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Land use pollen record from the Island of Valamo, Russian Karelia

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Four limnic sediment cores were analysed by means of pollen and plant macrofossil analyses and radiocarbon dated from the island of Valamo (Russian Karelia). The results show evidence of Bronze Age cultivation in the western part of the island. After a period lacking evidence for this activity, agriculture respread in the area between ca. 1400–1000 BP (ca. cal AD 650–1000), the main increase being dated to ca. 800 BP (ca. cal AD 1250).

Key words: Karelia, land use, plant macrofossils, pollen analysis, settlement indicators, Valamo

Introduction

Valamo Island on northern Lake Ladoga has been known for its monastery since Late Medieval times, and it has been a centre of cultural and economic activities of varying intensity throughout its history. The island measures some 8 × 8 km and it emerged from the waters of Lake Ladoga together with the formation of its present outlet, the River Neva, currently dated to ca. 3100 radiocarbon years BP (Saarnisto & Grönlund 1996, and the Russian literature cited therein). Before the opening of the Neva outlet the shoreline of Lake Ladoga was at 21 m a.s.l. in Valamo or at 16 metres above the present Lake Ladoga level (five m a.s.l.; Ailio 1915, Hyyppä 1943).

Before the formation of the Neva outlet, there was an archipelago comprising dozens of rocky islands within the area of the present island. No archaeological finds are known from this period (Spiridonov 1992) but, on the other hand, archaeological studies on the island have been rare. Judging from discoveries made on the mainland (Uino 1997, A. Saksa pers. comm.), pre-Neva Neolithic and Bronze Age seal hunters' and fishermens' dwellings may have occurred on Valamo. Most cultivated fields on the island are on former lake bottoms, below the 21-m level, where clearance of soft clays and silts was an easy task for early farmers. The formation of Neva and a sudden drop of the water level by several metres (M. Saarnisto unpubl.) resulted in emergence of extensive land areas in the coastal area of Lake Ladoga, which were suitable for early land use. Very little is known, however, of the prehistoric land use practices in the area. The present authors are not aware of any Russian palaeoecological studies relevant to early anthropogenic influence, but Finnish reseach since 1990 is contributing increasingly to the resolution of this problem. Taavitsainen *et al*. (1994) showed that in the Island of Kilpolansaari in the northwestern archipelago of Lake Ladoga the introduction of slash-and-burn cultivation is dated to the Late Roman Iron Age (AD 200–400). Saksa *et al*. (1996) studied human influence on the Karelian Isthmus where the empirical Cerealia level in the sediment has been dated to the Merovingian period (AD 600–700), while agriculture seems to have been established there as the principal subsistence source during the 11th and 12th centuries.

The current study is a continuation to the first palaeoecological work from the island of Valamo directed by Vuorela and Saarnisto (1997) on the sediments of Lake Niikkananlampi. Here three new sites are reported for their pollen and macrofossils: Luostarinlahti, Skiitanlahti and Lake Eastern (E.) Igumeeninlampi. The first two sites are closed bays of Lake Ladoga close to areas where early land use can be expected. Luostarinlahti is closest to the fields adjacent to the monastery, which are considered the oldest fields in the island according to historical sources. The loss-on-ignition of the cores of E. Igumeeninlampi suggests variations in the land use history, which was one reason for choosing that site for a detailed study. Another aim is to investigate the uplift history of the island of Valamo from the Lake Ladoga basin waters. The results of the latter study subject will be reported elsewhere.

Material and methods

The locations of the investigated sites are presented in Fig. 1 and Table 1.

The sediment cores from all nine lake basins on Valamo were sampled during a Finnish-Russian coring expedition led by the author M. Saarnisto in February 1996. In addition, sediments of two bays of Lake Ladoga were cored using a Livingstone-type piston corer (a PP-corer, modified by Seppo Putkinen of the Geological Survey of Finland) with a core diameter of 50 mm and a length of 1.9 m.

For all the sites, relative pollen frequencies, relative charcoal frequencies (% AP) and loss-on-ignition determinations were carried out. For pollen analysis, the material was treated, mounted and illustrated as described by Vuorela and Saarnisto (1997).

