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Vegetation history and human impact in the Parika area, Central Estonia

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Abstract. In order to reconstruct the Holocene vegetation history of the northern part of the Võrtsjärv Lowland, a sediment sequence was collected from the Parika bog and analysed for fossil pollen. Peat started to accumulate at the beginning of the Holocene. Peat increment has been more intensive since 1400 uncalibrated ^{14}C BP (peat increment 1.47–1.60 mm yr^{-1}) and slowest between 6600 and 5000 BP (0.40 mm yr^{-1}). Recorded vegetation development started with open birch–pine woodland. Temperate mixed forest was established before 7600 BP. The proportion of broad-leaved forest was modest throughout the Holocene. Specific to the Parika diagram is the high frequency of spruce since 4800 BP. Palynological and archaeological records indicate that the Võrtsjärv Lowland was inhabited during the Mesolithic. During the Late Bronze Age the area was rather open. However, compared to North Estonia, agricultural land-use was delayed about 1000 years; it was restricted in area and discontinuous. Cereal cultivation (*Hordeum* and *Triticum*) started at the end of the Pre-Roman Iron Age. The Parika bog is considered to be a new biostratigraphic reference site in the northern part of the Võrtsjärv Lowland.

Key words: pollen analysis, cultural history, chronology, vegetation history, land-use.

INTRODUCTION

Several latest publications have highlighted the vegetation history of North and West Estonia (Poska & Königsson 1996; Veski & Lang 1996; Veski 1998; Poska & Saarse 1999; Saarse et al. 1999a), but Central and South Estonia have received less attention (Mäemets 1983; Saarse 1994; Punning et al. 1995; Saarse & Rajamäe 1997). The role of human activity affecting the landscape change in the latter region is poorly documented (Ilves & Mäemets 1987; Pirrus et al. 1993) though, recently there has been an increased interest in this particular aspect (Poska & Saarse 1996; Kihno & Valk 1999; Laul & Kihno 1999a, 1999b).

This study was aimed at collecting biostratigraphical material from the northern part of the Võrtsjärv Lowland. It was once an important Mesolithic habitation centre, but the Holocene reference sites are absent there. The main objective of the present paper is to reconstruct the long-term vegetation and land-use history of Central Estonia, to examine the human impact impressions on the new detailed and well-dated pollen diagram, to compare our results with the published biostratigraphic and archaeological records. The Parika bog was chosen as the study area because biostratigraphic reference sites are absent in this particular region and peat is a good geological archive to reconstruct the environmental changes. *Sphagnum* peat is regarded as the best material for radiocarbon dating (Olsson 1986).

STUDY AREA

Parika is a raised bog in the northwestern part of the Võrtsjärv Lowland (58°30′ N, 25°47′ E), Central Estonia (Fig. 1A), in a NW–SE trending depression between the eastern slope of the Sakala Upland and the Kolga-Jaani drumlin field (Fig. 1C). The total area of the bog is 34 km^2, of that fen makes up 14 km^2, transitional bog 1 km^2, and raised bog 19 km^2 (Orru 1995). The elevation of the bog surface is uneven, between 45 and 50 m a.s.l. The Viljandi–Põltsamaa road, lakes Parika (1.14 km^2) and Väikejärv (0.05 km^2) and several mineral islands (0.5 km^2) divide up the bog. The eastern and southwestern shores of Lake Parika support pine, common to the transitional bog. Fen vegetation spreads widely in the NW and SE parts as sprouted grassland (Orru 1995). More than half of the peat is composed of *Sphagnum* peat, succeeded by *Sphagnum–Eriophorum*, *Carex–Phragmites*, and well-decomposed woody fen peat with a maximum thickness of 10 m (Orru 1995). A nature reserve was established in the central part of the Parika bog for the preservation of a mire ecosystem. Most of the surroundings is covered by pine–birch–spruce forest integrating patches of more open landscape.

The northern part of the Võrtsjärv Lowland is rich in archaeological monuments (Jaanits 1959; Moora 1968; Jaanits & Ibius 1973; Jaanits et al. 1982; Kiristaja et al. 1998; Kriiska 2001; Fig. 1B). Archaeological records show that this area was inhabited between 7000 and 4000 BC (Jaanits 1968). The indented shoreline of Lake Big Võrtsjärv (in the sense of Orviku 1973) with several islands offered suitable living conditions to the hunters, fishermen, and gatherers who were well adapted to the coastal environment and riverbanks. The first settlers were probably mobile and relocated according to season and availability of food. At present, twelve settlement sites (camps), typologically dated to the Mesolithic Kunda culture are known from this region (Jaanits et al. 1982; Kiristaja et al. 1998). Archaeological sites dated to this period, such as Siimusaare, Moksi, Umbusi, Leie, Lalsi, etc., have yielded evidence of settlers not knowing arable farming. Osteological data demonstrate utilization of a wide range of game, including small game, waterfowl and fish (Jaanits & Ilomets 1983). The artefacts

