From Forest to a Farmland. Palaeoenvironmental Reconstruction of the Colonization of Western Uusimaa

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Abstract

According to the traditional hypothesis formulated on the basis of earlier archaeological and historical records, it was not until between the 12th and 14th centuries, when Swedes colonised the new areas in the northeastern side of the Baltic Sea. In order to investigate this hypothesis and the settlement history of Uusimaa, the pollen analytical results from altogether six continuous sediment cores from small lakes are presented. Former pollen analytical studies in the southern coastal areas provide important reference material.

In the pollen data, after the isolation of the lakes, the earliest phase of land use extends from the Pre-Roman Iron Age (500 BC – AD 1) through the Early Roman Iron Age (AD 1 – 200) until the end of the Late Roman Iron Age (AD 200 – 400). This period of land use can be described as forest clearing associated in some places with sporadic, small-scale cultivation.

Intensification of land-use practices is recorded from the beginning of the Migration Period (AD 400 – 600). Among the six study sites, there is evidence for continuous rye cultivation from AD 390 – AD 440 onwards on the large maritime island of Orslandet (Ingå) and also in the more coastal environment in Prästkulla (Ekenäs in Raseborg).

A fully agrarian landscape with permanent settlements, cultivated fields, and pastures becomes observable in the southern coastal areas gradually. Among the six studied cultural sites, this is first demonstrated on the archipelagic island of Orslandet from as early as AD 670 onwards. In most study sites, there is evidence for permanent settlement and a fully agrarian landscape from AD 940 –1100 onwards.

Keywords: pollen analysis, Uusimaa, settlement history, cultivation history, grazing.

1. Introduction

The Iron Age (Finland: 500 BC – AD 11/1200) has been a poorly known period in the coastal area and archipelago of southern Finland. The main argument has been that for an agriculturally based economy, this rocky area was not suitable for other purposes than as a resource area – a fisherman's landscape. According to archaeological and historical records, the coastal zone was sparsely populated until around cal AD 950. Only when the Swedish colonists settled on the coastal areas of southern Finland between the 12th and 14th centuries and brought with them technological advances, the maritime landscape could be settled and cultivated (Orrman 1991).

Due to intensive archaeological and historical studies during the recent years, the former picture of the desolate maritime landscape during the latter part of the Iron Age and Medieval Period (ca. AD 500 to 1550) has started to change. Still, the understanding of the maritime activities in this period is poor. In this paper, the problem of settlement continuity is approached from a palaeoecological viewpoint. This paper aims to discuss the development of the environment, human activities, resource utilization, and settlement history in the province of Uusimaa. The emphasis is on the Iron Age (500 BC – AD 11/1200) and on the Middle Ages (AD 11/1200 – 1550). One aim is to present an analysis of the period from AD 950 to AD 1200, from which the archaeological and historical indications of settlement are rare. Another important question concerns the occurrence and intensity of human activity during and after the integration process during the 12th to 14th centuries when Finland became a part of Sweden. In order to investigate the settlement history of Western Uusimaa, the pollen analytical results from altogether six continuous sediment cores from small lakes are presented. The study area consists of 120 km of Finnish coastline and a narrow archipelago west of Helsinki in the province of Uusimaa. It comprises a coastal zone with long inlets and gulfs (Fig. 1).

1.1. Earlier pollen analytical studies from the area

During the last 40 years, a number of palynological studies have been carried out on the southern coast of Finland on aspects of prehistoric land use (Fig. 1). These studies provide important reference material for the new results. The following section presents a review of the pollen analytical studies made on the southern coast of Finland. Although the primary aim of this study was to investigate the colonization of Western Uusimaa, the following paragraphs cover the whole southern coast. It should be noted that the results presented here follow the conclusions made by the authors of each study without any attempts by the author of this article to reanalyse the pollen data.

Another comment concerns the radiocarbon datings. To make the radiocarbon results comparable, all the radiocarbon dates obtained from the previous pollen analytical studies and discussed in the following paragraphs have been calibrated using the radiocarbon calibration program CALIB version 5.0 (Stuiver and Reimer 1993) with the intcal04.^{14}c calibration dataset (Reimer et al. 2004). In the following text, in order to summarise the results and to make the text more reader-friendly, the median probabilities of the calibrated dates are presented first. After the median probabilities, the original uncalibrated radiocarbon dates (BP) and calibrated radiocarbon dates (cal AD/cal BC) are in parentheses. Calibrated radiocarbon dates are expressed as the time range from which the sample originates with a probability of 68.3% (1 sigma), rounded to the nearest 10 years. In cases where time estimations are based on interpolation, shoreline curves, and so on, the prefix "cal" is omitted. This is also the practice for normal historical calendar years.

In the Åland islands, the influence of Iron Age man on the vegetation has been studied first by Fries in 1961 and 1963, later by Sarmaja-Korjonen et al. in 1991 and Roeck Hansen in 1991. Fries obtained the sediment core from Dalkarbyträsk in Jomala[3] and dated the onset of a continuous cereal pollen curve to cal AD 450

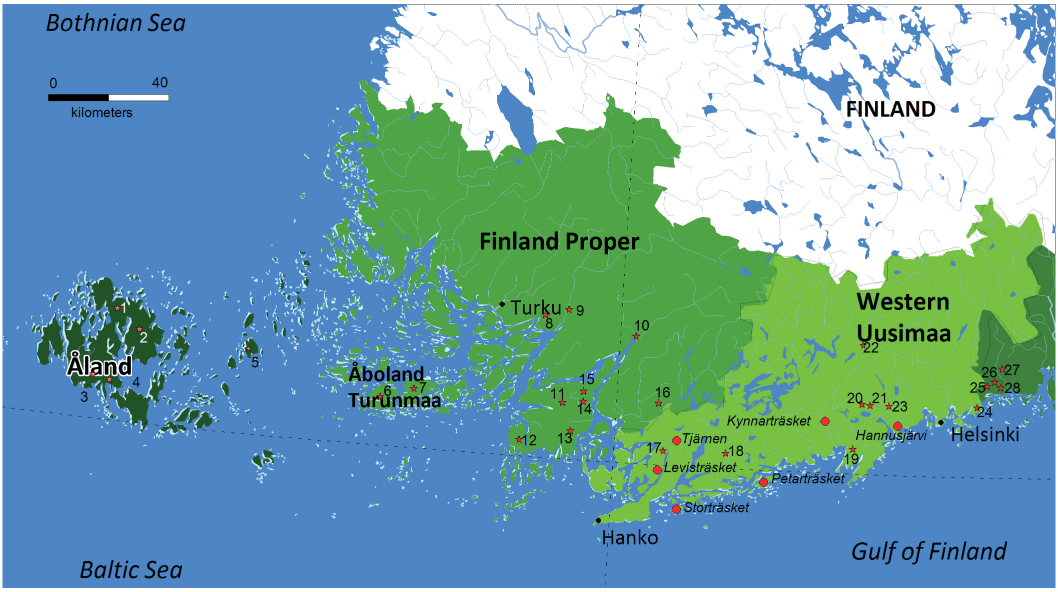


Fig. 1. Study area on the coast and in the archipelago of southern and southwestern Finland. Circles mark the basins studied in this article, and stars mark the sites with former pollen analyses:

1: Finström, Lake Kvarnträsk (Sarmaja-Korjonen et al. 1991)
2: Saltvik, Lake Kolmilaträsk (Sarmaja-Korjonen et al. 1991)
3: Jomala, Dalkarbyträsk (Fries 1961, 1963)
4: Önningeby, Flyet (Roeck Hansen 1991)
5: Kumlinge Island, Bomossen (Glückert 1989).
6: The island of Korpo (Vuorela 1990)
7: The island of Nagu (Vuorela 1990)
8: Piikkiö, Kuoppajärvi (Salonen et al. 1981)
9: Paimio, Vohteenkellarinsuo (Vuorela 1983)
10: Salo, Ketohaka (Tolonen 1985)
11: The island of Kimitoön, Gärdorna (Alenius 2008)
12: The island of Kimitoön, Söderbyträsk (Alenius 2008)
13: The island of Kimitoön, Västanfjärd, Labböleträsk (Alenius 2008)
14: The island of Kimitoön, Mossdalen (Asplund and Vuorela 1989)
15: The island of Kimitoön, Ilsokärret (Asplund and Vuorela 1989)
16: Perniö, Lemunsuo (Vuorela 1985)
17: Tenala, Bonästräsk (Tolonen et al. 1979)
18: Karis, Läppträsk (Tolonen et al. 1979)
19: Kirkkonummi, Molnträsk (Eskola, unpubl.)
20: Kirkkonummi, Lappböleträsk (Tolonen et al. 1979)
21: Kirkkonummi, Loojärvi (Tolonen et al. 1979)
22: Vihti, Katinhännänsuo (Vuorela 1972)
23: Espoo, Teirmossen (Vuorela and Kankainen 1998)
24: Helsinki, Vuosaari Kangaslampi (Vuorela et al. 1990)
25: Sipoo, Storträsk (Sarmaja-Korjonen 1992)
26: Sipoo, Hältingträsk (Sarmaja-Korjonen 1992)
27: Sipoo, Hampträsk (Sarmaja-Korjonen 1992)
28: Sipoo, Mörtträsk (Sarmaja-Korjonen 1992)

(1610 ± 90 BP, cal AD 380 – 550). This date agrees well with the work of Sarmaja-Korjonen et al. (1991), who dated the onset of a continuous cereal pollen curve from sediments obtained from Lake Kolmilaträsk in Saltvik[2] and Lake Kvarnträsk in Finström[1] to cal AD 370 (1670 ± 105 BP, cal AD 250 – 440) and cal AD 450 (1605 ± 95 BP, cal AD 380 – 560), respectively. Around the Lake Kolmilaträsk in Saltvik, the first phase of human influence was followed by a decrease or even a discontinuity in the anthropogenic indicators lasting from about AD 650 to AD 850, after which a new period of activity occurred. Also in Fries' analysis from the 1960s from Jomala, a temporary reduction in land use dated to cal AD 510 (1540 ± 100 BP, cal AD 420 – 610) was found. Around the study sites in Finström and Saltvik, the rise of the rye pollen curve indicating intensification in land-use activities dates to cal AD 1070 (975 ± 90 BP, cal AD 990 – 1160) and cal AD 1070 (980 ± 115 BP, cal AD 970 – 1190), respectively. The fall of rye pollen was visible in Kolmilaträsk and was dated to cal AD 1640 (270 ± 110 BP, cal AD 1470 – 1680).

In the fourth study site in Åland situated in the parish of Jomala, the sample obtained in Önningeby[4] from the bog of Flyet revealed that the cultivation of rye first started already during the first centuries AD (Roeck Hansen 1991). There was, however, a reduction in land-use activities when the landscape became less open with a tendency to overgrow. This period has been dated to between cal AD 1160 (860 ± 110 BP, cal AD 1150 – 1260) and cal AD 1400 (530 ± 115 BP, cal AD 1290 – 1460). After the gap in rye cultivation, rye reappears. However, according to Roeck Hansen, it seems probable that the radiocarbon dates for the regression period in the Önningeby diagram are too recent. She concludes that the introduction of agriculture in the neighbourhood of Flyet took place during the Early Iron Age, and therefore the break in settlement continuity or the movement of settlement(s) further away from Flyet took place during the 5th and 9th centuries.

On the island of Korpo[6], a development pattern similar to Åland can be followed, although the first cultivation attempts are recorded already from the beginning of the Christian Era, cal AD/BC 0 (1990 ± 90 BP, 110 cal BC – cal AD 90) onwards. In Korpo the first phase of land use lasts to cal AD 690 (1350 ± 90 BP, cal AD 610 – 770) and as in Åland, it is followed by a temporary reduction in land-use activities. A new beginning of cultivation is then visible from cal AD 1360 (580 ± 110 BP, cal AD 1290 – 1430) onwards (Vuorela 1990).

On the neighbouring island of Nagu[7] at Högsar, Vuorela (1990) studied the bog of Lalaxkärret, where the earliest human impact dated to the end of the Kiukainen culture, to 1960 cal BC (3600 ± 90 BP, 2050 – 1880 cal BC). Weak evidence of human activity was then discerned again starting from around 760 cal BC (2610 ± 90 BP, 860 – 750 cal BC) onwards.

In contrast to the early settlement signs in Åboland and on the islands of Nagu and Korpo, the island of Kumlinge[5] seems to have remained unsettled until AD 1100 when the cultivation of low-lying clay deposits started. The maximum values of rye occurred at around AD 1200 (Glückert 1989).

