ANTHROPOGENIC INFLUENCE ON THE NATURAL VEGETATION IN KURTNA LAKE DISTRICT (NORTH-EAST ESTONIA)

Tiiu Koff

ABSTRACT

The Kurtna Lake District is a unique area in the region of NE Estonian industrial landscapes. Around 40 lakes, numerous bogs and abundant forests are located there on 30 ha. The last decade have witnessed considerable negative influence of human activities in this area. The ashes from electric power stations have altered the natural vegetative cover. To determine the impact of long-term human activity, complex palaeobotanical studies of lake sediments were carried out in the region. The results were reconstruct the natural development of vegetation 8000, 5000, 3500 years ago and to compare it with the present one.

Introduction

Kurtna Lake District is a unique type of landscape, which by now has been taken under state protection, where around 40 lakes are situated on a territory of ca 30 km and which is characterized by very mosaic relief, soil and vegetation cover (fig 1). The present relief of the area has mainly formed at the end of the last glaciation. Lakes are mostly situated in hollows, formed between kames and eskars on the melting of big ice clods buried under gravel and sand. In its natural condition such sand is poor in carbonates, thus the source rock of soils with strongly aciduous reaction. On such soils mainly heath or sandy-heath pine-woods, poor in species, are distributed, the base vegetation of which is covered by lichens and evergreen shrub species. The Kurtna landscape is also characterized by bog plains which cover extensive areas in the Kurtna valley and the east side of the kames field.

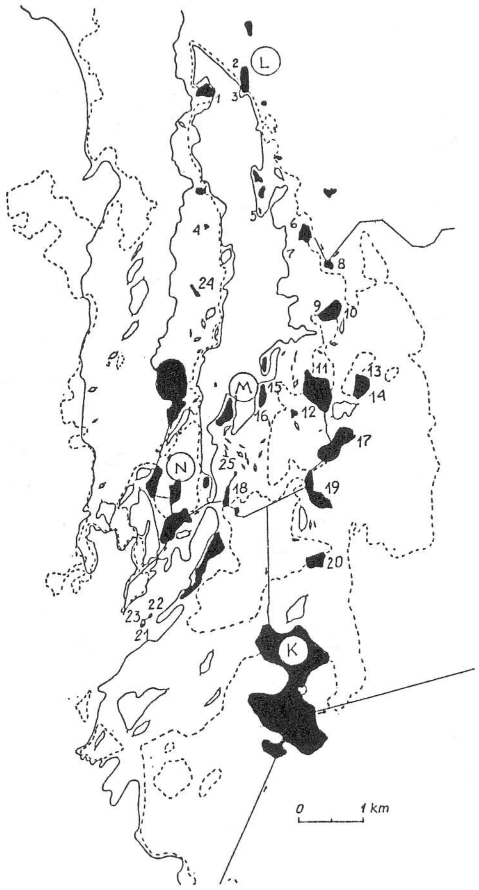

Fig 1. Kurtna Lake District, studied sections (K,L,M, N) and surface sampling sites.

Nowadays, especially during the last 25-30 years this area has been under the influence of heavy anthropogenic load. Being in the nearest vicinity of the NE Estonian industrial region (oil-shale mining and processing in electric power stations and chemical plants) the district is affected by the air pollution through the atmosphere and the water pollution brought by the mining waters directed through the lakes. An important factor violating the equilibrium of lakes must also be considered the fall of water-level in several lakes, connected with depressions in mining-areas and drinking-water consumption from the limnoglacial deposits in the primeval valley running through the area.

Communities and the surrounding environmental conditions are known always to be mutually related. Both components of an ecosystem change and develop influencing each other. To understand better the share of an important factor affecting the state and development of ecosystems - human activities, it is necessary to know the development dynamics of communities and environmental conditions in the pre-anthropogenic period. Much information on the events in the Holocene may be obtained by complex studies of lake and bog sediments.

Bearing in mind this main principle, investigations have been carried out in the Kurtna Lake District. In addition to several chemical and physical methods, the paleobotanical ones are of great importance, including the pollen analysis. Lake and bog sediments of different nutrient regime and at different development stage were subjected to complex studies. Palynological studies were here aimed at two main purposes.