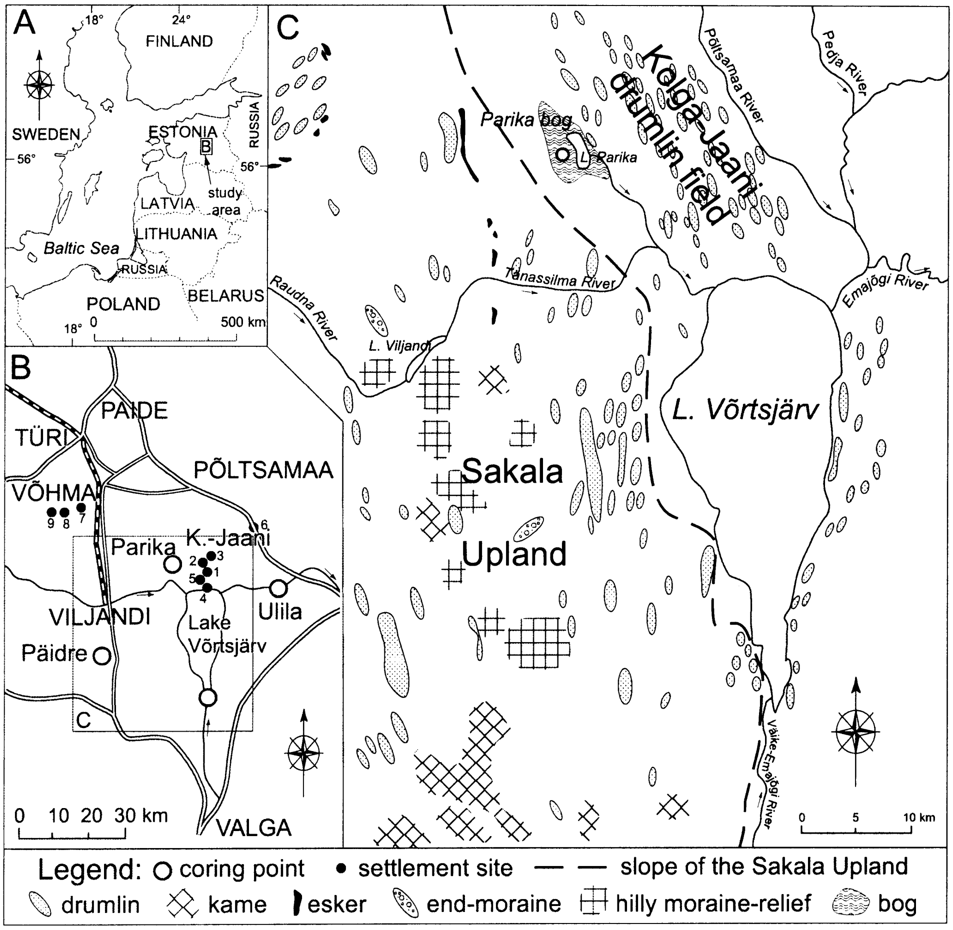


Fig. 1. (A) Location of the study area. (B) Location of the sites analysed for pollen and discussed in the text; archaeological settlement sites: 1, Lalsi I–II; 2, Lalsi III–IV; 3, Siimusaare; 4, Moksi; 5, Leie; 6, Umbusi; 7, Jälevere; 8, Tamme; 9, Lepakose. (C) Topography of the vicinity of the Parika bog; the sampling site is indicated.

related to the Early Bronze Age are scanty and settlement sites are not known. The population density increased during the Roman Iron Age, the settlement centre relocated to the Sakala Upland, and the Parika area became peripheral (Moora 1968). Archaeologists suggest some decrease in population density during the Migration Period and the Viking Age due to battles and attacks, which led local people to erect strongholds. The northern part of the lowland stayed sparsely populated up to the beginning of the second millennium AD. Only very few stone grave and stray finds from this period are known. The size of the population in the Kolga-Jaani region was significantly affected by the plague and the attacks in 1212 AD (Tarvel 1993), the Livonian War (1582–1623 AD), and the Northern War (1700–1721 AD). The population density grew rapidly during the 18th century. In 1771, there were 123 people per one plot of arable land at Kolga-Jaani (Jaanits & Ibius 1973).

MATERIAL AND METHODS

In 1998, a sedimentary sequence from the Parika bog was collected with a Belarus peat sampler from the deepest, western part of the bog, where the peat was 925 cm thick and the bog surface was at a height of c. 50 m a.s.l. Pollen and loss-on-ignition analyses, and the ^{14}C dating were used to examine the Late Glacial and Holocene environmental changes and human impact.

For pollen preparation and analysis a standard method described by Erdtman (1936) and Fægri & Iversen (1989) was used, 700–1000 grains of arboreal pollen (AP) were counted at each level, except the bottommost mineral portion of the sediment. The basis for the percentage calculations was the sum of terrestrial pollen; the percentages of other microfossils were calculated from the basic pollen sum. The summary pollen diagram was designed with TILIA and TILIA.GRAPH programs (Grimm 1992). The human impact diagram was constructed on the basis of the selection of identified nonarboreal pollen (NAP), yielding information about the changing landscape utilization practices. The herb taxa were grouped according to Behre (1981, 1988), Berglund & Ralska-Jasiewiczowa (1986), Hicks (1990), Berglund (1991), and Poska (2001) into eight land-use categories.

Numerical zonation of the pollen and human impact diagrams was made using the “psimpoll” program by the optimal splitting by the sum-of-squares method (Bennett 1996). The local pollen assemblage zones were determined on the basis of all identified taxa. The human impact zones were specified on the basis of taxa connected with human impact. Still, *Calluna* and Cyperaceae were excluded from the pollen sum to minimize the shadowing effect of the extra-local communities.

To determine organic matter, carbonate and terrigenous fractions, loss-on-ignition at 500 and 825 °C of 1-cm-thick samples at 10 cm interval was used. To obtain independent chronologies, conventional ^{14}C radiocarbon dating of bulk peat samples was performed at the Institute of Geology, Tallinn Technical University.

The ^{14}C age was determined for eight bulk peat samples (Table 1; Fig. 2). All radiocarbon dates are consistent with the pollen stratigraphy and applied to calculate the sample age and peat increment. Both, uncalibrated and calibrated radiocarbon dates are given to facilitate the comparison of the present and earlier published biostratigraphical material. For the same reason in the chapter on pollen stratigraphy and vegetation development uncalibrated radiocarbon years are used, but in the chapter on human impact calibrated radicarbon years are employed. Radiocarbon dates were calibrated according to Stuiver et al. (1998) at 1 sigma and expressed as calendar years BC and AD.

Table 1. Radiocarbon dates and the accumulation rate of the peat from the Parika bog

Depth, cm	^{14}C age, BP	Lab. index	Calibrated age, AD/BC	Peat increment, mm yr^{-1}	Material
100–110	770 ± 50	Tln-2295	1221–1283 AD	1.47	*Sphagnum* peat
200–210	1425 ± 45	Tln-2290	601–657 AD	1.60	*Sphagnum* peat
300–310	2215 ± 55	Tln-2292	363–203 BC	1.10	*Sphagnum* peat
400–410	3115 ± 65	Tln-2293	1489–1265 BC	0.91	*Sphagnum–Eriophorum* peat
550–560	5030 ± 60	Tln-2298	3941–3713 BC	0.61	*Carex* peat with *Phragmites*
620–630	6665 ± 60	Tln-2294	5657–5531 BC	0.40	*Carex* peat with *Phragmites*
720–730	7940 ± 65	Tln-2296	7031–6699 BC	0.79	*Phragmites–Carex* peat
820–830	9000 ± 75	Tln-2297	8287–8199 BC	0.73	*Phragmites–Carex* peat

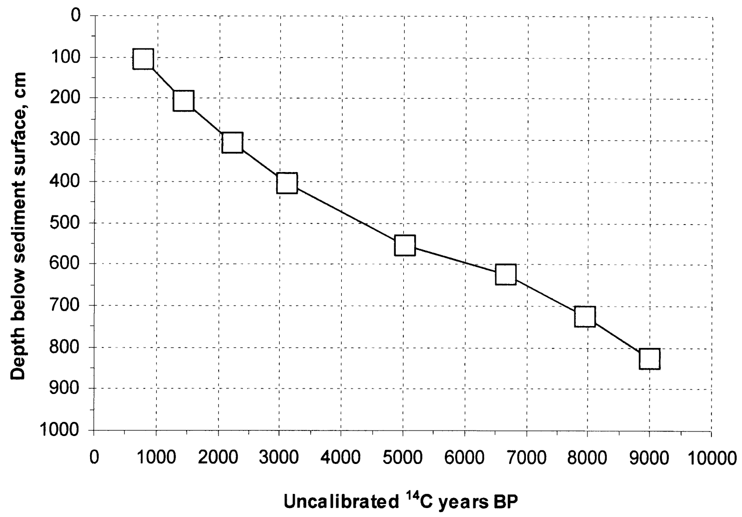


Fig. 2. Age–depth plot for the Parika bog. The ages of the dated levels are indicated by squares.

