ACADEMY OF SCIENCES OF THE ESTONIAN S.S.R.

WATER DEPOSITS AND WETLANDS REQUIRE CONSERVATION

ACADEMY OF SCIENCES OF THE ESTONIAN S.S.R.

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WATER DEPOSITS AND WETLANDS REQUIRE CONSERVATION

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THE PROBLEM OF UTILISATION of the water reserves is as old as civilisation itself and its satisfactory solution was one of the basic prerequisites for the development of agriculture and the formation of the first states known to history in Mesopotamia, India, China, the valley of the Nile, the Andes, and elsewhere. Neglect of the water reserves, destruction of the forests on the watersheds, and the inability of the victor to administer and preserve the water supply systems created by the vanquished inevitably led to the desolation of luxuriant irrigated areas, with the result that the former fields gave place to wastelands, the soil of the cultivated terraces was washed away and fertile plains were converted into barren deserts intersected by dry gullies.

During the past few centuries the control exercised by man over the forces of nature has grown immeasurably. Problems which former generations could never have contemplated have been raised and solved. In our own and many other countries, Socialism has opened up hitherto undreamt-of possibilities, and perhaps we shall be forgiven if we state our conviction that such potentialities must exist all over the world. Nevertheless the problem of water supply remains as acute as ever. Far from putting an end to it, technical progress has only succeeded in changing its nature, in certain respects making it more universal and more urgent. In many regions water is still the most desperately needed of all natural resources, and exhaustion of the water supply cripples every aspect of organised social life.

However paradoxical it may seem, this problem is slowly gaining ground even in Estonia, where there are thousands of lakes and hundreds of rivers and streams, where one-third of the territory is water-logged, where for centuries man has waged a stubborn struggle against excessive moisture — a struggle which, before the application of modern land improvement methods in Soviet times, seemed often hopeless.

Yet the fact remains that here and there tokens of a shortage of pure water are already beginning to be felt. The water works of the towns are meeting serious difficulties in attempting to cope with the ever-increasing demand. The rapid growth of industry is not only stimulating consumption but threatening to pollute important deposits to an alarming extent. At the present rate of development of the national economy, industrial output is expected to increase five or six times over during the next few decades, and as this tendency will inevitably be concentrated in the large industrial areas and the towns, the strain on the already overburdened water supply may well exceed the critical limit if adequate preventative measures are not applied. The reclamation of fens and peatlands, lowering of lakes and regulation of rivers may cause drastic changes in the outflow over wide areas of the drainage basin. Intensified cultivation of the soil calls for fresh supplies of water. Interference with the water deposits, especially their contamination with chemicals, may have an incalculable effect on living nature both in the water and in its immediate vicinity, most of all on the stocks of fish. At the same time, as a result of the steady urbanisation of the population, the shortening of the working day and improved means of transport, more and more people are spending their leisure time in the open air on the rivers and lakes. All this points to the extreme urgency of the water problem; and in our country, which is already engaged in the transition from Socialism to Communism, we envisage a rapid and continued growth of its importance in the immediate future.

Indeed, we believe this to be true of all the Socialist countries, where the land and all its riches, including the reserves of water, are the property of the people, and their protection and rational exploitation are guaranteed by the planned activities of the State. In the Soviet Union this is directly provided for by the new programme of the Communist Party, which specifies the following tasks: "to carry through a far-flung irrigation programme; to irrigate and water millions of hectares of new land in the arid areas and improve existing irrigated farming; to expand field-protective afforestation, building of water reservoirs, watering of pastures and melioration of over-moist land; and to combat systematically the water and wind erosion of soil. Considerable attention will be devoted to the conservation and rational use of forests, water reservoirs, and other natural resources, and to their re-stocking and development."

In Estonia a number of centres already exist where the work involved in the fulfilment of the tasks enumerated above can be organised and checked. They include the Board for the Utilisation and Protection of Water Resources, the Nature Conservation Board and the Board for the Preservation of Mineral Deposits, all of which are directly subordinated to the Council of Ministers. In addition to these we have the Water Supply Committee, the Commission for Nature Conservation, which operates within the framework of the Academy of Sciences, and a dense network of custodians and conservation trustees in the localities.

Science has the last word in formulating and solving the problems with which we are faced; and it is first and foremost the duty of our hydrologists, hydrogeologists, hydrotechnicians, hydrobiologists, limnologists, telmatologists, botanists and zoologists to ensure the adequate protection and rational exploitation of our reserves of water in the present conditions of rapid expansion of the national economy.

It is our hope that the present selection may present a brief outline, in simple and popular form, of a few of the related problems on which our naturalists and scientists are at present engaged.

E. VAREP

THE RIVERS AND LAKES IN THE ESTONIAN LANDSCAPE

THANKS TO THE HUMID CLIMATE the hydrographic network of Estonia is generally speaking rather dense, the total length of the streams, brooks and drainage canals attaining 30,681 kms. There are 375 rivers of 10 kms and more, and their total length amounts to 9406 kms. Only 40 rivers attain 50 kms, and only 9 of these 100 kms. Not more than 15 rivers have basins of 1000 sq. kms or over. The river which drains the largest territory (56,200 sq. kms) is the Narva, which also carries the heaviest volume of water (350 cubic metres per second at the Vasknarva profile).

The network of water-courses is more or less evenly distributed over the whole territory. In certain localities only, in Northern, Central and Western Estonia, where the bedrock is made up of Ordovician and Silurian limestones, drainage is mainly underground owing to the presence of karst. A notable example is the Pandivere uplands in North Estonia, which cover an area of more than 1000 sq. kms, but have no permanent surface streams. The rain and snow-water sink beneath the limestone surface, only to reappear in the form of powerful springs on the outermost slopes of the uplands. Karst phenomena are also be found in many places on the North Estonian plateau, as well as in the lowlands and islands of the West. Some of the karst areas have been placed under state protection. These include the hollows and caves at Kostivere (Harju district), the dry bed of the R. Uhaku (near Kohtla-Järve), the hollows at Pae and Kuimetsa (Rapla district), and similar formations at Küdema and Lepakõrve (on Saaremaa Is.).

With regard to the drainage, the territory of Estonia may be divided into two main areas — the inland and the coastal area, the watershed between them running along the Pandivere and Sakala uplands. The coastal area covers about 60 per cent of the territory of the Republic and is drained directly into the sea. In the inland drainage area, which accounts for 40 per cent of the territory, the water is first collected in the depressions of the hinterland, part of it flowing via L. Peipsi and the R. Narva into the Gulf of Finland, while the remainder makes its way into the Gulf of Riga by way of the rivers of Latvia.

The rivers of North Estonia, which flow into the Gulf of Finland, mostly follow parallel routes to the N or NW. They have few tributaries, and their basins are narrow and elongated. The courses of the streams are frequently interrupted by karst areas. Many of them flow partly underground and irrupt into their surface beds only during the spring spate. The middle and upper reaches on the limestone plateau fall very gently. Patches of moraine and denuded groundrock frequently appear in the bed, giving rise to rapids. When the groundrock lies deeper the streams carve their valleys out of the sedimentary sand, clay or peat. The fall is concentrated almost entirely in the lower reaches, where many rivers plunge in cascades over the edge of the Glint. Dropping down from the edge deep, steep-banked valleys are usually formed, often descending in terraces, which may have been produced by the oscillation of the level of the Baltic Sea.

Many beauty spots are situated along the rivers of North Estonia, especially in the coastal area. Among the landscape reserves here are the Pirita valley, near Tallinn, and the Valgejõgi valley, between Loksa and the Tallinn—Leningrad highway. The Toila—Ontika—Saka Glint reserve embraces the picturesque valley of the Pühajõgi. A number of waterfalls have been placed under

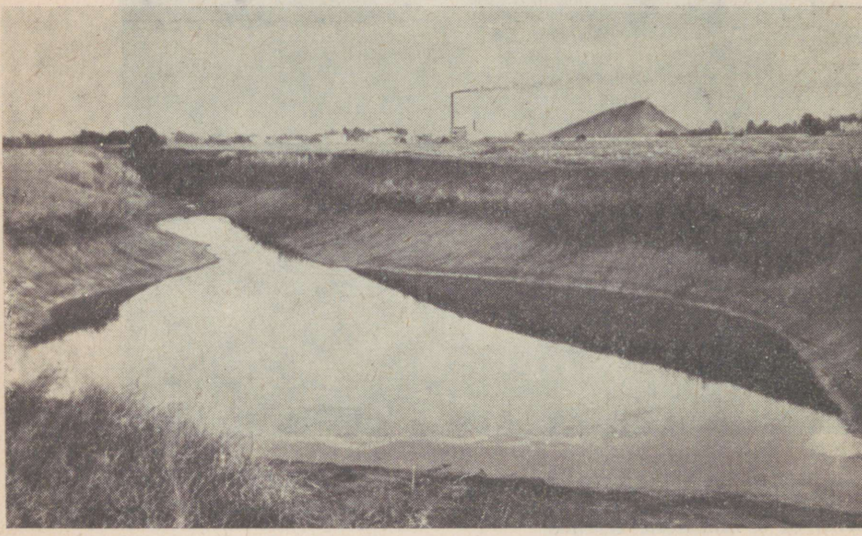
(Photo by J. Kala)

The picturesque falls of the River Keila plunging over the brow of a limestone terrace.

protection, including Keila and Treppoja (Harju district), Jägala, Nõmmeveski and Joaveski (Harju district), Langevoja (in the neighbourhood of Kohtla-Järve), Tõrvajõgi (near Narva), and the "shelf" of the former Narva falls (situated in the heart of the town). The R. Jänijõgi, which crosses the Aegviidu-Nelijärve landscape reserve, is the home of a colony of beavers, while the river banks are lined with wooded floodlands of a type extremely rare in Estonia.

The evolution of the rivers in North Estonia has been strongly influenced by the general rising of the earth, which is more powerful towards the NW than in the SE.

As a result of the tectonic uplift the fall of the rivers is gradually increasing, though this tendency is confined almost entirely to the lower reaches. Indeed, the fall in the middle and upper reaches is, if anything, even decreasing, as the rate of the uplift is greater than the erosive power of the water on the Glint.



(Photo by J. Kala)

The 'Long Grave' at Uhaku, North Estonia, a karst formation that is now under protection.

The largest rivers in West Estonia are the Kasari and the Pärnu, both of which have numerous tributaries spreading fanwise over a broad territory. On the whole the river valleys in the west are weakly developed, partly because the streams themselves are relatively young. The fall is slight and the beds of the streams are mainly cut into glacial clays and maritime deposits. Only occasionally is the groundrock visible at the bottom of the stream — limestone in the basin of the Kasari and Devonian sandstone in the middle reaches of the Pärnu. A remarkable outcrop of the latter is the so-called "Gate of Hell" at Tori, now placed under protection. A botanical reserve has been set up on the lower reaches of the R. Halliste for the purpose of preserving the wooded meadows, with their deciduous groves lining the river banks.

In the West Estonian archipelago the rivers and streams are small, on account of the reduced surface area of the islands.

The rivers of South Estonia take their rise in the hills, and many of them drop sharply from their source, flowing through steep gorges of recent origin. In their middle reaches most of them follow primeval valleys, whose direction does not always coincide with the general declivity of the land. Many of the river valleys in the south exhibit fine specimens of Devonian sandstone, including some of the most picturesque spots in the country. Special mention should be made of the middle reaches of the R. Ahja, where there are two much-visited landscape reserves — The Tilleorg Valley and The Primeval Valley of the R. Ahja itself, both in Põlva district. Protection has also been extended to the primeval valley at Paistu (Viljandi district), and to the Devonian outcrops on the banks of the R. Peetri (Võru district). A botanical reserve has been set up to protect the oak groves and wooded water-meadows of the R. Koiva (Valga district.)

The streams intersecting the low-lying swampland round Lakes Võrtsjärv and Peipsi (Peipus) fall almost imperceptibly and are extremely sluggish in movement. In the southern part of the Võrtsjärv and Peipsi-Pskov basins the water-level of both lakes is rising steadily, thus causing a further diminution of the fall.

According to the latest general survey, drawn up by the Sector of Hydrobiology of the Institute of Zoology and Botany attached to the Estonian Academy of Sciences, there are 1152 lakes in Estonia, with a total surface area of 2142.2 sq. kms. These figures include lakes and meres with a surface area of up to 0.5 hectares, and reservoirs, millponds, pools and hollow-pools larger than one hectare. They exclude a huge number of smaller lakes, ponds and pools. Estonia is, therefore, well furnished with lakes, thanks partly to its humid climate, and partly also to its surface forms of glacial origin. Indeed the hilly moraine areas are richest in lakes, though many of them have since degenerated into swamps. The post-glacial uplift of the coast has also created favourable conditions for the formation of lakes in the depressions cut off from the sea.