First of all the data were used geochronologically to compile a unitary time scale, and secondly, in the reconstruction of paleogeographical conditions. Pollen analysis plays an important part in compiling the age scale for the study of temporal changes of events. Investigations indicate (Varvas, Koff, Rajamäe, 1987) that the dating of lake sediments on the basis of the ^{14}C data is not possible in this area. Due to the "hard water" effect and to some extent also because of the carbon compounds separating in the biogeochemical decomposition of sediments and joining again the matter cycle, the ^{14}C results are, as a rule, up to 1500 years older than the actual ones. For this reason a complex of methods was elaborated in order to use pollen data in the stratification of lake deposits. We made use of indirect correlation with the datings of bog deposits, where ^{14}C results are rather reliable. The limits of the local pollen assembledge zones de-termined by the principal component analysis were used in the indirect correlation.

The results of pollen analysis were also used for more detailed dating of the upper part of the bog sediments. Departing from the proposition of the constant pollen input, it was possible to find the age of each definite layer with the help of cumulative pollen curve.

While obtaining the second aim, reconstructing paleogeographical conditions, it was born in mind that the study objects should be as versatile as possible as to their size, location and genesis. Such approach enables to distinguish between the influence of local and regional conditions on the formation of pollen spectra. The sediments of three lakes and two bogs were studied palynologically, as well as surface samples from 25 points in order to detect the pollen distribution regularities in such mosaic landscape (fig 1). The samples were prepared for pollen analysis by standard acetolyze method. Lycopodium tablets were used to calculate pollen concentration and influx.

Results and analysis

The biggest and most southern of all the studied objects is L. Konsu (fig 1 K) with an area of 127.6 ha. The section of Konsu has been taken from the deepest part of the lake, but as mining waters are directed through the lake some resedimentation has taken place in the upper part of the sediments. For this reason we will not deal in detail with this section in the present paper.

A bit further from the Kurtna Lake District, about 10 km to the north-west is situated Lake Ümarjärv, which is the smallest of the studied lakes with an area of 1.6 ha. Approximately of similar size is L. Martiska - 2.74 ha (fig 1 M), where the water-level has fallen 3.6 m over the last 10 years.

From the bogs the Liivjärve (L) and Niinsaare (N) bogs from the northern and central parts of the lake district (fig 1) have been studied. In both cases the lower part of the peat profiles consists of Phragmites-Carex peat, followed by Sphagnum-peat and Eriophorum-Sphagnum peat formed during the last 1000 years.

Comparing the obtained pollen diagrams between themselves several differences appeared alongside with common features, which, of course, is natural in case of so different objects. The diagrams from Ümarjärv (Punning et al 1987), the Liivjärve bog, the lakes of Konsu and Martiska have been published earlier (Koff 1990) and from Niinsaare bog in this paper (fig 4).

As the aquatory of, for instance, L. Konsu is considerably bigger than those of L. Martiska or L. Ümarjärv, the pollen spectrum of Konsu reflects the dynamics of communities on a wider territory. To this are added the more mosaic landscape surrounding the lake depression and the versatility of edaphic conditions. So, for example, alder found more suitable growing conditions for itself near L. Martiska only after the share of birch started to decrease. In case of L. Konsu these processes were simultaneous and maximum input found place earlier than on other lakes, ie 7000-7500 BP More detailed comparison of diagrams was performed by definite time intervals. We are interested in the time intervals 8000, 5000 and 3500 BP. These, namely, were the turning-points in the development of the vegetation in the Holocene. Thus, about 8000 BP the prevailing tree species had migrated to the Estonian territory and further successions were determined by the changes of climatic and hydrological conditions, as well as the changes of landscape structure resulting from them. The period 5000 BP was the time of the climatic optimum. The natural conditions 3500 BP can be compared with the present-day ones, only the anthropogenic load was missing.

Spectrograms have been compiled for these time periods about percentage composition (fig 2) as well as pollen influx (fig 3). Percentage composition indicates that the vegetation was rather uniform 8000 BP. A more widely spread tree species was birch, together with pine and to a smaller degree alder.

The input of pollen was biggest in the small lakes of Martiska and Ümarjärv, and comparatively small in Liivjärve bog and the big L. Konsu. Such big input in small lakes may be explained by the low water-level, due to which a considerable part of the lake depression was covered with trees. The share of pollen imported from the drainage area was also big. The pollen diagram of L. Ümarjärv differs considerably from others. Here rather big amount of alder and elm could be met already 8000 BP. The position of this lake - a high eskar from one side and an area of favourable moisture regime from the other favoured the formation of such micriclimatic conditions which made it possible for more particular tree species to grow there. This also accounts for such mosaic vegetation on this comparatively small territory.