RESULTS AND DISCUSSION

Sediment lithology

Sediment lithology of the studied sequence is displayed in Fig. 3. The basal silt (982–925 cm) contains up to 14% organic matter and up to 16% carbonates. Minerogenic deposits are covered by well decomposed fen peat (925–800 cm), *Phragmites–Carex* (800–650 cm), and *Carex* peat with *Phragmites* remains (650–500 cm). These beds are characterized by stable organic matter (92–96%) and low terrigeneous load. At the bottom of fen peat the content of organic matter slightly decreases to 72% and that of terrigeneous fraction increases 27%. The

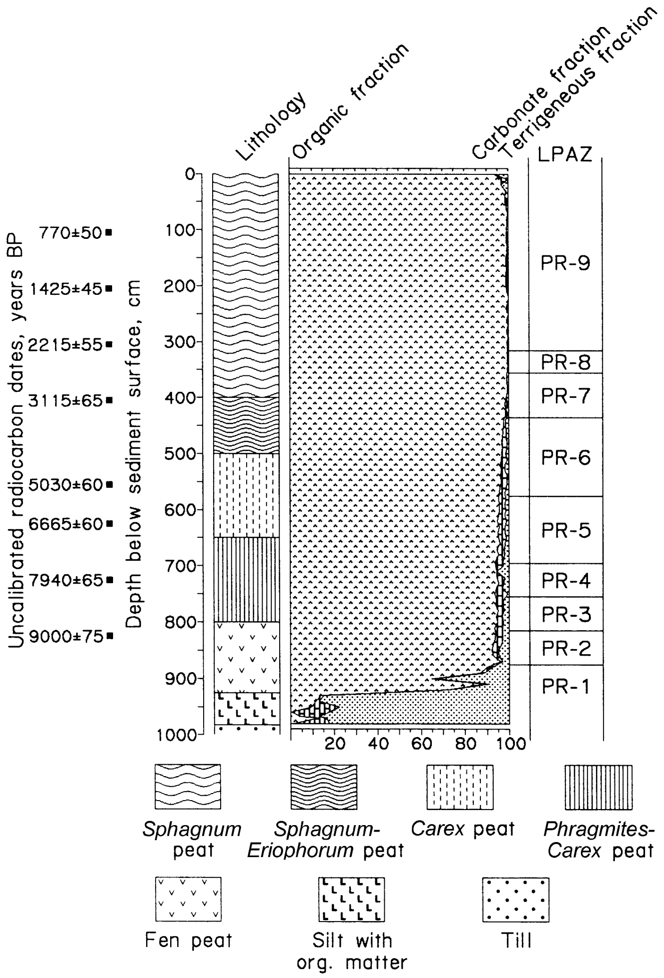


Fig. 3. Sediment lithology and contents of organic, carbonate, and terrigeneous fractions in the main core of the Parika bog. LPAZ – local pollen assemblage zone.

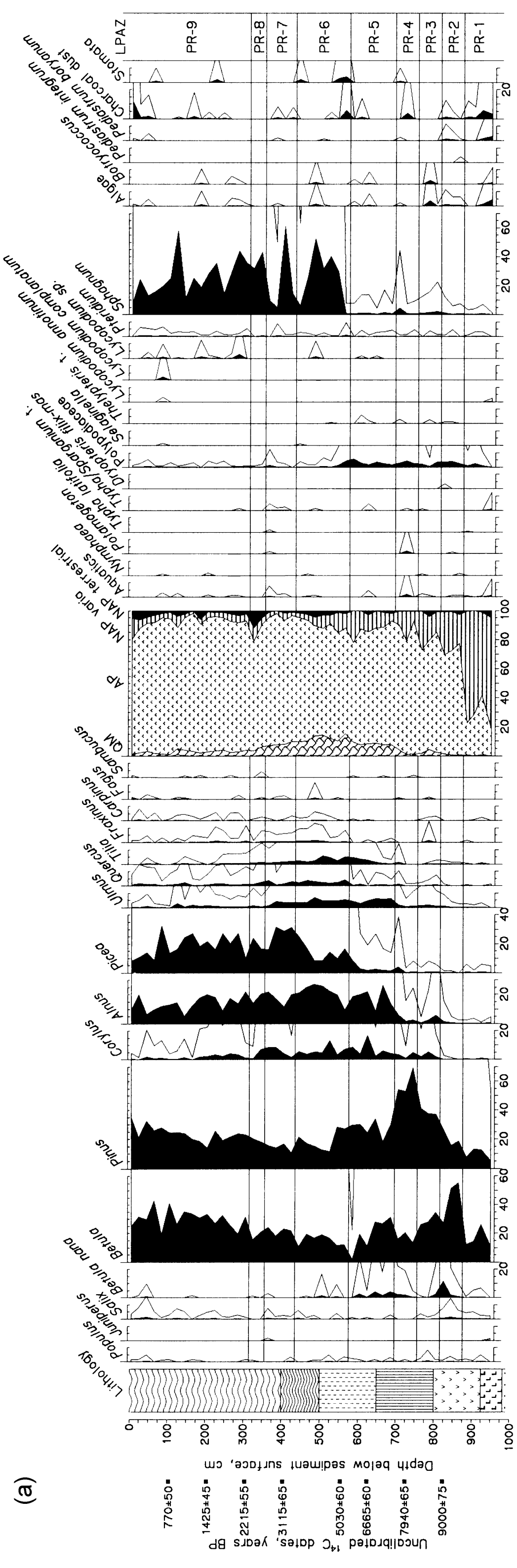
carbonate content is commonly less than 4%. The uppermost *Sphagnum–Eriophorum* (500–400 cm) and *Sphagnum* peat (400–0 cm) have a high and stable organic matter content (97–99%), with the exception of the topmost layer, where the organic matter decreases to 94%, mostly on account of the terrigeneous fraction. The increment of the *Sphagnum* peat is lowest (0.40 mm yr^{-1}) between 625 and 555 cm (6600–5000 BP) and highest (1.47–1.60 mm yr^{-1}) in the topmost part of peat, at 210–0 cm (from 1400 BP up to the present). Why the peat increment is slowest during the Late Atlantic is hard to explain, as generally climate was warm and humid. One possible reason could be decrease in groundwater table indicated by reconstructed lake level lowering in Estonia between 6500 and 5500 BP (Saarse & Harrison 1992). High peat increment in the topmost beds is partly explained by poor compaction of the topmost peat in combination with the climatic change in Estonia from continental to more maritime at least during the last 150 years (Tarand & Kallaste 1998).