Most Estonian lakes are small. The largest of them are L. Peipsi (3566 sq. kms, of which 1616.4 sq. kms belong to the Estonian SSR), L. Võrtsjärv (270.7 sq. kms) and the Narva reservoir (ca 200 sq. kms, of which 54.2 sq. kms belong to Estonia).

The distribution of the lakes is by no means even. They are most numerous in the hilly moraine countries of Haanja and Otepää in South Estonia. In North Estonia the area known as "Kõrvemaa," which lies on the border between the districts of Harju and Paide, and the environs of Kurtna (near Kohtla-Järve) are richest in lakes, this being the region of the eskers (*åsar*) marking the rim of the Continental ice-sheet. In West Estonia the greatest concentration of lakes is to be found on the NW and S shores of Saaremaa Is. The largest lakeless areas are the depression occupied by the basins of the Pärnu and Kasari rivers, and the territories lying to the N of L. Võrtsjärv and NW of L. Peipsi.

In all about 4.8 per cent of Estonian territory is taken up by lakes; and even if we leave out the largest of them — Peipsi and Võrtsjärv — we shall find that in certain regions, like the Drumlin country north of Tartu and the south shore of Saaremaa Is., lakes may account locally for as much as 10 per cent of the surface area. However, this proportion falls to 1—3 per cent in the hilly moraine country, where the lakes are mostly quite small, and elsewhere still lower.

The deepest lake in Estonia is, in the light of our present knowledge, L. Suurjärv at Rõuge (Võru district), which attains a depth of 38 metres. Most Estonian lakes are eutrophic, but about a score are oligotrophic. In origin they are heterogeneous. The two largest — Peipsi and Võrtsjärv — and a number of others are situated in preglacial depressions, flooded by the water of the melting ice towards the end of the Glacial period. The contours of these lakes have tended to fluctuate widely as a result of neotectonic movements of the earth's crust and resultant changes in the water-level. The irregular uplift recorded in the later geological history of the region has had the effect of displacing the water towards the south. Lakes Peipsi and Võrtsjärv are lined here and there (e.g. at Kallaste and Tamme) with steep banks of Devonian sandstone, which have been declared under state protection.

Among the characteristic features of the undulating moraine country are the picturesque lakes with their broken and jagged shorelines, abounding in coves, creeks and jutting headlands. Large numbers of smaller lakes are scattered in the hollows between the hills. L. Pühajärv — most beautiful of Estonian lakes — has together with its surroundings been placed under protection as a landscape reserve (Elva district), a privilege that has been extended to several small moraine lakes in other reserves, such as L. Nüpli (Elva district), LL. Vaskna and Tuuljärv, and the lakes round Vällamägi (all in the Võru district).

The Drumlin lakes, which are lined by ridges and occupy the furrows gouged out by the moving ice, are large by comparison, regular in shape and elongated in a direction stretching from SE to NW. Typical specimens may be seen in the country lying between Tartu and Jõgeva.

Valley lakes are plentiful in the boulder-clay country, especially on the slopes of the South-Estonian uplands. Most of them are long and narrow, enclosed between high banks, and very deep. Series of small lakes are by no means uncommon, and the concatenation at Rõuge (Võru district), which comprises 7 lakes (including L. Suurjärv, the deepest lake in Estonia, and L. Kahrila, a long, slender lake of exceptional beauty, winding along the bottom of the valley), enjoys protection as a landscape reserve.

Lakes are comparatively common in regions characterised by outwash sands left behind by the retreating ice. In general they resemble the lakes of the hilly moraine country, though they are, for the most part, poor in nutrients.

In North Estonia the lakes occur most often in conjunction with the great line of hills, marking the edge of the Continental ice-sheet. They are small as a rule, and usually appear in groups in the vicinity of *åsar*, kames and terminal moraines. Clusters of these tiny lakes are to be found lying between or running alongside the ridges in the Aegviidu-Nelijärve landscape reserve (Tapa district), and there are some more in the Neeruti hills reserve (also in the Tapa district). L. Uljaste, together with the *ås*, or ridge, bearing the same name (in the environs of Kohtla-Järve), has also been placed under protection.

On the North Estonian plateau only a few solitary lakes are to be found in local depressions, and for the most part they are shallow and very swampy. On the other hand there are plenty of lakes in the peatlands — relics, perhaps, of the large bodies of water formerly present here. L. Vanamõisa, and a number of the larger hollow-pools, are accorded protection as parts of the vast national park at Nigula.

In West Estonia and along the north coast there are numerous coastal lakes, which have been separated from the sea by the tectonic uplift. In many cases they are still referred to by the local inhabitants under the names of *laht* (bay) or even *meri* (sea), and when the sea runs

(Photo by J. Kala)

Huge erratic boulders in the bed of the River Pärnu.

high they are occasionally flooded with salt water. Of the coastal lakes in West Estonia the so-called *Linnulaht* (Bay of Birds) on Saaremaa Is. has been made into a bird sanctuary, while a number of smaller lakes are included in the Virtsu-Laelatu-Puhtu botanico-zoological reserve (Haapsalu district).

Unique in its origin is the little lake at Kaali, in Saaremaa, created by the impact of a meteorite, and now a geological reserve of exceptional interest.

Following the wide-scale construction of hydroelectric stations since the war, new reservoirs have come into being on many Estonian rivers. Millponds abound, even on the smaller streams.

The importance of the inland waters for the national economy can scarcely be overestimated. Nearly one-third of Estonian territory suffers from excessive moisture and needs to be drained. The rivers have a cardinal part to play in the process of hydromelioration. Many of those passing through low-lying, flat country, particularly the tributaries of the Kasari and Pärnu, have been rectified and dredged over long distances; and in many districts regulation and drainage operations have been virtually concluded. More serious difficulties attend the problem of drainage in the Peipsi depression, where a system of polders may have to be set up along the shore of the lake.

Navigable routes along the inland waters of Estonia total up to about 500 kms. Lakes Peipsi and Võrtsjärv, and the R. Suur-Emajõgi are navigable throughout. The R. Narva is open to shipping from Vasknarva to Kulgu, and from the city itself to Narva-Jõesuu on the beach. Roughly speaking, about 1000 kms of Estonian rivers are available for rafting and lumbering, though nowadays they are falling more and more into disuse on account of the rapid growth of road transport.

The water-power of the rivers of Estonia is *ca* 180—185 mWs, of which the greater part is on tap now that the Narva hydroelectric station has been completed. A number of small new stations have been built since the war. The waters of many rivers and lakes are utilised for industrial purposes, or to supply the population of the towns.

About 10 per cent of the fish derived from Estonian waters is obtained from inland sources, mainly from L. Peipsi; valuable fishing grounds are also to be found on L. Võrtsjärv, the Suur-Emajõgi and Narva rivers, the

Narva reservoir, the estuary of the R. Pärnu and other rivers. Many streams are popular among anglers. The smaller lakes are widely used for fish breeding and duck or geese farms, but the possibilities in this field are far from exhausted, and there is still much to be done.

No less valuable are the lakes and rivers of Estonia as health resorts and sources of natural beauty. Many of them provide the sites for rest homes, sanatoria, sports centres etc., and thousands of hikers and holiday-makers throng here all the year round. Several of the age-old myths and traditions of Estonian folklore (especially of the great legendary hero Kalevipoeg) are connected with various lakes and streams, not to mention many places of historical or cultural interest which deserve to be popularised and carefully preserved.

A. TRUU

ESTONIAN WETLANDS AND THEIR CLASSIFIČATION

BOGS AND FENS* occupy an important place among the natural resources of the Estonian SSR, and the Soviet government has devoted much attention to problems of their investigation and exploitation.

The distribution of the peatlands depends to a large extent on the climate. In Estonia precipitation exceeds evaporation, and in flat country swamp formation naturally ensues. Another factor which has promoted paludification is the prolonged inundation of the territory during the late glacial and post-glacial periods. Most Estonian bogs were formerly lakes, which were grown over and choked with vegetation in the course of time.

Apart from the foregoing there were many other forces at work. A frequent cause of swamp formation is to be

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* Pending a general agreement on the terminology, the following provisional distinctions have been adhered to in the present collection of articles. The terms "raised bogs" and "mosses" refer to the oligotrophic types (Est. kõrgsoo or raba). "Fens" and "marshes" are used to describe eutrophic types (Est. madalsoo). Mesotrophic localities are referred to as "intermediate" or "transitional." The expressions "wetlands" and "peatlands" are used in a quite general sense, as are also the common words "bogs" and "swamps", together with their derivatives, although in accordance with appears to be current usage the former tends to approximate to the first type, and the latter to the second. (Translator's note).

sought for in the impervious surface stratum extending over so great a part of Estonian territory, and in the clay deposits derived from it. In many cases swamp formation has been caused by the old coastal formations along the shores of the Baltic, which prevented surface discharge of the outflow in the direction of the sea.

Until quite recent times our knowledge of the distribution of the bogs and peat reserves of Estonia was fragmentary and inadequate. In order to obtain a detailed and comprehensive survey of the problem, the Soil Investigation Department of the Institute for Research in Soil Fertility and Land Improvement (IRSFLI) has drawn up a map of the swamps and bogs of the Estonian SSR and compiled a general work of reference on the peat reserves.

In the light of the information contained in these two sources, it appears that researches have already been extended to cover 375 bogs and fens, with a surface area of 597,495 hectares, or 64 per cent of the total. Of this number over 270,000 hectares have been studied from the point of view of agricultural exploitation.

A survey of the wetlands investigated, showing the main types represented according to administrative divisions, is given in Table 1.

The wet areas in the various localities have been investigated as follows:

Over 90% — Hiiumaa Is., the Haapsalu, Pärnu and Vändra districts, and the environs of Pärnu.

70—90% — the Kingissepp, Märjamaa, Rapla and Paide districts, and the environs of Narva.

50—70% — the environs of Kohtla-Järve and the districts of Põltsamaa, Tartu, Viljandi and Jõgeva.

30—50% — the Harju, Elva, Võru, Rakvere and Abja districts,

10—30% — the Valga and Põlva districts.

Of the total area investigated fens and marshes accounted for 45%, intermediate types between fens and boglands — 15%, raised bogs — 36%, and lakes, hollow-

Table 1

Distribution and typology of the wetlands of the Estonian SSR

District	Fens		Intermediate types		Raised bogs		Lakes and dry eminences		Total
	hectares	%	hectares	%	hectares	%	hectares	%	
Abja	2511	28	928	10	5576	61	84	1	9099
Elva	8830	63	1280	9	3415	25	375	3	13900
Haapsalu	26582	58	3085	7	14415	32	1361	3	45443
Harju	18571	61	2869	10	7908	26	896	3	30244
Hiiumaa	3479	49	1393	20	2103	29	175	2	7150
Jõgeva	15063	55	4698	17	5612	21	1927	7	27300
Kingissepp	12579	71	1858	10	3095	17	344	2	17876
Kohtla-Järve	20147	30	18894	28	24855	37	3017	5	66913
Märjamaa	6268	47	750	6	5795	44	371	3	13184
Narva	2516	49	65	1	2577	50	—	—	5158
Paide	40324	53	7651	10	23055	30	5603	7	76633
Põltsamaa	15293	47	3317	10	11364	35	2468	8	32442
Põlva	2827	28	555	6	6528	65	80	1	9990
Pärnu	27180	33	10381	13	43652	53	825	1	82038
Rakvere	7794	46	3045	18	5215	31	898	5	16452
Rapla	14224	41	1012	11	13152	38	3490	10	34878
Tartu	25092	54	10938	24	7303	16	2709	6	46042
Valga	2219	47	150	3	2321	50	—	—	4690
Viljandi	5098	20	4178	16	16274	63	422	1	25972
Võru	7577	65	644	6	3194	28	190	1	11605
Vändra	5998	30	6015	30	7536	38	437	2	19986
Total	270172	45	86706	15	214945	36	25672	4	597495

pools and dry eminences — 4%. Rich grassy fens were specially prominent in the Kingissepp district, where they made up 75% of the territory investigated. In the Võru, Elva and Harju districts, the fens contributed over 60%. On the other hand over 60% of the swamplands investigated in the Põlva, Viljandi and Abja districts were raised bogs or oligotrophic mires.

