposition of the shore. The number of species in the deeper subzone is small, but the stands are often uniform; the exposition of the shore does not influence these stands as much as those in the lower zone. Hence there are fewer bare patches in the deeper subzone than in the shallower zone.

3. *List of species*

The frequency of the species is given according to the following scale (ULVINEN 1937):

rr	= very rare	st fq	= rather common
r	= rare	fq	= common
st r	= rather rare	fqq	= very common
p	= local		

The figure in the parentheses after the letters states the number of observation sites in which the species has been found.

Helophytes

Equisetum fluviatile L.; Ehrh., r (3). All the stands in the lake are very sparse, except in a small marsh near the western shore where this species grew in abundance.

Carex aquatilis Wg, r (3). All the stands are on the northeast shore of the lake. In unexposed sites it forms quite dense pure stands some square metres in area.

Carex rostrata Stokes, r (3). The species grows in similar, partly even the same sites as *C. aquatilis*; however, it forms larger stands than the latter (the largest one is 40—50 m^2 in area).

Hippuris vulgaris L., st r (6). This species is found mainly on the western shore, but is even there quite sparse. All the sites are comparatively unexposed and in part the bottom is covered with silt. The sprouts growing in shallowest water are often emerged, those growing in deeper water are always submerged.

Hydrophytes

The most abundant hydrophyte stands are situated on the western shore of the lake and in the unexposed bays of the eastern shore.

Sparganium hyperboreum Laest., rr (1). The only certain stand of this species is in a cove surrounded by a birch forest near the mouth of a rivulet which flows into the central part of the western shore of the lake. Obviously the cove is cut off from the lake when the water level is low. The bottom is soft silt. The companions are *Hippuris vulgaris* and *Equisetum fluviatile.* The stand was quite dense and about 1 m^2 in area.

Sparganium angustifolium Michx., st fq (17). All sterile *Sparganium* stands are included in this species. Fertile individuals are sparse. The species is commonest on the western shore, to the south of the parsonage, but the largest coherent stands are in the eastern bays. It often forms belt-like stands on the outer edge of the erosion bottom and in many places it is the only aquatic plant which can be seen from ashore.

Potamogeton pusillus L., Fr., p (14). Most of the stands I found grew so deep that it was impossible to see them. In a cove on the western lake side there was a stand of 15 individuals at a depth of 25 cm. The species grows only under exceptional conditions at a smaller depth than 1 m, and is usually found at a depth of 2.5—3.5 m or more. The species seems to be confined to a silt layer. I found only two fertile specimens.

P. alpinus Balb., st r (8). The sites are mostly unexposed coves where the bottom is covered with silt. In such sites the number of species is greatest. The stands are generally mixed ones with companions such as *Myriophyllum alterniflorum, Potamogeton perfoliatus, P. pusillus* and *Sparganium angustifolium.* The species has both floating and submerged leaves or it occurs only submerged. The individuals with floating leaves were often fertile.

Potamogeton gramineus L., st fq (24). This species grows nearly all over along the western shore, but not on the eastern and northern shores. The stands are densest on moraine in the erosion zone. The species is not found on silt. In many places this is the aquatic plant which grows in the shallowest water. The sprouts were frequently fertile and sometimes bore floating leaves.

Potamogeton perfoliatus L., st r (6). In general this species occurs among other aquatic plants, usually on fine sand bottoms. I did not find any fertile plants.

Alopecurus aequalis Sobol., rr (1). The only stand I found grew near the parsonage and consisted only of four individuals; one of them was fertile. They grew near the water line.

Ranunculus peltatus Schrank, fq (26). This species is found regularly on all shores. Like many other species it is most abundant in the southernmost coves of the western shore. It usually does not grow at depths under 1 m. In the deepest sites the plants are sterile and submerged, but it can reach the water surface from a depth of at least 220 cm and forms many floating leaves and flowers. In many places it is the vascular plant which grows at the greatest depth.

R. trichophyllus var. *eradicatus* (Laest.) Drew, st r (5). The species grows fairly abundantly only at the southern end of the western shore; elsewhere it is very sparse. Generally there is fine sand covered by a thin silt layer on the sites. The plants were most abundant at depths of 60—90 cm. Fertility was common. There were several companions on these sites.