Pollen stratigraphy and vegetation development

Nine local pollen assemblage zones were recognized by numerical zonation (Table 2, Fig. 4a,b). At the end of the Late Glacial and beginning of the Holocene (PR-1 and 2; ?–8850 uncal. BP), the pollen assemblage with high Cyperaceae

Table 2. The biostratigraphical division of the main pollen diagram. LPAZ – local pollen assemblage zone

LPAZ/ Depth, cm	Uncal. ^{14}C age, BP	Description
PR-1 930–875	?–9500	Extremely high NAP content, mainly Cyperaceae. AP consists mostly of *Betula* and *Pinus* pollen.
PR-2 875–815	9500–8850	*Betula* pollen dominates and reaches a maximum, *Pinus* is rising. *Salix* has its maximum. NAP amount is still high with Cyperaceae and Poaceae dominating. At first *Ulmus* and *Alnus*, later *Corylus* occur.
PR-3 815–755	8850–8250	*Pinus* pollen increases, *Betula* decreases substantially. Occasional *Picea*, *Tilia*, and *Fraxinus* pollen is present. NAP has a peak on account of Poaceae, which reaches its maximum.
PR-4 755–695	8250–7500	At PR lower limit *Pinus* pollen reaches a maximum and starts to decrease along with increase in *Alnus* and *Ulmus*. *Tilia* appears, *Quercus* and *Picea* occur in low values. The total AP frequency is unstable.
PR-5 695–575	7500–5450	High appearance of *Corylus* and *Ulmus*, later *Tilia. S*ubstantial increase in *Quercetum mixtum* (QM) pollen. Significant rise in *Picea* at PR upper limit.
PR-6 575–435	5450–3400	QM maximum. *Picea* increases. NAP composition changes drastically. Cyperaceae and Polypodiaceae diminish substantially, substituted by *Sphagnum* and its satellites and *Calluna vulgaris*. The representation of NAP has diminished.
PR-7 435–355	3400–2600	*Picea* dominates; QM decreases considerably on account of *Ulmus*, *Tilia*, and *Fraxinus.* Total AP reaches a maximum. In the NAP composition the proportion of aquafilous taxa has diminished.
PR-8 355–315	2600–2300	*Betula*, *Alnus*, and *Corylus* pollen decreases. NAP rises considerably, especially *Calluna* and *Vaccinum.*
PR-9 315–0	2300–up to present	*Betula* and *Pinus* are dominant, *Picea* remains as high as *Alnus.* QM decreases to the content similar to that of today. *Corylus*, *Ulmus*, and *Quercus* are present. NAP frequency rises considerably in the top of the sequence. The cultural indicators are constantly present.


(a)
Uncalibrated 14C dates, years BP
770±50
1425±45
2215±55
3115±65
5030±60
6665±60
7940±65
9000±75
Depth below sediment surface, cm
Lithology
Populus
Juniperus
Salix
Betula nana
Betula
Pinus
Corylus
Alnus
Picea
Ulmus
Quercus
Tilia
Fraxinus
Carpinus
Fagus
Sambucus
QM
AP
NAP varia
terrestrial
Aquatics
Nymphaea
Potamogeton
Typha latifolia
Typha/Sparganium t.
Dryopteris filix-mas
Polypodiaceae
Selaginella
Thelypteris
Lycopodium annotinum
Lycopodium complanatum
Lycopodium sp.
Pteridium
Sphagnum
Algae
Botryococcus
Pediastrum boryanum
Pediastrum integrum
Charcoal dust
Stomata
LPAZ
PR-9
PR-8
PR-7
PR-6
PR-5
PR-4
PR-3
PR-2
PR-1

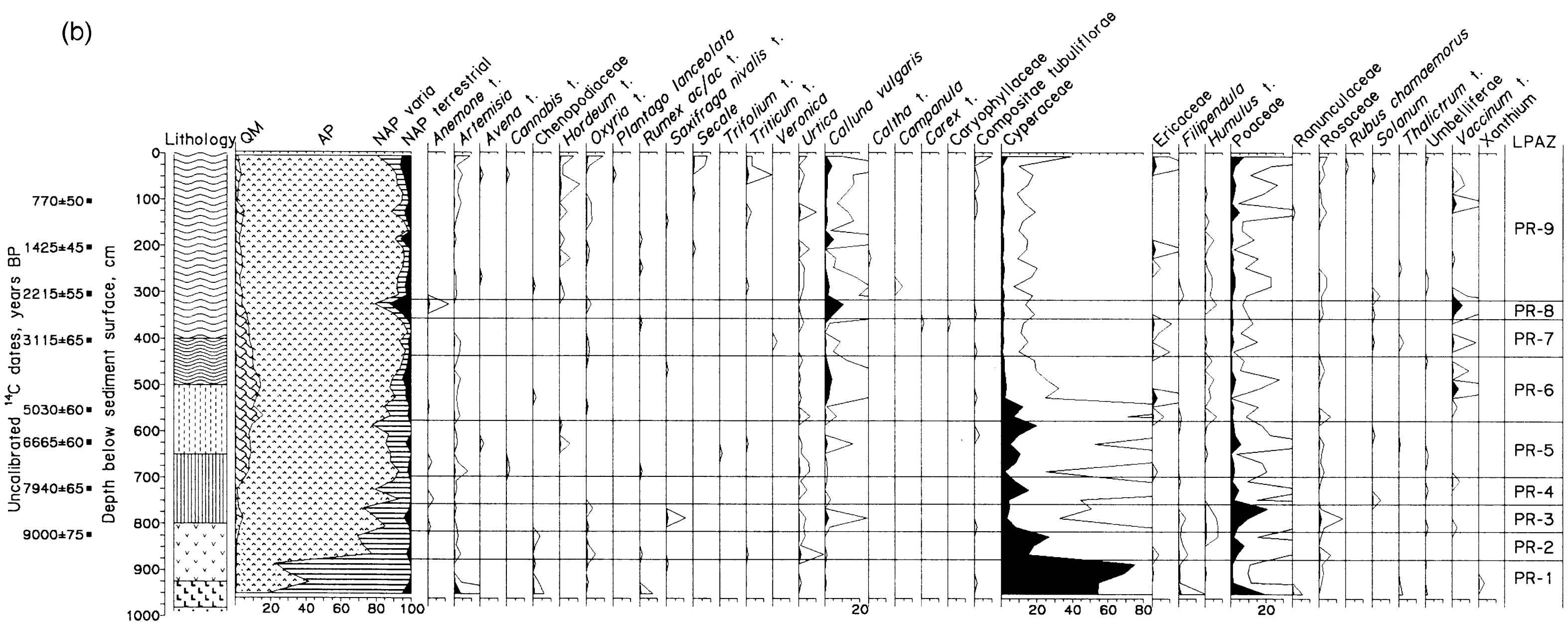


Fig. 4. (a) Selected pollen percentage diagram of the Parika bog. Curves not filled show percentage values ×10. (b) Selected herb pollen percentage diagram of the Parika bog. LPAZ – local pollen assemblage zone. For legend see Fig. 3.