According to data obtained from aerial photos and from the soil and vegetation maps prepared by the IRSFLI,

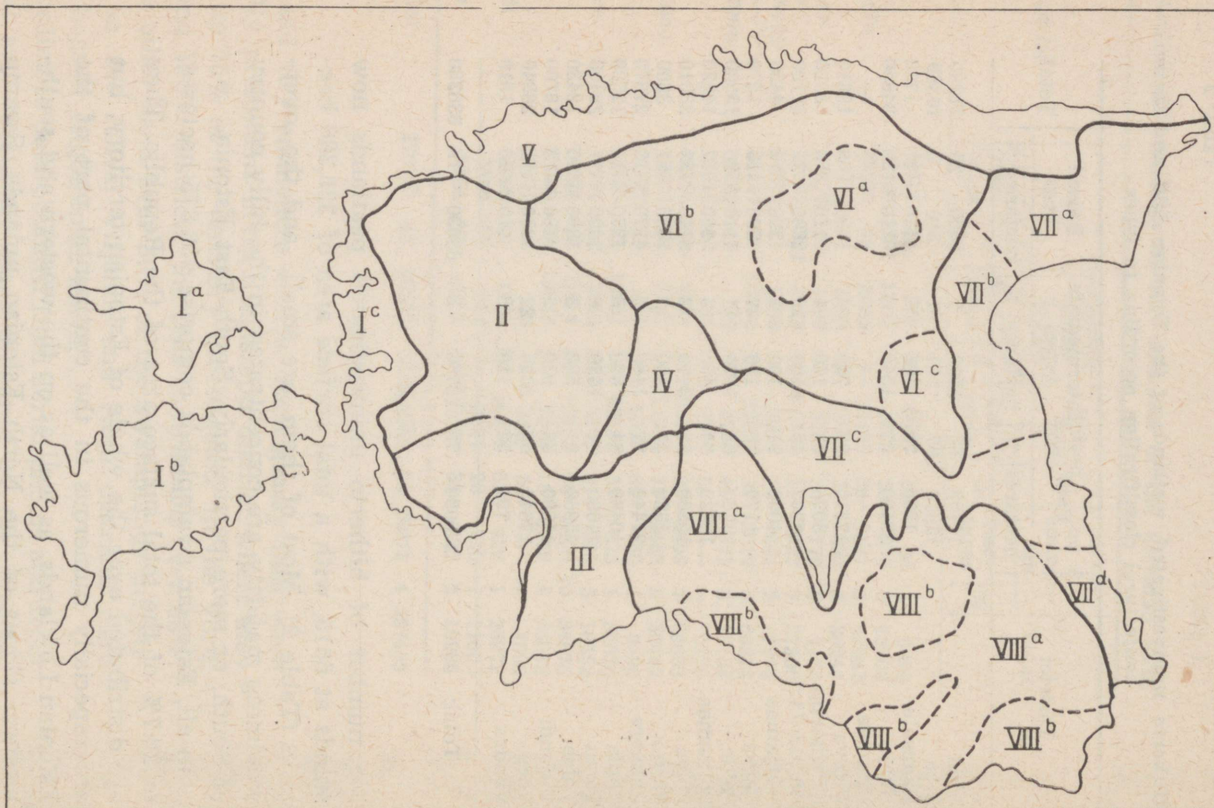
Table 2

Hitherto uninvestigated wetlands of the Estonian SSR and their conjectural classification according to types

District	Fens		Intermediate types		Raised bogs		Total
	hectares	%	hectares	%	hectares	%	
Abja	14400	68	1540	7	5350	25	21290
Elva	15810	97	240	1	310	2	16360
Haapsalu	1390	79	180	10	190	11	1760
Harju	23400	67	1340	4	10110	29	34850
Hiiumaa	—	—	—	—	—	—	—
Jõgeva	17310	88	720	4	1580	8	19610
Kingissepp	3090	93	120	4	110	3	3320
Kohtla-Järve	18200	49	6100	16	12800	35	37100
Märjamaa	4060	91	100	2	290	7	4450
Narva	1170	75	110	7	290	18	1570
Paide	9780	63	1670	11	4110	26	15560
Põltsamaa	13220	90	450	3	960	7	14630
Põlva	15380	55	3490	12	9140	33	28010
Pärnu	1320	37	450	12	1830	51	3600
Rakvere	21440	77	1460	5	4970	18	27870
Rapla	10460	84	690	5	1370	11	12520
Tartu	24680	87	1630	6	2090	7	28400
Valga	15960	87	580	3	1890	10	18430
Viljandi	15590	83	930	5	2180	12	18700
Võru	17640	66	5850	22	3350	12	26840
Vändra	790	52	110	8	610	40	1510
Total:	245090	73	22760	8	63530	19	336380

the number of hitherto uninvestigated peatlands now stands at 6615, with a total surface area of 336,380 hectares (Table 2). Most of them are small, and the overwhelming majority are concentrated in the hilly country of South, or more particularly, South-East Estonia.

In all, Estonian swamplands comprise 933,875 hectares, or 20.7% of the total surface area of the Republic. They are distributed over the whole of Estonian territory, but are especially numerous in the continental part of the Estonian Lowlands, as well as on the western and south-western slopes of the North Estonian uplands. Swamp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formation is least developed in the uplands of the south and in the West Estonian archipelago.

The proportion of swamplands in the administrative divisions is respectively:

over 30% — the environs of Kohtla-Järve and Narva, and the districts of Paide and Tartu;

20—30% — the environs of Pärnu, and the Põltsamaa, Rapla, Jõgeva, Haapsalu, Elva and Viljandi districts;

10—20% — the Vändra, Põlva, Harju, Võru, Abja, Väike-Maarja, Valga, Rakvere and Märjamaa districts;

less than 10% — the district of Kingissepp and Hiiumaa Is.

We shall now proceed to consider the Estonian swamps from the point of view of their classification into types.

On the basis of their primary characteristics and their genesis and evolution, the IRSFLI divides the Estonian wetlands into the following eight basic regions (Fig. 1):

I. The small and medium eutrophic fens of West Estonia

Subregions:

a) Hiiumaa Is.;
b) Saaremaa Is.;
c) the west coast of the mainland.

This group embraces a total surface area of 5620 sq. kms, or 12% of Estonian territory.

The proportion of wetlands is low — barely over 6%. Of the estimated total 85% has been investigated, inclu-

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Basic regions of the Estonian wetlands.
I — The small and medium eutrophic fens of West Estonia. II — The medium and large swamps of West Estonia. III — The large peatlands of South-West Estonia. IV — The small peat bogs of Central Estonia. V — The small and medium swamps of the North Estonian plateau. VI — Miscellaneous swamps of the North Estonian uplands. VII — The vast swamplands of Central and Eastern Estonia. VIII — The small swamps of the South Estonian uplands.

ding probably all the swamps on Hiiumaa Is. Grassy fens make up 65% of the area studied, intermediate types 13%, and raised bogs or mosslands 22%. The average size of the investigated swamps is 431 hectares, and of the non-investigated swamps 72 hectares.

The relative prominence of the fen and marsh types in the region is due to its recent origin. The main sources of paludification are the lakes.

II. The medium and large swamps of West Estonia

This region comprises most of the western part of the Estonian Lowlands — 5060 sq. kms in all, or 11% of Estonian territory.

The proportion of wetlands — 23% — is slightly above average. The vast majority of the swamps — 91% of the total surface area — have been investigated. Fen-type vegetation covers predominate, accounting for 57% of the area investigated; next come the oligotrophic raised bogs with 27%, and lastly the intermediate types with 13%. The average size of the investigated swamps is 2023 hectares, and of the non-investigated swamps 63 hectares. The region contains a number of large peat-producing enterprises.

III. The large peatlands of South-West Estonia

This region, which covers 3170 sq. kms, represents 7% of Estonian territory. The degree of paludification is higher here than anywhere else, the wetlands taking up over 31% of the total area. Most of the swamps (89%) have been studied. Commonest are those with raised-bog vegetation cover, which form 67% of the investigated territory. Grassy fens and eutrophic mires account for

20%, while the remaining 13% belong to intermediate types. The average area of the investigated swamps is 3121 hectares, and that of the non-investigated swamps 99 hectares. The huge Lavassaare peat works are located here.

IV. The small peat bogs of Central Estonia

This region falls mainly on the middle reaches of the R. Pärnu and its tributaries. With its 1170 sq. kms it constitutes 2% of Estonian territory.

Here the wetlands comprise only 6% of the surface area. About 74% of the estimated total number of swamps have been studied. A characteristic feature is the presence of thick peat layers, attaining a depth of 9 metres. The fens contribute only 6% of the swamplands, the intermediate types 11%, and the fully developed mosslands 83%. The average size of the investigated swamps is 156 hectares, and of the non-investigated swamps 45 hectares.

V. The small and medium swamps of the North Estonian plateau

This group is scattered over the region of the North Estonian Glint to form an elongated zone stretching from east to west, with an area of 3850 sq. kms, or 8.5% of Estonian territory.

The proportion of swamps is low — barely more than 6%. Researches have been extended to cover 64% of the estimated swampy area. Since many of the wetlands belong to the type of flooded water-meadows, fens and marshes account for 50% of the total investigated area, while the other half is shared by the intermediate types

(12%) and raised bogs (38%). The average area of the swamps examined is 746 hectares.

VI. Miscellaneous swamps of the North Estonian uplands

Subregions:

a) the peat country of rudimentary swamp formation in the central zone of the Pandivere Hills;
b) the dense complex of swamps on the outer slopes of the North Estonian uplands;
c) rich fens and eutrophic mires occupying the hollows between the ridges of the Drumlin country.

This is the region of the Pandivere uplands and their immediate environs. With a surface area of about 9450 sq. kms, it occupies 21% of Estonian territory. Swamps make up exactly one-quarter (25% of the total area, though their distribution and local characteristics differ widely in the subregions. Thus in the least swampy section of the Pandivere Hills, the wetlands constitute only 3% of the surface area. Studies have been made of 19% of the estimated swampy area, and the proportion of fens is high (79%). On the outskirts of the uplands the proportion of wetland is 30%, and 62% of the estimated surface area has been investigated. Fen-type surface vegetation predominates (57%), next come the mosslands (29%), and lastly the intermediate types between fen and bog (14%). In the Drumlin country swamplands form 20% of the surface area, while 23% of them have been investigated. Here the fen-type vegetation cover is almost ubiquitous (92% of the area investigated).

VII. The vast swamplands of Central and Eastern Estonia

Subregions:

a) the north section of the Peipsi depression;
b) the north-west section of the Peipsi depression;
c) the Võrtsjärv depression and mouth of the R. Emajõgi;
d) the south section of the Peipsi depression.

The surface area of the region as a whole is 7495 sq. kms, or 16.5% of Estonian territory.

The proportion of wetlands is well above average (31%). Researches have been mainly carried out in the huge wetlands characteristic of this part of Estonia, with the result that the number of individual swamps investigated is small (only 4%), though they represent by far the greater part of the surface area (70%). Fen and raised-bog vegetation types are roughly equal, but their relative proportions vary sharply in the different subregions. Thus in the northern part of the Peipsi depression raised bogs predominate (41%), though intermediate types are frequent (28%), — hardly less so than the pure fens (31%). In the north-west sector of the Peipsi depression the fens and marshes rule supreme. Fen-type plant covers are also well to the fore in the basin of L. Võrtsjärv and round the mouth of the R. Emajõgi, where they make up 54% of the area investigated, the intermediate types supplying 17%, and the raised bogs 29%. On the contrary raised-bog vegetation types predominate in the southern part of the Peipsi depression, the surface stratum of which is relatively poor in nutrients, and their total of 62% of the area investigated is exactly twice that of the fens (31%).

The average surface area of the swamps studied is 5024 hectares, and of the non-investigated swamps 80 hectares.

VIII. The small swamps of the South Estonian uplands

Subregions:

a) the area characterised by valleys and dells between the hills,
b) the undulating moraine country.

This region covers 10,000 sq. kms, or 22% of Estonian territory.

The proportion of swampy areas (18%) is somewhat below normal. Researches cover 14% of the estimated surface area. Fen-type plant covers predominate. An outstanding feature of the region is the remarkable number of small units. The vast majority of the swamps (97%) are less than 250 hectares in extent, and together they form only 33% of the swampy surface.

The average area of the swamps investigated is 509 hectares, and of the non-investigated swamps 47 hectares.

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The present vegetation layer of the Estonian wetlands carries frequent traces of human activity. In certain localities the exploitation of fens and marshes as natural grasslands and pastures has modified many of their characteristic features. Some of the fens and marshes have been drained and brought under cultivation, while the raised bogs are used for the production of peat. The data available indicate that something in the neighbourhood of 50,000 hectares of reclaimed fens were cultivated in 1960. Utilisation of the fens was most intense in the Kingissepp district, where roughly 70% of the fen country was sown to wetland cultures.

