Proc. Estonian Acad. Sci. Geol., 1998, **47**, 4, 242–261

PITKASOO – A WEST ESTONIAN HOLOCENE REFERENCE SITE

Lars-König KÖNIGSSON[a] and Anneli POSKA[a,b]

[a] Department of Quaternary Geology, Institute of Earth Sciences, Uppsala University, Villavägen 16, S-75236 Uppsala, Sweden; e-mail: lars-konig.konigsson@Ekoforsk.uu.se

[b] Institute of Geology at Tallinn Technical University, Estonia pst. 7, 10143 Tallinn, Estonia; e-mail: anneli.poska@natgeog.uu.se

Received 5 January 1998

Abstract. An early diagram from the Pitkasoo Bog (Pitkasoo 1) is rediscussed and the results of new investigations are included. The biostratigraphical material covers nearly the entire Holocene, except the earliest Pre-Boreal and the end of Sub-Atlantic time, and represents the pattern of regional development. A new diagram (Pitkasoo 2), which represents more local conditions, covers the later development of the Pitkasoo area.

The Pitkasoo 1 diagram comprises a number of signals pointing to human disturbances of the area during the Mesolithic. The Neolithic *landnam* phase appeared *c.* 4400 BP, but there may be hiatuses included both in the beginning and the end of it. A 200–300 years lasting settlement phase, with both crop cultivation and animal husbandry, is suggested. The first traces of farming appeared during the Bronze Age. Permanent habitation, with a full spectrum of agrarian activities, started *c.* 1000–1500 BP. Traces of human impact are present throughout the Pitkasoo 2 diagram; still, the signals of agricultural activities concentrate in the upper half of the diagram.

Key words: Holocene, pollen analysis, vegetation history, human impact, *landnam.*

INTRODUCTION

The aim of this paper is to describe the Pitkasoo Bog in Saaremaa (formerly Ösel) as a possible Holocene biostratigraphic reference site and to compare new results with already published ones (Saarse & Königsson, 1992; Poska, 1994; Saarse, 1994).

The Pitkasoo Bog has been examined twice before (Kessel & Raukas, 1967; Saarse & Königsson, 1992). New material was collected during the summer 1991 (sampling of three cores: Pitkasoo 2–4, and coring of two stratigraphic transects; Königsson et al., 1998a) and additionally in summer 1996 (samples for ^{14}C dating).

The redesigned diagrams from the Pitkasoo Bog, where ecological and semiecological groups have been introduced, are presented. Owing to peat cut and agricultural reclamation, the uppermost layers in the bog are destroyed. A new diagram, Pitkasoo 2, worked out on a very shallow gyttja-peat sequence, is considered to represent the latest phases (Sub-Atlantic or parts of it) of the landscape history.

METHODS

Two transects were cored through the bog in 1991 with a Belarus peat auger (Königsson et al., 1998a; Fig. 1). Two cores, Pitkasoo 3 and Pitkasoo 4, were selected for sampling, both from the eastern part of the bog. Pitkasoo 4 comprises only the lowermost parts of the sequence, while Pitkasoo 3 was made through the whole stratigraphy and yielded information comparable with materials from Pitkasoo 1 gathered by Helgi Kessel.

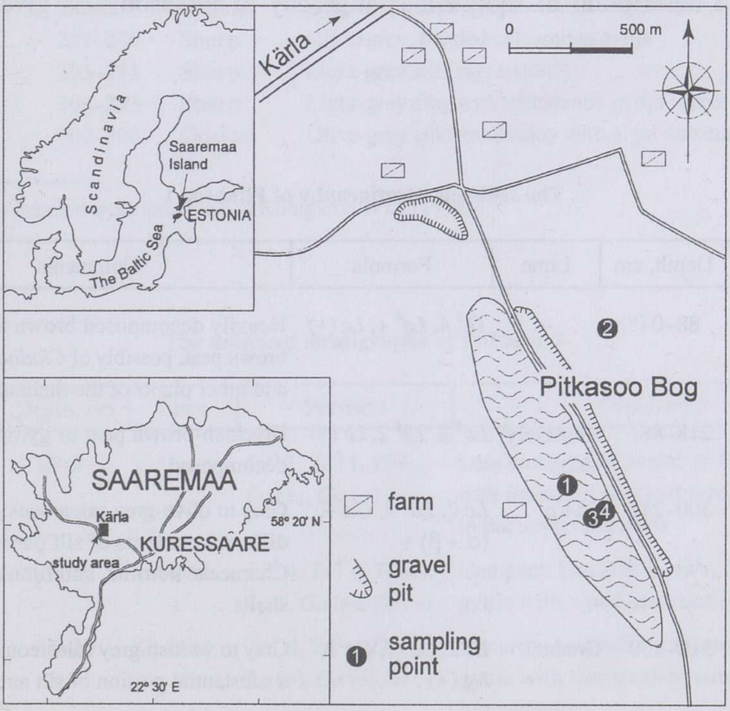

Fig. 1. Location of the Pitkasoo Bog and sampling sites.

As the uppermost parts of the bog have been destroyed by amelioration works and subsequent oxidizing, a small fen NE of the Pitkasoo Bog proper, traversed by a small tributary stream was selected for sampling (Pitkasoo 2). It was expected to cover the vegetation and the landscape development during later times, which could not be received in the other parts of the bog. The principles of the construction of pollen diagrams are published in Königsson et al. (1998b).

LITHOSTRATIGRAPHY

For every sediment unit, along with usual description, the formula according to Troels-Smidt (1955) and upper *limes* (gradual: ≥1(2) cm and sharp: ≤1(2) mm) are described.

The material for the Pitkasoo 1 diagram was collected by Helgi Kessel in 1971. The description of the section was made on the basis of the dried material received from her (Saarse & Königsson, 1992). Due to problematic conditions of the original core, a detailed description of the new core (Pitkasoo 3) is included in the present paper and rough comparison with Pitkasoo 1 is made (Tables 1, 2). A detailed description of sediment stratigraphy of Pitkasoo 2 is given as well (Table 3).