(Fig. 4b) and *Pediastrum* (Fig. 4a) suggests waterlogged conditions and the existence of a lakeshore not far away, which in the middle of PR-1 turned to fen. Open birch and pine woods dominated, with scattered willow. At first *Ulmus* and *Alnus*, later *Corylus* occurred. High representation of *Betula nana* at the end of PR-2 (Fig. 4a) is remarkable. The vegetation at 8850–8250 BP (PR-3) was characterized by a marked dominance of the light-demanding *Pinus* (Fig. 4a). The forest succession favoured *Corylus* and *Ulmus*, but due to unfavourable edaphic conditions they probably became integrated members of the forest rather than forming pure stands in the area. At 8250–5450 BP (PR-4 and PR-5), the share of broad-leaved trees (QM) increased and arboreal vegetation became more variable. At c. 7900 BP, *Alnus* quickly expanded due to favourable local topography – swampy areas. With the immigration of *Tilia*, all broad-leaved trees had arrived, except *Carpinus*. The proportion of QM stayed low throughout the Middle Holocene, probably because of the lack of suitable habitats and progressive paludification of the Võrtsjärv Lowland. *Picea* immigrated to the area about 7700–7600 BP and spread at 6300–6200 BP, which is in accordance with the earlier obtained pollen records (Saarse et al. 1999b). With the spread of *Picea*, both *Pinus* and *Betula* obtained a competitor for habitat.

At the beginning of PR-6 (5450–3400 BP), *Fraxinus* and *Carpinus* immigrated to the area, QM had two pronounced maximums, at 5300 and 4500 BP, and a distinct *Ulmus* decline occurred at 4250 BP (Fig. 4a). At the beginning of PR-6 (Fig. 4a,b), a rapid and distinct change took place in the development of the investigated basin. The Cyperaceae pollen and Polypodiaceae spores decreased substantially and were substituted by Ericaceae pollen and *Sphagnum* spores, marking the beginning of the raised bog stage.

In PR-7 (3400–2600 BP), *Picea* spread abundantly, with its maximum between 3300 and 2300 BP, followed by a decline of mixed oak forests. This is usually explained with the deterioration of climate and degradation of soils. The last period in the forest history (PR-8 and PR-9; 2600 BP – up to present) is expressed by a decreasing content of temperate trees and return to the pine–birch–spruce woodland. The vegetation composition remained quite stable; only a slight increase in *Betula* and *Pinus* and a general decrease in *Picea*, *Alnus*, and *Corylus* and trees of mixed oak forest were observed. By today, almost all QM stands have been cut down, only *Fraxinus* forms groves on the slopes of the ancient valleys of the Sakala Upland (Saarse et al. 1995).

Apart from the drastic and sudden changes in herb and grass assemblages due to by the natural development of the bog, also some long-term vegetation trends are noticed, probably caused by human impact in combination with natural processes like climate and soil deterioration. A comparison of the *Betula* and *Corylus* pollen percentages shows the prevalence of *Betula* over *Corylus*, especially from 2500 BP (Pre-Roman Iron Age). A similar trend was observed in southern Sweden (Berglund 1991; Lagerås 1996). This trend has been more pronounced since the pasture expansion and is explained as a combined effect of natural and anthropogenic influence (Lagerås 1996).

Environmental changes

In the studied part of the Parika bog three main development stages can be followed: fen, transitional and raised bog. During the fen stage well-decomposed woody peat, during the transitional stage *Phragmites–Carex* and *Carex* peat with *Phragmites* remains, and during the raised bog stage *Sphagnum–Eriophorum* and *Sphagnum* peat were formed. It appears that every next stage in the bog history was longer than the previous one. So, the fen stage lasted about 1200 years, transitional stage 3800 years, while the last, bog stage has already lasted over 5000 years, and is still continuing.

The most drastic environmental changes traced on the pollen diagram occurred before 9500 BP (interpolated age) and 5400–5300 BP. By about 9500 BP the shallow water body which filled the Parika basin was overgrown and minerogeneous sedimentation replaced by organogeneous one. The high frequency of Cyperaceae diminished drastically, giving ground to Poaceae and other terrestrial herbs. The AP : NAP ratio became distorted in favour of AP (Fig. 4a). The lake in the Parika basin was obviously not connected with the Ice Võrtsjärv in the sense of Orviku (1973), as the Parika threshold at 45 m exceeds the suggested Ice Võrtsjärv water level by 2–3 m. Another drastic change in the pollen composition is connected with the development of the bog itself – with its turn to the raised bog stage. This was accompanied with a sharp increase in the *Sphagnum* spores, a decrease in the total NAP, and an increase in the *Alnus* pollen frequencies (Fig. 4a).

Human impact

Eight land-use phases have been distinguished in the human impact diagram (Fig. 5). When reconstructing human impact on the basis of pollen record from a rather large bog like Parika, it is important to know that indications of forest disturbance may not be clearly registered in the pollen diagram. Still, the Parika pollen diagram displays some evidence of vegetation disturbance during Mesolithic time (8000–4900 BC). The early and late Mesolithic part of the mentioned diagram (PRH-2 and PRH-3; Table 3) reveals fluctuating and markedly reduced AP values (Fig. 4a, PR-3 to PR-5), caused by the natural development of the bog in combination with climate and soil deterioration. Still, the high proportion of Poaceae and the ruderal (especially *Urtica*) pollen may have been facilitated by forest disturbance, attesting well with archaeological records of the colonization of the Võrtsjärv Lowland during Mesolithic time (Jaanits 1968). At the end of the Mesolithic, settlers most probably relocated close to food resources, along the contemporary riverside and lakeshore. Due to rapid paludification of the area, these settlement sites were probably short-lived and soon buried by peat. Obviously, for this reason the traces of the Neolithic forest disturbance and Bronze Age arable farming are rather weak in the Parika diagram (Fig. 5, PRH-4). The anthropogenic indicator graphs diminish slightly, AP recovers distinctly from the previous fall, and