There are altogether five pollen analytical studies from the island of Kimitoön (Asplund and Vuorela 1989; Alenius 2008) in which archaeologically identifiable settlement continuation can be followed from the late Mesolithic to the Early Iron Age. After this, only sporadic finds indicating land use are recorded (Asplund 2008). In general, pollen analyses from the island of Kimitoön have revealed lots of evidence for human activity, with sporadic, small-scale cultivation clearly connected with cultivation in the Kiukainen Culture/Bronze Age. In the northern part of the island, in the former municipality of Kimito around the sampling place of Mossdalen[14] (Asplund and Vuorela 1989), slight human activity, probably the grazing of livestock, was recorded from 1320 cal BC (3070 ± 100 BP, 1440 – 1210 cal BC) onwards, as well as in the southern part of the island in Söderbyträsk[12] situated at the municipality of Dragsfjärd (Alenius 2008), where the onset of the early stages of human activity with some cultivation signs has been detected from

1100 cal BC (2910 ± 30 BP, 1130 – 1040 cal BC) onwards. Also in the eastern part of the island in the municipality of Västanfjärd, the first pollen of rye and barley was detected as early as 2100 cal BC (3715 ± 30 BP, 2100 – 3040 cal BC) in the mire of Labböleträsk[13], where signs of human impact then continue until c. 1300 BC (Alenius 2008). Also outside the island at Salo, where prehistoric settlement has been studied at two sites, Ketohaka basin and Santamäki[10], the first cultivation evidence dates to 1530 cal BC (3240 ± 110 BP, 1640 – 1410 cal BC) (Tolonen 1985).

On the island of Kimitoön, the Pre-Roman Iron Age land use is demonstrated clearly at two study sites in the northern part of the island. In the pollen data from bog of Mossdalen, Bronze Age grazing is followed by a clear change in tree pollen proportions: a decrease in spruce and QM trees together with an increase in birch and alder from ca. 900 BC onwards. This development proceeded along with the increasing intensity of human activity from 640 cal BC (2530 ± 110 BP, 780 – 520 cal BC) onwards, when the earliest *Cerealia*-type pollen is recorded and herb pollen frequencies start to increase. According to the authors, agricultural activity in the area has remained at a relatively low level, while grazing was more important. In Mossdalen a clear decrease in broad-leaved tree pollen at the beginning of the Christian Era, cal AD 40 (1960 ± 100 BP, 100 cal BC – cal AD 140) onwards, also seems to be in connection with land use for agriculture. About 4 km north of Mossdalen, an opening up of the landscape is also visible around the mire of Ilsokärret[15] from the beginning of the Pre-Roman Iron Age, 550 cal BC (2420 ± 110 BP, 590 – 400 cal BC) onwards (Asplund and Vuorela 1989). In the southern part of the island in Dragsfjärd, around the mire of Söderbyträsk, Pre-Roman Iron Age activity is visible in the form of *Cerealia*-type pollen findings dating to ca. 530 BC, 470 BC, 415 BC and 65 BC (and AD 800).

Outside the island, in Salo, Pre-Roman human activity is reflected as a short-term clearance of lime forest, visible around 410 cal BC (2320 ± 120 BP, 540 – 340 cal BC). Also at Salo, continuous cultivation of rye, associated with cattle grazing in the forest, was demonstrated as early as cal AD 170 (1850 ± 130 BP, cal AD 20 – 270). In the other profile in Salo, in the bog of Santamäki, the first random cultivation was dated to cal AD 330 (1700 ± 140 BP, cal AD 210 – 470), and further random cultivation of barley was dated to cal AD 450 (1590 ± 140 BP, cal AD 330 – 610).

After the grazing period with signs of small-scale cultivation in the Pre-Roman Iron Age, the second major change is visible on the island of Kimitoön and in Salo from the beginning of the Viking Age (ca. AD 800). At Salo continuous regional cultivation was demonstrated from AD 800 – 1000 onwards in the Ketohaka basin profile, and continuous cultivation of rye and wheat was demonstrated from cal AD 960 (960 ± 130 BP, cal AD 810 – 1050) onwards. Intensive cultivation is practiced from cal AD 840 – 890 onwards in the northern and eastern parts of the island around the mires Ilsokärret and Labböleträsk. In the southern part of the island, around the mire of Söderbyträsk in Dragsfjärd, intensive land use, permanent settlement, grazing, and the cultivation of rye and barley date to a couple of hundred years later, to the beginning of the Crusade period, cal AD 1100 (955 ± 30 BP, cal AD 1080 – 1120). Also in the northern part of the island, around the mire of Gärdorna[11], a decrease in the spruce pollen proportion clearly shows land use from cal AD 980 (1070 ± 30 BP, cal AD 970 – 1020) onwards, with continuous cultivation of rye and barley from cal AD 1350 (605 ± 30 BP, cal AD 1340 – 1360) onwards. The start of the most intensive phase of land use has been radiocarbon dated only in the mire of Gärdorna. According to the dating, the indications of a mostly open landscape, with maximum values of rye and juniper simultaneously with minimum spruce values, date to cal AD 1660 (245 ± 30 BP, cal AD 1640 – 1670).

In the mainland east of Turku, human activity has been studied from Lake Kuoppajärvi in the parish of Piikkiö[8] (Salonen et al. 1981) and from the bog of Vohteenkellarinsuo in Paimio[9]

(Vuorela 1983) situated about 10 km apart. In Piikkiö, evidence of slash-and-burn cultivation in the form of a decrease in spruce proportions appeared already at the isolation of the lake that, according to radiocarbon dating, took place in cal AD 480 (1550 ± 160 BP, cal AD 340 – 650). A similar dating for the onset of agricultural activities was obtained in Paimio, where the dating was based on the clear ash layer dated earlier by Glückert (1976) and resulted in the date of cal AD 400 (1640 ± 130 BP, cal AD 310 – 550). The transition to cattle grazing and field cultivation was dated only in Piikkiö, and took place from the beginning of the Viking Age, cal AD 810 (1230 ± 120 BP, cal AD 670- 890) onwards. In Paimio the maximum values of grasses and heathers were dated to cal AD 1290 (710 ± 100 BP, cal AD 1220 – 1320).

Moving eastwards in the coastal area, the next pollen data comes from the parish of Perniö[16], situated in the mainland about 23 km east of island of Kimitoön where altogether three pollen diagrams have been constructed from the bog of Lemunsuo (Vuorela 1985). The pollen data from Lemunsuo provided evidence of agricultural activity from around cal AD 760 onwards. This very modest evidence of human activity decreases during the Viking period before a more distinct relative rise of *Cerealia*-type pollen frequencies is demonstrated from cal AD 1180 – 1190 onwards.

The next pollen diagram comes from the Tenala-Karis area in Raseborg, where the land use history has been studied by Tolonen, Siiriäinen, and Hirviluoto in 1979 from the sediment profiles obtained from the lakes Bonästräsk in Tenala[17] and from Läppträsk in Karis[18]. The results revealed that around the study site in Karis, the cultivation of rye and barley was, as on the island of Kimitoön, practiced already from the beginning of the Pre-Roman Iron Age, ca. 430 BC onwards. In Tenala rye and barley type pollen was already found by the time of the isolation of the basin and, according to the abundant occurrence of juniper and sorrel pollen, also animal husbandry was evidently intensive. According to the isolation niveau, the authors dated the beginning of cultivation to ca. AD 1400. The radiocarbon dating, however, disagreed with the dating obtained from the isolation niveau, resulting in the date of cal AD 780 (1240 ± 50 BP, cal AD 690 – 750) for the beginning of cultivation. In the both studies there is a gap in cultivation signs that includes at least the Merovingian period and the early part of the Viking period, ca. AD 600 – 900.

In the Kirkkonummi–Espoo area, altogether four sites have been studied. Lake Loojärvi[21] and Lake Lapinkylänjärvi (Sw. Lappböleträsk)[20] are situated about 2 km apart in Kirkkonummi and have been studied by Tolonen, Siiriäinen, and Hirviluoto in 1979. The third site, Lake Molnträsk[19] in Kirkkonummi, has been analysed by Maarit Eskola. The fourth site, the bog of Teirmossen in Espoo[23], has been studied by Vuorela and Kankainen in 1998.

The first anthropogenic indication dates around Lake Loojärvi and Lake Lapinkylänjärvi in Kirkkonummi in the Pre-Roman Iron Age, ca. 450 – 200 BC. According to the authors, the presence of prehistoric settlement and cattle raising is demonstrated by an occurrence of plantain, mugwort, and sorrel, as well as a steep decline of spruce pollen values together with a sudden appearance of juniper pollen. In Loojärvi, the first indication of cultivation with cereal pollen together with a steep decline of spruce was dated to cal AD 290 (1740 ± 130 BP, cal AD 130 – 430). This first period of cultivation was brief. However, in Lapinkylänjärvi, evidence of more intensive Iron Age cultivation, cattle raising and permanent settlement was dated to cal AD 730 (1320 ± 140 BP, cal AD 610 – 880). Also in the bog of Teirmossen in Espoo, the increase in some native species favoured by human presence points to slash-and-burn cultivation and/or grazing from 360 cal BC (2300 ± 60 BP, 410 – 350 cal BC) onwards, and the first cultivation events date to cal AD 110 (2090 ± 40 BP, 170 – 85 cal BC). Around the bog of Teirmossen in Espoo, the increase in charcoal particles, together with an increase in some apophytes, points to the use of fire and land use on a regional scale starting from cal AD 260 (1770 ± 60 BP, AD 210 – 340). Around the third study site in Kirkkonummi, Lake Molnträsk, the onset of permanent settlement with grazing and cultivation dates to cal AD 1180 (870 ± 30 BP, cal AD 1160 – 1220) and the most intensive cultivation phase dates to cal AD 1350 (635 ± 30 BP, cal AD 1350 – 1390) (Eskola, pers. comm.).

The dates for the first cultivation signs in Kirkkonummi are in close agreement with the pollen analytical results from Vihti[22], about 22 km north of the study sites in Kirkkonummi. Also in Vihti, pollen evidence obtained from the bog of Katinhäntä dates the early agriculture to cal AD 390 (1650 ± 140 BP, cal AD 240 – 550) (Vuorela 1972). The cultivation includes rye, barley, and oat. Small-scale human activity and cultivation continued until ca. AD 1700, when permanent fields are recorded.

In Helsinki, there is a pollen diagram constructed from Vuosaari[24] (Vuorela et al. 1990). According to the pollen data, the onset of permanent cultivation dates to cal AD 930 (1120 ± 45 BP, cal AD 890 – 980).

East of Helsinki, in the commune of Sipoo, Sarmaja-Korjonen (1992) has studied four small lakes, Storträsk[25], Hältingträsk[26], Hampträsk[27], and Mörtträsk[28], that all lie within a radius of 7.5 km. The burial cairns of the Late Bronze Age (900 – 500 BC) and the Pre-Roman Iron Age (500 – AD 1) show that the study area was populated at the time. In general, Sarmaja-Korjonen found three phases of human activity. The first indication of human activity was dated in Hältingträsk to 990 cal BC (2800 ± 120 BP, 1110 – 830 cal BC), where the peak in juniper was interpreted to reflect the important role of grazing. The first rye pollen grains were stratigraphically immediately above the juniper peak. The second period was the clearance period that was dated to 480 – 350 cal BC onwards. The duration of this phase was about 130 years, and according to Sarmaja-Korjonen, no palynological evidence of human activity could be discerned after the clearance period during the interval approximately between 300 BC and AD 800. The third phase, permanent agriculture and animal husbandry in the area with an open, cultivated, and grazed landscape, was radiocarbon dated at Lake Hampträsk to the beginning of the Viking Age, cal AD 790 (1240 ± 80 BP, cal AD 690 – 830) onwards.

2. Material and methods

2.1. Study sites and sediment coring

The aim of the study was to obtain samples from the outer and inner archipelagoes and from the mainland, and because the samples were meant to be used to register land use history, an important criterion for the selection of samples was the closeness to archaeological and historical evidence. Another, equally important criterion for the selection of study sites was the reconstruction of the sea level history of the area, discussed in detail by Miettinen (2011, this volume).