Table 1

The sediment stratigraphy of Pitkasoo 1

Unit	Depth, cm	Lime	Formula	Comments
4	88–0 (?)	–	Th^4 4, Ld^4 +, Lc (+)	Heavily decomposed brown to blackish-brown peat, possibly of *Cladium mariscus* and other plants of the thelmatic zone
3	218–88	Relatively sharp	Ld^4 2, Th^4 2, Lc (+)	Blackish-brown peat or gyttja, heavily decomposed
2	300–218	Sharp	Lc 2, Ld^2 2, Ga +, $(\alpha + \beta)$ +	Grey to olive-grey calcareous gyttja with different contents of silt particles, algal Characeae detritus, and limnic mollusc shells
1	310–300	Gradual	Lc 2, Ld^2 1, Ga 1, Ag (+)	Grey to whitish-grey calcareous gyttja with a substantial portion of silt and clay
Substratum				Unknown

Table 2

The sediment stratigraphy of Pitkasoo 3 and comparison with Pitkasoo 1

Unit: Pi 3/Pi 1	Depth, cm	Lime	Comments
32 / 4	16–0	–	*Stratum confusum*
31 / 4	115–16	Gradual	Dark-brown peat
30 / 4	150–115	Gradual	Well-preserved brown peat
29 / 4	155–150	Gradual	Dark-brown peat
28 / 3	**175–155**	**Sharp**	Compact black peat
27 / 3	185–175	Gradual	Blackish-brown, rather compressed peat
26 / 3	200–185	Gradual	Blackish-brown peat with wood fragments
25 / 3	210–200	Gradual	Transition from reddish-brown to brown gyttja
24 / 3	214–210	Gradual	Brown algal gyttja
23 / 2	221–214	Gradual	Pink, calcareous gyttja with shells
22 / 2	231–221	Gradual	Characeae-banded calcareous gyttja
21 / 2	250–231	Gradual	Grey, Characeae-banded calcareous gyttja
20 / 2	266–250	Gradual	Yellowish to grey Characeae-banded lime gyttja
19 / 2	272–266	Gradual	Yellowish to white Characeae-banded lime gyttja
18 / 2	**277–272**	**Sharp**	Brownish to olive-grey Characeae-banded lime gyttja
17 / 2	280–277	Gradual	Grey calcareous gyttja without visible structures
16 / 2	**291–280**	**Sharp**	Olive-grey, banded calcareous gyttja
15 / 1	**293–291**	**Sharp**	Light-grey silt (ingression?)
14 / 1	**306–293**	**Sharp**	Light-grey clay with calcareous gyttja layers
13 / 1	309–306	Gradual	Olive-grey calcareous clay with algal detritus

Units 1–12 – detailed description see in Königsson et al. (1998a).

Table 3

The sediment stratigraphy of Pitkasoo 2

Unit	Depth, cm	Lime	Formula	Comments
3	10–0	–	*Ld*^{4} 3, *Th*^{4} 1, *Tl* +, *Lc* (+), *Ga* (+)	Less compact brownish to black gyttja with increased peat and rootlet contents in the uppermost parts
2	28–10	Gradual	*Ld*^{4} 4, *Th*^{4} +, *Tl* (+), *Lc* +, *Ga* (+), *Gs* (+)	Compact, blackish-brown, fine-grained gyttja with wood and rootlets, silty
1	35–28	Gradual	*Ld*^{3} 4, *Th*^{3}+, *Tl* +, *Lc* (+), *Ga* (+),*Gs* (+)	Minerogeneous (silty to sandy) brown gyttja with fine particle structure, homogeneous
Substratum		Sharp		Clay-rich till

DATING

Altogether six ^{14}C dates are available from the site considered. Unfortunately the main core (Pitkasoo 1) has never been dated. During field work in 1991 three new cores were sampled (Pitkasoo 2–4). One date from the Pitkasoo 3 core is available (Königsson et al., 1998a), but both diagrams discussed here do not reach the same stratigraphic level. In 1996 a new core was taken from the central part of the basin to supplement earlier diagrams with ^{14}C dates. Five samples for conventional ^{14}C dating were collected; the dating was made at the Radiochemistry Laboratory, Institute of Geology, University of Tartu (Table 4). From the same levels samples for pollen analysis were taken. The correlation analysis was used to match the dated levels with those analysed in Pitkasoo 1. However, it must be taken into consideration that the time estimations presented here may be inaccurate due to uncertainty in correlating the sequences.

Table 4

The radiocarbon dates available and correlation with Pitkasoo 1

Depth, cm	Sediment	^{14}C date	Dendrocalibrated	Laboratory No.	Depth in Pi 1, cm
50–60	Peat	2720 ± 30	2920 ± 80	TA-2566	40–50
100–110	Peat	4360 ± 40	5000 ± 160	TA-2567	80–90
150–160	Peat	5390 ± 40	6200 ± 100	TA-2568	132–142
200–210	Peat	6280 ± 40	7100 ± 80	TA-2569	185–193
210–223	Peat	6640 ± 50	7500 ± 90	TA-2570	197–205
250–260	Gyttja	7280 ± 50	7900 ± 100	TA-2571	225–235

BIOSTRATIGRAPHY

The biostratigraphical material has been combined with chronozones proposed by Mangerud et al. (1974) and Raukas et al. (1995).

Pitkasoo 1

The lowermost parts of the sequence reach into the Pre-Boreal, but most likely only the latest parts of it (Figs. 2–5). The general impression is that tree pollen is dominating the pollen spectra throughout the diagram. *Corylus* starts, as does *Ulmus*, already in the lowest analyses, and both of them reach the rational limit already within the Pre-Boreal. *Corylus* and *Ulmus* increase in the middle of the Early Boreal. The *Salix*, *Juniperus*, *Populus*, and *Hippophaë* pollen appear in considerable amounts both in the Pre-Boreal and Early Boreal.

Arboreal Pollen (1; Fig. 2). The increase in the Arboreal Pollen (AP), introduced with the Late Boreal, is mainly due to an increase in *Alnus*, which is so prominent that one could suspect the presence of a hiatus. The *Ulmus* curve has rather high levels from the middle of the Early Boreal, and a low amount of *Quercus* is present. *Tilia* is considered to have immigrated (with scattered occurrences before), when it passes its rational limit by the end of the Late Boreal. At the initiation of the Early Atlantic, all the Quercetum Mixtum (QM) constituents (1A:b) appear in very large amounts. *Acer* is mostly present only in the uppermost part of the diagram. *Picea* immigrates quite early and has a pronounced maximum during the Atlantic times, but it increases further in the Sub-Boreal zones, and especially with the beginning of the Sub-Atlantic.

The most impressive part of the diagram is, however, the *landnam* phase (Iversen, 1941), which is evident at the beginning of the Early Sub-Boreal. It is a rather characteristic phase, marked by an increase in the *Juniperus* pollen concurrently with a big drop both in the *Alnus* curve and in the curves of various QM constituents. At the same time, *Pinus* and *Picea* increase their share in the sum, which may be due to the introduction of a temporary open landscape, which favoured distantly produced and long-distance transported pollen. There is also a simultaneous increase in the bush pollen curve (1E), possibly for the same reason.

With the beginning of the Early Sub-Atlantic the *Picea* growth increases markedly. It is combined with a drop in all QM curves. However, there are signs of two culminations in the *Ulmus*, *Tilia*, and *Fraxinus* curves later. The amount of dwarf bushes (2) rises again, mainly due to an increase in the *Calluna* curve. *Juniperus* increases notably in the upper parts of the diagram.