The sediment samples used in macrofossil analysis were the same as in pollen analysis (except the samples used for ^{14}C-dating). Volumes of the samples were from 10 to 40 cm^3. The macrofossil material was extracted in the laboratory by washing the soil, without salt flotation, on a sieve of mesh size 0.125 mm using a gentle stream of lukewarm water. All soil particles passed through the mesh of the sieve while the seeds and other remains that

Table 1. The locations, altitudes (m a.s.l.) and water depths (m) at the Valamo sites.

Site	Location	Altitude (m a.s.l.)	Water depth (m) at the coring site
Niikkananlampi	61°22´N 30°55´E	8.1	3.7
E. Igumeeninlampi	61°22´N 30°55´E	7.5	6.0
Luostarinlahti	61°23´N 30°60´E	5.1 (L. Ladoga)	9.6
Skiitanlahti	61°23´N 30°55´E	5.1 (L. Ladoga)	6.2

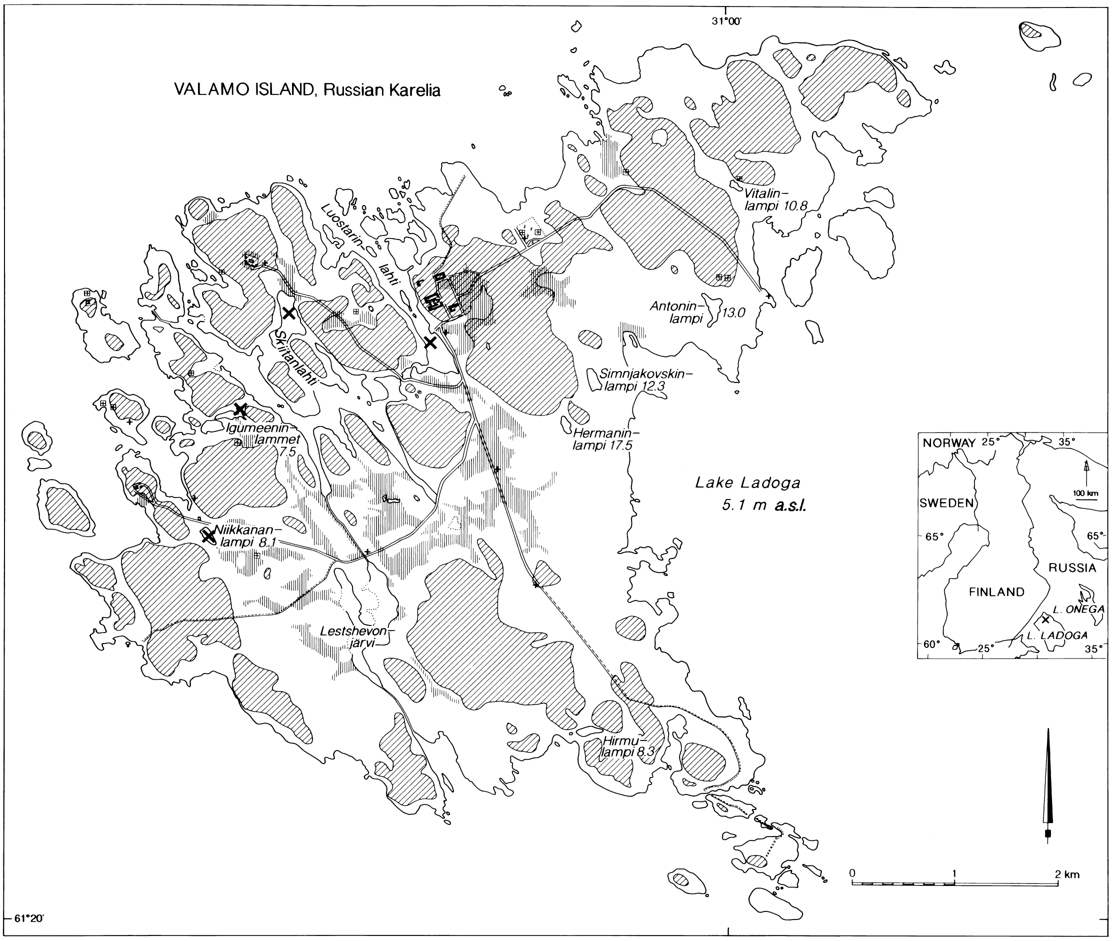

Fig. 1. Map of Valamo Island. Crosses (X) indicate the lakes investigated. Areas with coarse lines indicate the archipelago (later unified by the opening of River Neva), areas with fine vertical lines indicate fields.

were retained were separated using a stereoscopic microscope (OLYMPUS SZX9) and identified.