5000 BP the vegetation had become still more versatile. The prevailing tree species were pine, birch and alder. The deposits of Konsu and Liivjärve are also rich in fir pollen. The share of broad-leaved species is approximately equal in all sections. Ulmus is prevailing here, the amount of Tilia and Quercus is smaller.

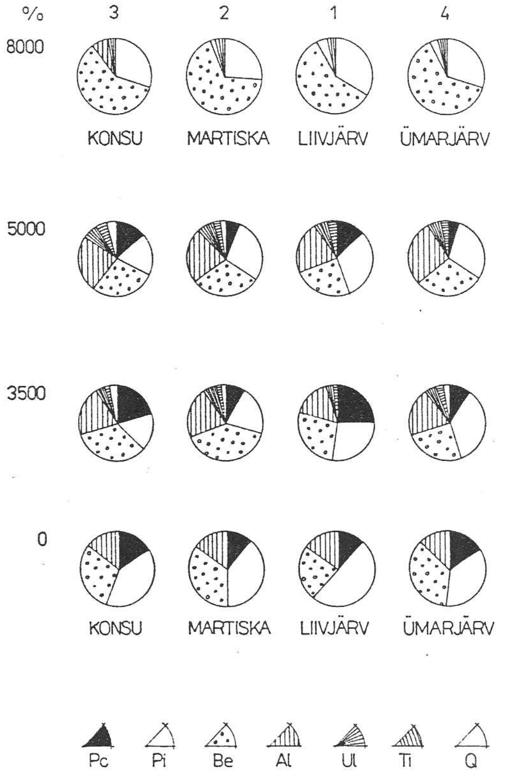

Fig 2. Pollen percentage composition spectrograms for different sections 8000, 5000, 3500 and 0 BP.

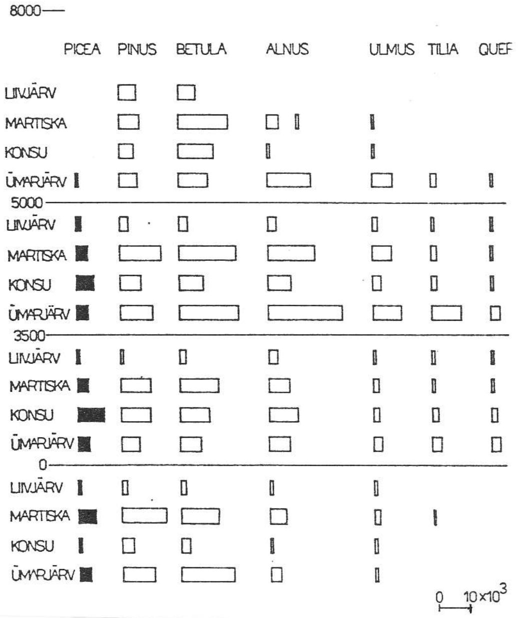

Fig 3. Pollen input spectrograms 8000, 5000, 3500 and 0 BP.

Annual pollen input in this period in lakes Martiska and Ümarjärv was about twice as big as in L. Konsu or the Liivjärve bog. This could be explained, for example, by the size of L. Martiska being only 100x150m. This is optimum distance to were the greater part of tree pollen is deposited forming the