Xerophytic plants (3A:a,b; Figs. 2, 3). There are abundant *Artemisia*, Chenopodiaceae, *Juniperus*, and *Populus* both in the lower and upper parts of the diagram. Pollen of *Plantago lanceolata* appears in the Sub-Boreal and upwards.

Terrestric plants (3B; Fig. 3), except for *Melampyrum* pollen which occurs both in the lower and upper parts of the diagram are mainly connected to the entering Sub-Boreal conditions and later time.

Cultivated plants (3C; Fig. 3). Most of this pollen appears during the Sub-Boreal, but some amounts are recorded also in the lowermost parts of the diagram within the Cannabaceae pollen which has been interpreted as derived from the *Humulus*-type.

Hemerophilous plants (3D:a,b; Fig. 3). The expected subdivision of the culturally adopted plant pollen occurs and is especially evident in the following taxa which are represented both in the bottom parts of the diagram, and in the Sub-Boreal and later: *Artemisia*, Asteraceae tubuliflorae, Chenopodiaceae, *Filipendula*, *Galium*, Gramineae, *Melampyrum*, *Potentilla*, Ranunculaceae, and *Rumex acetosa*-type. Both *Juniperus* and Gramineae show appreciable quantities in the later parts of the Atlantic.

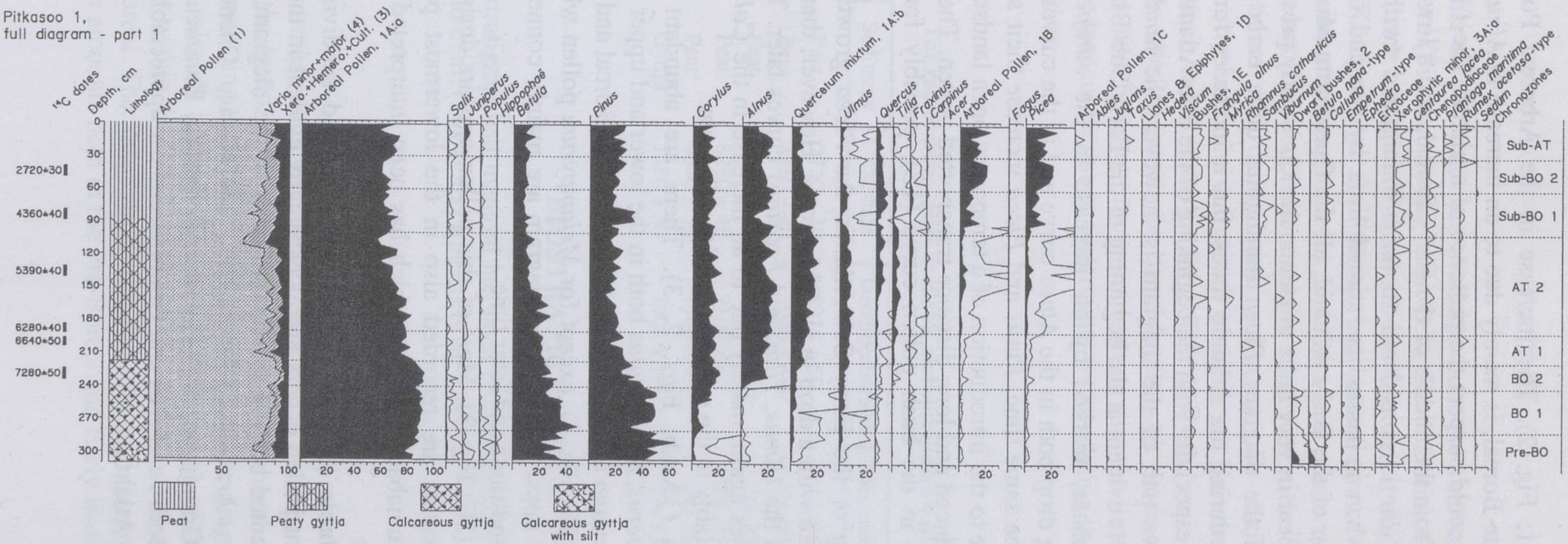

Fig. 2. Pollen diagram of the Pitkasoo Bog (Pitkasoo 1), full diagram, part 1. Analyses by I. Lundwall. In Figs. 2–9 all taxa are presented as percentage (solid graphs) of the terrestrial pollen. Hollowed graphs show an exaggeration by 10 (1A–1B, 10A) or by 20 (1C–9A).

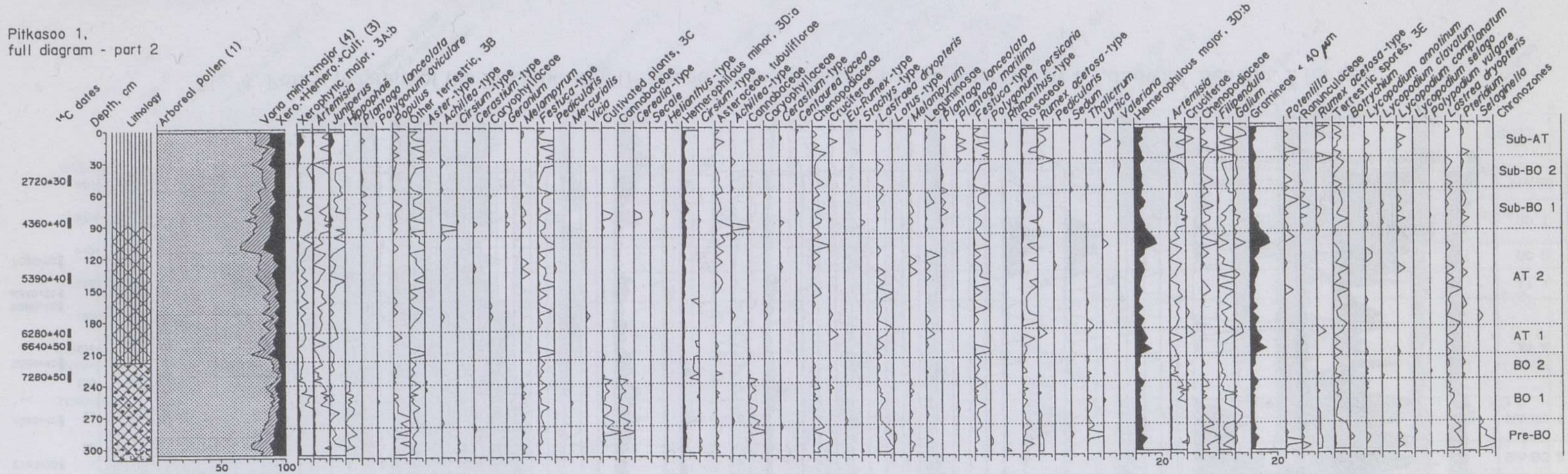

Fig. 3. Pollen diagram of the Pitkasoo Bog (Pitkasoo 1), full diagram, part 2. Analyses by I. Lundwall. See Fig. 2 for key.