Altogether six sediment profiles were obtained (Fig. 1). The sediment profiles of Lake Storträsk and Lake Petarträsk are from the most maritime context of this study taken on the islands of Älgö and Orslandet, which are located about 15 km apart. Both are large islands (about 3,5 km across) consisting mainly of barren bedrock with coniferous forest. The island of Älgö is situated on sailing routes and there are numerous prehistoric grave findings. There are also findings dating to the end of the Iron Age, but the earliest settlement remains to be found. The third sediment profile was taken from Lake Levisträsk in coastal surroundings in Ekenäs, Prästkulla. In the Early Middle Ages, the area was still a 0,5 – 2,0 km wide strait with mainly sandy slopes and bedrock outcrops. The fourth sediment profile comes from Lake Tjärnen also in coastal surroundings in Ekenäs, Tenala. Today it is located about 4,2 km from the seashore, but in prehistoric times, it was located at the end of a long and narrow bay. The landscape is dominated by large plains with clay sediments at lower elevations and sand at higher elevations. The settlement history of this area is in a key position in studying the complex relationship between the settlement history of the mainland and the coastal areas. This is also the only area with Iron Age sites known before the 1990s. Several burial sites dated to the Middle and Younger Iron Age were excavated in the early 20th century.

The sediment profiles taken from Lakes Hannusjärvi in Espoo and Kynnarträsk in Siuntio represent the mainland setting. Archaeological rescue excavations in Espoo Kauklahti have revealed a medieval village site, and the results indicate that the settlement started in Espoo at least 200 years before the village appears in the historical documents. In Siuntio, one important criterion is the archaeological evidence from the Iron Age found north of Lake Kynnarträsk. Another criterion for selecting this study site was the closeness to the Sjundby estate, which together with large field areas may have attracted early cultivation.

In Table 1, the geographical position of the sampling places, the area of the lake, its altitude above sea level, water depth, and zone in the archipelago (maritime/coastal/mainland) is presented. Five of the pollen profiles were taken from small lakes that vary in size between 3 and 12 hectares, only Lake Storträsk in Älgö is 28 hectares in size. The relatively large size of Lake Storträsk influences the pollen source area that must be considered when interpreting the results. Large sedimentary basins collect pollen from larger areas than smaller basins and small vegetation patches will not be recorded in the pollen data (Sugita et al. 1999; Broström et al. 2004; Bunting et al. 2004).

Fig. 2. A freeze-box sample obtained from Lake Petarträsk, Ingå, Orslandet. Persons from left to right: Henrik Jansson, Georg Haggrén, Arto Miettinen, Heikki Hyvärinen.

Sediment cores were obtained in the winter, when the lakes were frozen, from the deepest point of the lake using a Russian peat sampler. In order to demonstrate the land use events in the upper and topmost part of the loose surface sediment, most likely representing the medieval period, the freezing technique (Shapiro 1958; Saarnisto 1975) was used in Lake Stor-

	Ekenäs, Älgö, Lake Storträsk	Ingå, Orslandet, Lake Petarträsk	Ekenäs, Prästkulla, Lake Levisträsk	Ekenäs, Tenala, Lake Tjärnen	Siuntio, Lake Kynnarträsk	Espoo, Lake Hannusjärvi
Geographical position	N 59° 52.467' E 23° 23.64'	N 59° 58.388' E 23° 54.679'	N 59° 59.217' E 23° 16.292'	N 60° 4.673' E 23° 22.456'	N 60° 9.455' E 24° 16.588'	N 60° 9.044' E 24° 41.139'
Area (ha)	28	3	3	3	12	6
Altitude (m) a.s.l.	5.9	9.5	0.2	13	4.9	8.1
Water depth (cm)	280	470	0	550	490	230
Zone	Maritime	Maritime	Coastal	Coastal	Mainland	Mainland

Table 1. Studied basins in Western Uusimaa.

träsk and Lake Petarträsk (Fig. 2). In Lake Storträsk in Älgö, a 50 cm long frozen sample was obtained, and in Lake Petarträsk in Orslandet, an 80 cm long frozen sample was obtained. The sediment properties and isolation contacts of the basins are all based on the determinations by Miettinen (see Miettinen et al. 2007; Miettinen 2011, this volume), and are only briefly discussed here.

2.2. Pollen and charcoal analysis

Subsamples were taken from the cores at a 1 cm resolution. To calculate pollen concentrations (grains cm^{-3}), determined in Lake Hannusjärvi and Lake Petarträsk, and charcoal particle concentrations, determined in Lake Petarträsk, Lycopodium tablets (Stockmarr 1971) were added to sediment samples of 1 cm^3. The treatment for pollen samples followed standard procedures, with KOH and HF treatments (Berglund and Ralska-Jasiewiczowa 1986; Bennett and Willis 2001; Whitlock and Larsen 2001). Safranin-stained glycerine was added to the pollen subsamples for staining and mounting.

At least 500 arboreal pollen grains (AP) were counted from the subsamples. Charcoal particles were counted from the pollen slides against 30% of the Lycopodium count achieved in the pollen analysis. The charcoal particles were measured along the longest axis and the charcoal particles longer than 25 µm were counted. The identification of pollen species was based on publications by Erdtman et al. (1961), Faegri and Iversen (1989), Moore et al. (1991), and Reille (1992, 1995), as well as on the pollen and spore reference collection kept at the Geological Survey of Finland. The pollen and spore nomenclature is according to Moore et al. (1991). The pollen percentages of arboreal trees (=AP incl. *Picea, Pinus,Betula, Alnus*), non-arboreal pollen (NAP), and broad-leaved trees (= QM = *Quertum mixtum* incl. *Populus, Corylus, Ulmus, Quercus, Tilia, Carpinus, Fraxinus, Fagus*) were calculated from the basic sum of terrestrial pollen grains, P = AP + NAP + QM. The aquatic pollen and spores were calculated from the sums P + AqP and P + Spores.

2.3. Dating

The dating of the profile was based on altogether 22 ^{14}C determinations from bulk sediment and performed in the Poznań Radiocarbon Laboratory with accelerator mass spectrometry (AMS). Radiocarbon datings are presented in Tables 2 and 3. The radiocarbon dating in Table 2 was obtained from the freeze box sampler from the surface sediment, and the radiocarbon datings in Table 3 were obtained from the Russian peat sampler. The radiocarbon ages are presented as years before present (BP), calculated from the year 1950 backwards. Radiocarbon ages have been converted to calibrated years (cal yr), that is, years that represent true

Table 2. Radiocarbon dating obtained from the freeze box sampler from the surface sediment.

Lab number	Sample depth	^{14}C age BP	Dated event	One Sigma Ranges (68.3%) start : end relative area under distribution	Two Sigma Ranges (95.4%) start : end relative area under distribution	Median probability
Inkoo, Orslandet, Lake Petarträsk						
Poz-14675	15 cm	365±30 BP	Most intensive land use	[1457 AD:1521 AD] 0,675069	[1449 AD:1528 AD] 0,540855	1522 AD

calendar years using the radiocarbon calibration program CALIB version 5.0 (Stuiver and Reimer 1993) with the intcal04.14c calibration dataset (Reimer et al. 2004). It presents calibrated calendar years by calculating the probability distribution of the sample's true age. Probabilities are expressed in a time range with a 68.3% (1 sigma) and a 95.4% (2 sigma) probability. Also the relative area under the one and two sigma ranges and median probability are presented.

For the sake of readability, median probabilities are presented first in the text. After the median probabilities, calibrated radiocarbon dates are presented in brackets, expressed in terms of cal BC or cal AD at one sigma range (68.3%) confidence intervals, rounded to the nearest 10 years. For summarizing purposes, only median probabilities are presented in the discussion and conclusion sections.

Table 3. Radiocarbon datings obtained from the Russian peat sampler.

Lab number	Sample depth	^{14}C age BP	Dated event	One Sigma Ranges (68.3%) start : end relative area under distribution	Two Sigma Ranges (95.4%) start : end relative area under distribution	Median probability
Ekenäs, Älgö, Lake Storträsk						
Poz-12508	51 cm	1355 ± 30	Continuous occurrence of cereal	[648 AD:676 AD] 1	[632 AD:710 AD] 0,939024	663 AD
Poz-10692	82 cm	1 745 ± 30	Earliest indications of human activity	[272 AD:335 AD] 0,767342	[228 AD:388 AD] 1	297 AD
Poz-14677	105 cm	1790±30	Isolation	[210 AD:258 AD] 0,563105	[132 AD:263 AD] 0,767251	232 AD
Poz-12509	151 cm	2865 ± 35	Pre-isolation, cereal pollen	[1094 BC:996 BC] 0,854627	[1130 BC:922 BC] 0,981608	BC 1037
Ingå, Orslandet, Lake Petarträsk						
Poz-4502	16-18 cm	1350 ± 30	Most intensive land use	[650 AD:679 AD] 1	[637 AD:713 AD] 0,923579	666 AD
Poz-3547	30-32 cm	1665 ± 35	Decrease in spruce, increase in herb pollen	[342 AD:421 AD] 1	[316 AD:437 AD] 0,847327	382 AD
Poz-3549	54-56 cm	1960 ± 30	Decrease in spruce	[16 AD:72 AD] 0,909247	[39 BC:87 AD] 0,960925	40 AD
Poz-14723	87 cm	2415 ± 35	Isolation	[537 BC:406 BC] 1	[567 BC:399 BC] 0,780643	494 BC
Poz-3550	94-96 cm	2440 ± 40	Isolation contact	[545 BC:412 BC] 0,712581	[598 BC:406 BC] 0,642985	543 BC

(Table continues >)

Table 3. (continued)

Ekenäs, Prästkulla, Lake Levisträsk						
Poz-8273	33 cm	1100 ± 35	Beginning of extensive land use	[939 AD:986 AD] 0,617695	[883 AD:1017 AD] 1	944 AD
Poz-8274	69 cm	1660 ± 30	Continuous occurrence of rye	[378 AD:422 AD] 0,737729	[322 AD:436 AD] 0,906363	389 AD
Ekenäs, Lake Tjärnen						
Poz-17110	70 cm	930 ± 30 BP	Beginning of extensive land use	[1116 AD:1154 AD] 0,431242	[1025 AD:1168 AD] 1	1099 AD
Poz-17112	88 cm	1045 ± 30 BP	Continuous occurrence of rye	[982 AD:1020 AD] 1	[947 AD:1029 AD] 0,910537	996 AD
Poz-17113	195 cm	2510 ± 35 BP	Isolation	[647 BC:550 BC] 0,649806	[790 BC:519 BC] 1	BC 638
Poz-12513	206 cm	2925 ± 30	Isolation contact	[1133 BC:1055 BC] 0,628299	[1215 BC:1019 BC] 0,94755	BC 1128
Espoo, Lake Hannusjärvi						
Poz-14673	53 cm	1035 ± 30	Beginning of extensive land use	[988 AD:1022 AD] 1	[961 AD:1036 AD] 0,935383	1002 AD
Poz-10690	121 cm	2165 ± 30	Isolation	[351 BC:298 BC] 0,551034	[261 BC:148 BC] 0,479984	BC 240
Poz-10691	136 cm	2410 ± 35	Isolation	[522 BC:404 BC] 0,966959	[560 BC:397 BC] 0,803957	BC 489
Poz-14721	163 cm	2875 ±35	Pre-isolation, barley	[1116 BC:1006 BC] 1	[1132 BC:968 BC] 0,879761	BC 1052
Siuntio, Lake Kynnarträsk						
Poz-24055	80 cm	1105 ± 30 BP	Beginning of extensive land use	[940 AD:980 AD] 0,59936	[885 AD:998 AD] 0,98106	942 AD
Poz-22527	88 cm	1155 ± 30 BP	Continuous occurrence of rye	[860 AD:899 AD] 0,41653	800 AD:907 AD] 0,59481	885 AD

3. Results

3.1. Ekenäs, Älgö, Lake Storträsk

The lowermost part of the sediment, from 180 cm until 105 cm, consists of clay gyttja and obviously represents the phase before the isolation of the lake (Fig. 3). Therefore the pollen source area is difficult to interpret, but obviously the samples from before the isolation represent the regional pollen. In the pollen data, *Pinus* (pine), *Betula* (birch), *Alnus* (alder), and *Picea* (spruce) dominate. The radiocarbon dating at the level of 151 cm resulted in the date of 1040 cal BC (1090 – 1000 cal BC). This is also the level where the earliest pollen of cultivated plants was found. The pollen of *Secale* (rye) is then followed by three grains of the pollen of *Hordeum* (barley), the uppermost one found at the level of 127 cm. Even when the origin of the anthropogenic pollen is difficult to interpret, the pollen evidently indicates cultivation somewhere in the region in the Bronze Age.