The environment of the sample sites, the stratigraphy and the loss-on-ignition value (LOI) of the bottom sediments are presented below.

Niikkananlampi

The distance of Niikkananlampi from the western shore of Valamo island is 500 m. The lake covers 0.5 ha being, in south and east, surrounded by coniferous forest and, in north, by deciduous trees. A wide field of an area of 1000 × 800 m is situated east of the lake.

The cores were as follows: 3.90–5.74 m (I), 3.77–5.49 m (II), 3.82–4.03 m (III). For the loss-on-ignition (LOI) values, *see* Fig. 2. The lithology was as follows (cf. Vuorela & Saarnisto 1997):

— 377–380 cm: dark-brown loose detritus gyttja, LOI 35%
— 380–392 cm: gyttja-laminated grey clay, LOI 10%–15%
— 392–502 cm: dark brown gyttja with dark sulphide bands in the lower part,
a dark band of coarse organic detritus at 484 cm, and a thin clayey horizon at 403 cm.
LOI increases from 20% to 50% towards the top
— 502–530 cm: clay gyttja, LOI 5%–15%
— 530–536 cm: sand, LOI 1%

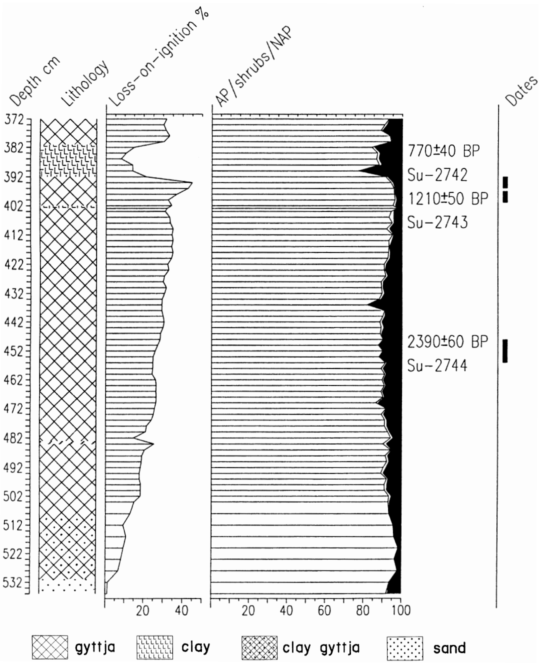

Fig. 2. Loss-on-ignition, AP/shrub/NAP ratio and radiocarbon dates of Lake Niikkananlampi, Valamo.

Eastern Igumeeninlampi

Eastern Igumeeninlampi consists of the eastern part of the small twin-lake situated in the NW part of the island. It is surrounded mainly by coniferous trees and has a slight connection to the small field situated south of the basin. *Quercus*, *Fagus* and *Larix* trees have been planted in the vicinity of E. Igumeeninlampi in the mid-1800s. An oak alley, an old spruce forest and aged pines still grow on the shore. The fields are overgrown by *Alnus* and *Salix*.

The sediments were sampled close to the eastern shore and close to the field in two overlapping cores: 220–390 cm (I) and 317–490 cm (II). The stratigraphy was as follows:

— 220–317 cm: gyttja, LOI fluctuating mainly between 25% and 40% but reaching 55% at the 250 cm level.
— 317–340 cm: clay gyttja, LOI from 8% to 12%.
— 340–390 cm: gyttja, LOI increasing upwards from 15% to 30%
— 390–426 cm: clay gyttja, LOI from 5% to 17%.
— 426–432 cm: clay, LOI less than 5%.