A. VERTE

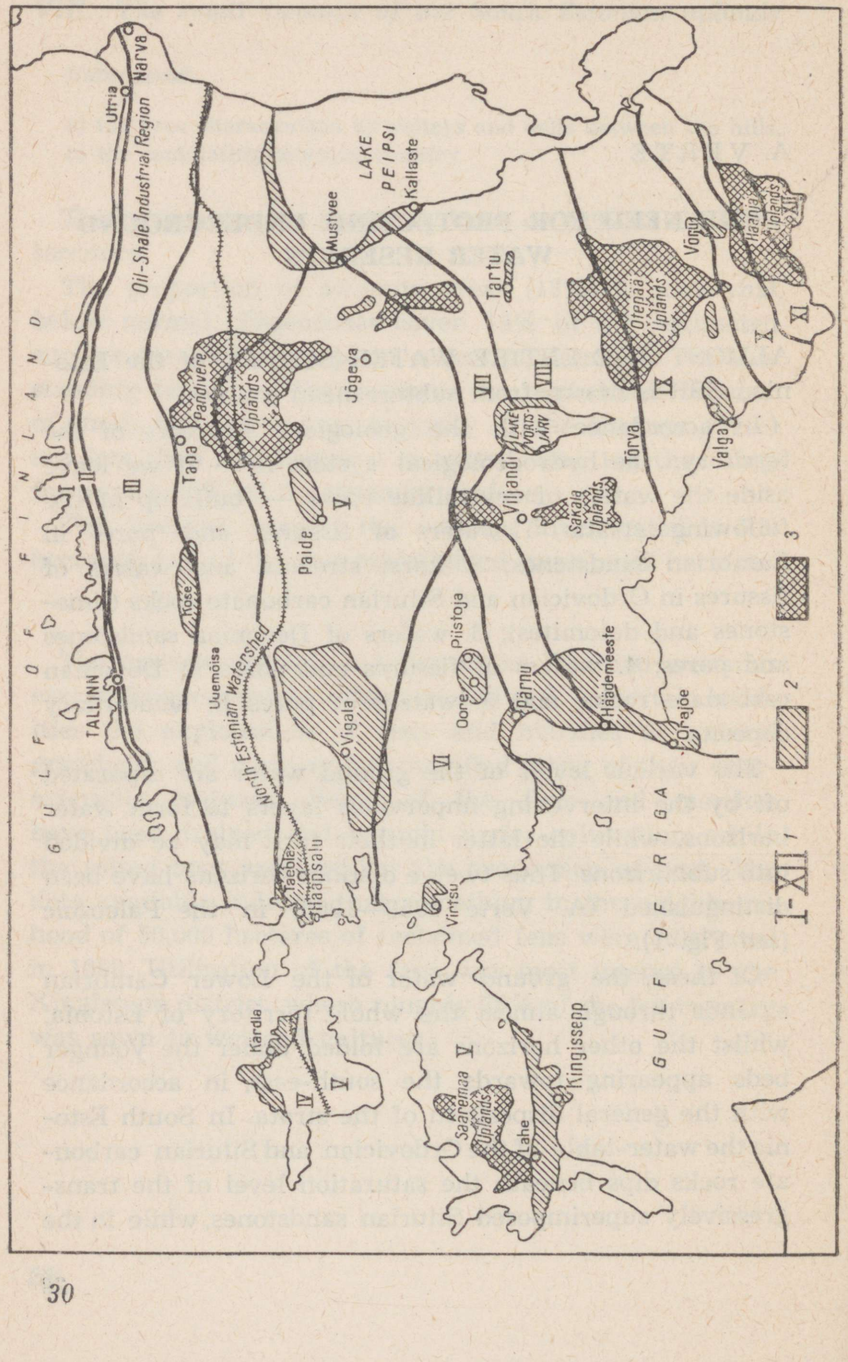
THE NEED FOR PROTECTING UNDERGROUND WATER RESERVES

ALMOST THE ENTIRE WATER SUPPLY of the Estonian SSR is drawn from subterranean sources.

In accordance with the geological structure of the territory, the hydrogeological system is — if we leave aside the waters of crystalline rocks — built up of the following strata: 1. waters of fissures and pores in Cambrian sandstones; 2. karst streams, and waters of fissures in Ordovician and Silurian carbonate rocks (limestones and dolomites); 3. waters of Devonian sandstones and pores; 4. waters of fissures and pores in Devonian carbonate rocks, and 5. waters of pores in Quaternary deposits.

The various levels of the ground water are separated off by the intervening impervious layers to form water horizons, while the latter in their turn may be divided into subhorizons. Thus twelve distinct horizons have been distinguished (A. Verte 1958—1960) in the Paleozoic (see Fig. 1).

Of these, the ground water of the Lower Cambrian extends through almost the whole territory of Estonia, whilst the other horizons are folded under the younger beds appearing towards the south-east, in accordance with the general disposition of the strata. In South Estonia the water-table of the Ordovician and Silurian carbonate rocks dips beneath the saturation level of the transgressively superimposed Silurian sandstones, while in the


GULF OF FINLAND
Narva
Utria
Oil-Shale Industrial Region
LAKE PEIPSI
Kallaste
Mustvee
Tartu
Jõgeva
Pandivere Uplands
Tapa
Kose
Paide
TALLINN
Uuemõisa
North-Estonian Watershed
Piistoja
Oore
Pärnu
Häädemeeste
Orajõe
Vigala
Taebla
Haapsalu
Virtsu
Kärdla
Kingissepp
Lahe
Saaremaa Uplands
GULF OF RIGA
Viljandi
LAKE VÕRTSJÄRV
Sakala Uplands
Tõrva
Valga
Otepää Uplands
Võru
Haanja Uplands
I
II
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XII
I-XII 1
2
3

far south-east the latter are overlaid by the bed of the Devonian carbonate rocks. The uppermost horizons nourish all the rest, except in cases of direct precipitation on the outcrop. The waters of Quaternary deposits occur sporadically according to the local formation, branching off into two, or even three horizons in the thick surface strata of various watersheds and watershed-uplifts, where fresh pressure is engendered. From here the underground streams flow in every direction, mainly, however, in the direction of the Baltic Sea. If wells are bored on the slopes of the watersheds or in the intermediate hollows, as well as in the flat country along the littoral, the water is forced by the great pressure to the surface, forming in many places beautiful artesian wells.

In general the water, beginning from the second horizon from the top, is pure and fit for consumption, and (with the exception of only a few Devonian deposits) contains a number of substances essential to the human organism.

On the other hand the waters of the upper horizon, which are widely used not only by the inhabitants of the countryside, but also by large numbers of townspeople dependent on shallow wells, are often contaminated, and from the point of view of their composition fall far short of the standard requirements. In farms, in the countryside, the well is very often situated in the farmyard near the midden or cowshed, as a result of which the water is subject to constant pollution.

Purest of all are the waters of springs, since their places of origin, apart from the karst areas, are usually situated at a reasonable distance from the nearest settle-

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Hydrogeological map of the Estonian SSR (A. Verte, 1961).

1 — Orifices of water horizons of the Paleozoic. 2 — Region of artesian springs. 3 — The line of the watershed in the hills.

ment. Thus, when sinking wells, it is always desirable to tap springs wherever possible, though this should be done in such a way as to allow the water to flow freely as before, without stoppage or hindrance. The spring should be fenced round and drinking troughs should be placed from five to ten metres downstream from the point of sally. In addition to being a source of good drinking water, springs have the additional advantage of their natural beauty, celebrated so often in poetry.

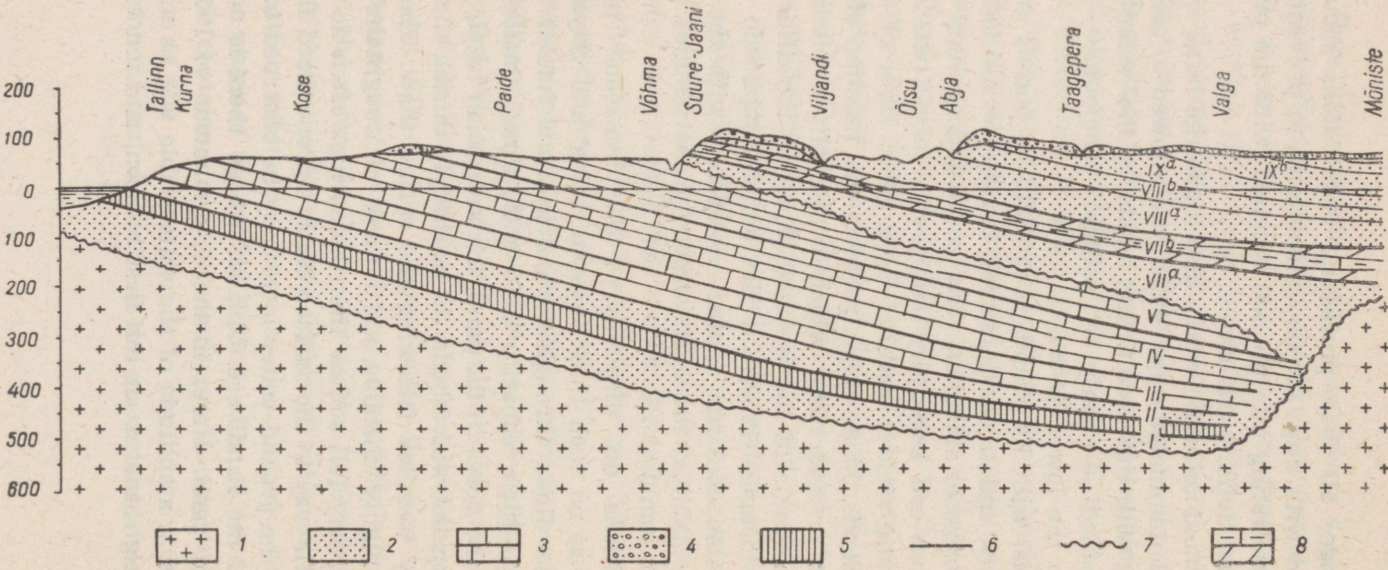
Very often the defiled waters of the upper horizon may seep through semi-impervious strata, tectonic interstices, or occasionally through deep primeval valleys choked with Quaternary sands, thus penetrating to the second, sometimes even to the third horizon. This may also happen when proper use has not been made of guarding pipes, with the result that the water from the upper horizon finds its way into the shaft and is allowed to trickle down to the next level. The waters of different horizons may also mingle in cases where the upper section of the boring, adequately fitted in its time with a protective steel casing, has rusted through to such an extent that the polluted water of the top horizon leaks through to the lower levels.

At certain points in the oil-shale mining area industrial refuse (shale tar, phenols, etc.) is allowed to sink into the ground, where it is borne on down the crevices and funnels of the karst until it is absorbed into the streams and rivers. When this occurs, wells that are situated downstream may be defiled not only at the upper, but even at the second horizon; and as the impervious layer between the two is frequently slight and apt to let through the heavier substances, such as the phenols, sulphates etc., the water of the second horizon often tastes of phenol, and contains larger quantities of sulphur in the direction of the outflow, that is to say in the area separating the oil-shale basin from the sea. In order to combat this danger all shale-processing installations should be equipped with traps for tar, phenol etc., to prevent them from penetrating into the soil together with the polluted water and defiling the rivers.

Paper and cellulose works also discharge large quantities of contaminated water which are allowed to seep into the soil, with the result that wells in the vicinity are often defiled — mainly by sulphur compounds — even down to the lower levels.

Estonia, with its abundant rainfall, its porous and fissured rock and its comparatively temperate and damp climate, possesses abundant reserves of underground water. Conditions are especially favourable in districts where the ground rock is covered by a thick layer of fluvio-glacial sands. These sands perform the function of accumulators or reservoirs, which continually replenish the water horizons of the bedrock. Even in the drier years (as for instance 1959) the fluctuation amplitude of the water-table does not exceed one metre, with the result that the debit of the outflowing streams remains practically constant.

Conditions are different on the limestone plateau, which has no such thick layer of sands and clays. Here the water flows through the crevices and funnels of the karst. As their capacity is 10 to 20 times smaller than that of the pores in the sand, the saturation level, particularly on the watersheds, drops sharply during the warm and dry weather following the spring thaw. The debit here is highly unstable, and in times of drought the general level may fall so low that the springs often no longer find their way to the surface. Such a pronounced fluctuation of the ground-water level may be observed in those parts of the Pandivere Uplands where there is no thick layer of sand. Here, in the dry summer of 1959, the fluctuation amplitude of the water-table was as much as six to eight metres at the first horizon, and ten to four-



Tallinn
Kurna
Kase
Paide
Võhma
Suure-Jaani
Viljandi
Õisu
Abja
Taagepera
Valga
Mõniste
200
100
0
100
200
300
400
500
600
I
II
III
IV
V
VIIa
VIIb
VIIIa
VIIIb
IXa
IXb
X
XI
1
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8

teen metres at the second. This was due to the fact that the pressure of the upper horizon diminished to such an extent that it was unable to nourish the lower horizon through the relatively impervious stratum between the two. The fluctuation is also great on the limestone plateau at the edge of the Glint, where in the dry autumn of 1947 the rest-level of the wells dropped by as much as eight to nine metres. The amount of water pumped out of the mines during the dry season may be from 40 to 50 times less than in the spring, while the pumping of the water itself is an additional factor conducing to hinder replenishment of the second horizon in the mining areas.