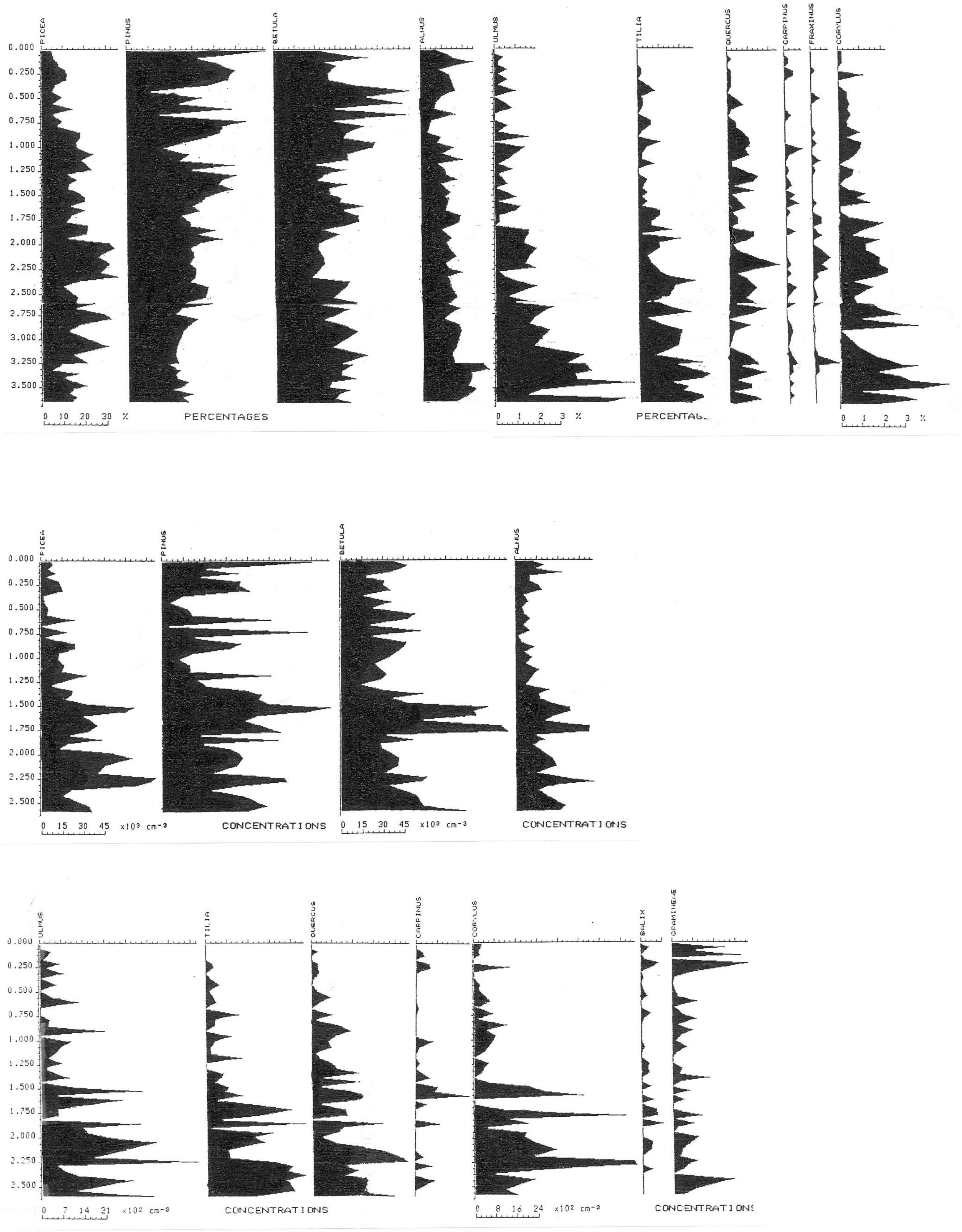

Fig. 4. Pollen diagram for the Niinsaare section.