Callitriche verna L., Lönnr., st r (6). On the sites the bottom was finely granulated and covered with a thin layer of silt. The number of plants on each site was small. The usual companions were *Subularia aquatica, Eleocharis acicularis* and *Ranunculus flammula* v. *reptans.*

Myriophyllum alterniflorum DC., fqq (42). The species forms a fairly coherent belt around the lake that is broken only by the bare patches mentioned. On the eastern shore, however, the stand is relatively thin in many places. The most flourishing stand is in the innermost end of the long bay which is situated in the northern part of the eastern shore. Here and in other unexposed places where the stands grew at a smaller than average depth fertile individuals were abundant (1959). The average growth depth is 130—240 cm. As a rule the stands are pure.

Isoëtes lacustris L., fq (28). In the number of sites and abundance this species is second in Lake Mantojärvi. It is common on every shore, but the widest and densest stands are on the eastern shore, on sites where *Myriophyllum* stands are generally poorly developed. In many places the stands are bounded by stony shores. Isolated *Ranunculus peltatus* and *Myriophyllum* sprouts sometimes grew in these stands.

Isoëtes echinospora Durieu, r (2). The species grows only in the southernmost part of the area studied, and even there it is rare. The sites are soft silt bottoms.

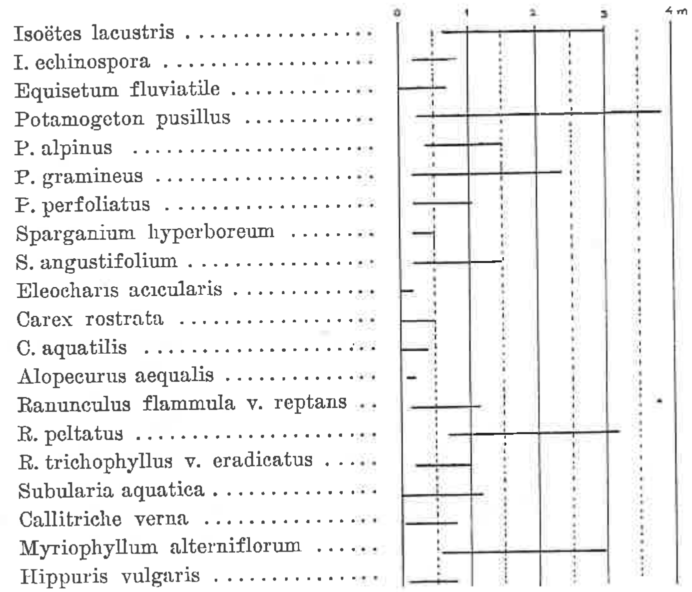
Eleocharis acicularis (L.) R. Br., st r (5). The largest stands are situated near the parsonage (at depths of 45—90 cm). The only stand on the eastern shore was partly above the water line and the plants were fertile. *Callitriche verna* was the most regular companion.

Ranunculus flammula v. *reptans* (L.) Hart., p (16). This species grows quite uniformly on all the shores. Submerged it is sterile to a depth of 115 cm, but it is at least as common above the water line in the eulitoral zone and then it is regularly fertile. The submerged stands occur mostly on coarse or fine sand bottoms and the commonest companions are *Sparganium, Subularia,* and *Potamogeton gramineus.*

Subularia aquatica L., p (11). This species is found on the same sites as *Ranunculus flammula* v. *reptans,* but is less common than the latter. The stands are usually small and not very dense; the largest are a few square metres in area (on the western shore). On the sites there is at least a thin silt layer on a hard bottom. Fertility is common.

Table 1

The depth ranges of water plants in Mantojärvi.