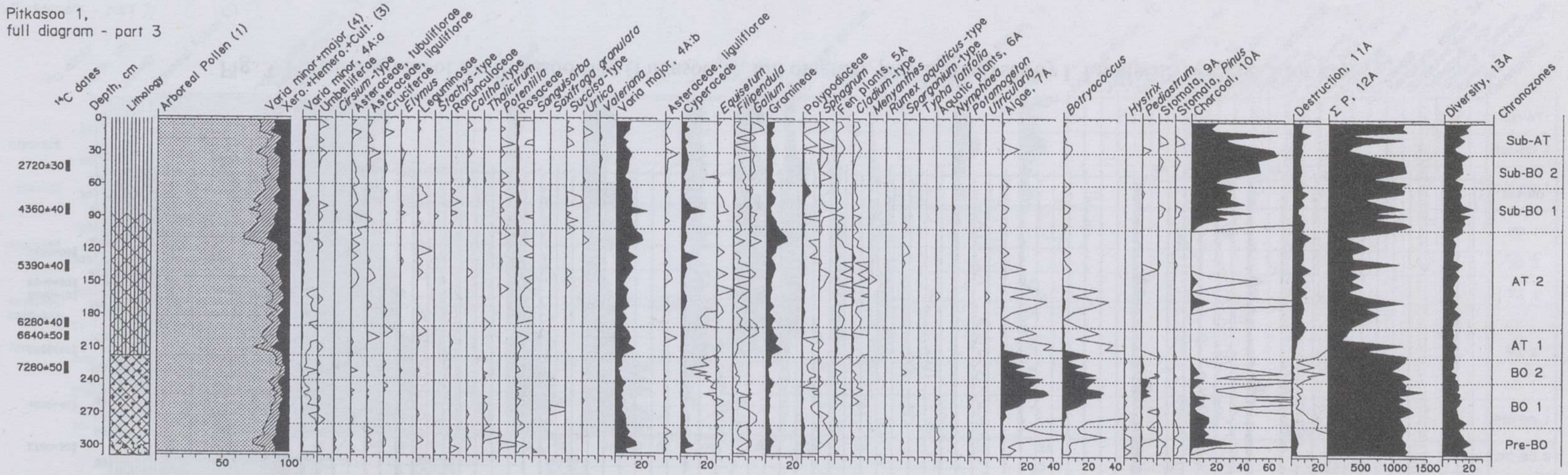

Fig. 4. Pollen diagram of the Pitkasoo Bog (Pitkasoo 1), full diagram, part 3. Analyses by I. Lundwall. See Fig. 2 for key.

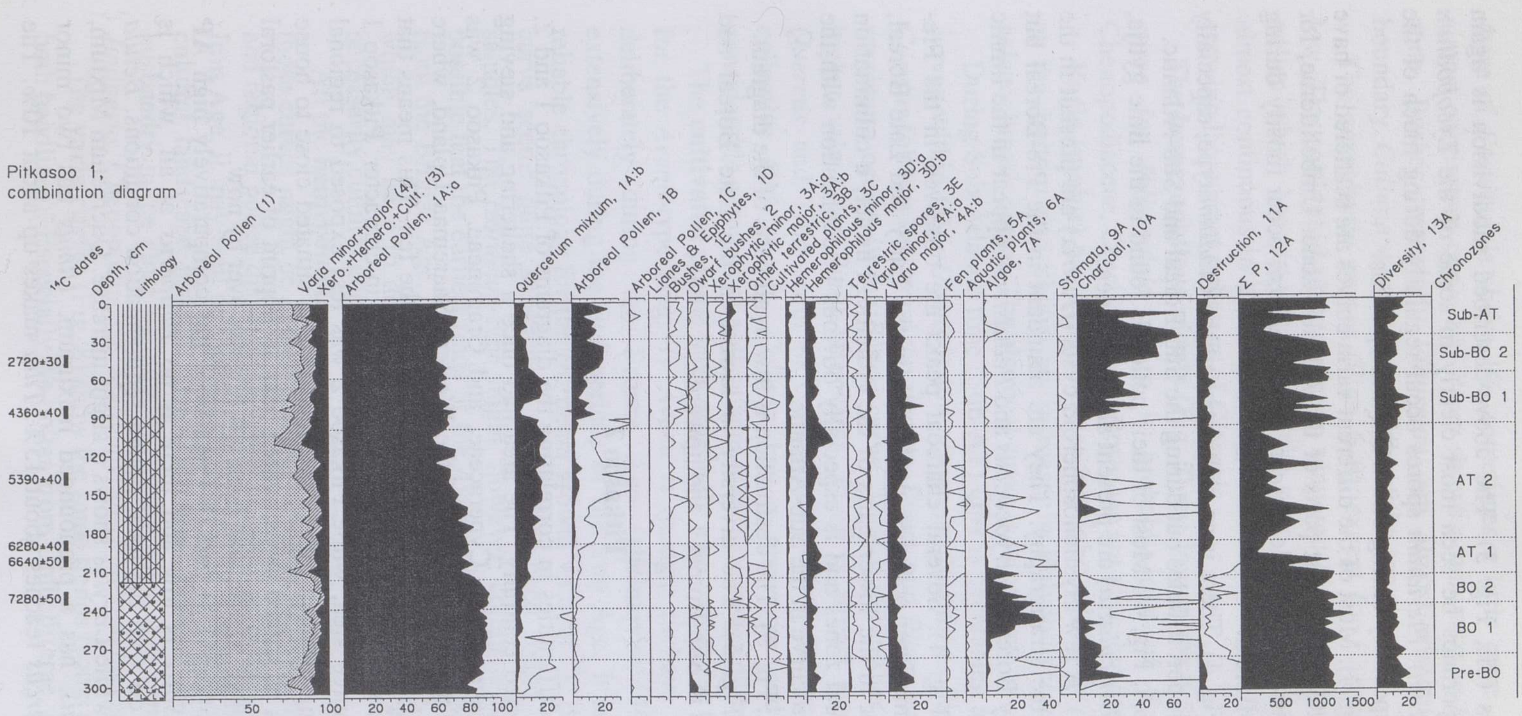

Fig. 5. Pollen diagram of the Pitkasoo Bog (Pitkasoo 1), combination diagram. Analyses by I. Lundwall. See Fig. 2 for key.

Terrestric spores (3E; Fig. 3). The above-described subdivision is again obvious, but might perhaps be seen most clearly in some of the *Lycopodium* spores (*L. complanatum*). *Pteridium* spores occur regularly during much of the Atlantic times, but especially during Sub-BO 1 and upwards.

Varia (4A:a,b; Fig. 4). Most of the different varia curves are scattered or have a special affinity to the uppermost parts of the Atlantic zone. Umbelliferae, for instance, appears in this way, while *Potentilla* and *Succisa* occur mostly during the Atlantic and Sub-Boreal.