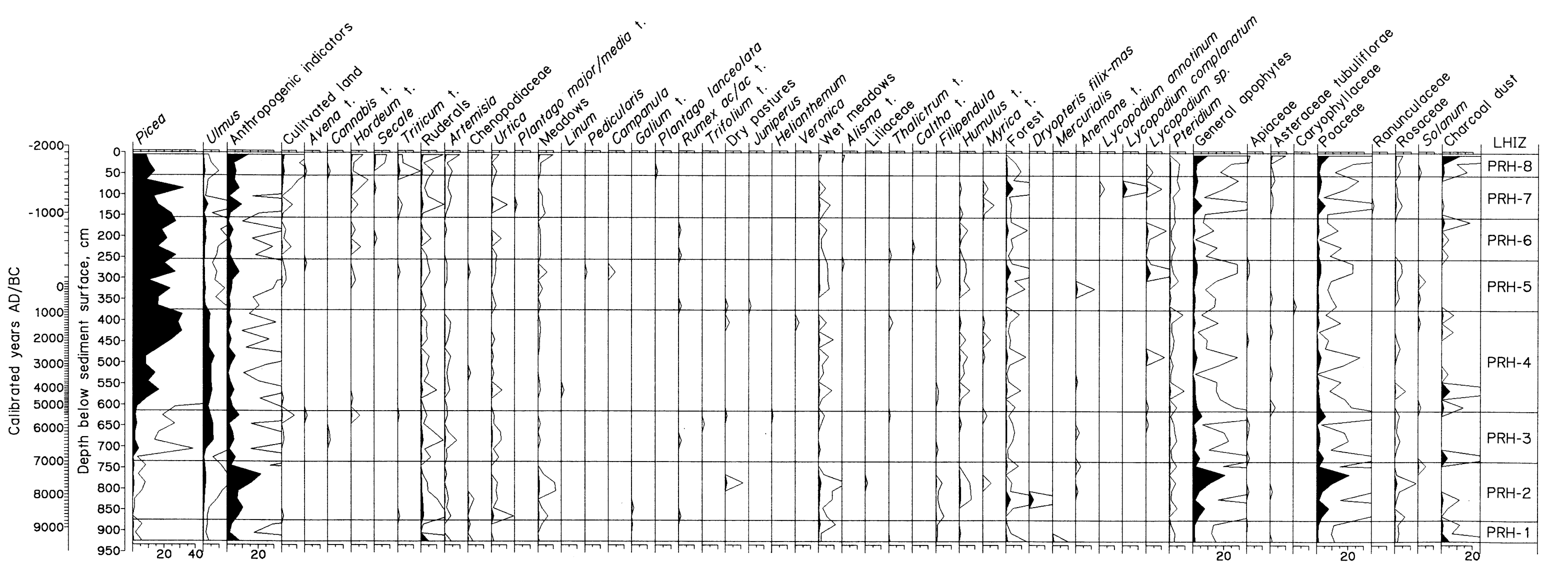


Fig. 5. Human impact diagram of the Parika bog plotted against the calibrated timescale. LHIZ – local human impact zone.

the NAP amount reaches almost a minimum (Fig. 3, PR-6). This points to the forest regeneration in the area. Peaks in the curves of *Betula*, *Alnus*, and *Salix* (quickly regenerating and early successional trees) indicate overgrowth of the earlier opened up landscape (Fig. 4a, PR-6 and PR-7). One reasonable explanation is the transition to farming and relocation of people from hunting and gathering areas to areas with soils suitable for agriculture (Lang 1999). The tillage here did not give as good results as in the areas with light calcareous soils in North Estonia. The other explanation is that the settlers on the Võrtsjärv Lowland were mostly orientated to cattle breeding, and less to arable farming (Jaanits 1968). After the second *Ulmus* decline the area around the Parika bog was more intensively used as wooded pasture (Fig. 5). From the Late Bronze Age onwards the area was rather open, but the agricultural land-use was still restricted and discontinuous.

Table 3. The biostratigraphical division of the human impact diagram. LHIZ – local human impact zone

LHIZ/ Depth, cm	Cal ^{14}C age, BC/AD	Description
PRH-1 930–875	?–8880 BC	Low frequencies of meadow, forest, and general apophyte (Poaceae) pollen. Very high proportion of wet meadow taxa (Cyperaceae).
PRH-2 875–735	8880–7000 BC	At certain levels significant frequency of ruderal, meadow, and forest taxa. Wet meadow indicators are constantly present. General apophytes make a maximum on account of Poaceae. Charcoal particles are sporadic.
PRH-3 735–615	7000–5430 BC	Impressive decline in meadow, wet meadow, and general apophyte curves. Charcoal occurs sporadically.
PRH-4 615–375	5430–1010 BC	Slight decrease in all defined land-use groups and charcoal particles. First *Ulmus* decline at about 2700 BC. Expansion of *Picea*.
PRH-5 375–255	1010–220 BC	Final *Ulmus* decline. Opening up of forest. Rise in summary anthropogenic indicators curve. Sporadic *Hordeum* and *Triticum* pollen. Charcoal particles are not identified.
PRH-6 255–155	220 BC–900 AD	*Picea* is unstable. Decrease in meadow, wet meadow, forest taxa, and general apophytes. *Hordeum* pollen is more frequent.
PRH-7 155–55	900–1500 AD	Well-developed cultivated plants and ruderal curves. Sharp rise of Poaceae and summary anthropogenic indicators graphs. Charcoal particles are not identified.
PRH-8 55–0	1500–1950 AD	Clear increase in all defined land-use groups. The cultivated plants are present in considerably high values.

Within 300–350 AD (Roman Iron Age; Fig. 5, PRH-5) the population density increased. *Triticum* and *Hordeum* were cultivated, which is considerably later than in the northern coastal areas (Veski & Lang 1996; Poska & Saarse 1999). The cultivation and probably settlement density diminished during the Migration Period (400–500 AD) and the Viking Age (800–900 AD), as pollen of cereals decreased considerably, and *Picea* and *Ulmus* recovered slightly. The agrarian activities intensified from AD 1100 (Fig. 5, PRH-7), with a small decline at the end of the Late Iron Age. At about 1200–1250 AD all cereals disappear to reappear later and with higher values. Diminishing of meadow plants and the formation of the *Picea* peak hint that pastoral farming also decreased or relocated to some distance from the Parika bog. The collapse in arable farming was obviously caused by battles and plague, which, according to written sources befell in 1212 (Jaanits & Ibius 1973).

CONCLUSIONS

A new biostratigraphic reference site, the Parika bog, for the northern part of the Võrtsjärv Lowland was suggested and studied. Vegetation development in the vicinity of the Parika bog started at the end of the Late Glacial with open *Betula* forest, which gradually became denser. At about 8800 BP *Pinus* became a dominating species. Soon after, at about 7600 BP, many deciduous trees immigrated to form temperate mixed forests. The proportion of broad-leaved forest was modest throughout the Holocene. Specific to the Parika area is the high frequency of *Betula nana* pollen (up to 6000 BP) and *Picea* (since 4800 BP). An extremely high amount of sedges is observed in the lower part of the diagram.