Statistics show that the intensive drainage of swamps, resulting in a sharp reduction in the quantity of surface water and a corresponding fall in the level of the upper horizon, may cause some springs to dry up altogether and bring about a serious drop in the water-levels of the rivers. As yet it has not been ascertained exactly to what extent such drainage may affect the lower horizons.

The heavy consumption of water drawn from the carbonate rocks in the coastal district has given rise to a certain influx from the sea, with the result that the ground water here is tending to become slightly brackish. This is also to be feared at Tallinn, where, in consequence of the heavy consumption of recent years, the water horizon of the Lower Cambrian has fallen to as much as 25—28 metres below sea level; and we shall appreciate

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Hydrogeological cross-section of the Estonian SSR along the line Tallinn—Viljandi—Mõniste.

1 — Waters of the crystal bedrock. 2 — Waters of the sandstone complex. 3 — Waters of limestone rocks. 4 — Waters of Quaternary deposits. 5 — Impervious complex of blue clays of the Lower Cambrium. 6 — Relatively impervious stratum. 7 — Erosion face. 8 — Waters of the boulder-clays and dolomites of the Narova stage.

the gravity of the situation more fully if we bear in mind that the rest-level of the first bored well (sunk here about a hundred years ago) was *ca.* one metre *above* sea level.

(Photo by J. Kala)

An artesian well at Võru-Kubija.

At present the situation at Tallinn and Pärnu is being investigated by the Estonian Hydrogeological Station, and until sufficient information is available for the formulation of a reliable prognosis it has been decided to sink no additional wells.

In districts where artesian springs are to be found, the water is often allowed to run to waste all the year round. As a result the general pressure of the water may fall so sharply — (the speed depending on the number of the wells) — that spontaneous flow may cease altogether. Thus the output of a number of wells in the Vigala artesian district has shown a continual tendency to decrease. All artesian wells should be equipped with taps or stoppers, so that water may be drawn according to need and may be left to flow freely only to prevent freezing during the winter frosts. Artesian fountains are among the most picturesque features of our landscape, and should be carefully preserved for their beauty.

I. VELDRE

THE FIGHT AGAINST WATER POLLUTION

NOT ONLY are the rivers, streams, lakes and bays natural reservoirs of inestimable importance for the supply of water to the population at large, but they are also used for a thousand other purposes. Some are valuable breeding-grounds for fish. Others supply industry with water and power. Many of them are popular health resorts, beauty spots, or holiday-making and sports centres. They are used for both passenger and goods transport. They both irrigate and drain the land. They perform a service of invaluable social utility in receiving large quantities of the unwanted garbage and refuse of the towns.

On the other hand many industrial and municipal enterprises discharge their liquid wastes in an unpurified or inadequately purified form back into the sources from which the water was drawn. As a result the water deposits are contaminated with chemicals. Polluting on a large scale of the smaller deposits may render them totally unfit for both human consumption and domestic use.

As a result of the powerful growth of Soviet industry, the task of combating industrial pollution is one of great and increasing importance. Large numbers of scientists — chemists, engineers, technicians, biologists, etc. — are already engaged in the problem of purifying liquid industrial wastes and protecting the water reserves. Special studies have been made of the chemical composition, physical qualities and toxic effect of contaminated water and the necessary hygienic precautions and methods of purification to be recommended for each branch of industry.

Broadly speaking, modern cleansing methods may be divided into two classes: chemical methods (extraction of the polluting agent by means of solvents, evaporation, dilution with limewater, etc.), and biological methods (sewage farms, aeration tanks, biological filters, etc.). The chemical methods often have the advantage of making it possible to extract valuable derivatives. But full purification cannot be achieved by chemical methods alone, and for this reason the latter should always be rounded off by a supplementary biological treatment.

Before chemical purification the polluted waters must be subjected to a process of clarification, or sedimentation in various types of settling basins with the object of freeing them from foreign bodies (suspended matter, oils, tars etc.). Waters containing pathogenic microbes are treated with chloride before being reintroduced into the reservoir.

Extensive studies of sanitation problems have been made in the Soviet Union; and in Estonia, too, such researches have been carried on for years. Yet the large-scale pollution caused by the oil-shale industry — the biggest in Estonia — has hitherto been little investigated. Since the shale-processing installations release huge quantities of liquid wastes contaminated by shale-tars, phenols and other chemicals, the matter has been taken up by the Institute of Experimental and Clinical Medicine (the IECM, attached to the Estonian Academy of Sciences), which has launched a comprehensive series of research operations at the Kiviõli works.

Preliminary results indicate that the wastes of the plant are endowed with an extremely complex chemical composition, and are toxic to aquatic plants, Daphniae, fish etc., even when highly diluted. On the basis of these investigations a number of practical hygienic measures have already been elaborated, together with an overall treatment in four main stages: the removal of oils; dephenolisation; the extraction of ketones; and the final biological filtration. In 1959 a special department was opened at the works for the isolation of phenols from the waste.

In the Lenin shale-processing combine at Kohtla-Järve there is a somewhat fuller purification cycle, the efficacy of which was checked by the IECM in 1959. The results obtained in the dephenolisation department were found to answer the requirements specified in the project (0.4 grs/l of residual phenol). In normal conditions the tar separator and biological filters functioned satisfactorily. The two principal defects of the system as a whole were that: 1) separation of the tars was occasionally incomplete, thus hampering the functioning of the biofilters, and 2) the discharge capacity of the biofilters themselves was sometimes exceeded, with the result that some of the polluted water escaped final purification. The disclosure of these defects made it possible to adopt practical measures for their elimination.

The installation at the plant of the new experimental apparatus for the distillation of tars and the fractional dispersal of phenols drew attention to the necessity of extending research work in order to acquire fresh experience which might be utilised in the construction of new combines of a similar type. The IECM now organised a broad complex investigation into the toxic qualities of the contaminated water. The wastes were proved to exercise a highly toxic effect on both warm-blooded animals and aquatic organisms, and also to retard the processes of spontaneous self-purification taking place in the experimental reservoir. These tests helped us to determine the maximum permissible concentration of toxic elements in the water before it can be returned to the source of extraction.

Another broad line of investigation is being pursued within the reservoirs themselves (detailed topographic charting with indication of hygienic conditions, chemical and bacteriological analysis of the water, etc.)

Thus, in 1958, the IECM conducted research operations with the object of determining the sanitation conditions and degree of pollution in the R. Emajõgi. It found that large amounts of unpurified industrial sewage and domestic waste are discharged into the river at Tartu. In spite of the favourable conditions for spontaneous self-purification (the swiftness of the current, the heavy volume of the flow, etc.) the water in the town revealed abundant traces of contamination.

Test samples revealed a high BOD (biochemical oxygen demand), the presence of suspended substances and a low titre of *coli* bacteria.

Since the R. Emajõgi failed to meet the requirements of Sanitation Standard N 101-54 for water deposits of the second category, the IECM drew up a comprehensive project for improving the hygienic condition of the river.

Sanitation conditions and industrial pollution of the R. Pärnu have also been studied, this time in connection with the projected construction of a centralised municipal sewage and water supply system. In the course of these researches, which were carried out in 1959 and 1960, a series of important emendments were introduced into the project with the aim of providing more effective guarantees against contamination.

In 1961 workers of the IECM undertook the investigation of the Narva reservoir — the first large artificial inland lake in the Estonian SSR — in order to assess the quality of the water supplied to the population of Narva and Ivangorod.

In recent times the staffs of the numerous public health stations have everywhere co-operated in the research activities of the Institute, and the struggle against water pollution is assuming ever broader dimensions. Nevertheless a number of important water deposits have not yet been studied, or have been only partially investigated, and there is no lack of urgent problems which demand solution in the immediate future.

In 1960 a new organ, the Board for the Utilisation and Protection of Water Reserves, which is directly responsible to the Council of Ministers, was set up (Decree 238 of the Council of Ministers of the Estonian SSR, June 25th., 1960) to deal with problems of the protection of both surface and underground waters from contamination.

Under the same decree a co-ordinating council was organised at the Estonian Academy of Sciences with the task of supervising and co-ordinating all scientific researches carried out in the Republic into problems of the protection of the water deposits.

It is to be hoped that these new organisations will carry us still further along the road to our ultimate goal — the final elimination of the menace of pollution from Estonian waters.

J. RISTKOK

THE PROTECTION OF FISH IN THE INLAND WATER DEPOSITS

FOR OVER A HUNDRED YEARS the fish reserves of most European countries have been accorded some sort of protection. Already during the early half of the past century a diminution of the stocks was noted, especially in the inland waters. The reasons for the decrease were multiple. They included poaching, obstruction of the migration routes, the practice of fishing during the spawning-season and landing the young, fishing with illicit contrivances and pollution of the water. In our days the factors making for the reduction of the stocks have grown still more acute, and as a result modern conservation measures have become stricter and more far-reaching.

Protection of the fish stocks of the inland waters of the Estonian SSR is provided for in a number of government decrees from which the following items and general statements of principle may be extracted.

The term "fisheries," i.e. water deposits for which the protection regulations are valid, is applied to all bodies of water which are either used, or may be used, for the wholesale extraction of marketable fish and other aquatic animals or plants, or which play their part in the renewal of the stocks. The task of organising work in the localities and enforcing observance of the statutes and regulations devolves upon the custodians and inspectors of the fish conservancy boards.

The fishing-grounds themselves may be made over to the use of government enterprises, fishing artels and other organisations concerned with the purveyance of fish, including sporting clubs and societies. The proprietor is obliged to do all that is necessary for the adequate maintenance of the water deposit, to perform all the tasks and processes of fish-breeding, to carry out the necessary ameliorative measures, to protect the young, to confine fishing activities within the official limits and to furnish the conservancy authorities with full statistical information on the catches. Angling and fishing as a sport (without right of sale and in general only with fishing-rods and hand-nets) are permitted in all waters, with the exception of nurseries and other prohibited sites.

Contamination of the deposit with polluted liquids, garbage and noxious wastes, including the residues of timber-dressing, is forbidden, as is also the utilisation of the water for steeping hides, retting flax or bast, etc. Lumber-rafting is not allowed in waters used as spawning-grounds by the salmons and sturgeons. One of the most vital problems confronting fish conservation today is the necessity for combating pollution, which is threatening to become, if not checked, a serious menace to the fish-breeding industry.

In order to protect the fish from wanton damage or wholesale destruction, the use of explosives in or near the water is strictly prohibited, unless special permission be obtained; and it is similarly forbidden to catch fish with the help of explosive or poisonous substances, firearms, thrusting or stabbing implements, electricity or harpoon-guns. The latter may be used by amateurs of underwater sport only in waters officially appointed for the purpose, and only while swimming.

Great importance attaches to the task of preserving the migration routes of the fish free from let or hindrance. At least one-third of the breadth of migratory waterways must be kept permanently free. For the same reason fishing is prohibited in the vicinity of dams, bridges etc., and at the foot of waterfalls on rivers flowing into the sea. Alterations in the water-levels of lakes and ilmens (limans) may be effected only by permission of the conservancy authorities. All erections intercepting the current must be provided with channels or passages for the fish. Projects for the construction of reservoirs and artificial lakes must make provision for their eventual use as breeding-stations.

Floodlands and water-meadows used by the fish as spawning-grounds may not be fenced in by dykes or embankments. Timber may not be cut on the banks of spawning-grounds used by the salmons and sturgeons. Fishing at the point of issue or on the lower reaches of migratory streams — of which there are several dozen in Estonia — is forbidden all the year round.

On many stretches of rivers flowing into the sea, as well as in certain parts of L. Peipsi-Pskov and other inland waters, fishing is prohibited when spawning is in actual progress among the members of a certain species or the entire fish community, the times of prohibition being announced by the conservancy authorities according to need.

All activities calculated to disturb the fish during the summer spawning-season are forbidden, including the use of stirring-poles and other fish-stampeding devices in many inland waters, the unauthorised reaping of aquatic vegetation in the spawning-grounds and the anchorage of shipping within the boundaries of closed fishing reserves.

In order to prevent indiscriminate catching of the young, minimum measurements for 19 species have been introduced, the permitted proportion of undersized individuals ranging between 2 and 15 per cent of the total catch.

Destruction of the young is one of the chief factors leading to diminution of the stocks, coming second in importance only to water pollution. For this reason fishing is often prohibited altogether in localities visited by swarms of fry and baby fish.

For the further protection of the young, other regulations lay down minimum dimensions for the meshes of nets. Not only is the unauthorised use of closer-meshed nets forbidden, but so also is the use of new und unapproved methods and devices, the placing of stationary ground-nets in staggered rows, the simultaneous casting of sweep-nets from opposite banks, etc. Trawling from motor-craft is prohibited on the two largest lakes of Estonia — Peipsi-Pskov and Võrtsjärv, — and on the former from sailing-ships also.

All in all, 23 fish species are protected in Estonia. Of other aquatic animals the fresh-water crayfish also enjoys protection, and has its prohibited seasons, localities, and minimum dimensions.