Luostarinlahti

The eastern shore of Luostarinlahti, a northwards opening, 2-km long bay in the northern part of Valamo island, is characterised by a steep rock precipice, on the top of which the monastery is situated. The western shore is more gently sloping and covered by mixed forest. The closest fields, situated on the eastern and southern side of the monastery, are supposed to be the oldest on the island.

The samples were cored at 30-m distance from the western shore, at the southern end of the steep rock precipice. The present material covering only the upper core (I) of the two sampled is as follows:

— 0–10 cm (9.6–9.7 m): dark sulphide gyttja
— 10–187 cm (9.7–11.6 m): clay gyttja. LOI increases upwards from 4% to 15%. Sulphide bands in the upper part, the frequency of which increases upwards.

Skiitanlahti

Skiitanlahti is an approximately one-kilometre long bay of a south–north direction in the NW part of the island. The surroundings are dominated by park-like forest, with oaks more than 100 years old and pines of an estimated age of more than 150 years. The sediment was sampled at a ca. 100 m distance from the northern shore into two cores: 620–787 cm (I) and 700–887 cm (II), the material being as follows:

— 620–693 cm: gyttja with a band of clay gyttja at the 687–685 cm level. LOI 15%–25%.
— 693–887 cm: clay gyttja with gyttja bands at the levels of 882–878, 842–838 and 757–760 cm. LOI 12%–17% for 887–785 cm and 5%–12% for 785–693 cm.

The relatively high LOI value and the lack of evidence of recent field erosion on the sediment surface could be explained by the adjacent abandoned fields, which have not been plowed for a long time.

Dating of the profiles

Dating of the sediments of the Lakes E. Igumeeninlampi and Niikkananlampi was carried out in the Radiocarbon dating laboratory of the Geological Survey of Finland. The goals were (1) for E. Igumeeninlampi to date its isolation from Lake Ladoga (M. Saarnisto unpubl.), and (2) for Niikkananlampi to date the clay horizon at the 380–392 cm level, the slight increase in herb pollen frequencies at 442–472 cm, and the isolation of the lake.

The Skiitanlahti material (plant macrofossils) was dated at the Tandem Laboratory, Uppsala University. For Skiitanlahti the dating focused on anthropogenic evidence, such as the absolute (682 cm) and rational (650 cm) Cerealia limits, the start of an even pollen curve of *Rumex* (694 cm), and an abrupt decline of *Picea* (828 cm).

Since the Luostarinlahti material is less suitable for radiocarbon and palaeomagnetic datings, the dates were estimated according to the regional forest history reflected on the Skiitanlampi diagram (Fig. 3).

In the text, ^{14}C ages (BP) and calibrated ages (cal BC/AD; Stuiver & Reimer 1993) are used.

Results and interpretation

Radiocarbon dates

The radiocarbon dates (Table 2), together with the lithostratigraphy, show that the sediment cores of Skiitanlahti and Lake Niikkananlampi are the only ones reaching the period preceding the opening of the Neva outlet 3100 BP (as dated by Grönlund & Saarnisto 1996). The cores of E. Igumeeninlampi reach the isolation period, and Luostarinlahti represents the deposits of approximately the last 2000 years.

Calibration of the radiocarbon years was done according to Stuiver and Reimer (1993).