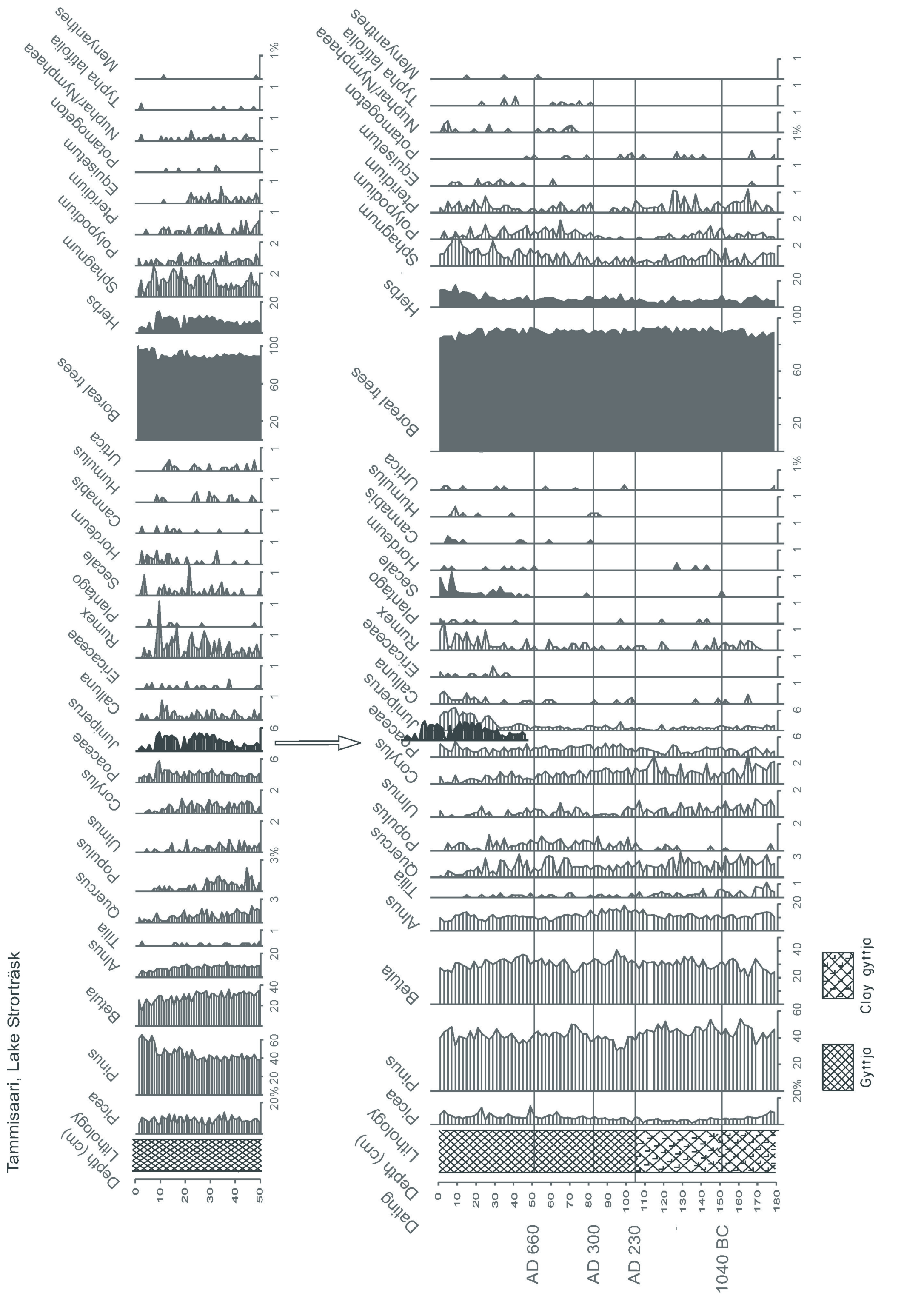
From 105 cm upwards, the sediment changes from clay gyttja to dark brown gyttja as a result of the isolation of the lake. According to Miettinen (2011, this volume), the isolation was a slow process that started at 105 cm, cal AD 230 (cal AD 210 – 260) according to the radiocarbon dating from this depth. The isolation process was completed at 82 cm, cal AD 300 (cal AD 270 – 340) according to the radiocarbon dating. After the isolation, aquatic *Typha latifolia* (great reedmace) and *Nuphar/Nymphaea* (water lily) increased and at the same level, pollen of *Secale* was detected. The uppermost radiocarbon dating at the level of 51 cm then dates the regular occurrence of *Secale* starting at cal AD 660 (cal AD 650 – 680).

The freeze box sample (Fig. 3, upper diagram) obtained from the uppermost 50 cm from the sediment surface can, according to changes in *Juniperus* (juniper) and total herb pollen percentages, be roughly correlated with the sediment core obtained with the Russian peat sampler. Increasing *Juniperus* and total herb pollen percentages visible in the freeze box sample at the level of 40 cm most likely correspond with the level of ca. 30 cm in the lower sediment core. The values of *Juniperus* then remain high until they drop suddenly in the uppermost 8 cm. The freeze box sample is not radiocarbon dated but, nevertheless, confirms the continuation of the occurrence of *Hordeum* and *Secale* type pollen to the present. High values of *Juniperus* and the regular occurrence of *Urtica* (nettle) are likely to be connected with grazing and permanent settlement.

3.2. Ingå, Orslandet, Lake Petarträsk

In the sediment core obtained from Lake Petarträsk at Orslandet, Ingå, the lowermost part of the sediment from 190 cm to 103 cm consists of clay gyttja representing the Baltic Sea stage (Miettinen et al. 2007; Miettinen 2011, this volume). As in Lake Storträsk, *Pinus, Betula, Alnus,* and *Picea* dominate in the pollen data, and also in Lake Petarträsk, a few *Cerealia* pollen, yet undated, were found (Fig. 4). As the lake became isolated, organic gyttja started to accumulate in the basin. In the sediment sample, the isolation contacts at the levels of 94 – 96 cm and 87 cm have been dated to 540 cal BC (550 – 410 cal BC) and 490 cal BC (540 – 410 cal BC), respectively (Miettinen 2011, this volume).

Fig. 3. (next page). Pollen percentage diagrams from Lake Storträsk in Ekenäs, Älgö. The upper diagram shows the pollen percentages taken with the freeze box sampler and the lower diagram shows the pollen percentages taken with the Russian peat sampler. The connection between the upper and lower diagrams is demonstrated with the Juniperus pollen values, marked with an arrow. From left to right: Median probabilities of AMS ^{14}C dates, depth from the sediment surface, sediment lithology, a selection of the most important pollen and spore types. Horizontal lines extending over the diagram indicate the dated levels. Pollen percentages of arboreal pollen (AP; including Picea, Pinus, Betula, Alnus), non-arboreal pollen (NAP), and QM trees were calculated from the basic sum of terrestrial pollen grains, P=AP+NAP+QM. Spores and aquatic pollen are calculated from the sums P+spores and P+aquatics.


Tammisaari, Lake Strorträsk
Depth (cm)
Lithology
Picea
Pinus
Betula
Alnus
Tilia
Quercus
Populus
Ulmus
Corylus
Poaceae
Juniperus
Calluna
Ericaceae
Rumex
Plantago
Secale
Hordeum
Cannabis
Humulus
Urtica
Boreal trees
Herbs
Sphagnum
Polypodium
Pteridium
Equisetum
Potamogeton
Nuphar/Nymphaea
Typha latifolia
Menyanthes
Dating
AD 660
AD 300
AD 230
1040 BC
Gyttja
Clay gyttja

At the isolation contact at the level of 94 – 96 cm, the concentration of charcoal particles increases notably. The peak in the charcoal content obviously refers to secondary charcoal, that is, material introduced several years after the actual fire as a result of surface run-off and within-lake sedimentary processes (Whitlock and Larsen 2001). The peak at *Poaceae* percentages and concentrations (meadowgrasses) at the isolation contact is likely to be connected with the dispersal of local lakeshore vegetation around the exposed lake.

The first changes in the pollen data, apparently connected with human activity in the region, appear in the pollen data at a depth of 56 cm. According to the radiocarbon dating, this dates to cal AD 40 (cal AD 20 – 70). In the pollen data, possible human activity is reflected by a sudden decrease in *Picea* pollen percentages and concentrations, together with a slight decrease in QM tree (broad-leaved trees) pollen. From the same level upwards, local wetland vegetation, such as *Carex* (sedge) and *Sphagnum* (Sphagnum peat), shows an increasing trend, and pollen percentages and concentrations of *Poaceae* increase somewhat. The pollen occurrences of *Humulus/Cannabis* types (hop/hemp) together with *Urtica* are also likely to be connected with human activity in the region.

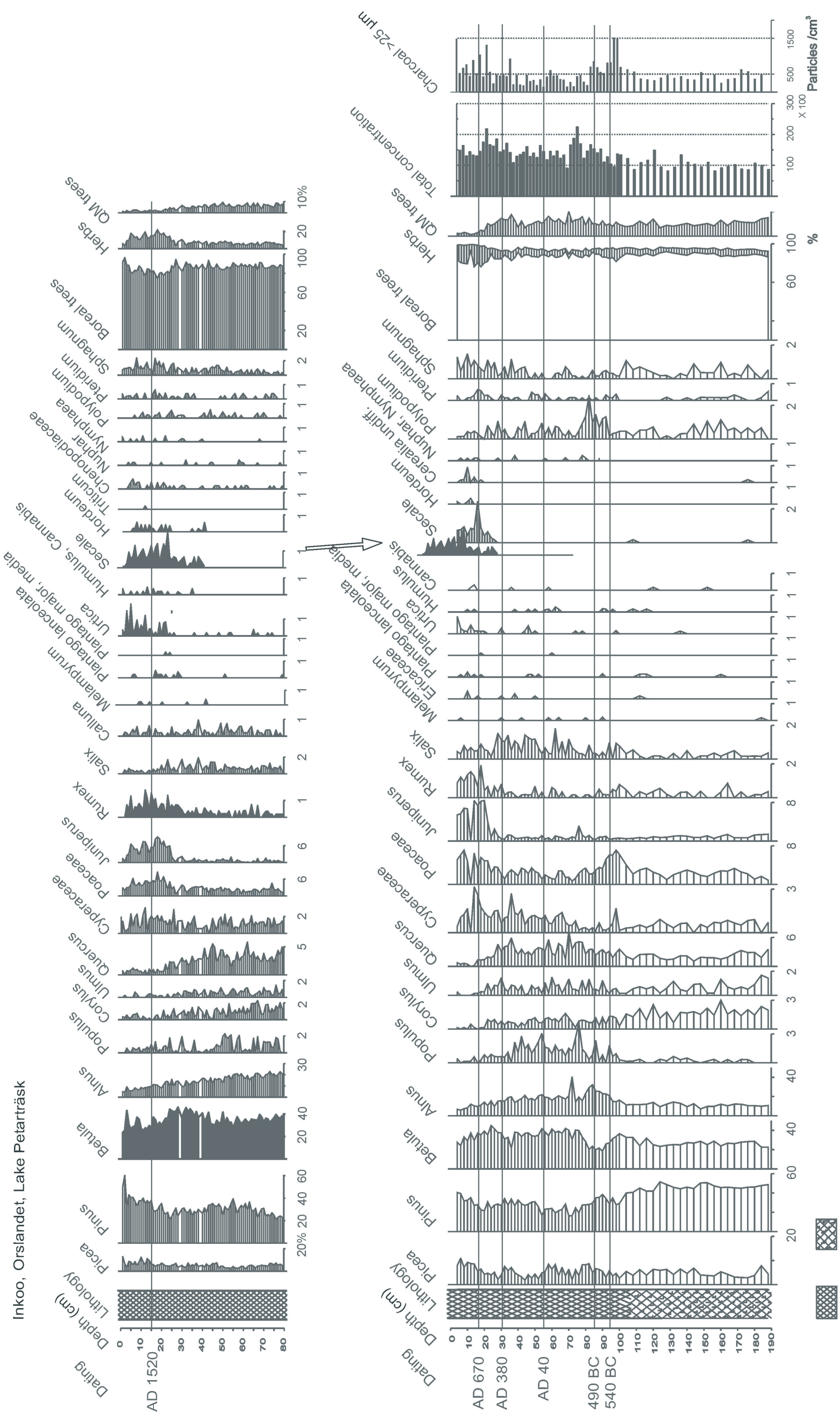
A clear change in the pollen data can be seen from c. 32 cm upwards, cal AD 380 (cal AD 340 – 420) onwards according to the radiocarbon dating from 30 – 32 cm, as the total proportion of tree pollen starts to decrease, together with increase in non-arboreal pollen proportions. The most prominent decrease is recorded in the *Picea* pollen percentages and concentrations. A decrease in the proportion of broad-leaved trees (QM pollen) is also clearly visible. The earliest *Secale* pollen was recorded a couple of centimetres upwards at the 28 cm level, and, according to linear interpolation, the onset of cultivation can be roughly dated to ca. 440 AD onwards.