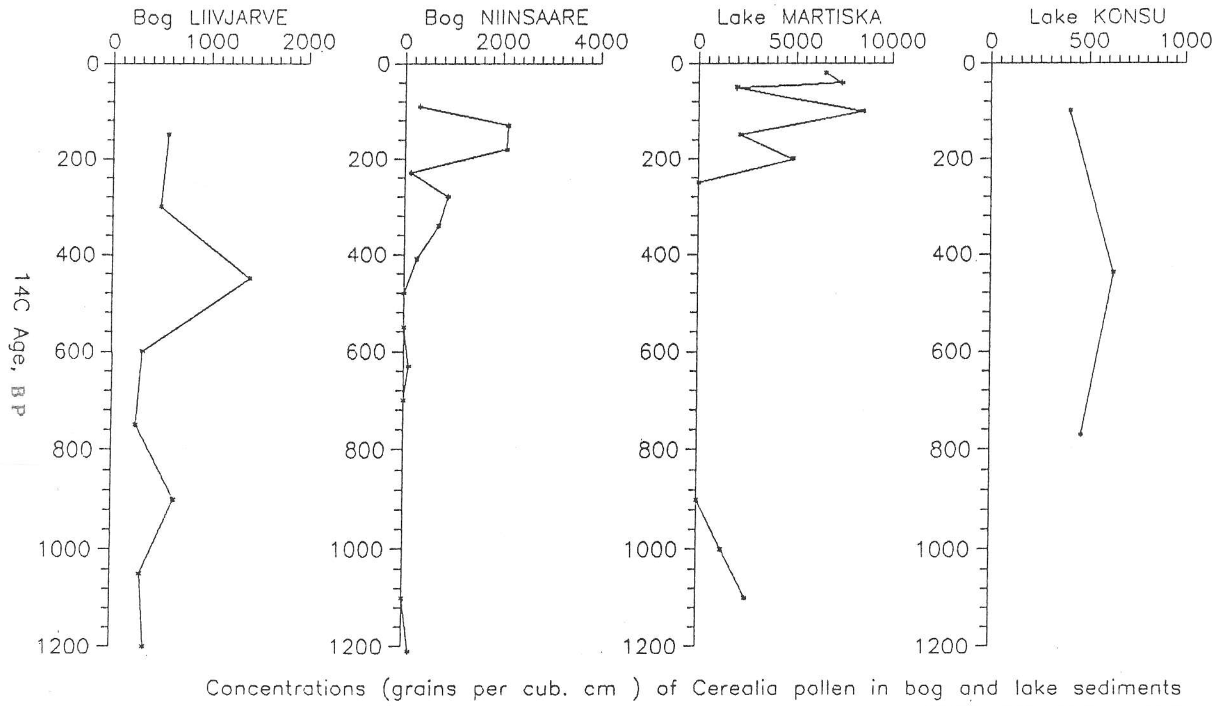

Fig 5. Cerealia input curves for different sections.

s.c. local component of the pollen spectrum (Jacobson & Bradshow, 1981). In Liivjärve, where the forest retreated in front of advancing bog, the regional component become prevailing. The same tendency can be observed also in the case of the big-sized L. Konsu.

In the time interval from 5000 to 3500 BP significant changes took place in the development of climate as well as vegetation. The share of broad-leaved species decreased and that of fir increased. Input into small lakes decreased, which might be explained by worse climatic conditions as well as the widening of bogs in the Kurtna Lake District. Pollen input remains the same in L. Konsu, probably due to its big size, which reduced the influence of changes in the lakes morphology.

In the time interval from 3500 BP to the present day the anthropogenic influence is expressed already: fires, wood filling, the beginning of agriculture. On the basis of the coal layers found in peat it has been determined that bigger fires took place 3000-2700 BP around L. Martiska and 1500 BP in the Niinsaare bog. Within the last 500 years at least five fires observable in the peat deposit haven taken place on the eastern shore of L. Konsu (Ilomets 1989).

To determine the direct anthropogenic influence on the basis of pollen data is an extremely complicated task because of the big complex of factors affecting the formation of pollen spectra. An indicator of direct influence should be the distribution regularities of the pollen of Cerealia.

The pollen of Cerealia can be met in the diagrams of all the studied sections, however, the contents nowhere exceeds 1-2%. Earliest of all, in the sediments formed 1300 BP, is fixed the appearance of the pollen of Cerealia on the Liivjärve diagram. According to archeological data settlements became more frequent in the Middle Iron age (5th-9th cent.). The settlement, which was earlier located mainly on the thinner calcareous soils in the coastal part of the North-Estonian Plateau, moved in the direction of inland to the thicker soils, in the cultivation of which burnt-over clearing played an important part. Water was more easily obtainable because of denser water-net, the vegetation of river meadows and valleys offered possibilities for the breeding of domestic animals (Eesti esiajalugu 1982).