Fen plants (5A; Fig. 4). There is an abundance of the *Cladium*-type, especially during the Atlantic proper. It fades out during the Sub-Boreal and Sub-Atlantic.

Aquatic plants (6A; Fig. 4). Most of their pollen is found in the lime gyttja, but some quantities (*Utricularia*) are present also in the peat.

Algae (7A; Fig. 4). A few Hystichospheroid cysts (*Hystrix*) are present in the lowermost levels of the stratigraphy. They are abundant in the Pre-Boreal but occur also in the Early Boreal. *Botryococcus* and *Pediastrum* appear in the limnic part of the sequence.

Charcoal (10A; Fig. 4). Several charcoal peaks are observed in the Pre-Boreal. There are some later peaks as well, both in the Early and Late Boreal, and two peaks appear in the lower parts of the Atlantic. Further, a culmination starts in the Sub-Boreal zones and is especially obvious in connection with the maximum of the *Picea* curve in the Sub-Atlantic.

Destruction (11A; Fig. 5). The destruction is low in all parts of the diagram.

Diversity (13A; Fig. 5). The diversity is lowest in the Late Boreal and Atlantic but increases in Sub-Boreal 1 and upwards.

Pitkasoo 2

There are several difficulties in correlating the diagrams of Pitkasoo 1 and 2. Pitkasoo 1 was collected centrally. The area had once a sheltering and sieving curtain of *Salix*, *Betula*, *Alnus*, Cyperaceae, and Gramineae. Pitkasoo 2 was collected NE of the fen on the slopes of the Western Saaremaa Upland, where surplus water (possibly spring water) was drained into the fen. This means that the pollen sedimentation in the two basins was different in character. Pitkasoo 1 had a wide pollen source area, while Pitkasoo 2 was less exposed to regional sedimentation and long-distance transport. Pitkasoo 2 is situated close to house remains and remnants of grazed areas, which bear an imprint of earlier pastoral or agricultural landscapes, which have been left to grow over by now.

The Sub-Boreal (Sub-BO 2) part of Pitkasoo 2 has comparatively high **AP curves** (Figs. 6–9). *Salix* is low and there is no *Juniperus* at all, which is surprising but has to do with the local pollen sedimentation conditions. *Betula* and *Pinus* are stable, while *Corylus* shows a slight increase. Quercetum Mixtum, dominated by *Quercus,* has a pronounced maximum. *Ulmus* has two minor culminations and *Quercus* reaches about 15%. *Tilia* makes up about 10%. The share of *Fraxinus* is above 1%, sometimes a little more. *Acer* occurs with an almost continuous curve and *Picea* shows a minimum in the upper parts of the zone. Bushes, especially *Viburnum*, are almost continuous below the zone boundary. *Calluna* starts in the middle of the zone.

The **xerophytic curves** (Figs. 6–9), except for Chenopodiaceae, are rather low. The **cultivated plants** contain scattered *Hordeum*-type and the *Avena*-type pollen which become common at the zone boundary. Gramineae, > 40 μm, is almost continuous in the whole diagram, but could also include spontaneously growing large grass pollen as of *Glyceria*.

The **hemerophilous plants** (Fig. 7) are low in the bottom part, with a high curve for *Filipendula* which is probably part of the local pollen rain. Chenopodiaceae, Cruciferae, and Rosaceae are also abundant.

Varia (major) has a high *Filipendula* (also within the hemerophilous curve) at the bottom and shows an increase in Polypodiaceae, which might be a palaeoclimatic signal. The charcoal curve is rather low.

During Sub-Atlantic time (Sub-AT) **QM** is decreasing and this is valid for all curves within QM: *Ulmus* is low, *Quercus* diminishes like *Tilia* and *Fraxinus*. *Corylus* follows this trend too. *Betula*, *Pinus*, and *Picea* increase. The first slight maximum occurs in the *Betula* curve. Then it diminishes and instead there are higher values for *Pinus* afterwards. *Picea* is almost evenly distributed. Both *Quercus* and *Tilia* seem to correspond well to the uppermost parts of the collective QM curves. *Calluna* has a maximum and is accompanied by considerable amounts of pollen from other Ericaceae and by the *Vaccinium*-type.

The **cultivated plants** have especially high values for the *Hordeum*-type and for the *Avena*-type (Fig. 7). *Avena* is thought to have been cultivated more deliberately during the Bronze Age (Hjelmqvist, 1955), and especially extensively during the first periods of the Iron Age. It is impossible to give a reliable chronology for the *Hordeum* growth without ^{14}C dates, but the *Hordeum* curve seems quite substantial, and it has been found present in almost all samples. The *Hordeum*-type might, however, comprise also millet pollen. It is possible that the earliest finds of the *Avena*-, *Hordeum*-, and *Triticum*-types date from the Bronze Age. There are a number of other finds (Gramineae, > 40 μm) which may have to do with human activities, even if all these finds are not necessarily cultural grasses.

All the **hemerophilous** curves (Figs. 7, 8) show increasing numbers. Many of those curves might be expected to rise towards the present time, but as the local and regional pollen dispersal probably does not increase after the initiation of the Iron Age, it may well be that the curves reflect a growth in plant diversity of the cultural landscape instead. The Gramineae curve might reflect an increasing husbandry in the close vicinity, especially when it is combined with *Artemisia*, *Juniperus*, Chenopodiaceae, *Melampyrum*, *Plantago lanceolata*, and *Pteridium*.

The **varia curves** (Fig. 8) show the same trends (some curves are found under both headlines). Especially the pollen from Umbelliferae, Asteraceae liguliflorae,