From the beginning of the regular occurrence of *Secale* pollen, signs of steadily increasing land use are recorded. This includes the steadily increasing *Secale* pollen and growing proportions of *Rumex* (sorrel), *Juniperus*, *Poaceae*, and *Cyperaceae*, apparently connected with enlarging areas of fields and meadows. At the same time, proportions of broad-leaved trees, *Populus* (aspen), and *Salix* (willow) decrease, also potentially indicating grazing in the surroundings. An increase in charcoal particles points to slash-and-burn cultivation in the region. This development culminates at ca. 16–18 cm, ca. cal AD 670 (cal AD 650 – 680) according to the radiocarbon dating. This also dates not only the peak in the *Secale* pollen values, but also the first occurrence of *Hordeum* pollen, which, together with a regular occurrence of *Plantago lanceolata* and *Urtica*, are evidently connected with increasing cultivation and permanent settlement.

In order to demonstrate land-use practices in the Middle Ages, the freeze box sample was obtained from the loose surface sediment (Fig. 4, upper diagram). Although no exact correlation can be found between the sediment sample obtained with the Russian peat sampler and the freeze box sample from the uppermost 80 cm, it can be assumed that an onset of *Secale* cultivation, seen at the freeze box sample at the level of 42 cm, roughly represents the level of 28 cm visible in the material cored with the Russian peat sampler.

In the pollen record obtained with the freeze box sampler, the onset of *Secale* cultivation is visible from 42 cm onwards and continues without interruptions to the topmost samples.

Fig. 4. (next page). Pollen percentage diagram from Lake Petarträsk in Ingå, Orslandet. The upper diagram shows the pollen percentages taken with the freeze box sampler and the lower diagram shows the pollen percentages, total pollen concentration (pollen grains / cm^3) and charcoal particle concentration for charcoal particles over 25 µm taken with the Russian peat sampler. In both diagrams from left to right: Median probabilities of AMS ^{14}C dates, depth from the sediment surface, sediment lithology, a selection of the most important pollen and spore types. Horizontal lines extending over the diagrams indicate the dated horizons. Pollen and spore percentage calculations as in Figure 2.


Inkoo, Orslandet, Lake Petartträsk
Dating
Depth (cm)
Lithology
Picea
Pinus
Betula
Alnus
Populus
Corylus
Ulmus
Quercus
Cyperaceae
Poaceae
Juniperus
Rumex
Salix
Calluna
Melampyrum
Ericaceae
Plantago lanceolata
Plantago major, media
Urtica
Humulus
Cannabis
Humulus, Cannabis
Secale
Hordeum
Triticum
Cerealia undiff.
Chenopodiaceae
Nuphar, Nymphaea
Polypodium
Pteridium
Sphagnum
Boreal trees
Herbs
QM trees
Total concentration
Charcoal >25 µm
Particles /cm3
AD 1520
AD 670
AD 380
AD 40
490 BC
540 BC
Gyttja
Clay gyttja

The freeze box sample was dated at the level of 15 cm and, according to the radiocarbon dating, this level dates to cal AD 1520 (cal AD 1460 – 1520). The results verify that human activity continued without major interruptions in the area throughout the late Iron Age and the Middle Ages (ca. AD 500 to 1550).

3.3. Ekenäs, Prästkulla, Lake Levisträsk

The lithostratigraphy from Lake Levisträsk reveals that clay gyttja, typical for large lakes, is deposited from the bottom of the 200 cm long sediment sequence to the 62 cm level, where organic gyttja starts to be deposited into the basin (Fig. 5). The sediment then turns back to clay gyttja between 57 cm and 32 cm, possibly indicating field erosion around the basin. The actual isolation of the lake is not dated, but according to lake level and sediment properties, isolation took place less than a thousand years ago (Miettinen 2011, this volume).

In the lowermost part of the pollen diagram, to c. 82 cm, *Pinus* and *Betula* pollen constitute the main pollen types in the diagram, c. 45 and 35%, respectively. *Alnus* pollen constitutes about 10 – 15% of total land pollen. The percentage of *Picea* pollen remains relatively low, only about 5% of total land pollen in the diagram until around 82 cm. The low level of *Picea* pollen could be explained by the deposition conditions. The lowermost part of the sediment may be deposited in a relatively large water basin, and the pollen represents regional instead of mainly local pollen.

Above 82 cm, *Picea* pollen values increase, while the proportion of *Pinus* and *Alnus* decreases. This may be connected with changes in the deposition environment. On the other hand, changes in the tree proportions may well be connected with human activities in the lake surroundings, as continuous cultivation of *Secale* is recorded in Lake Levisträsk from 69 cm upwards. The cultivation of *Secale* is associated with an increase in *Calluna* (heather), *Poaceae*, and *Juniperus*, and can be associated with increasing open areas. According to the radiocarbon dating at 69 cm, this event took place in cal AD 390 (cal AD 340 – 420). The cultivation of *Hordeum* is registered from cal AD 940 (cal AD 940 – 990) onwards, associated with a sudden increase in *Secale* pollen, as well as pollen of *Juniperus* and *Rumex*. The uppermost phase from cal AD 940 to the top is also associated with a clear increase in aquatic pollen, and it is most likely to be connected with the eutrophication and the isolation of the lake.

3.4. Ekenäs, Tenala, Lake Tjärnen

A sediment core with a total length of 260 cm was analysed from Lake Tjärnen (Fig. 6). The sediment changes from clay gyttja to gyttja at the level of 205 cm, 1130 cal BC (1130 – 1060 cal BC) according to the radiocarbon dating. The second ^{14}C date, 640 cal BC (650 – 550 cal BC), was obtained above the isolation contact at the depth of 195 cm (Miettinen et al. 2007). Until ca. 195 cm, pollen of main tree species *Pinus, Betula, Alnus,* and *Picea* dominate in the pollen diagram. *Ulmus* (elm), *Quercus* (oak), *Tilia* (lime), and *Corylus* (hazel) are the most abundant QM trees. Also a few pollen grains of *Cerealia* type, three *Hordeum* and one *Secale*, were present. Before and after the isolation contact between the 185 and 210 cm levels the pollen proportions of the main tree species fluctuate strongly suggesting unstable sedimentary conditions and reworking of the sediment.

The pollen proportions stabilize by 180 cm, and after the isolation, the *Betula* pollen constitutes altogether c. 50% of total land pollen, *Pinus* c. 25%, *Picea* less than 10%, and *Alnus* from 20% to 10%. Even occasional pollen of *Hordeum* was recorded from after the isolation from 640 cal BC (650 – 550 cal BC) to the present. Also *Rumex* and *Humulus/Cannabis* pollen are present sporadically. Especially at depths from 190 cm to 152 cm, according to linear interpolation representing the time period of 255 BC to 20 AD, pollen of *Hordeum* was recorded nearly in every centimetre. During the same interval, proportions of *Picea, Quercus*, and *Tilia* fall remarkably. For the second time after the isolation, pollen of *Hordeum* is

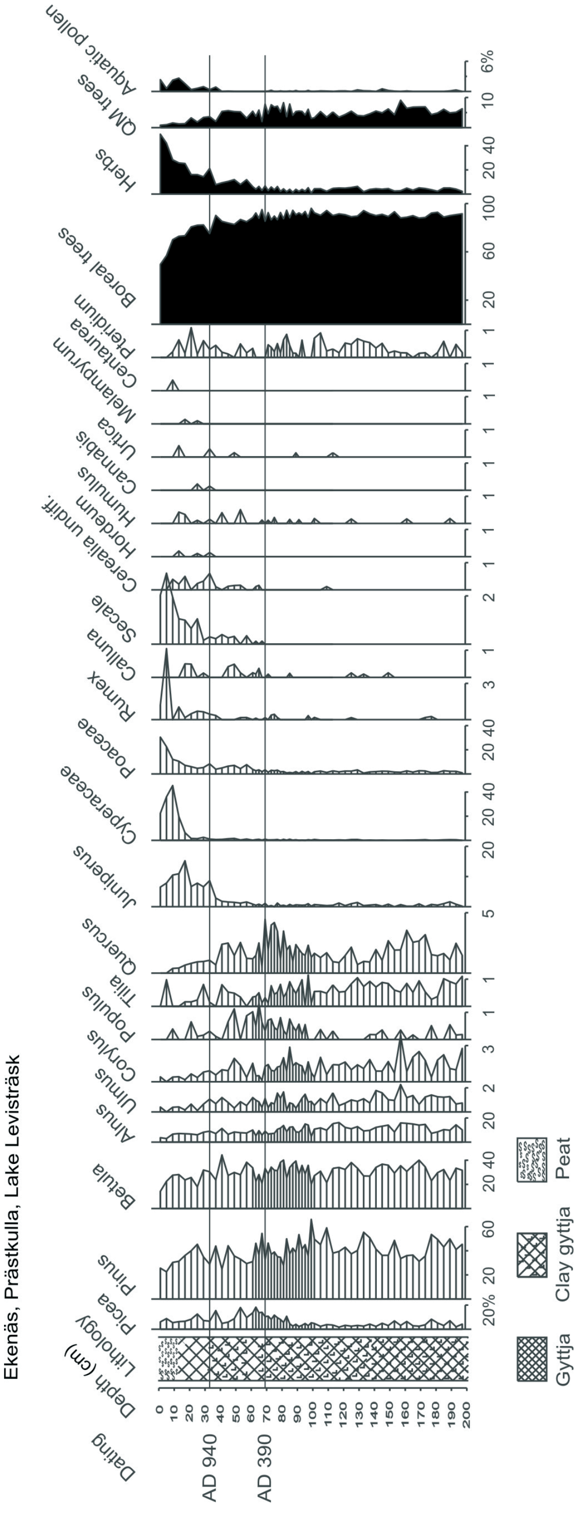


Fig. 5. Pollen percentage diagram from Lake Levisträsk in Ekenäs, Prästkulla. From left to right: Median probabilities of AMS ^{14}C dates, depth from the sediment surface, sediment lithology, a selection of some illustrative pollen and spore types. Horizontal lines extending over the diagram indicate the dated horizons. The sums for pollen and spore percentages are calculated as in Figure 2. QM = broad-leaved deciduous trees.

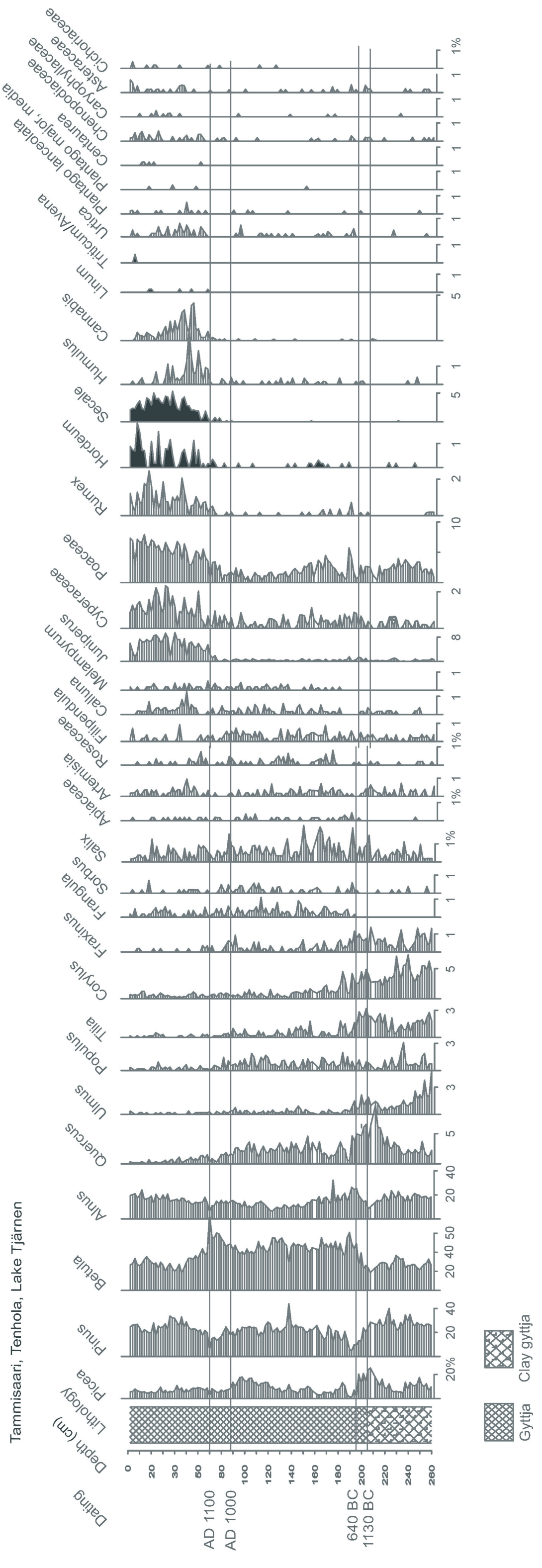


Fig. 6. Pollen percentage diagram from Lake Tjärnen in Tenala. From left to right: Median probabilities of AMS ^{14}C dates, depth from sediment surface, sediment lithology, a selection of the most important tree pollen and some herb pollen. Horizontal lines extending over the diagram indicate the dated horizons. Pollen percentages are calculated from the total land pollen.

recorded according to interpolation in years AD 200, AD 280, AD 690 and AD 935.