Following the course of the Cerealia curves certain regularities may be pointed out concerning the occation of different sections on the landscape. Earliest of all, pollen grains of Cerealia appear on the diagrams of the Liivjärve and Niinsaare sections (fig 5) in the western part of the area. This is especially clearly observable with the Liivjärve bog where

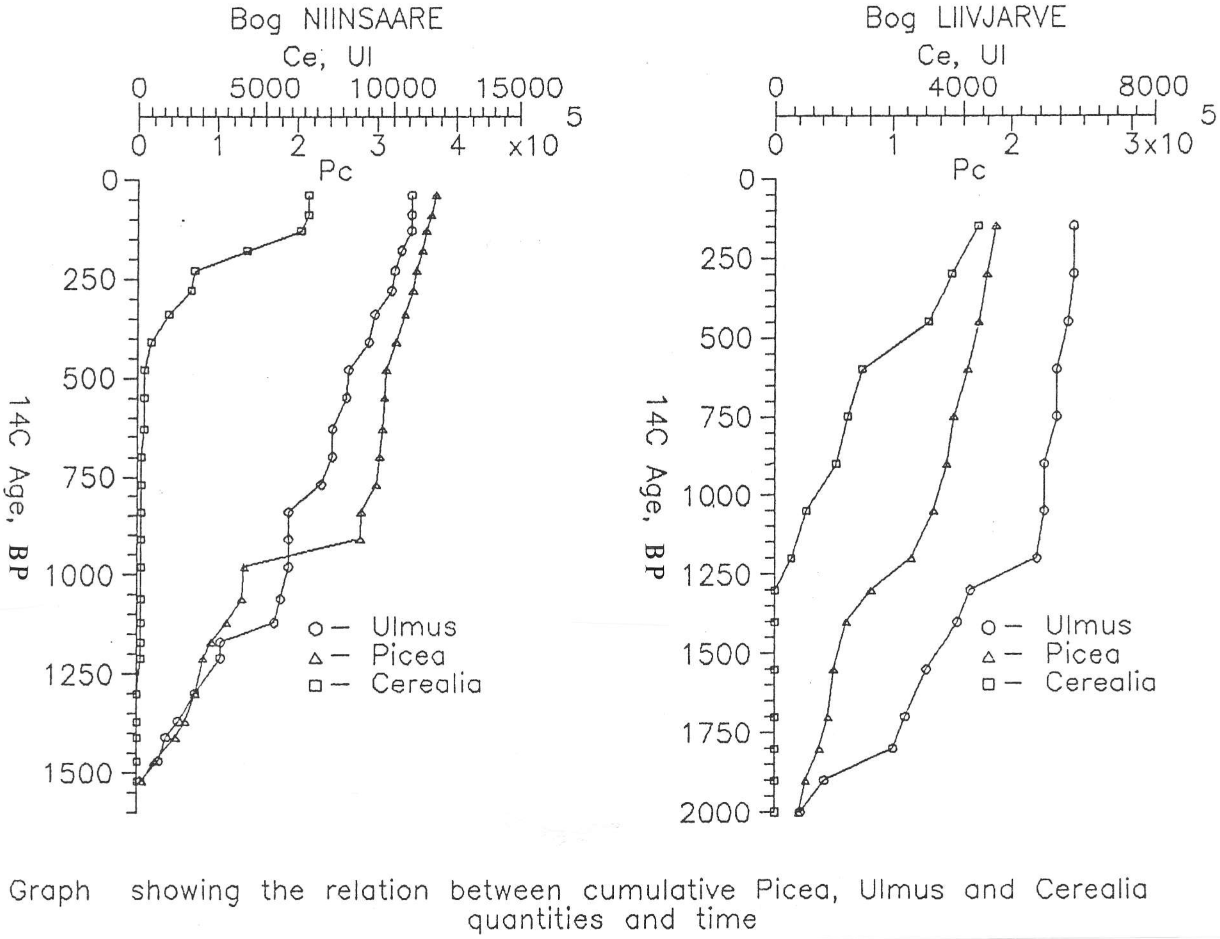

Fig 6. Cumulative curves of Cerealia, Picea, and Ulmus pollen for the Liivjärve and Niinsaare sections.

practically beginning from the depth of 1,5m Cerealia is represented in all spectra. Certain decrease is observable, however, in the sediments formed about 500 BP, which in turn is followed by a clearly felt increase. Approximately from this age limit Cerealia also appears among heath woods or on the pollen diagrams of the southern Martiska and Konsu lakes. This hints to considerable advances in land cultivation. Ceralia must also have risen above the tree-crowns which enabled it to spread rather far away (1/2 km) from the cultivated area.

At first sight it is difficult to distinguish changes connected with widened human activities on the pollen diagrams. The use of cumulative curves offers interesting possibilities here. Figure 6 presents the Liivjärve and Niinsaare sections as an example.