4. *Lake type*

On the basis of the higher vegetation Maristo (1941) has divided Finnish lakes into 12 floristic lake types. Territorially these are divided into two groups, the southern and the northern. The northernmost of the lakes he studied are situated in the coniferous zone in the commune of Inari. According to him these lakes form a lake type of their own, which he calls the *"Carex"* type. A special characteristic of this oligotrophic lake type is the scarceness of helophyte stands. The most prevalent physiognomical feature is the waterside flora, especially the sedges. Typical species of the lake type are *Sparganium angustifolium, Myriophyllum alterniflorum, Equisetum fluviatile,* and *Carex* species. The general features of the higher vegetation of this lake type and also the flora and properties of the water (acidity, colour, and depth of vision) are identical to those in Mantojärvi. This lake can therefore be included among the *Carex* type lakes on good grounds. There are 7 aquatic plant species in the *Carex* lakes investigated by MARISTO that do not occur in Lake Mantojärvi, but these are very rare even in the former. *Sparganium hyperboreum* is the only aquatic plant species in Mantojärvi that MARISTO has not found in his lakes, and this species is very sparse even in Lake Mantojärvi. Possibly the most distinct difference between the *Carex* type lakes studied by MARISTO and Mantojärvi is that the helophyte stands are even more poorly developed in Mantojärvi than in the others. This is also the only difference which one could ascribe to climatic factors. The differences in the hydrophyte stands are apparently due only to edaphic dissimilarities. Thus the boundary line between the coniferous and birch forest zones which is determined by climatic factors does not have its counterpart in the aquatic vegetation. The *Carex* lake type as a whole is determined by climatic factors, but these climatic factors exist not only in the birch zone but also in the coniferous zone.

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ÜBER DIE WASSERVEGETATION DES FLUSSES VASKOJOKI IM NÖRDLICHSTEN FINNLAND

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I. EINLEITUNG

Die Zoologische und Botanische Gesellschaft in Turku führte i.J. 1960 eine Untersuchung zur Klärung der Nordgrenze der Kiefer in Finnland sowie der damit verknüpften floristischen Probleme durch. In den westlichen Teilen des östlichen Fjeld-Lapplands (siehe Suomen kartasto 1960) verläuft diese Grenze dicht nördlich des Vaskojoki, und dieses Gebiet wurde auf nordsüdlich verlaufenden Taxierungslinien durchsucht, die beiderseits des Flusses im Gelände verliefen. Auf Grund des Bildes, das sich dabei ergab, erhielt ich sodann i.J. 1961 von Prof. Dr. PAAVO KALLIO den Auftrag, die Pflanzenwelt des Vaskojoki selbst näher zu untersuchen.

In bezug auf die Wasservegetation im allgemeinen ist Lappland bis in heutige Zeit mangelhaft bekannt gewesen. In der grundlegenden Untersuchung von KIHLMAN (1884) über die Flora der naturhistorischen Provinz Inari-Lappland finden sich jedoch Angaben u.a. auch schon vom Vaskojoki. Das von KLOCKARS & LUTHER (1938) untersuchte Gebiet des Viibus-Marastotunturi-Massivs grenzt im Norden an den Vaskojoki, und auch in dieser Arbeit sind Angaben über die Wasservegetation des Flusses enthalten. Dies sind aber, soviel mir bekannt, bisher die einzigen auf den Vaskojoki bezüglichen botanischen Untersuchungen gewesen.

Durch die neuere Lapplandsforschung haben sich indessen bessere Voraussetzungen als bisher zur Gewinnung eines Allgemeinbildes auch von der Wasservegetation Inari-Lapplands ergeben. Diesbezügliche Angaben finden sich u.a. bei KUJALA (1962) für das Gebiet des Ivalojoki (etwa 68°20′), bei MARISTO (1941) für seine *Carex*-Seen Talvitupajärvi (etwa 68°40′), Inarijärvi (etwa 68°54′) und Vastusjärvi (etwa 69°05′), bei SILTANEN (1964) für den Kevojärvi in Utsjoki (etwa 69°45′) sowie bei NYMAN (1964) für den Mantojärvi ebendort (etwa 69°52′). Den besten Vergleichspunkt für den Vaskojoki dürften die beiden letztgenannten Untersuchungen bieten, die ausschliesslich die Wasservegetation der betreffenden Seen betreffen. Dazu kommt, dass die seenartigen Erweiterungen des Flusses in dessen unterem