The start of a continuous occurrence of *Secale* associated with sporadic pollen of *Hordeum* at the depth of 88 cm dates to cal AD 1000 (cal AD 980 – 1020). Distinct changes in the major tree species are also clearly demonstrated. *Picea* and *Pinus* pollen show a sudden decrease, while pollen of *Betula* increases. The increase in the relative proportion of *Betula* pollen in the percentage pollen diagram most probably represents not only the increasing proportions of birch as the forests were replaced by tree species of young succession stages, but also regional pollen from source assemblages further away, as the local coniferous trees were cleared from the surroundings of the lake. At the same time the decrease of *Quercus* is clearly visible.

The intensification of land use and cultivation at the level of 70 cm dates to cal AD 1100 (cal AD 1120 – 1150). In the pollen diagram, this is reflected by a continuous and plentiful occurrence of *Secale* and *Hordeum* pollen, and also an increase of *Rumex*. Also Poaceae and *Juniperus*, indicative of fields and meadows, increase suddenly. An increase in *Calluna* can be the result of pasture, the thinning of forests, and forest clearances in the area (Behre 1981; Vuorela 1992). A clear increase in *Urtica* is obviously connected with the nitrogen enrichment around the lake (Behre 1981), and in addition to *Urtica*, an increase in other weed pollen, such as *Plantago* (plantain), (Plantago *lanceolata*, *Plantago major/media*), *Centaurea* (knapweed), *Chenopodiaceae* (goosefoot), *Caryophyllaceae* (chickweeds), and *Asteraceae* (asters), indicates permanent settlement around the lake.

From cal AD 1100 onwards *Cannabaceae* (hop/hemp) pollen increases profoundly, and even some pollen of *Linum* (flax) provides evidence of cultivation for fibre. Unlike *Cannabis*, *Humulus* is found as a wild plant in Finland growing on the seashores and along streams and lakes (Suominen 1978). *Cannabis*, on the other hand, does not belong to the native flora in Finland. The separation between these two pollen types is difficult. It is based mainly on pollen size, and different size limits have been determined for these two species (Faegri and Iversen 1989; Erdtman 1961; Beug 1961). The clear peak of both *Humulus* and *Cannabis* type pollen from cal AD 1100 onwards, however, points to cultivation. The peak of cultivation of *Humulus* and *Cannabis* is reached at 52 cm, and according to a very robust linear interpolation, this dates to 1540 AD. An increase in *Asteraceae* and *Calluna* pollen is also recorded from AD 1540 onwards. In the pollen diagram, the occurrence of *Hordeum* and *Secale* continues to the topmost samples.

3.5. Espoo, Lake Hannusjärvi

The lowermost part of the sediment between 180 and 140 cm consists of clay gyttja obviously representing the Baltic Sea phase. In the pre-isolation phase, the pollen composition is similar to the corresponding phase in Lake Tjärnen. Pollen of the main tree species *Pinus, Betula, Alnus*, and *Picea* dominate in the diagram, and also in Lake Hannusjärvi, three pollen grains of *Hordeum* were recorded between 180 and 140 cm (Fig. 7). According to the radiocarbon dating from the middlemost *Hordeum* occurrence, this dates to 1050 cal BC (1120 – 1010 cal BC).

The isolation was a gradual process. Due to the gradual land uplift, the connection to the Litorina Sea finally ended around BC 250, and Lake Hannusjärvi became isolated (Miettinen 2011, this volume). In the pollen data, a transition from a larger lake complex into a small isolated basin is demonstrated at the level of 121 cm, ca. cal AD 240 (cal AD 350 – 300) (Miettinen et al. 2007). At this stage, total pollen concentration suddenly increases notably as a result of a change in the deposition environment. After the isolation, pollen of *Picea, Pinus, Betula*, and *Alnus* still constitute over 90 % of total land pollen, representing the dominance of boreal trees around Lake Hannusjärvi until about 50 cm.

Human impact is clearly demonstrated in the pollen data in the uppermost 50 cm, as

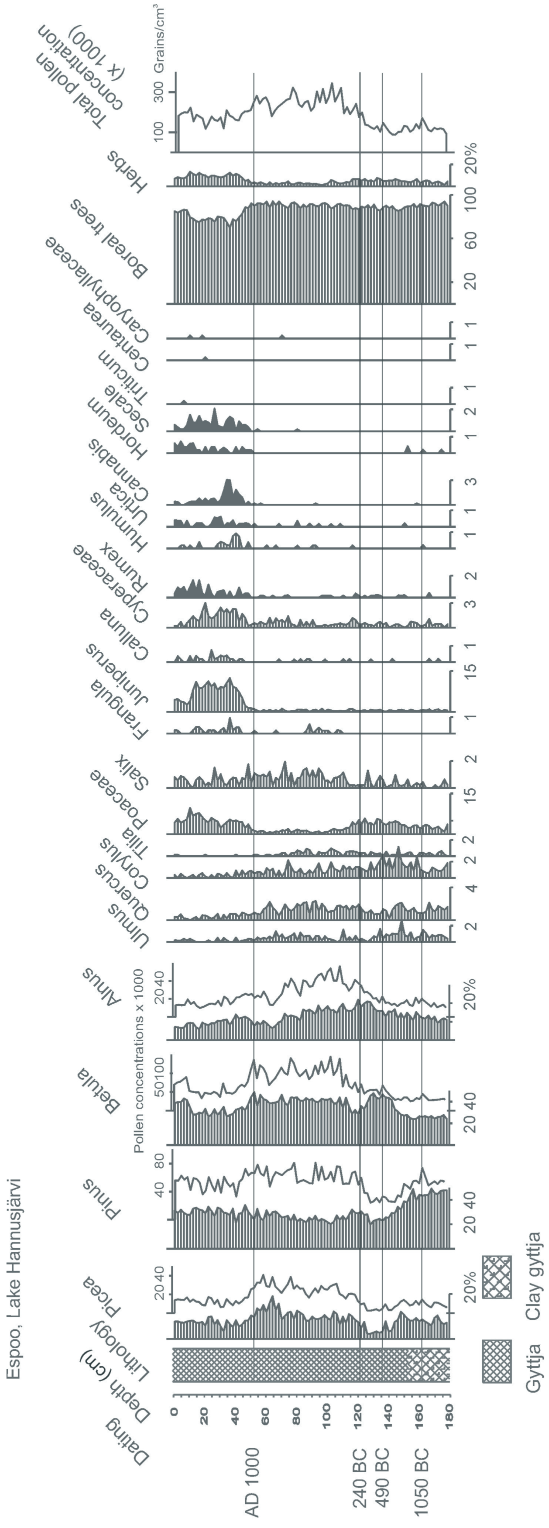


Fig. 7. Pollen percentages and concentrations from Lake Hannusjärvi in Espoo. From left to right: Median probabilities of AMS ^{14}C dates, depth from sediment surface, sediment lithology, a selection of the most important pollen species. Pollen concentrations (grains/cm^3) for the main tree species (*Picea, Pinus, Betula, Alnus*) are shown beside each percentage diagram. Total pollen concentration is shown on the right. The sums for pollen percentages are calculated as in Figure 2.

pollen types such as *Poaceae, Juniperus, Cyperaceae*, and *Rumex*, suggesting increasing light and open landscape, increase notably. At the same level, pollen of cultivated species, *Secale* and *Hordeum,* appear in the pollen data, indicating the onset of cultivation in the surroundings of Lake Hannusjärvi. Also *Humulus/Cannabis, Calluna*, and *Urtica* type pollen frequencies increase notably. According to the radiocarbon dating at the level of 53 cm, the onset of cultivation dates to the beginning of the Crusade period, ca. cal AD 1000 (cal AD 1000 – 1020). The onset of cultivation is followed by a drastic change in the tree pollen proportions. Especially *Picea* and *Betula* pollen concentrations and proportions decrease, and the total pollen concentration decreases notably in the uppermost 50 cm.

3.6. Siuntio, Lake Gynnarträsk

Based on recent shore displacement reconstruction from Western Uusimaa (Miettinen 2011, this volume), the isolation process of Lake Gynnarträsk took place c. 1800 years ago, that is, in about AD 200. A pollen analysis was carried out from a sediment sequence with a total length of 190 cm, which covers the whole deposition after the transition from the Baltic Sea.

The main tree species, *Betula, Pinus, Picea*, and *Alnus*, dominate the pollen data from the isolation until 88 cm, when the proportion of boreal trees suddenly falls and herbs and the pollen of cultivated species become more a dominant element in the pollen data basin (Fig. 8). Occasional pollen of *Hordeum, Linum, Fagopyrum* (buckwheat), and *Secale*, together with the regular occurrence of apophytes such as *Urtica, Rumex*, and *Chenopodiaceae*, however, indicates small-scale sporadic human activity starting from the isolation.

The dating at the level of 88 cm resulted in the date of cal AD 860 – 900 (cal AD 890) and indicates the onset of continuous *Secale* pollen occurrence, together with a decrease in *Picea* pollen and an increase in overall herb pollen. A continuous occurrence of *Secale* pollen is followed by a continuous occurrence of *Hordeum* pollen starting from 80 cm upwards and continuing to the topmost samples. The radiocarbon dating at the level of 80 cm resulted in the date of cal AD 940 (cal AD 940 – 980). From this point (80 cm) upwards, a plentiful occurrence of *Hordeum* and *Secale*, together with regular and high occurrences of pollen types such as high levels of *Poaceae, Juniperus, Rumex*, and *Urtica*, indicates permanent settlement and intensive land-use around Lake Gynnarträsk.

4. Discussion

The Iron Age has been a poorly known period in the coastal mainland and the archipelago of southern Finland. The main argument has been that for the agriculturally based economy, this rocky area was not suitable for other purposes than a resource area – a fisherman's landscape. According to the traditional hypothesis based on earlier archaeological and historical records, the coastal areas of southwestern Finland were unsettled until around AD 950. It was not until between the 12th and 14th centuries, when Swedish colonists arrived with technological advances, that the maritime landscape could be settled and cultivated. In this study, the problem of onset of settlement and settlement continuity was approached from a palaeoecological viewpoint. In order to investigate the settlement history of Uusimaa, the pollen analytical results from altogether six continuous sediment cores from small lakes were presented. The former pollen analytical studies in the southern coastal areas provided important reference material. In Fig. 9 a summary of the most important land use phases around the six studied lakes is presented.