Together with the distribution of the pollen of Cerealia certain changes also occurred in the pollen concentrations of such taxons as Picea and Ulmus (fig 6). Especially the amount of pollen of Ulmus in Liivjärve diagram decreases considerably beginning from the layers where the contents of Cerealia starts to increase. No considerable change is observed in the concentration of Picea pollen. At the same time such connections are lacking on the diagram of the Niinsaare section.

As pollen distribution may differ in every landscape region and wood type it is necessary to know definite relationships determining the formation of pollen spectra in order to understand better the distribution regularities of pollen. The openness of landscape is known to be an important factor here, besides - broad-leaved and coniferous forests act as different filters (Vuorela 1986). The age of a forest, its degree of covering etc also play a certain role in the formation of pollen spectra. Of course, we must bear in mind that we won't find an exact analogue to the conditions in the past, but we can still get additional information to elucidate the relations between communities and pollen spectra in present conditions.

Surface moss samples were gathered in the Kurtna

Table 1. Pollenspectra over 20x20 m squares from the Kurtna Lake district.

SAMP. NR	LAKE	*PICEA*					*PINUS*					*BETULA*					*ALNUS*					*CEREALIA*
		SS	20	100	500	1000	SS	20	100	500	1000	SS	20	100	500	1000	SS	20	100	500	1000	SS
1	RAAKJARV	21	20	-	-	2	37	40	100	93	94	30	30	-	7	4	11	10	-	-	-	2
2	LIIVJARV	23	20	-	-	-	45	50	100	100	95	22	20	-	-	5	9	10	-	-	-	0.2
3	LIIVJARV	25	20	-	-	-	46	50	100	100	95	21	20	-	-	5	7	10	-	-	-	0.4
4	RATASJARV	79	30	-	-	-	8	20	33	62		11	30	67	38		1	20	-	-	-	1
5	MATASJARV	13		-	-	4	23		100	100	91	46		-	-	5	17		-	-	-	0.6
6	NOOTJARV	14		20	19	2	39		20	43	94	37		60	38	4	9		-	-	-	0.4
7	ALLIKJARV	15		-	-	7	29		10	43	46	45		90	57	46	11		-	-	-	0.4
8	VIRTSIKU	6		-	-	8	56		25	33	41	27		75	73	51	10		-	-	-	2
9	AKNAJARV	9		-	15	8	50		87	54	77	29		13	31	15	11		-	-	-	2
10	AKNAJARV	17		-	-	10	34		50	35	58	31		50	65	32	17		-	-	-	0.4
11	JAALA	20	20	10	7	4	20	40	80	72	78	51	30	10	21	8	9	10	-	-	-	4
12	MUST-JAALA	14	20	-	-	9	17	30	25	71	74	57	50	75	29	17	12	10	-	-	-	0.6
13	VALGEJARV	17	10	-	-	2	41	50	100	87	84	30	30	-	13	14	11	10	-	-	-	0.6
14	VALGEJARV	14	-	10	6	3	50	60	90	94	88	29	40	-	-	8	7		-	-	-	-
15	MARTISKA	7		-	-	3	22	30	100	67	25	60	60	-	20	69	11	10	-	3	3	0.2
16	MARTISKA	13		-	-	3	50	60	100	82	60	27	30	-	18	34	10	10	-	-	3	0.6
17	S.KIRJAK	18		-	-	5	26	70	87	75	77	41	20	13	25	18	12	10	-	-	-	0.6
18	SARGJARV	9		-	-	-	52		25	53	45	30		75	47	55	18		-	-	-	2
19	V.KIRJAK	8		-	-	4	65	70	66	64	72	21	20	34	36	24	8	10	-	-	-	2
20	SAAREJARV	31		-	25	13	13	60	50	44	62	30	20	50	31	25	25	20	-	-	-	0.6
21	POTRI	18		-	-	-	37	70				32					12		-	-	-	1.4
22	LINAJARV	3	10	-	-	9	31	30	68	75	65	15	20	52	25	26	51	40	-	-	-	2
23	LINAJARV	5	10	-	-	9	21	30	68	75	65	51	40	52	25	26	22	20	-	-	-	1
24	PIIRAKA	8	10	-	19	11	44	50	75	50	74	33	30	25	31	15	14	10	-	-	-	0.4
25	PUNANE	15		-	-	-	30	50				37	40				16	10	-	-	-	-

Lake District from 25 sampling sites near different lakes (fig 1). The samples were taken from the green part of the moss which should be cover 5-10 years, from a 4 cm area.