Artificial changes in the aquatic fauna, including the introduction, acclimatisation and breeding of exotic species, may be effected only by permission of the authorities, as all irregular experiments of this kind have been doomed to failure on account of their unscientific approach.

In cases of infringement of the regulations, the conservancy inspectors and public custodians have the right to take down the names and addresses of the transgressors, confiscate their fishing tackle, and seize the haul. Offences against the regulations are punishable by fines, while the conservancy inspectors and public custodians may be rewarded for their diligence.

Nevertheless, desipte the multiplicity of the conservancy regulations, they have had hitherto little effect, as the production plans have in most cases been set far too high. Moreover, the management and workers of the fisheries are often more interested in exceeding their targets at any cost than in ensuring the maintenance of the stocks.

In order to guarantee adequate protection of the existing reserves, researches in parasitology must be intensified, and more attention must be paid to the role of the natural enemies of the fish — both mammals and birds.

The harmful influence of water transport and motorboats (races, pleasure-trips etc.) is patent, though as yet no effective provision has been made for combating it. The protection regulations partly ignore or sidestep the problem of the destruction of the trees and shrubs growing on the banks, while sterner measures would seem to be called for if the task of saving the young fish left stranded in the water-meadows after the spate is to be taken seriously. In certain cases it may be necessary to grant the fish a long term of respite by prohibiting fishing altogether over a number of years.

Not the least of the duties confronting us is the education of the general public, towards which much has already been done over the past few years. That there is favourable ground for work of this nature is shown by the fruitful collaboration already existing between professional research workers and amateur observers. The latter have sent in a large number of useful proposals concerning various problems of an ichthyophenological nature, many of which have been adopted with beneficial results.

E. KUMARI

THE ROLE OF WATERS AND MARSHLANDS IN THE PRESERVATION OF RARE ANIMALS

THREE OUT OF THE FOUR national parks in the Estonian SSR, and 14 out of the 26 nature reserves are, in one way or another, connected with the protection of aquatic fauna, especially birds. The reserves themselves may be classed as follows: open expanses of water; coastal areas and marshlands; and territories on which water deposits (rivers, lakes pools), with their characteristic fauna, are to be found.

Of the species haunting waters or fens, the Osprey, White Stork, Black Stork, Crane and Beaver, have been declared nature monuments, i.e. have been accorded unqualified protection. Birds protected all the year round include the Willow Grouse, Peregrine Falcon, Black Kite, divers, grebes, Razorbill, Black Guillemot, swans, Greylag Goose, Sheld-Duck, Eider, Kingfisher, and a number of passerines which are bound by their nesting or feeding habits to waters or fens. Of the other animals placed under protection some of the bats and shrews, and the river pearl-mussel are either partly or wholly dependent on the presence of water. If we add to the foregoing those

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(Archives of the Commission for Nature Conservation)

Lake Pühajärv (the 'Holy Lake'), one of the loveliest lakes in Estonia, in its setting among the hills of the undulating moraine country.

species which, though they have not been formally placed under protection, frequent waters and marshes during the breeding season, when hunting is forbidden, we shall get a list of considerable length. All this shows how many of the species represented in our fauna are connected with the landscape types in question, and moreover testifies to the importance of the role played by the latter in the preservation of rare animals.

We may begin with the coastal region and adjacent islands, with their distinctive bird communities, which have been placed under protection in a number of localities. One of the most interesting of these areas is the reserve at Vaika, which with its unusual landscape (treeless rocky islands, almost devoid of vegetation) and populous bird life (huge colonies of sea birds flocking densely in a confined area) is something in the nature of an anomaly in this part of the world. The Vaika bird sanctuary, which was founded in 1910, is the oldest nature reserve in the Baltic area, and one of the chief sanctuaries of the Eider. Before the war nearly 1000 pairs nested on the islands here. During recent years, after reinforcement of the protection regulations, the species has begun to recover its former strength, but there is still much to be done before it exceeds or even attains the pre-war level. Among the most firmly established denizens of the islands the gulls are well to the fore. Indeed, since the war the flocks of Great Black-backed Gulls, Lesser Black-backed Gulls and Herring Gulls have grown to such unprecedented dimensions that these large species have become the scourge of the other

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(Photo by E. Kumari)

South-eastern sector of the Muraka bog. The wooded humps visible in the background shelter the Brambling *Fringilla montifringilla*, while the open space to the fore is frequented by the Wood-Sandpiper *Tringa glareola*.

birds, and in the interests of the later the custodians of the reserve have been obliged to take steps to reduce their numbers.

In encouraging the growth of the remaining bird population of the islands (particularly the ducks), effective aid has been rendered by such biotechnical devices as artificial nests, already used with success by A. Toom, the first curator of the reserve. Later large sets of boxes, sometimes containing as many as 100 compartments, were installed, becoming known on the reserve as 'Toom's bird hotels'. As it turned out they were occupied *en masse* by not only the hollow-breeding ducks, which had difficulties in finding suitable natural cavities on the rocky surface of the islands, but also a few species which habitually nest in the open.

The ornithofauna of the islands in the Väinameri (Muhu Sound), which forms part of the Matsalu National Park, recalls that of the Vaika islands and has many species with them in common (e.g. the Eider, Sheld-Duck, some of the more sea-faring gulls, waders etc.). For this reason the protective measures adopted in this sector of the Matsalu reserve are much the same as those operated at Vaika.

But the bird fauna of Matsalu Bay itself, with its almost fresh water and rich vegetation, is that of a typical lacustrine habitat, though part of the shores and the swampy water-meadows are inhabited by marsh birds. The park was founded mainly for the purpose of protecting and studying the bird life of the water-meadows, reed-beds, and hayfields and pastures along the coast, for the bay is frequented by a number of species (e.g. the Greylag Goose, Bittern, Little Gull, Blacktailed Godwit, Dunlin, Water-Rail, Little Crake etc.) which do not occur anywhere else in the Baltic area in such numbers, or in such associations. It is one of the specific functions of the reserve to preserve and investigate these species.

Not only is Matsalu Park the largest and richest sanctuary for waterfowl and marsh birds in the country, but it would perhaps be true to say that both standards of protection and methods of scientific research are elaborated and applied here with an exemplary technique that makes the park a model of its kind.

Another important centre for the protection and investigation of lacustrine and paludal bird communities is the so-called Linnulaht ('Bay of Birds') in the island of Saaremaa. This relict coastal lake with its shallow water and abundant vegetation is a populous haunt of waterfowl and marsh birds which, not so many years ago, included even the Mute Swan. Now that this fine species, which is exceptionally valuable from the point of view of nature conservation, is gradually spreading to the north in the region of the Baltic Sea, it is to be hoped that it may return to its former haunts in the Linnulaht, not to mention other suitable reserves. The lake itself possesses an added importance as a bird haven in the fact that it has already been held under persistent observation over a period of *ca.* fifty years.

The other protected lakes and lake-possessing areas in Estonia have considerably less to show from the point of view of the preservation of rare animals. The landscape reserves in the Rõuge lake country and at L. Pühajärv (the 'Holy Lake'), are both relatively poor in animal life, and the same may be said of the lakes in the Aegviidu-Nelijärve landscape reserve. The botanico-zoological reserve at Harilaid on Saaremaa Is., which embraces a strip of the beach and a number of relict coastal lakes is of importance only in so far as the protection of migrant species is concerned.

Of the s t r e a m s a n d r i v e r s which, together with their valleys, have been placed under protection, many are of prime importance for the preservation of rare animals. Beavers have been introduced into the R. Jänijõgi, which flows through the Aegviidu-Nelijärve reserve, and seem to have made themselves at home here. Other landscape reserves, such as the valleys of the rivers Tille, Pirita and Valgejõgi, the primeval valley of the R. Ahja and the botanical reserve set up for the protection of the wooded water-meadows of the R. Koiva, are all regular breeding-haunts of the Kingfisher, while several of them are visited in winter by the Dipper. The Osprey, Black Kite and Black Stork are also known to frequent the banks of these rivers in search of food, at least in certain seasons and at certain points.

The only extensive swamp listed among the official nature reserves is Nehatu Marsh, but the characteristic fauna of fens and marshes also finds protection in the Matsalu National Park, as well as in the swampy sectors of some other reserves.

Natural features of the b o g s a n d p e a t l a n d s are accorded comprehensive protection in the Nigula National Park and the botanico-zoological reserves at Nätsi and Muraka. All three have an interesting bird population, exhibiting such characteristic species of the Estonian bogs as the Willow Grouse, Crane, Golden Plover, Whimbrel (at Nätsi and Muraka), Herring Gull (particularly at Nätsi), Peregrine Falcon, Great Grey Shrike, etc. After the islands off the west coast the boglands come next in importance in the Estonian landscape as a complex habitat sheltering characteristic bird populations, including a number of northern species which in Estonia must evidently be regarded as survivors from the late glacial period. For this reason the avifauna of the bogs vies with the bird populations of the archipelago and certain coastal regions in point of scientific interest, and stands in special need of protection.

The Virtsu-Laelatu-Puhtu botanico-zoological reserve occupies a place of its own from the point of view of its specific landscape features, which attract rich and unusually varied bird communities. To mention only the haunts of waterfowl and marsh birds, the reserve contains such distinctive habitats as Kivilaid Is. and the small cluster of islets in the Kõbaja archipelago; the large islands covered with grass and bushes, of which the protection regulations have converted Ulluta Is. in particular into a genuine 'bird paradise'; various types of bays; shallow coastal lakes rich in vegetation and consequently also in bird life (at Mõisalaht and Kaselaht); reed swamps (Heinlaht), etc. The extensive research activities carried out here are co-ordinated and directed at the Puhtu Bird Station; and on the whole the reserve may be regarded as one of the leading ornithological centres in the country not only for the preservation and study of rare species (especially shore birds and waterfowl), but also for the dissemination of scientific knowledge and propagation of the idea of nature conservation in general. Special training courses in practical ornithology for amateurs are arranged here every summer, and plans for the further development of the reserve on still broader lines have already been tabled for discussion.

Moreover, in addition to the all-round expansion of scientific and conservation activities in the existing parks and reserves, steps have been taken to set up a number of new reserves, mostly of an ornithological character. In view of the exceptionally favourable conditions obtaining at many points along the coast of the Baltic Sea there is still plenty of scope for expanding the present network of nature reserves, already growing to be one of the densest and best-equipped of its kind.

Swamps, marshes and water deposits play an important role in the Estonian landscape, and their characteristic fauna is represented here in such variety and abundance as to make the preservation of some of the rarest species a matter of prime and urgent necessity. Moreover, we cannot but take into account the fact that certain general changes now taking place in the countryside, such as the drainage of fens and bogs, lowering of the water-level in lakes and rivers etc., are already developing into a serious threat to the local fauna, the continued existence of which can only be guaranteed by the active intervention of man.

At the same time we should bear in mind that the preservation of the different types of fauna involved, inhabiting respectively the open expanses of water, the marshes, and the peatlands, calls for carefully differentiated measures, in so far as each of them reacts differently to the changes introduced by man into their environment.

Of these three types of fauna, the most restricted in its distribution over the landscape is that of the peatlands. All the characteristic bog species (the Willow Grouse, Golden Plover etc.) are extremely 'choosy' in their choice of habitat. Many of them (the Corncrake, Lapwing, in recent times also the Curlew etc.) occur freely not only in swamps and water-logged hayfields, but also in more cultivated districts, even in the open fields.

Since one of the chief preconditions for the existence of the bird communities of both marshes and peatlands is the openness of the countryside, it follows that afforestation must inevitably bring in its train the complete loss of the original ornithofauna. In the same way the natural precondition for the existence of the waterfowl is the presence of the water deposits in which they live. Thus the preservation of the bird population depends entirely on the extent to which it has proved possible to preserve the existing habitats or create new ones. Secondary, or man-made, bodies of water may often develop into populous haunts for waterfowl after standing long enough to acquire the necessary reserves of vegetable life. Steps should also be taken to protect the picturesque bodies of water, with their no less picturesque bird life, to be found in many of our towns, and wherever possible to create new ones.

Nevertheless it must remain our principal task to counteract the detrimental effect exercised by the intensified cultivation of the landscape on our reserves of natural life by means of the careful and systematic protection of the local fauna, more particularly of the rarer species inhabiting the waters, marshes, and peatlands.

A. KUKK

THE NIGULA NATIONAL PARK AS A SPECIMEN PEATLAND

AS A RESULT of the swift growth of the national economy increasing attention is being paid to the problem of exploiting fallow and little-cultivated lands, including the reclamation of fens and bogs.