4.1. Evidence of land use in the Bronze Age

The new pollen analytical results from Lake Storträsk, Lake Petarträsk, Lake Hannusjärvi, and Lake Tjärnen indicate some agricultural land use already in the Bronze Age. These

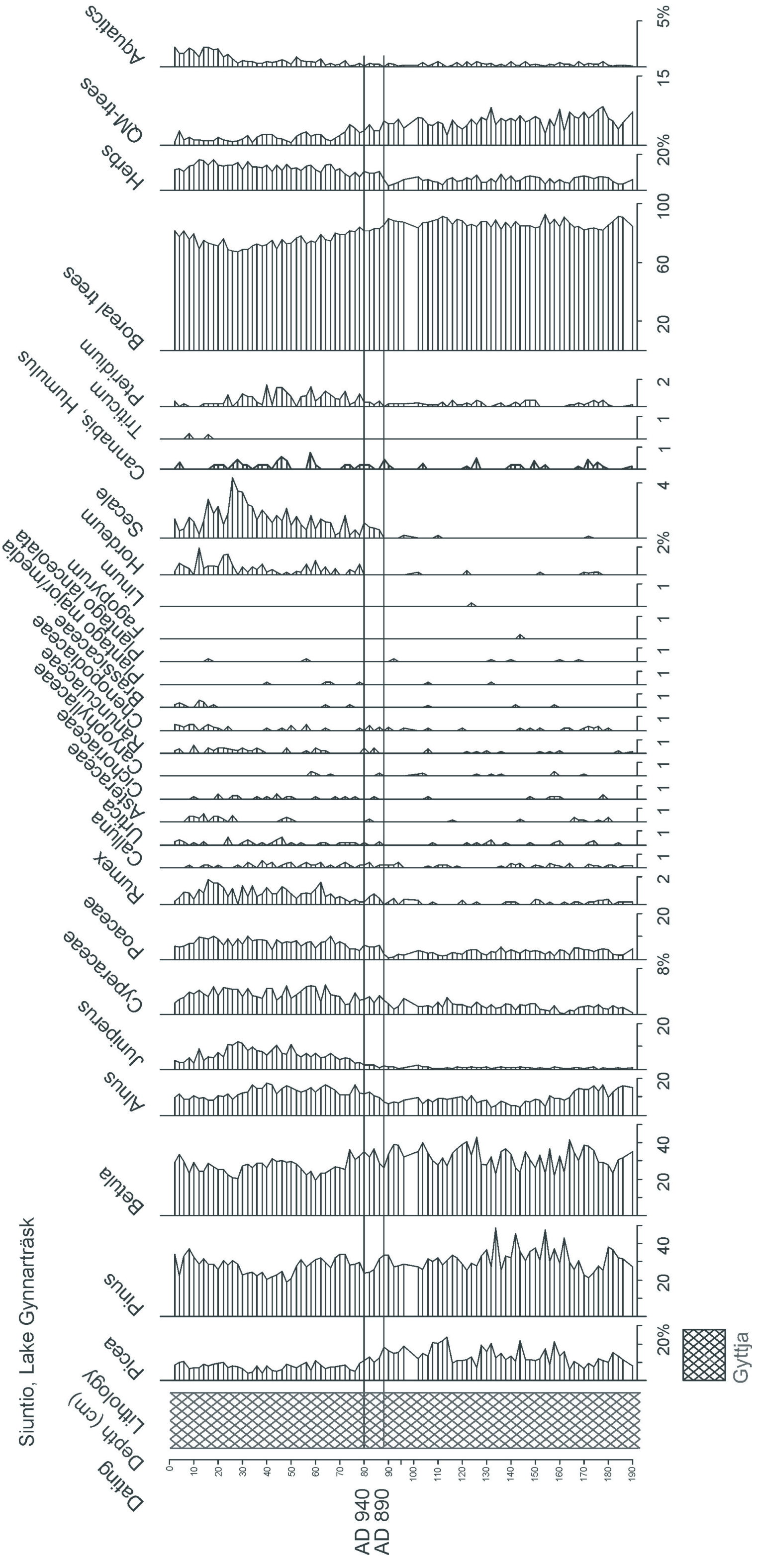


Fig. 8. Pollen percentage diagram from Lake Kynnarträsk in Siuntio. From left to right: Median probabilities of AMS ^{14}C dates, depth from sediment surface, selection of the most important pollen types. The sums for pollen percentages are calculated as in Figure 2.

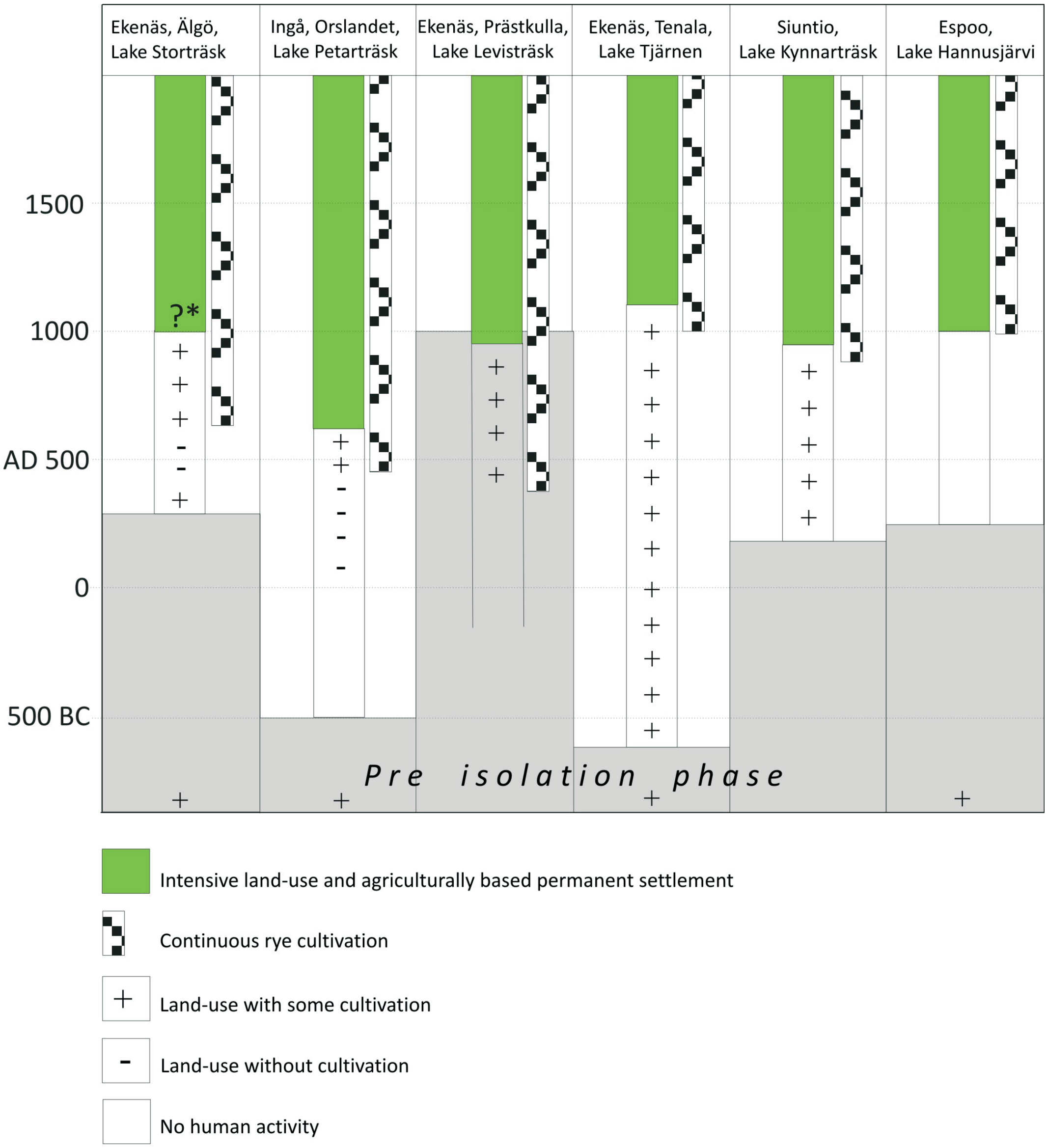


Fig. 9. Figure summarizing the most important land use phases around the six studied lakes.
*The phase of intensive land-use is not radiocarbon dated in Lake Storträsk.

small-scale cultivation events were dated in Lake Storträsk, where the earliest signs of cultivation date to 1040 cal BC, and in Lake Hannusjärvi, where some cultivation attempts of barley were dated to around 1050 cal BC. Also in Lake Tjärnen and Lake Petarträsk, a few undated *Cerealia* type pollen grains were present in the pre-isolation phase possibly representing the Bronze Age.

The origin of the pollen of cultivated plants is difficult to interpret due to the fact that these lowermost stages in the profiles represent the phase before the isolation of the lake. The lowermost part of the sediment may be affected by coastal factors such as erosion and redeposition, and the sediment may be deposited from distant areas into a relatively large water basin, in which case the pollen represents the regional vegetation. However, regardless of the numerous uncertainties in the interpretation of the results, it can be argued that some small-scale cultivation attempts were made in the region in the Bronze Age. This argument is also supported by numerous former pollen analytical studies from the southern coastal area. On the island of Nagu, the earliest cereal pollen findings have been dated to 1960 cal BC (Vuorela 1990), and on the island of Kimitoön, evidence of cultivation attempts has been found between 1600 – 1100 cal BC from the eastern, northern, and southern parts of the island. In the southern part of the island, some evidence of grazing from 1320 cal BC onwards has been found (Asplund and Vuorela 1989; Alenius 2008). Also outside the island of Kimitoön, in the Salo Ketohaka basin, the first evidence of cultivation has been dated to 1530 cal BC, and in the commune of Sipoo, human activity has been dated to 990 cal BC (Tolonen 1985; Sarmaja-Korjonen 1992).

4.2. Iron Age

4.2.1. Forest clearing and small-scale cultivation in the Pre-Roman (500 BC – AD 1), Early Roman (AD 1 – 200), and Late Roman (AD 200 – 400) Iron Age

Among the six new study sites, the earliest evidence of human presence after the isolation of the lakes comes from Lake Tjärnen in Tenala, Lake Petarträsk in Orslandet, and Lake Gynnarträsk in Siuntio. In Tenala, there is a scanty but clearly visible presence of barley pollen from the isolation in 640 cal BC onwards, indicating small-scale human presence and at least periodic local cultivation. Especially in the period of c. 255 cal BC to 20 cal AD, the continuous cultivation of barley was recorded, associated with the regular occurrence of sorrel and hemp/hop pollen. The cultivation and clearing of forests around Lake Tjärnen has also caused changes in the tree pollen proportions, as relative frequencies of spruce, oak, and lime fall remarkably. Also in Orslandet, human activity in the Roman Iron Age is visible from cal AD 40 onwards, even when no pollen of cultivated species was found at this stage. However, a decrease in spruce pollen percentages together with broad-leaved trees and hemp/hop pollen, as well as the occurrence of nettle pollen, all obviously indicate forest clearing around the lake. In the third site, around Lake Gynnarträsk in Siuntio, sporadic, small-scale cultivation has been practiced from the isolation of the lake, which according to land uplift rate took place around AD 200. It should be noted that also on Älgö, in the pollen data from Lake Storträsk in the outer archipelago, aquatic vegetation shows signs of eutrophication from ca. cal AD 300 onwards, associated with a single find of rye pollen.

All in all, the results indicate forest clearing and small-scale cultivation in the Pre-Roman, Early Roman and Late Roman Iron Ages. According to Zwelebil (1985; also Solantie 1988 and 2005) the cultivation of crops was only a very secondary livelihood till the end of the Early Roman Iron Age c. AD 200 before the Iron tools became available, even though winters were milder than today and the climate around the time of the birth of Christ was not too severe for crop cultivation as a main livelihood (see also Solantie 1988).

In the earlier pollen analytical studies from the southern coast of Finland forest clearing in the Pre-Roman and Early Roman Iron Ages, in some places also associated with small-scale cultivation, has been reported on the islands of Nagu, Korpo, and Kimitoön (Vuorela 1990; Asplund and Vuorela 1989), in Salo (Tolonen 1985), Karis (Tolonen et al. 1979), Kirkkonummi (Tolonen et al. 1979), Espoo (Vuorela and Kankainen 1998), and Sipoo (Sarmaja-Korjonen 1992). In the northern part of the island of Kimitoön, the clearing of spruce forests started in c. 900 cal BC with *Cerealia* type pollen found at two study sites from 640 cal BC and 550 cal BC onwards and followed by a clear decrease in broad-leaved trees at the beginning of the

Christian era. Also at Nagu, weak evidence of human activity was visible from around 760 cal BC onwards, and in Salo, the clearing of lime forest started in 410 cal BC. Also on the island of Korpo, the first cultivation attempts were recorded from the beginning of the Christian era. Eastward on the coast, in Karis, some rye and barley cultivation was practiced from ca. 430 BC onwards, and in Kirkkonummi and Sipoo, human-induced forest clearance, in places associated with some cultivation, has been revealed to have taken place in the Pre-Roman Iron Age. In Kirkkonummi, the presence of prehistoric settlement and cattle raising was dated to the Pre-Roman Iron Age, c. 450 – 200 cal BC, and a first, though brief, period of forest clearance associated with some wheat and barley cultivation was dated to cal AD 290. In Sipoo, a prehistoric clearance period with a duration of about 130 years was dated to 480 - 350 cal BC, as well as in Espoo, where evidence of swidden cultivation or/and grazing appears from 360 cal BC onwards. In Espoo, the first cultivation event has been dated to cal AD 110 followed by the use of fire on a regional scale from cal AD 260 onwards.