The present study also highlights the peat increment trend. The exact time of the start of the paludification in the vicinity of Parika is not known, but pollen correlation with the stratigraphic chart suggests it started in the Preboreal, at the beginning of the Holocene. Peat increment has been the most intensive since 1400 BP, partly due to slight compaction of the uppermost layer, and was slowest between 6600 and 5000 BP (0.40 mm yr^{-1}).

The Mesolithic Kunda culture settlers left few traces in the environmental history. Still, the increased proportion of ruderals, especially *Urtica*, is significant. The *Ulmus* decline at 4200–4300 BP is registered later than in the other areas of Central Estonia and therefore can be assigned to forest clearance. The area around the Parika bog was more intensively used after the second local *Ulmus* decline at about 2900 BP, first as wooded pasture, and later for arable farming. From the Late Bronze Age onwards, the area was rather open, but the agricultural land-use was still limited and discontinuous. The cultivation and probably settlement density declined during the Migration Period (400–500 AD) and the Viking Age (800–900 AD) and at the end of the Late Iron Age, about 1200 AD. The meadow plants also diminished, and *Picea* generated a peak. This suggests that pastoral farming also decreased or relocated to some distance from the Parika bog. Cereal cultivation (*Hordeum* and *Triticum*) started during the Roman Iron Age, being first rather restricted, but expanded during the Middle Ages. Slash-and-burn cultivation, if although occurred, was probably introduced during the Iron Age. So, the agrarian expansion into the Võrtsjärv Lowland took place about 1000 years later than into North Estonia.

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REFERENCES

Behre, K. E. 1981. The interpretation of anthropogenic indicators in pollen diagrams. *Pollen et Spores*, **23**, 225–245.

Behre, K. E. 1988. The role of man in European vegetation history. In *Vegetation History. Handbook of Vegetation Science 7* (Huntley, B. & Webb III T., eds.), pp. 633–672. Kluwer, Dordrecht.

Bennett, K. 1996. Determination of the number of zones in a biostratigraphical sequence. *New Phytologist*, **132**, 155–170.

Berglund, B. E. (ed.). 1991. The Cultural Landscape During 6000 Years in Southern Sweden – the Ystad Project. *Ecol. Bull.*, 41, Munksgaard, Copenhagen.

Berglund, B. E. & Ralska-Jasiewiczowa, M. 1986. Pollen analyses and pollen diagrams. In *Handbook of Holocene Palaeoecology and Palaeohydrology* (Berglund, B. E., ed.), pp. 455–484. John Wiley, Chichester.

Erdtman, G. 1936. New methods in pollen analysis. *Sven. Bot. Tiddsskr.*, **30**, 154–164.

Fægri, K. & Iversen, J. 1989. *Textbook of Pollen Analysis*. John Wiley, Chichester.

Grimm, E. 1992. TILIA and TILIA.GRAPH: Pollen spreadsheet and graphics program. In *8th International Palynological Congress. Program and Abstracts*, p. 171. Aix-en-Provence.

Hicks, S. 1990. Pollen evidence for the activities of man in peripheral areas. *Publ. Karelian Inst., Univ. Joensuu*, **102**, 21–39.

Ilves, E. & Mäemets, H. 1987. Results of radiocarbon and palynological analyses of coastal deposits of lakes Tuuljärv and Vaskna. In *Palaeohydrology of the Temperate Zone III. Mires and Lakes* (Raukas, A. & Saarse, L., eds.), pp. 108–130. Valgus, Tallinn.

Jaanits, L. 1959. *Siedlungsplätze des Neolitikums und der Frühen Metallzeit im Mündungsgebiet des Emajõgi.* Inst. History, Acad. Sci. Estonian SSR, Tallinn (in Russian).

Jaanits, L. 1968. Sakala asustusest kivi- ja pronksiajal. In *Viljandi rajoonis* (Maaring, E., ed.), pp. 57–61. Tallinn.

Jaanits, L. & Ibius, O. 1973. Ajaloost. In *Võrtsjärv* (Timm, T., ed.), pp. 224–234. Valgus, Tallinn.

Jaanits, L. & Ilomets, M. 1983. Umbusi mesoliitilise asula vanusest ja kohast Eesti keskmise kiviaja kronoloogias. In *Loodusteaduslikke meetodeid Eesti arheoloogias* (Rõuk, A.-M. & Jaanits, L., eds.), pp. 54–63. Inst. History, Acad. Sci. Estonian SSR, Tallinn.

Jaanits, L., Laul, S., Lõugas, V. & Tõnisson, E. 1982. *Eesti esiajalugu.* Eesti Raamat, Tallinn.

Kihno, K. & Valk, H. 1999. Archaeological and palynological investigations at Ala-Pika, South-eastern Estonia. *PACT*, **57**, 221–237.

Kiristaja, A., Tvauri, A. & Vindi, A. 1998. 1997. aasta arheoloogilised inspektsioonid. In *Arheoloogilised välitööd Eestis 1997*, pp. 210–236.

Kriiska, A. 2001. *Stone Age Settlement and Economic Processes in the Estonian Coastal Area and Islands*. PhD Dissertation. University of Helsinki.

Lagerås, P. 1996. Vegetation and land-use in the Småland Uplands, Southern Sweden, during the last 6000 years, *LUNDQUA THESIS*, **36**, 1–39.

Lang, V. 1999. Pre-Christian history of farming in the Eastern Baltic Region and Finland: a synthesis. *PACT*, **57**, 359–372.

Laul, S. & Kihno, K. 1999a. Prehistoric landuse and settlement history on the Haanja Heights, Southeastern Estonia, with special reference to the Siksali-Hino area. *PACT*, **57**, 239–254.

Laul, S. & Kihno, K. 1999b. Viljelusmajandusliku asustuse kujunemisjooni Haanja kõrgustiku kaguveerul. *Eesti arheoloogia ajakiri*, **3/1**, 3–18.

Mäemets, H. 1983. Palynological and radiocarbon data on the postglacial vegetational history of Haanja Elevation (ESSR). In *Man, Vegetation and Soils* (Kurvits, J., ed.), pp. 98–111. Tartu (in Russian).

Moora, H. 1968. Sakala maakonna kujunemine. In *Viljandi rajoonis* (Maaring, E., ed.), pp. 62–66. Tallinn.

Olsson, I. 1986. Radiometric dating. In *Handbook of Holocene Palaeoecology and Palaeohydrology* (Berglund, B. E., ed.), pp. 273–312. John Wiley, Chichester.