Comparing the obtained pollen spectra with current vegetation we departed from 4 different levels. Wood composition and general aspects were described:

1) on a square of 20x20m,
2) in a circle with a diameter of 100m,
3) 500m,
4) 1000m.

The community surrounding the direct sampling site was described during the sampling. Material of wood assessment was used to get the remaining data. Analyzing the results it seems that the pollen spectrum characterizes best the vegetation in the square of 20x20m (tab 1). This leads to the idea that in the conditions of a heath wood a pollen spectrum characterizes only very local vegetation. At the same time the pollen of Cerealia can be met in almost every sample, although the nearest fields are located at the distance of several kilometers from the sampling sites. It must be pointed out that according to several authors (Vuorela 1973, Behre & Kucan 1986) the pollen of Cerealia species is not distributed further than to the distance of 1 km even under the conditions of present day intensive agriculture. The wide distribution of Cerealia pollen in surface samples can be explained either by the peculiarities of the local meteorological conditions or by certain atmospheric reservoir of the pollen of regional cultural graminaceous species.

Conclusions

The palynological method is of great importance in paleoecological studies for the investigation of the dynamics of natural conditions as well as to distinguish different factors.

It is rather difficult to perform definite reconstructions of wood communities or to give comparative estimations on the basis of pollen diagrams. Thus, studies in NE Estonia indicate that the pollen spectra of surface samples are in good correlation only with the wood community directly surrounding the sampling site. Agreement with the community within a 100 m radius is very weak already. The complicated correlations cause difficulties in estimating the influence of human activities on the development of woods. So, according to our data there are no definite connection between the contents or influx of the Cerealia pollen and that of tree species in the spectra of the early stage of the agriculture. Here also the main problem is evidently to distinguish between the shares of the local and long-distance transported pollen. So, the surface samples from among heath woods at the distance of at least 1/2km from the nearest fields were quite rich (about 1200 grains/cm^3) in the pollen of Cerealia. Consequently, it is not possible to make extensive conclusions about primary habitation or land usage relying only upon pollen data.

References

Behre, K.E.,Kucan, D., 1986, *Die reflektion archäologisch bekannter Siedlungen in Pollendiagrammen verschiedener Entfernung - Beispiele aus der Siedlungskammer Flügeln, Nordwestdeutschland,* in Anthropogenic Indicators in Pollen Diagrams. Behre K.-E.(ed.), A.A. Balkema/Rotterdam/Boston, 95-114.

Eesti esiajalugu, 1982, Tallinn, 454 p.

Ilomets, M., 1989, *Puhatu soostiku arengust holotseenis.* in Kurtna järvestiku looduslik seisund ja selle areng. Tallinn, 75-83.

Jacobson, G.L., Bradshow, R.H.W., 1981, The selection of sites for paleovegetational studies. *Quater. Res., 1, 80-96.*

Koff,T., 1990, Reconstruction of palaeogeographical conditions in NE Estonia on the basis of bog and lake deposits, in *Estonian-finnish seminar on enviromental questions 21.-22.08.1989*Joensuu, Finland. University of Joensuu. Karelian Institute. Working papers 4, 99-115.

Punning, J.-M., Ilomets, M., Koff, T., Paap, Ü., Rajamäe, R., 1987, On the development of Lake Ümarjärv (NE Estonia) in the Holocene. *Paleohydrology of the temperate zone Tallinn,* 123-137.

Varvas, M., Koff, T., Rajamäe, R., 1987, *The use of pollen, ^{14}C and ^{210}Pb analyses in the investigation of sedimentation dynamics in lakes,* in Methods for the investigation of lake deposits: paleoecological and paleoclimatological aspects, Vilnius, 149-161.

Vuorela, I., 1973. Relative pollen rain around cultivated fields. - *Acta Bot.Fennica,* 102, 1-27.

Vuorela, I., 1986. *Palynological and historical evidence of slash-and-burn cultivation in South-Finland.*, In, Anthropogenic Indicators in Pollen Diagrams. Ed. by K.E.Behre. A.A.Balkema/Rotterdam/Boston, 53-64.