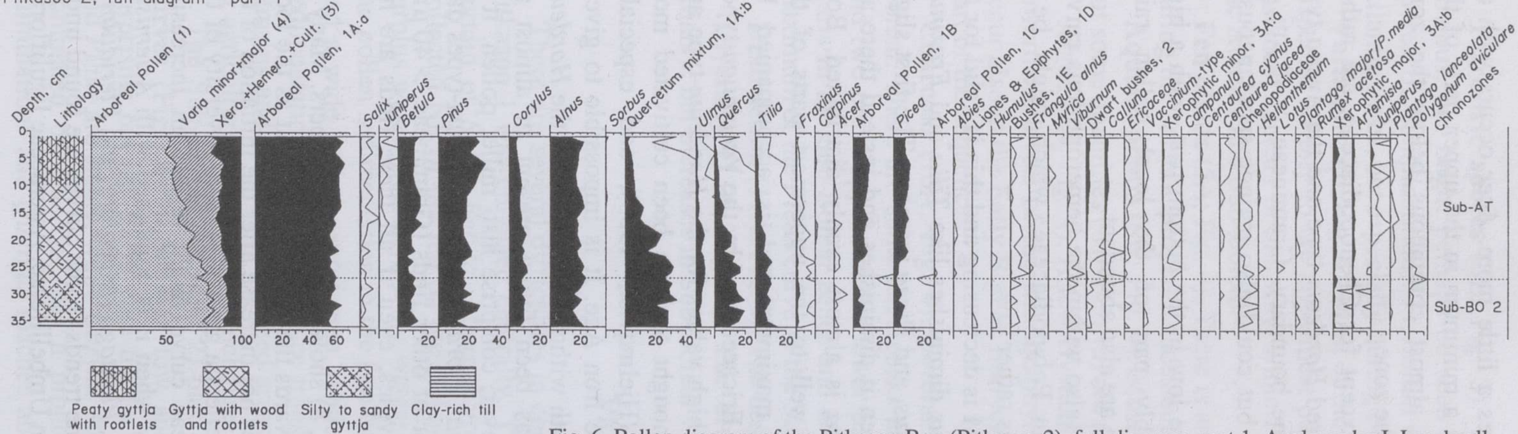

Fig. 6. Pollen diagram of the Pitkasoo Bog (Pitkasoo 2), full diagram, part 1. Analyses by I. Lundwall.

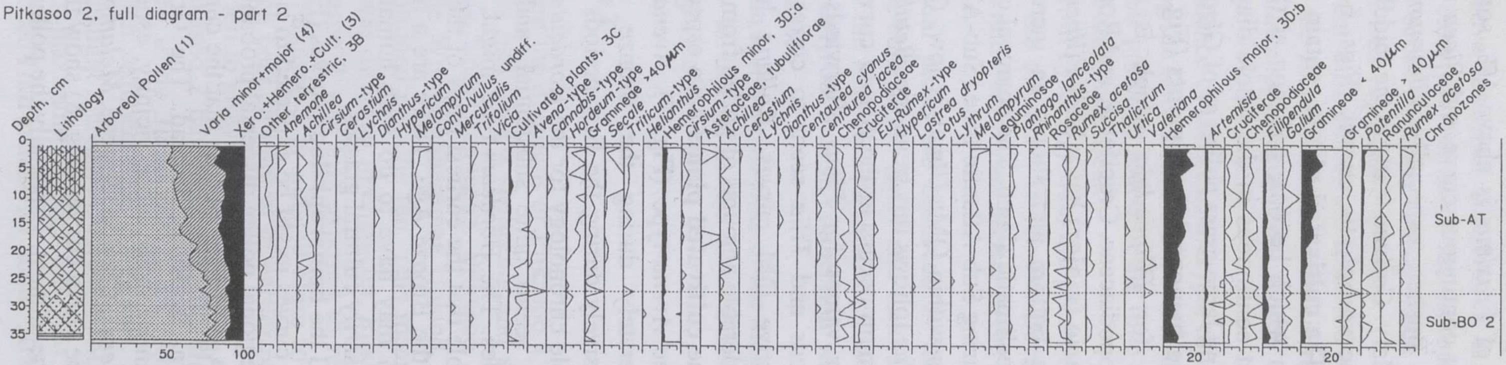

Fig. 7. Pollen diagram of the Pitkasoo Bog (Pitkasoo 2), full diagram, part 2. Analyses by I. Lundwall. See Fig. 6 for key.

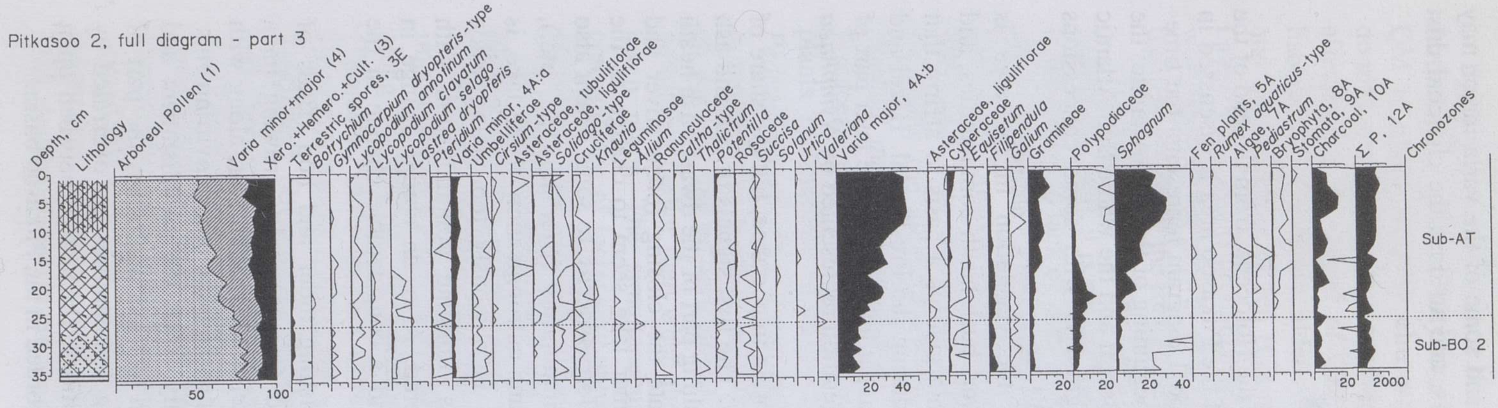

Fig. 8. Pollen diagram of the Pitkasoo Bog (Pitkasoo 2), full diagram, part 3. Analyses by I. Lundwall. See Fig. 6 for key.

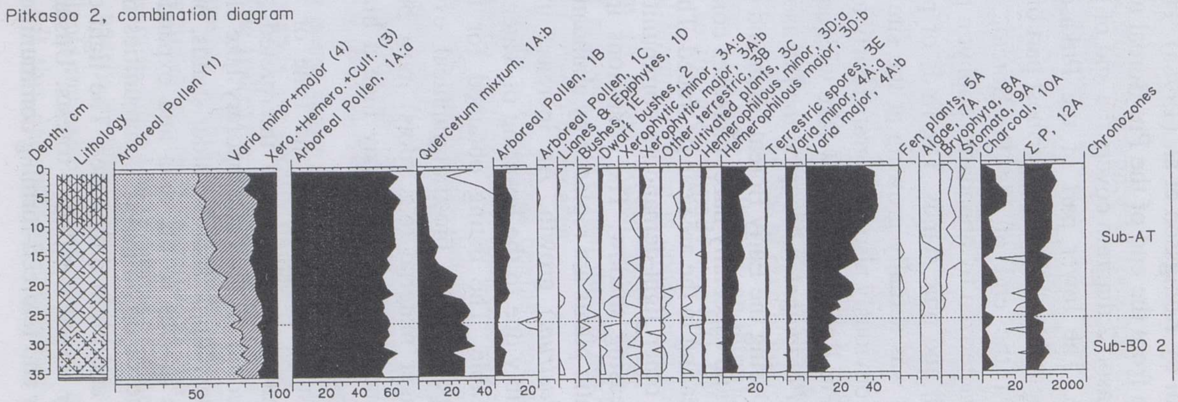

Fig. 9. Pollen diagram of the Pitkasoo Bog (Pitkasoo 2), combination diagram. Analyses by I. Lundwall. See Fig. 6 for key.

the *Solidago*-type, Ranunculaceae, *Potentilla*, and some of the varia major may support the development of cultural landscapes, and so does the charcoal dust curve.