In order to preserve at least part of the original landscapes in their natural state, as well as to ensure the survival of rare plant and animal species and to study the processes taking place in nature uninfluenced by human interference, it has become necessary to set up special reserves. Among the areas thus placed under protection in 1957 by decree of the Council of Ministers of the Estonian SSR was Nigula bog and the surrounding woods in the south-west part of the country. The total area placed under protection is 2730 hectares, of which peatlands account for 2050, forested areas 640, grassy fens 20 and open expanses of water 20 hectares. The overall length of the bog from north to south is 7.5 kms, and its breadth from east to west 4 kms.

Nigula bog belongs to the well-developed peatlands of the Baltic littoral. One of the most prominent elements of its vegetation, apart from the heather, is the Deer-grass *Scirpus caespitosus* characteristic of the bogs of West Estonia. *Chamaedaphne calyculata* — so common in the east — is entirely absent. Of the peat mosses *Sphagnum fuscum*, *S. magellanicum* and *S. acutifolium* predominate.

In general the convexity of the bog is slight. The slopes are either quite bare, or covered with rare, stunted pines. The greater part of the surface area is treeless and pitted with shallow depressions of the hollow-complex type.

There is no lack of hollow-pools, the largest being the *Suur Laugas* ('Great Pool') — 200 metres long and 125 metres broad, and the *Pikk Laugas* ('Long Pool') — almost 300 metres long and 70 broad. Some of the pools do not freeze over in the winter, even at a temperature of 25° C below zero, and are evidently traversed by one or other of the many inner channels of the bog.

Another unusual feature is the lake at the eastern extremity, with its steep peat banks, almost devoid of vegetation, though stumps of trees are to be found at the bottom of the water. The banks themselves have been undermined by the waves, and on the west shore of the lake subsidence of the surface has given rise to long rifts or slits in the peat. No less interesting is the stream which flows beneath the peat deposit. After taking its origin in a complex of hollow-pools, it first flows for some distance over the surface of the bog. Then, on approaching a small clump of pines, it suddenly plunges underground, to reappear at the surface about 1 km to the south. After advancing about 200 metres over the peat again it vanishes once more, to reappear only at the very edge of the bog. The stream does not freeze over in winter, though in blizzards it may be partly covered in with snow.

A chain of humps crosses the bog from north to south. In all, there are four of these islets of firm land (locally called *peaksi*), which are relics of a ridge which formerly traversed the bog. Biggest of all is the Fourth *Peaksi*, which is 1.25 kms long and 0.3 kms broad. The hump is covered with ancient primeval forest, with a sprinkling of broad-leaved deciduous species. Huge aspens, birches, elms, maples and lime-trees grow here, of which the largest attain a height of 30 metres and a diameter of 70 cms. The ground vegetation is luxuriant and varied, containing many species characteristic of fertile soils — the Gout-weed *Aegopodium podagraria*, Mercury *Mercurialis perennis*, Lungwort *Pulmonaria officinalis*, Windflower *Anemone nemorosa*, Archangel *Lamium galeobdolon*, etc. Here is also to be found the Lady's slipper *Cypripedilum calceolus* — most beautiful of the wild orchids growing in Estonia, — and the Common Polypody *Polypodium vulgare*, which is rarely to be found on humps of this kind.

The other 'islands' are covered with fern-woods, and the rate of swamp formation is so intense that it is possible to register changes in the degree of paludification.

The woods in the park consist mainly of birch stands (337 hects), which are followed by the aspen and black alder (220 hects), the fir (55 hects), and pine-dominated stands (48 hects). The ash, elm, maple, lime and white alder (*Alnus incana*) also occur. The forest types in order of frequency are the *Equisetum-type* — 60%. *Oxalis*-type — 19%, *Myrtillus*-type — 13%, *Vaccinium*-type — 3%, *Sphagnum*-type — 3%, and *Polytrichum*-type — 2%.

Of the animals inhabiting the reserve the elk, roe and wild boar may be mentioned. A solitary wolf or lynx may put in an occasional appearance. The badger, fox and raccoon dog dig their burrows in the humps. The mountain hare is plentiful, but the brown hare occurs only rarely. Of the smaller mammals, the squirrel, pine marten, weasel and a number of mice are not uncommon.

The bird population is rather rich in species, over 70 having been recorded on the restricted territory of the park. Typical breeding birds are the Crane (one pair in the thick reed beds of the fens), Willow-Grouse (10 pairs, nesting mainly in the shrubby heath-bog), Golden Plover (15 pairs, mostly haunting the shallow depressions of the open bog), Herring Gull (one pair on the islets in the hollow-pools), Lapwing (12 pairs), Curlew (4 pairs), Wood-Sandpiper (6 pairs, frequenting both the hollow-complex and the open heathy expanses), Great Grey Shrike (one pair on the wooded heathland), Mallard (3 pairs in the hollow-pools), and Teal (4 pairs). Of the rarest species the Three-toed Woodpecker has been met with, while one or other of the eagles may put in a sporadic appearance, especially the Lesser Spotted Eagle.

The park affords rich opportunities for the most varied research work. It is possible to investigate the process of swamp formation, the structure and growth of timber stands in different site-types, the dynamics of plant associations, the population dynamics of breeding-haunts and habitats, and the ecology and phenology of a large number of interesting species.

Regular observations are taken of climatic and meteorological conditions, including the measurement of air and surface temperatures, the freezing depth of the soil (up to 3.2 metres), and the depth and density of the snow in the different forest site-types, on exposed or forested mineral soils, wooded peatlands, heathy pine peat bogs, hollow-complex areas and hollow-pools. Permanent sample plots are marked off in the vegetation cover with the object of investigating the process of paludification, and a system of wells is being sunk to check the ground-water level.

Phenological observations of plant life are carried out on permanent objects throughout the whole of the vegetation period. Special studies are being made of the height and diameter growth increment of the pine in different habitats, including wooded heathlands and mineral soils.

Ornithophenological observations cover all features of the spring arrival, nesting and autumn departure of migrant birds, while invaders and stationary species are similarly dealt with. Bird-ringing is carried out on a broad scale.

A. SOMANN

THE VIIDUMÄE NATIONAL PARK AND THE PROTECTION OF FEN VEGETATION

THE ISLAND OF SAAREMAA is popularly considered to be a country of barren pasturelands covered with a sparse cloak of vegetation scattered with stunted junipers. But for the naturalist the flora of Saaremaa has much of interest to offer, thanks above all to the distinctive wooded meadows, spring fens and coastal belt, where species may be found which occur nowhere else in the Soviet Union, or even in the world.

The Viidumäe National Park (*ca* 600 hectares) is situated on the skirts of the Central Uplands of Saaremaa, and embraces the spring fens at their foot. The hills rose from the sea as a result of the neotectonic uplift of the Ancylus period, and the characteristic terraces and coastal barriers were lashed into shape by the restless action of the waves. The mixed oak and pine forest on the slope, running down to merge with the spring fens at the foot, constitute a sort of natural open-air museum, where relics of all the climatic periods that have ever existed in Estonia are gathered together. Here, in the widely differing botanical habitats of the reserve, there may be found roughly one-third of all the Estonian species that have been declared under protection. In the clearings and dry airy pine groves certain species of steppe origin, such as *Vicia cassubica* and *Oxytropis pilosa*, are represented by occasional large and flourishing colonies. *Hypericum montanum* is also met with, together with a few solitary specimens of *Sorbus aria,* whose only known habitat in the Soviet Union is West Saaremaa. In the damp and shady woods at the foot of the slope *Hedera helix* and *Taxus baccata,* for which Estonia marks the extreme north-eastern limit of the range, occur as Sub-Atlantic relics.

The foundation of the reserve on July 7th, 1957 marked the beginnings of regular scientific research, of which the present phase, as planned by the Commission for Nature Conservation of the Estonian Academy of Sciences, covers the years 1961—1965. The main object of the researches, in which not only the local staff but also a number of outside specialists are engaged, is the description and investigation of the gradual changes taking place in natural conditions. As the reserve is chiefly of a botanical character, one of the first tasks is to draw up a preliminary floristic and geobotanical survey of the whole area, including the compilation of a soil map. The local habitats and general distribution of the rarer species have already been ascertained, and the vegetation units determined. In this connection it may be observed that, in spite of the restricted area of the reserve, most of the vegetation units occurring on Estonian territory are to be found here. There is a rich variety of forest types, including wooded heaths and swamplands, alvar and grove forests, and mixed spruce, pine and birch woods intermingled with various combinations of broad-leaved deciduous types growing on peaty, marshy and intermediate-type swampy sites, etc. Among the grasslands dry calciphilous meadows predominate, while the prevalent swamp type is the eutrophic calciferous marsh commonly known as the 'Viidumäe spring fen.'

Permanent plots have been cut into the more characteristic vegetation units, and their detailed description and systematic examination should make it possible to record the regular changes taking place in the plant cover during the course of time.

Phytophenological observations are carried out jointly by a member of the research team and a technician-observer. Special attention is paid to the rarer species. In addition to the work involved in compiling a complex annual calendar of phenological data, simpler hydrometeorological observations are taken throughout the year.

The Viidumäe spring fen is a typical specimen of the West-Estonian fenlands, which are characterised by a relatively shallow peat deposit. For the most part the peat is rich in lime and calciphilous species are widespread. From the foot of the slope, at the edge of the fen, trickle tiny, highly distinctive rivulets of spring water. Somewhat lower down these converge to form brooks and streams, which have cut beds of varying breadth and depth into the peat layer.

On this part of the territory the tree layer is poorly developed, consisting only of a few solitary specimens of *Pinus silvestris* L., rarely accompanied by *Betula pubescens* Ehrh. em. Gunn. The prevalent element of the shrub layer is *Myrica gale* L., a pseudo-Atlantic species which is mainly concentrated in the region of Saaremaa and North-West Estonia. *Frangula alnus* L. is by no means rare. Well to the forefront of the field or grass layer we find *Schoenus ferrugineus* L., one of the most prominent characteristic species of the West-Estonian marshlands. Occasional specimens of *S. ferrugineus* × *S. nigricans* may be met with. *S. nigricans* L., which has since been placed under protection in the Estonian SSR, was formerly also present in the Viidumäe fen. The present local companions of *Schoenus ferrugineus* are *Sesleria coerulea* L., *Epipactis palustris* (L.) Crtz., *Liparis Loeselii* (L.) Rich., *Tofieldia calyculata* Wahlb. etc., of which the last two are determinative species of the *Schoenus ferrugineus* association. Quite often

Carex Hornschuchiana DC forms independent communities of its own. Patches of *Cladium mariscus* (L.) R. Br. are to be found here and there, survivors of the warmer climate of the post-glacial period when, as stratigraphical investigations show, this species was widely distributed in Estonia.

Another interesting protected species growing in the Viidumäe spring fen is *Rhinanthus osiliensis* (Ronn. et Saarsoo) Eichw., which appears as a neo-endemic of Estonian flora throughout the whole of the post-glacial period, but which so far has been traced in no other part of the country, nor even in the whole of the Soviet Union, the nearest related species not appearing until the Balkans.

Juncus subnodulosus Schrank. must be primarily regarded as a Sub-Atlantic relic. This species is distributed widely over the Atlantic part of Europe, and the northern limits of its range extend as far as the Faroe islands. The finds recorded in the calciferous spring fens of Viidumäe and Koltsi, are unique in the Soviet Union. Nevertheless its environment here is congenial enough for it to occur sporadically in almost pure — though somewhat narrow — colonies.

The permanent habitats of *Pinguicula alpina* L. in Estonia are also to be found in West Saaremaa, in the environs of Kuusnõmme and the Viidumäe spring fen.

Together with other orchids (*Orchis incarnata, O. Traunsteineri, Liparis Loeselii, Ophrys muscifera, Gymnadenia conopsea* etc.) the spring-fen sector of the reserve boasts of a few scattered specimens of a rare survival of the Sub-Boreal period — *Gymnadenia odoratissima* (L.) Rich.

In conclusion, mention may be made of the uncommon *Rhynchospora fusca* (L.) Ait., representing the pseudo-Atlantic element in the flora.

V. MASING

THE STUDY OF PEATLANDS AND PROBLEMS OF NATURE CONSERVATION

IN THE EARLY STAGES of its development classical natural science acknowledged as legitimate objects of study only the isolated individual plant, animal, rock (or mineral). But this viewpoint could not be maintained in the face of the rapid advance of science which took place during the last century, and it soon became clear that much more complex and intricate phenomena must also be taken into account — phylogenetic series, systematic units of various sizes, the entire local flora or fauna of a given habitat, or plant associations and the vegetable cover taken as a whole. It was left to the present century to make the discovery that the object of research need not be confined to phenomena of a single type — only plants or only animals, — but that the local combinations occurring in nature, — biocenoses, as they came to be called, — should also be studied as complex units in their own rights. Lastly, in quite recent times, it was eventually recognised that these nature-complexes do not merely consist of living organisms, but also include the soil, water and air — in short the whole of the environment in which they live and develop. Thus modern science has reached the conclusion that nature must also be investigated in its ecosystems (Tansley), biogeocenoses (Sukachev), or landscape facies and types. But whatever the name we give them, these nature-complexes are real phenomena of varying size and complicacy which have their own independent existence, whether we are aware of them or not, and which in a number of ways may affect our lives, or are influenced in their turn by our activity.