4.2.2. Intensification of land use in the Migration Period (AD 400–600)

Among the six new study sites, the onset of the continuous cultivation of rye is first recorded in the mainland setting in Prästkulla around Lake Levisträsk, where this event dates to cal AD 390 and is associated with an increase in heatland and grasses indicative of a more open landscape. The onset of rye cultivation started practically simultaneously in outer archipelago in Orslandet from c. AD 440 onwards. However, total tree pollen frequencies start to decrease and those of herbs and grasses start to increase very clearly already from cal AD 380 onwards, even when the actual rye pollen is not recorded until a couple of centimetres higher in the sediment core.

It is worth noting, however, that the recent isolation of Lake Levisträsk, less than a thousand years ago, has affected the use possibilities of the area. Before isolation, Lake Levisträsk was a shallow bay, the shores situated further away. Obviously this has also affected the transportation of pollen into this large bay, complicating the interpretation of the pollen data. Nevertheless, pollen data proves that rye was cultivated around the bay already from AD 390 onwards.

At the beginning of the continuous rye cultivation in Prästkulla and Orslandet, the pollen data shows little evidence of vegetation typical for rural communities, and according to pollen data the prevailing agricultural practice was most probably swidden cultivation. Unfortunately, due to the nature of pollen analysis itself, it is not possible to define the proportions of swidden areas and permanent field areas. According to Soininen (1974), rye was the most important crop cultivated in the swidden plots, even when rye, as well as barley, was grown both in swidden plots and in fields. Swidden areas are likely to be over-represented in the pollen diagram because wind-pollinated rye is more visible in the results than other cereals. Permanent fields, if there were any, become visible only when the fields are situated in the vicinity of the sampling place (e.g. Bakels 2000; Alenius et al. 2008). Regardless of the fact that arable cultivation is not visible in the pollen data at this stage, attempts at early forms of arable cultivation were probably made in the coastal area. On the southwestern coast extending c. 20 km into the inland, the fine-grained deposits in the plough layer are dominated by light postglacial Litorina clays. Broad-leaved and other deciduous forests, located on coarse and fine silty clays and fine silt, were the most advantageous environments for the early forms of arable cultivation (Orrman 1991).

The beginning of continuous rye cultivation in Prästkulla and Orslandet between cal AD 390 and cal AD 440 is in close agreement with former studies from the parish of Piikkiö, the Åland islands, and Vihti, where continuous cultivation has been dated to occur between cal AD 375 and 480. In the Åland islands, continuous cultivation has been dated to cal AD 375 – 450 in the municipalities of Jomala, Saltvik, and Finström (Fries 1961; 1963; Sarmaja-Korjonen et al. 1991), and also in the parish of Jomala, the cultivation of rye first started already during the first centuries AD (Roeck Hansen 1991). In the parishes of Piikkiö and Paimio, swidden cultivation has evidently been practiced from c. cal AD 400 – 480 onwards (Salonen et al. 1981; Vuorela 1983; Glückert 1976), and also in Vihti, early agriculture with cultivation of oat, rye, and barley has been dated to cal AD 390 (Vuorela 1972). In Salo, the onset of the continuous cultivation of rye and barley has been reported to have taken place even earlier, from cal AD 170 onward (Tolonen 1985).

All in all, the present and former pollen data from the southern coast suggest, that the intensification of land use took place from the beginning of the Migration period, c. cal AD 370 – cal AD 480 onwards. According to Zwelebil (1985) and Solantie (2005) agriculture as the main livelihood become possible as the main livelihood when iron tools became available from AD 200-400 onwards. Intensification of land use may also be connected to the population growth that must have given rise to a slowly expanding and denser settlement, including reclamation of new natural resources (Pitkänen 2007).

4.2.3. Agrarian expansion

It is difficult to draw a sharp boundary between small permanent fields associated with permanent occupation and areas that were utilized but were not permanently settled. In general, agriculturally based settlement and rural communities created a mosaic of different land use practices that resulted in an increase in apophytes, such as sorrel, goosefoot, hop, hemp, brassicas, chickweeds, asters, the chicory family, nettle, and plantain, that all belong to the principal anthropogenic pollen types (Behre 1981; Hicks 1988; Vuorela 1970, 1986, 1992). In addition to the anthropogenic pollen types mentioned above, one good indicator is a high value of juniper pollen that can be connected with the presence of livestock. Juniper thrives in open areas and improved light conditions and it is considered to be the best indicator of grazing and pastures in Finland (Behre 1981; Gaillard et al. 1992; Hæggström 1990; Pykälä 2001).

Somewhat surprisingly, among the six new study sites in Western Uusimaa, the large island of Orslandet showed the earliest permanent human utilization, grazing and continuous cultivation of barley at around cal AD 670 onwards. According to pollen data from Orslandet, besides livestock pasturing, also hay was grown and the cereals barley and rye were cultivated. Also on another large island, Älgö, located about 15 km from Orslandet, the onset of the somewhat regular cultivation of barley and rye dates to c. cal AD 660. The interpretation of the pollen data from Älgö is, however, complicated by the fact that that the apophytes and anthropochores are generally weakly registered in the pollen data. The reason for this may be the basin size. The basin selected for the pollen analysis, Lake Storträsk, was larger (28 ha) than the other lakes (3–12 ha), and the lake might also be a little bit more on the periphery of the island. In Älgö, the proportions of juniper, however, remain low until the uppermost 30 cm in the core, and evidently grazing did not play an important role on the island in general until in the uppermost 30 cm, which obviously represent the 12th and 13th centuries. In contrast to poorly produced and dispersed barley pollen, juniper is a high pollen producer (Broström et al. 2004), and changes in juniper should therefore be well registered in the pollen data. It can also be hypothesized that the island of Älgö has been used at low intensity until the 12th and 13th centuries, when the overall openness increases, together with an increase in apophytes and anthropochores. These areas of low intensity were, according to Tuovinen (2011, this volume), formed on large islands located outside the primary units of settlement, where natural resources were utilized in different ways.

In most of the new study sites, that is, in the results from Lakes Tjärnen, Hannusjärvi, Levisträsk, and Kynnarträsk, agriculturally based permanent settlement becomes visible from the beginning of the Crusade period. This phase of agrarian expansion dates in

Lake Tjärnen to AD 1100, in Kynnarträsk and Leviträsk to AD 940, and in Hannusjärvi to AD 1000. Also in the results from Lake Storträsk, the intensification in human activities, most clearly seen in increasing juniper values, obviously dates to the beginning of the second millennium.

Around the studied lakes, human impact has caused major alterations in the vegetation, such as the withdrawal of trees and an increase in open areas. The structure and tree species composition of the surrounding forest altered substantially, with decreasing proportions of birch and spruce and boreo-nemoral broadleaved trees. These changes also included the expansion of juniper and grasses as a result of the creation of fields and pastures. There is also an increase in annual weeds, such as brassicas and goosefoot, that can be associated with arable land. At the same time, the cultivation of barley becomes continuous around these lakes. Especially in the Tjärnen and Hannusjärvi sediment profiles, intensive cultivation of both rye and barley is recorded, and around Lake Tjärnen, even flax was cultivated for fibre, as can be deduced from the occurrence of *Linum* pollen. Another group of apophyte pollen types indicative of meadows and pastures, such as hemp/hop and nettle, which grow on nitrogen-enriched soils, increase notably. This is especially prominent in the Lake Tjärnen and Lake Hannusjärvi results.

The results of Lakes Tjärnen, Hannusjärvi, Levisträsk, and Kynnarträsk for the onset of agriculturally based settlement, visible in the data from cal AD 940 – 1190 onwards, confirm the general impression provided by former pollen analytical studies from the southern coastal areas in Finland. The former studies have demonstrated that permanent agriculture and animal husbandry with open, cultivated, and grazed landscape can be dated in the Åland islands in Finström and Saltvik to cal AD 1070, on the island of Kumlinge to AD 1100, in Salo to cal AD 960, in parts of the island of Kimitoön to cal AD 1100, in Perniö to cal AD 1180- 1190, in Kirkkonummi to cal AD 1180, and in Helsinki to cal AD 930.

However, there are numerous earlier studies in which the start of permanent agriculturally based settlement and animal husbandry started already several hundred years earlier, as now demonstrated on the large island of Orslandet from cal AD 670 onwards. Earlier, Sarmaja-Korjonen (1992) and Tolonen et al. (1979) have dated the start of permanent agriculture and animal husbandry in Sipoo to cal AD 790, in Kirkkonummi to cal AD 730, and perhaps also in Tenala to cal AD 780 onwards. In the western coastal area, permanent settlements were formed in some parts of the island of Kimitoön from cal AD 860 – 890 onwards (Asplund and Vuorela 1989; Alenius 2008) and in Piikkiö from cal AD 810 onwards (Salonen et al. 1981).

One study question concerned the occurrence and intensity of human activity during and after the integration process during the 12th to 14th centuries when Finland became a part of Sweden. This was studied in more detail from the freeze box sample taken from the uppermost layers of the sediment in Lakes Petarträsk and Storträsk. In general, the integration process is not visible in the pollen analytical results; in both study sites, land use seems to have continued without major interruptions throughout the Middle Ages (AD 11/1200 – 1550). In fact, in all six study sites, intensive agriculture is recorded.

5. Conclusions

The six studied sites, together with the earlier pollen data from the areas, clearly show that the coastal areas of southern Finland were not a totally desolate landscape before the Swedish colonists settled the area between the 12th and 14th centuries. In the pollen data, after the isolation of the lakes, the earliest phase of land use extends from the Pre-Roman Iron Age (500 BC – AD 1) through the Early Roman Iron Age (AD 1 – 200) until the end of the Late Roman Iron Age (AD 200 – 400). This period of land use can be described as forest clearing associated in some places with sporadic, small-scale cultivation. Among the six new studied lakes, this was visible on the mainland in Tenala from c. 450 cal BC onwards, in Orslandet from c. cal AD 40 onwards, and in Siuntio from the isolation, which occurred around cal AD 200, onwards.

The second phase of land use roughly covers the Migration Period (AD 400 – 600) and extends to the beginning of Viking Age. During this period, the intensification of land use practices is recorded. Among the six new study sites, continuous rye cultivation was demonstrated from AD 390 – AD 440 onwards in the large maritime island of Orslandet and also in the more coastal environment in Prästkulla, and in the island of Älgö from AD 660 onwards. This phenomenon may be connected to the reclamation of new areas and the increasing use of the slash-and-burn technique for cultivation as a result of population growth and denser settlement. According to pollen data, the prevailing agricultural practice was swidden cultivation. Even when permanent fields are not visible in the pollen data at this stage, early forms of arable cultivation were probably practiced, as natural conditions in the study area were favourable.

The third phase of land use can be described as "agrarian expansion", indicating a fully agrarian landscape with permanent settlements, cultivated fields, and grazed areas. This becomes visible in the southern coastal areas gradually, in places from AD 700 – 800, more profoundly from AD 900 – 1000 onwards.

The time period from AD 950 to AD 1200 is the period when pollen analytical results and archaeological material strongly contradict. While archaeological and historical indications of settlement are rare, pollen data shows transformation of the landscape from mainly forested areas to fully agrarian landscape. Among the six new study sites, the archipelagic island of Orslandet showed the earliest signs of permanent settlement reflecting a cultural landscape with cultivation and grazing from as early as AD 670 onwards. In earlier studies, the start of permanent agriculture and animal husbandry has been placed between cal AD 730 and cal AD 790 in Sipoo, Kirkkonummi, and Tenala, in the western coastal area in some parts of the island of Kimitoön from cal AD 860 – 890 onwards and in Piikkiö from cal AD 810 onwards, indicating that there were Finnish population in the area before Swedish colonists settled on the coastal areas. In most of the new study sites, that is, in Lake Levisträsk in Prästkulla, Lake Tjärnen in Tenala, Lake Hannusjärvi in Espoo, and Lake Gynnarträsk in Siuntio, the agrarian expansion becomes clearly visible from around cal AD 940 – 1100 onwards. The reasons for the strong contradiction between palaeoecological and archaeological material remains to be found.

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