DISCUSSION

The studied material covers the main part of the Holocene, from the end of the Pre-Boreal. The earliest development history of the Pitkasoo area is discussed in detail by Königsson et al. (1998a). The Pitkasoo 1 diagram represents the time-span from the end of the Pre-Boreal up to the beginning of the Sub-Atlantic; the Pitkasoo 2 diagram covers the end of the Sub-Boreal and the whole Sub-Atlantic time. The lower part of the Pitkasoo 2 diagram is with some concessions comparable with the uppermost part of Pitkasoo 1.

At the end of the Pre-Boreal, much of the vegetation in the area is characterized by abundant apophytic plants, dwarf bush heath communities, and birch and pine stands. The finds of pine stomata give us a basis to affirm that pine was actually growing at the site already during the Pre-Boreal. Hazel and elm obviously also immigrated early to Saaremaa, at least during the later part of the Pre-Boreal. A shallow lake with aquatic vegetation represented by *Nymphaea* and *Potamogeton* occupied the Pitkasoo basin.

During the Early Boreal birch and pine maintain importance, but the share of elm and especially hazel increases considerably. The first signals of oak and ash appearing in the area can be traced. The diminishing part of the dwarf bush heath and other light-demanding communities indicate the closing forest cover and increasing shadow. The conditions in the former lake seem to change as the aquatic plants are replaced by abundant algae (*Botryococcus*, to some extent also *Pediastrum*) growth. An increase in fen communities (*Cladium*-type, etc.), possibly due to the lowering of water level or/and eutrophication of the lake, is traceable. The dating obtained for this zone is obviously too young when compared with biostratigraphical expectations. Possible contamination with younger material (e.g. roots) must be considered. Also, an abrupt change in sediment composition may hide a hiatus or/and a considerable change in the sedimentation rate.

The Late Boreal is the time of the flourishing alder and hop (finds of Cannabaceae pollen are interpreted as derived from naturally growing liana *Humulus*) on the contemporary lake shore. Hazel is thriving further, along with the development of the alder stands, but apparently in quite other environments. Lime arrives to the area and expands gradually. With the establishment and spread of broad-leaved communities in addition to hazel and alder, the part of pine and birch diminishes. The light-demanding communities are overruled by shady mixed deciduous forests. Unstable conditions, fluctuation between open water and fen/reed-forming communities, are recorded in the Pitkasoo basin.

During the Early Atlantic the portion of broad-leaved trees in forest increases further. Oak and especially lime become more frequent, but the main phase of the QM is represented by elm which together with hazel must have been the dominant tree in the surroundings of Pitkasoo. The alder stands seem not to be affected by the spread of QM, most probably due to different demands for habitat; on the contrary, alder still expands to some extent. The final immigration and establishment of fen (*Cladium*-type) and reed (the main part of the rising Gramineae curve is probably derived from *Phragmites* reeds) communities, along with diminishing growth of algae and disappearance of aquatic plants, indicate the overgrowth of the former lake.

At the initiation of the Late Atlantic the first appearance of spruce in the area is detected. Still, it is not quite able to compete successfully with deciduous trees. Possibly due to lack of suitable habitats in a close vicinity of the basin its portion stays negligible. The vegetation development is characterized by luxuriant deciduous forests with a high content of broad-leaved trees. During the second part of the Late Atlantic, a slight instability of forest development is traceable; especially the alder stands and broad-leaved trees seem to be affected. Two charcoal maxima, simultaneous with the increase in *Juniperus*, *Sambucus*, and Ericaceae, are accompanied by high values of light-demanding and xerophytic plants (Asteraceae liguliflorae, A. tubuliflorae, Leguminosae, *Melampyrum*, *Pedicularis*, and *Pteridium*), and an increase in the diversity of taxa is interpreted as indicative of opening up of the landscape. This may well mark an introduction of pastoral and/or agricultural practices to the area already *c.* 5400 BP, thus noticeably earlier than when the classical *landnam* phase is considered to have taken place. The simultaneous increase in *Picea* pollen may rather be a consequence of increasing importance of regional pollen rain due to landscape opening up than of a real advance of spruce growth in the area.

In the Early Sub-Boreal the share of broad-leaved trees begins generally to decrease simultaneously with a considerable increase in spruce frequencies. Nevertheless, the hazel and alder stands are not affected and oak seems to gain in importance, obviously favoured by the above shift. This change may be brought along by climate deterioration at the beginning of the Sub-Boreal period (Thomson, 1929; Iversen, 1941; Mörner & Wallin, 1977). In the middle of the Early Sub-Boreal, *c.* 4400 BP, a *landnam* phase in the sense of Iversen (1941) is remarkably obvious. All deciduous tree stands are greatly damaged, only hazel and birch seem to maintain their place. The following notable increase in *Pinus* and *Picea* pollen is probably more connected with their overrepresentation in open landscape than with the actual number of trees present in the area. Nevertheless, the finds of pine stomata point to the actual presence of pine trees around the site. The diversity of taxa nearly doubles; the portion of light-demanding, xerophytic, and cultivated plants increases, accompanied by a very well developed maximum of charcoal. All this can only be explained as an introduction of a cultural landscape. Still, it does not look like crops had ever been grown in the immediate vicinity of Pitkasoo. Instead, the settlement site surrounded by grazing and mowing grounds could be expected. The contemporary Pitkasoo basin itself, with prevailing fen communities (mainly Gramineae and Cyperaceae), got somewhat drier (the sedimentation of peaty gyttja was replaced by peat) and must have been an attractive ground for cattle rearing. The settlement phase lasted about 200–300 years; then the area was abandoned and forest cover was restored into its previous state. A possible reason for settlement abandonment may be a change in vegetation, induced by impoverishment of land. The appearance of *Sphagnum*, *Myrica*, *Calluna*, etc. mark such shifts in the Pitkasoo basin.

The Late Sub-Boreal is a relatively stable period in the Pitkasoo area; the forest communities prevail. The vegetation is dominated by rapidly expanding spruce and relatively abundant pine. The portion of broad-leaved trees is small and diminishes further on. It seems that spruce competes mainly with elm, lime, and ash for habitat and overrules these quickly, but has a much lower effect on oak stands. Hazel, alder, and birch seem to be able to hold their position. The charcoal curve is still very substantial and forms a remarkable maximum. The increase in spruce may be related to the assumed climatic deterioration (Sernander, 1910; Bergeron et al. 1956; Gräslund, 1980) which starts during the Bronze Age and becomes accentuated during the Early Iron Age (*La Tène*; cf. Hjelmqvist, 1955).