One consequence of the appearance of these new objects of study, lying on the borderline between the spheres of biology and geography, was the opening of new branches of research to investigate them. These, too, proved to be 'hybrids,' embracing many different elements of classical natural science.

One such new field of research is telmatology or paludology, the science of swamps,* which deals with the various types of wetlands as complex natural phenomena.

Yet another aspect should be emphasised: swamp science is concerned not only with static phenomena — a certain saturated, peat-covered plot of land as such, — but also its dynamics, i.e. the natural processes leading to the formation and development of swamps, the process of paludification, the general trends of soil formation, the regular migration of certain substances in characteristic biogeochemical cycles which have been taking place in the earth's surface ever since its emergence, in many cases throughout the whole of the post-glacial period.

The word 'telmatology' was used in Estonia already in the sixties of the last century by Asst Prof. J. Klinge, of Tartu University, who read a special course on the sub-

* Author's note. It is to be regretted that in many languages there is no generally accepted term for the phenomenon in question. The Estonian word *soo* was at first mainly used in the sense of "fen," and when it was desired to use the term in its broadest and most general sense, it was — and still is — customary to say *sood ja rabad* ("fens and bogs"). In English there also seems to be no suitable equivalent for the German *Moor* or the Russian *boloto*. The Scandinavians recommend the use of the word *mire*, while most British authors seem to prefer the expression 'peat land,' though this is vague and sometimes misleading.

ject. Although Klinge himself was a botanist, he did not regard the swamps as a mere vegetation unit. He touched on the water regime and discussed a number of distinctive features of swamp water which at that time were not studied or even known to exist, but which

(Photo by E. Kumari)

A complex of hollow-pools in the Muraka-bog.

nowadays have become one of the basic problems of research and an important key to the origin and development of the wetlands.

Another botanist, E. Russow, the well-known sphagnologist, collected and studied the peat-mosses of the Tähtvere bog near Tartu, and described a number of new *Sphagnum* species.

It was no coincidence that the problem of the wetlands should have evoked such interest among the naturalists of this part of the East Baltic area. Indeed, the Estonian swamps are not only so numerous as to constitute some of the most characteristic landscape types, but they are also represented in a great variety of forms and, in spite of the general prevalence of cultivated areas, have preserved a number of interesting plant and animal species which have elsewhere become long extinct (see articles by E. Kumari and A. Somann).

Although the breadth of Estonia from east to west is not more than 300 kms, the local climatic and geological preconditions for swamp formation vary considerably from place to place and have deeply changed in the course of time. The total precipitation attains 500 to 750 mms per annum. The average air temperature in the west is 2° C higher, and the minimum temperature 9.3° lower, than in the east. Swamp formation began in lagoons filled with marine deposits, or on the level limestone plateaus. As a result Estonia may boast of a variety of swamp types which occur elsewhere only in territories several times larger. As P. Thomson (1924) and H. Gams (1929) have shown, the Estonian wetlands may be divided into at least the following three regions or provinces, all of which extend beyond the frontiers of the Republic:

1) the islands in the Baltic Sea (including Oland and Gottland);
2) open peatlands of the transgression area along the eastern shore of the Baltic (including Estonia, Latvia and Lithuania);
3) the wooded boglands of Eastern Estonia and the region of Lakes Ladoga and Ilmen.

A rather more detailed division into eight regions (together with a brief survey of earlier regionalisation projects) has been presented by H. Kurm (1960).

In each of these regions swamp development has taken place in different geomorphological and climatic conditions, and the local flora and fauna exhibit certain differences in genesis and ecology. Although the first attempts at regionalisation were based on the presence and identification of certain prominent features, such as peculiarities of the vegetation or notable forms of the microrelief, it soon became apparent that these were merely the external — but not always essential — concomitants of deeper causes.

New methods, introduced by specialists from Leningrad and Moscow, have now been applied in Estonia, where they have already yielded interesting results.

To the investigator moving with difficulty over the terrain, the pattern of the surface seems a chaotic labyrinth. Seen from the air, it acquires vital significance as an indicator. Now, thanks to the achievements of J. Galkina and others, the surface pattern has become a reliable means of distinguishing between the basic bog types, ascertaining their phases of development and determining the directions of the outflow and the sources of replenishment. The hydrologist G. Ivanov has formulated equations to express the relationship between the diameter of a raised bog and such essential indicators of the water regime as the coefficient of filtration and the depth of the ground-water level.

With these new developments the breadth, orientation and location of the hollow-complexes and peat ridges on the face of the bog were now scientifically accounted for; and the micro-landscapes ('complexes' in the narrower sense of the word), consisting of hollows, pools and ridges arranged in various combinations, were shown to be dependent on specific factors, including the drainage conditions and the degree of declivity.

According to S. Tyuremnov, the disposition of the plant associations not only affords evidence of the formation of certain types of peat, but also provides information concerning the succession of peat types in the deeper strata, and in so doing throws light on the generic type of the peat deposit itself. Thus the vegetation cover serves as a useful guide to the depth and other characteristics of the underlying layers of peat, and enables us both to classify the area as a unit and to draw conclusions with regard to the water regime.

It now remains to apply these general principles to each of the basic swamp regions, in order to determine the specific local peculiarities of each.

Valuable contributions to the study of the Estonian boglands have been made by workers of the Institute for Research in Soil Fertility and Land Improvement, including A. Truu (swamps of the Silurian region), H. Kurm (West Estonia), K. Veber (Central Estonia) and L. Rätsep (South-East Estonia).

Problems of an ecological or biocenological nature call for intense stationary research, or at least regular observations along a permanent route. Such investigations have already been carried out in many types of swamps, especially by members of the Institute of Zoology and Botany (E. and A. Kumari, V. Maavara and others in the field of zoology, U. Valk in that of forestry etc.). Successions of the plant cover are being studied by the botanists of Tartu University (H. Trass on fens, V. Masing on raised bogs). Certain very important general problems of hydrology and climatology, such as the influence of swamps on the outflow or on the climate of adjacent areas, etc., need to be investigated over long periods at well-equipped observation stations. One such research centre is the Tooma hydrometeorological station on the edge of the huge bog-complex at Endla, Jõgeva district.

But the most favourable sites for permanent observations of all kinds are the national parks and nature reserves, where the factor of economic exploitation is eliminated. Here are to be found ideal facilities for the investigation of such natural processes as paludification, peat formation, successions of plant associations etc., which it is practically impossible to study elsewhere. Quite apart from their purely theoretical value, such lines of research are pregnant with practical implications, and often help to elucidate the most expedient methods of swamp reclamation and conversion.

The nature reserves also afford plentiful opportunities for experimental research in the field of ecology. To determine the reciprocal relations of plants both on and beneath the surface of the soil is an enterprise which calls for years of careful observation and the systematic experimental elimination of individual factors. This is a task which will have to be undertaken in the course of the next few years. In the sphere of plant associations one of the most interesting problems is that of the influence of the *Sphagnum* cover on forest trees and other plants, especially on their generative and vegetative reproduction. Attention must also be paid to the problem of determining the annual growth increment of the peat mosses and elucidating the factors by which it is regulated.

Another urgent task of the immediate future concerns the stratigraphy of the protected wetlands, which may be expected to throw new light on the genesis of the surface structure.

The research work which is being carried out at present in the state nature reserves of Estonia is still in its initial phase. It is frequently hindered by the lack of trained personnel, equipment and experience. Every now and then difficulties may still arise with citizens who have not yet managed to shake off their old social prejudices and sense of private property, or even with officials who fail to understand the public and national importance of the work of nature conservation. But we have no lack of youthful enthusiasm, for the scientific personnel attached to the staffs of the reserves has been recruited exclusively from young specialists. Their conscientious and self-sacrificing labour gives us every reason to hope that our nature reserves will rapidly develop into such first-class research centres as those of the Russian Federative Republic and some foreign countries.

Lastly a word should be added on the role played by the parks and reserves in disseminating scientific knowledge and inculcating a sincere love of nature in the broad masses of the people. There are many ways of making the Estonian public swamp-conscious, and of those which have proved most effective perhaps the following may be recommended: 1) the organisation of school excursions to the nearest swamp or bog with the object of explaining to the children interesting features of its structure, vegetation and animal life; 2) tourist hikes through different swamplands under the leadership of a competent guide (these should prove at least quite as thrilling as any other kind of hiking trip within the frontiers of the Republic; 3) photo competitions (which might incidentally help to provide materials for the compilation of albums popularising our bogs and fens); 4) the shooting of amateur films dealing with the mysterious animal life of the swampy areas (these could be utilised not only as scientific documentaries, but also as visual aids in the schools).

THE NATIONAL PARKS AND PERMANENT NATURE RESERVES OF THE ESTONIAN S. S. R.

(Note: The numbers given correspond to those shown on the map)

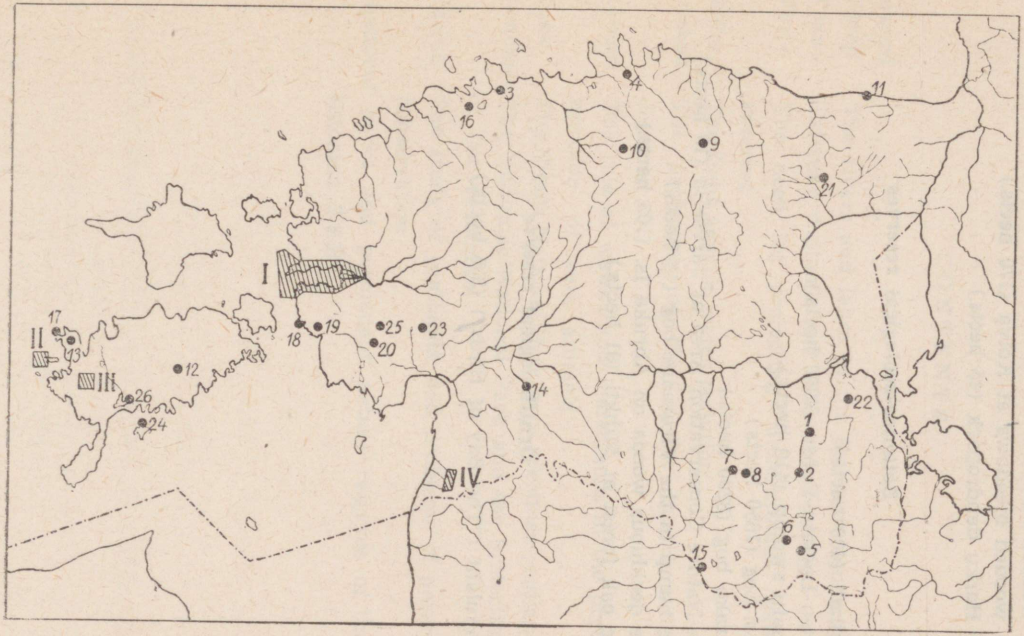
I. The Matsalu National Park (60,000 hects.)
II. The Vaika National Park (35 hects.)
III. The Viidumäe National Park (593 hects.)
IV. The Nigula National Park (2730 hects.)

Landscape reserves

1. The primeval valley of the R. Ahja (1040 hects.)
2. Tilleorg (190 hects.)
3. The valley of the R. Pirita (550 hects.)
4. The valley of the R. Valgejõgi (665 hects.)
5. The Suur-Munamägi and Vällamägi hills (475 hects.)
6. The Rõuge lake country (1210 hects.)
7. Lake Pühajärv (870 hects.)
8. The Väike-Munamägi and Tedremägi hills (355 hects.)
9. The Neeruti hills (885 hects.)
10. Aegviidu-Nelijärve (1555 hects.)
11. The Saka-Ontika-Toila Glint (890 hects.)

Geological reserve

12. The Kaali meteorite craters (4.8 hects.)



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Botanical reserves

13. The wooded meadows at Tagamõisa (130 hects.)
14. The wooded meadows at Halliste (270 hects.)
15. The wooded meadows at Koiva (170 hects.)
16. The Harku dendropark (45 hects.)

Botanico-zoological reserves

17. Harilaid (400 hects.)
18. Virtsu-Laelatu-Puhtu (4900 hects.)
19. Nehatu swamp (410 hects.)
20. Nätsi bog (1650 hects.)
21. Muraka bog (8200 hects.)
22. The Nature Conservation Area at Järvselja (19 hects.)
23. The hump in the Virusaare bog (42 hects.)
24. The deciduous woods on Abruka Is. (103 hects.)
25. The oak forest at Mihkli (91 hects.)

Ornithological reserve

26. Linnulaht ("The Bay of Birds") (335 hects.)

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