Orru, M. 1995. *Estonian Mires. Handbook*. Estonian Geol. Survey. Ramona, Tallinn (in Estonian).

Orviku, K. 1973. Võrtsjärve geoloogilisest arengust. In *Võrtsjärv* (Timm, T., ed.), pp. 26–32. Valgus, Tallinn.

Pirrus, R., Hang, T. & Liiva, A. 1993. On the geological development of the Väike-Emajõgi valley and the southern part of Lake Võrtsjärv. *Proc. Estonian Acad. Sci. Geol.*, **42**, 28–37 (in Russian).

Poska, A. 2001. Human impact on vegetation of coastal Estonia during the Stone Age. *Acta Universitatis Upsaliensis*, 652.

Poska, A. & Königsson, L.-K. 1996. Traces of Mesolithic land-use in a pollen diagram from the Arusoo Mire at Kunda. *PACT*, **51**, 299–309.

Poska, A. & Saarse, L. 1996. Prehistoric human disturbance of the environment induced from Estonian pollen records. A pilot study. *Proc. Estonian Acad. Sci. Geol.*, **45**, 149–164.

Poska, A. & Saarse, L. 1999. Holocene vegetation and land-use history in the environs of Lake Kahala, Estonia. *Veget. Hist. Archaeobot.*, **8**, 185–197.

Punning, J.-M., Koff, T., Ilomets, M. & Jõgi, J. 1995. The relative influence of local, extra-local, and regional factors on organic sedimentation in the Vällamäe kettle hole, Estonia. *Boreas*, **24**, 65–80.

Saarse, L. 1994. *Bottom Deposits of Small Estonian Lakes*. Inst. Geol. Estonian Acad. Sci., Tallinn (in Russian).

Saarse, L. & Harrison, S. P. 1992. Holocene lake-level changes in the eastern Baltic region. In *Estonia. Man and Nature*, pp. 6–20. Acad. Sci. Estonia, Estonian Geographical Soc., Tallinn.

Saarse, L. & Rajamäe, R. 1997. Holocene vegetation and climatic change on the Haanja Heights, SE Estonia. *Proc. Estonian Acad. Sci. Geol.*, **46**, 75–92.

Saarse, L., Veski, S., Heinsalu, A., Rajamäe, R. & Martma, T. 1995. Litho- and biostratigraphy of Lake Päidre, South Estonia. *Proc. Estonian Acad. Sci. Geol.*, **44**, 45–59.

Saarse, L., Heinsalu, A., Poska, A., Veski, S. & Rajamäe, R. 1999a. Palaeoecology and human impact in the vicinity of Lake Kahala, Northern Estonia. *PACT*, **57**, 373–403.

Saarse, L., Poska, A. & Veski, S. 1999b. Spread of *Alnus* and *Picea* in Estonia. *Proc. Estonian Acad. Sci. Geol.*, **48**, 170–186.

Stuiver, M., Reimer, P. J. & Braziunas, T. F. 1998. High-precision radiocarbon age calibration for terrestrial and marine samples. *Radiocarbon*, **40**, 1127–1151.

Tarand, A. & Kallaste, T. (eds.). 1998. *Country Case Study on Climate Change Impact and Adaptation Assessment in the Republic of Estonia.* Stockholm Environmental Institute, Tallinn.

Tarvel, E. (ed.). 1993. *Henriku Liivimaa kroonika*. Olion, Tallinn.

Veski, S. 1998. Vegetation history, human impact and palaeogeography of West Estonia. Pollen analytical studies of lake and bog sediments. *STRIAE*, **38**.

Veski, S. & Lang, V. 1996. Prehistoric human impact in the vicinity of Lake Maardu, north Estonia. A synthesis of pollen analytical and archaeological results. *PACT*, **51**, 189–204.

Taimestiku areng ja inimmõju Parika ümbruses Kesk-Eestis

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On käsitletud taimestiku muutusi Parika raba piirkonnas. Hilis-Glatsiaali lõpul ja Vara-Holotseenis valdasid siin kasemetsad, mis umbes 9000 ^{14}C aastat tagasi (siin ja edaspidi kõikjal kalibreerimata radiosüsiniku aastad) asendusid kase-männi ja 8000 ^{14}C aastat tagasi sega- ja laialehiste metsadega. Laialehiste metsade osakaal on olnud väike kogu Holotseeni vältel. Spetsiifilise joonena tuleb esile tõsta vaevakase rohket õietolmu kuni 6000 ^{14}C aastat tagasi ja märkimisväärset kuuse levikut alates 4800 ^{14}C aastat tagasi. Parika raba asub nõos, mis hakkas soostuma juba Holotseeni alguses. Turba juurdekasv on kogu selle aja vältel olnud muutlik: suurim viimase 1400 aasta jooksul (1,47–1,60 mm aastas), väikseim (0,40 mm aastas) 6600–5000 ^{14}C aastat tagasi. Esimesi inimmõju ilminguid on täheldatud juba mesoliitikumis: ruderaalide õietolmu on oluliselt rohkem. Maastiku avatus suurenes järsult nooremal pronksiajal, kuid esimesed kultuurkõrrelised ilmusid õietolmuspektritesse eelrooma rauaaja lõpul, umbes 2000 aastat tagasi, s.o märksa hiljem kui Põhja-Eestis. Biostratigraafiline materjal lubab oletada, et laiemalt hakati siinseid maid kultuuristama alles 1000 aastat tagasi.

Голоценовые природные и антропогенные изменения в окрестностях Парика, Центральная Эстония

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Исследовалось развитие растительности в голоцене в окрестностях населенного пункта Парика – в северо-западной части Выртсъярвеской низменности. В послеледниковый период и в раннем голоцене здесь преобладали густые березовые леса, которые примерно 9000 лет назад (некалиброванные ^{14}C данные) уступили место березово-сосновым, а

8000 лет назад – смешанным и широколиственным породам, доля которых оставалась скромной на протяжении всего голоцена.

Болото Парика расположено во впадине, заболачивание которой началось еще в начале голоцена, примерно 9500 лет назад. Прирост торфа варьировал от 0,40 мм/год (6600–5000 лет назад) до 1,47–1,60 мм/год (в последние 1400 лет). Первые следы присутствия и деятельности человека в окрестностях Парика отмечены уже в мезолите. На это указывает заметное увеличение количества пыльцы сорняков в палинологических спектрах. Более заметные вырубки леса стали практиковаться примерно 3000 лет назад (во второй половине бронзового века). Выращивание культурных злаков вблизи болота Парика началось примерно 2000 лет назад, т.е. гораздо позднее, чем в Северной Эстонии. Биостратиграфический материал позволяет предполагать, что крупномасштабное окультуривание местности началось лишь 1000 лет назад.