The Sub-Atlantic period is characterized by open landscape with conifer dominated forests. The rising diversity index and spread of xerophytic and heliophytic plants indicates the establishment of open cultural landscape. Finds of cultivated plant pollen are scarce. The first, quite short-lived, but distinguishable rise in cultivation indicators (barley, oats, and wheat pollen), coinciding with the introduction of *Calluna*, could, in this case, be dated to the change between the Bronze Age and the Early Iron Age. This is the time of the "celtic fields" which might have promoted *Calluna* growth, at least as far as the Gotlandic circumstances are concerned. The continuous presence of cultivated plants, antropochores and apophytes starts somewhat later, during the second part of Sub-Atlantic time, indicating that both crop cultivation and pastoral farming have been exercised in the area during the last 1500 years BP.

CONCLUSIONS

The general pattern of vegetation succession in the Pitkasoo area during the Holocene with more detailed references to the local environment and impact of man could be outlined. From the end of Pre-Boreal time, the Pitkasoo basin was occupied by a lake – relicts of an earlier Ancylus or Yoldia lagoon. The eutrophication and shallowing of waters took place during the second half of the Boreal up to the beginning of the Atlantic, when a wet swamp developed. The reed and fen communities immigrated into the basin; the basin could still be at least periodically covered with a shallow water layer. Only at the initiation of the Sub-Boreal the conditions changed to somewhat drier and the reeds were replaced by fen communities.

The forest succession in the Pitkasoo area follows more or less the pattern typical of Estonia (Thomson, 1929). During the Pre-Boreal, the surrounding forests were represented by pine and birch with a small but steadily increasing portion of hazel and elm. From the second part of the Boreal, primarily hazel and elm may be looked upon as the main forest-forming species. The time of alder immigration is questionable, as the achieved dating is considered to be much too young (7280 ± 50, TA-2571). By the end of the Boreal, oak, lime, and ash appeared. The development of forests was characterized by a gradual increase in broad-leaved trees, with a culmination in the middle of the Atlantic. The immigration of spruce took place at the beginning of the Late Atlantic, *c*. 6500 BP, but its amount stayed moderate up to the beginning of the Sub-Boreal, when coniferous forests gradually replaced the deciduous ones.

The first traces of the presence of man in the area appeared already *c*. 5400 BP. The more open landscape, possibly due to some pastoral practice, could be the cause. The traces of a rather well developed *landnam* phase appeared *c*. 1000 years later. The 200–300 years lasting settlement phase with both crop cultivation and animal husbandry is suggested. The area was recolonized at intervals during the first part of the Sub-Atlantic. Permanent habitation with a full spectrum of agrarian activities started *c*. 1000–1500 BP.

ACKNOWLEDGEMENTS

The field work was carried out by Helgi Kessel in 1972 and by Kerstin Alm-Kübler, Lars-König Königsson, Aivo Lepland, Anneli Poska, and Leili Saarse in 1991. Pollen analysis of the collected material was made by Ivan Lundvall, Quaternary Ecological Laboratory, Uppsala University. Birgit Burman and Edward Ledwaba, MSc, prepared the samples for analysis, and Edward Ledwaba fed the obtained data into the computers. Siim Veski structured the material of analysis in the computer using the TILIA program (Grimm, 1992) according to ideas put forward in Königsson (1968) and Königsson et al. (1995). ^{14}C datings were made at the Radiochemistry Laboratory, Institute of Geology, University of Tartu. The investigation was supported by the Uppsala University, Estonian Science Foundation (grant 1958), and Institute of Geology, Tallinn. The material collected in 1971 was included in the project "*Ölands Stora Alvar*" ("The Great Alvar of Öland"), sponsored by the Tricentennial Fund of the Bank of Sweden.

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PITKASOO KUI HOLOTSEENI TÜÜPLÄBILÕIGE LÄÄNE-EESTIS

Lars-König KÖNIGSSON ja Anneli POSKA

Varasemad andmed Saaremaal asuva Pitkasoo kohta (Pitkasoo 1) on taas läbi vaadatud ning lisatud uute uuringute tulemused (Pitkasoo 2). Pitkasoo 1 biostratigraafiline materjal kajastab piirkonna üldist arengut ja katab peaaegu kogu holotseeni, välja arvatud varane preboreaal ja subatlantikumi lõpp. Uus diagramm (Pitkasoo 2) iseloomustab kohalikke olusid rohkem ja hõlmab Pitkasoo piirkonna hilisema arengu.

Pitkasoo 1 sisaldab mitmeid mesoliitilisele inimmõjule osutavaid märke. Neoliitiline maakasutusfaas (*ca*. 4400 aastat tagasi) on diagrammil selgesti eristatav. Näib, et tegeldi nii teravilja- kui ka karjakasvatusega. Faasi kestus on võimalike settelünkade tõttu nii selle alguses kui ka lõpus ebaselge. Esimesed jäljed põlluharimisest ilmuvad pronksiajal. Tõeline maaharimine ja karjakasvatus algab pisut hiljem, umbes meie ajaarvamise alguses. Pitkasoo 2 diagrammil on inimtegevuse jälgi võimalik leida kogu analüüsitud setteprofiilis, eriti selle ülemises osas.

ПИТКАСОО – ГОЛОЦЕНОВЫЙ ТИПОВОЙ РАЗРЕЗ ЗАПАДНОЙ ЭСТОНИИ

Ларс-Кёниг КЁНИГССОН и Аннели ПОСКА

Пересмотрена предыдущая спорово-пыльцевая диаграмма болота Питкасоо на о-ве Сааремаа (Питкасоо 1) и приведены новые данные по разрезу Питкасоо 2. Биостратиграфический материал Питкасоо 1 отражает общее развитие местности в течение почти всего голоцена, за исключением начала пребореала и конца субатлантической фазы. Новая диаграмма (Питкасоо 2) восполняет недостающие пробелы и дает более полное представление о позднем этапе развития исследованной местности.

На диаграмме Питкасоо 1 четко видны признаки хозяйственной деятельности человека в неолите, особенно в фазе *landnam* (около 4400 лет т. н.). Уже тогда проживавшие здесь люди занимались выращиванием злаковых и скотоводством. К сожалению, из-за перерыва в отложениях пока не удается точно определить продолжительность фазы *landnam*. Первые признаки обработки земли относятся к бронзовому веку. По-настоящему же земледелием и скотоводством стали заниматься на рубеже нашего летоисчисления. На диаграмме Питкасоо 2 следы хозяйственной деятельности человека прослеживаются по всему изученному профилю отложений. Особенно информативна верхняя часть этой диаграммы, где много присутствует пыльцы культурных злаков.