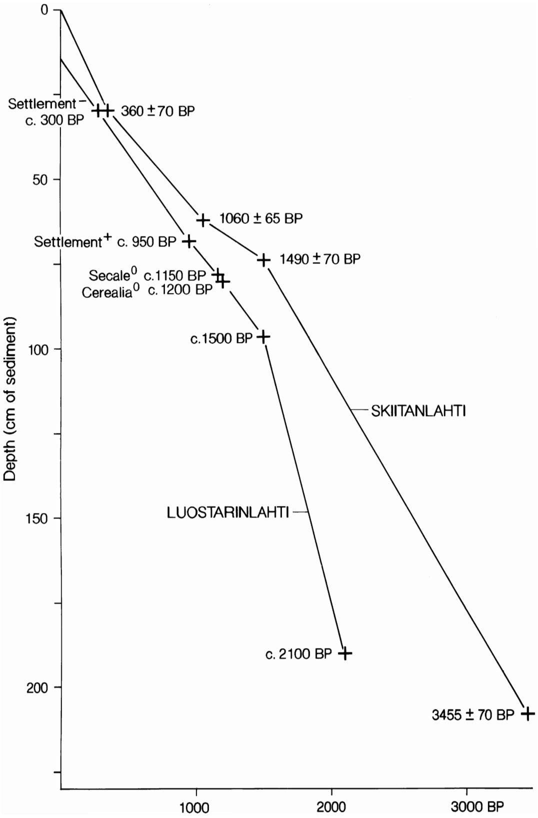

Fig. 3. The age/depth curves of Luostarinlahti and Skiitanlahti.

The estimated age of the 97-cm level of Luostarinlahti is based on the radiocarbon age of Skiitanlahti at the 692–696 cm level (1490 ± 70 BP) which corresponds to the most prominent change in *Pinus* pollen frequencies at both sites. *Pinus* pollen is considered as being least affected by the human activity. According to the *Pinus* and QM pollen frequencies, the age of the bottom layer in Luostarinlahti (the bottom part of Fig. 3) was estimated to correspond to the 755-cm level in Skiitanlahti, dated to ca. 2100 BP. The dates of the absolute Cerealia level (C°; 78 cm), of the increase in *Rumex* pollen frequencies (indicating increased habitation at the 68-cm level), of increased agriculture at the 55-cm level and a decline in habitation at the 30 cm level, are based on the age/depth curve (Fig. 3). The ages for the Luostarinlahti core then should be considered as best estimates.

Relative pollen data

Trees and shrubs

In connection with the isolation of Eastern Igumeeninlampi (Fig. 4), relative *Picea* pollen frequencies increase from 10% to 35% AP. This is most probably a result of accumulation of this floating pollen type into closing bays. Since this phenomenon, however, seems to have taken place mainly at an expense of *Betula* and broad-leaved deciduous trees (QM), it could also reflect the invasion of *Picea* on the emerged land areas. After isolation, the relative tree frequencies remain stable (*Betula* 30%, *Pinus* 55%, *Alnus* 20%) up to the 284-cm level, where strong fluctuations especially in *Betula* and *Pinus*, together with a distinct decrease in *Picea* and *Alnus* pollen frequencies, probably indicate human activity. No clear changes in the tree pollen relations were found in connection with the clay–gyttja layer at the 317–340-cm level. In the uppermost 20 cm of the diagram *Quercus* pollen increases, most probably as a result of planted trees, and the increasing *Picea* pollen frequencies probably reflect abandonment of the fields. Sporadic occurrences of *Acer*, *Fagus*, *Sorbus* and *Prunus* were found. In spite of planted trees in the area, *Fagus* or *Larix* pollen was not found in the uppermost part of the core.

Shrub pollen frequencies, especially those of *Juniperus*, increase immediately after the isolation, at the 390-cm level. The final increase at the 305-cm level, in connection with the earliest evidence of local agriculture, is accompanied by an increase in *Salix* and *Sambucus*, and by the start of pollen occurrences of *Frangula alnus,* and a Caprifoliaceae pollen grain. Total herb pollen do not, however, increase until at the 245-cm level, which represents the maximum phase of land use, reflected in reduction in *Alnus* and *Juniperus* pollen.

The relative tree pollen frequencies of Lake Niikkananlampi (Fig. 5), which were earlier described in more detail by Vuorela and Saarnisto (1997), are very much the same as in E. Igumeeninlampi. A short-lasting slight increase in *Alnus* and *Betula* was recorded in the thin

Table 2. ^{14}C dates BP, calibrated dates (cal BC/cal AD) and some estimated dates of the Valamo profiles.

Lab. no.	Depth (cm)	^{13}C (‰ PDB)	^{14}C date (years BP)	Calibrated time (1σ)(cal AD/cal BC)
Eastern Igumeeninlampi				
Su-2763	390–398	–28.3	2570 ± 80	820–720, 680–560 cal BC (780 cal BC)
Su-2764	398–406	–27.5	2630 ± 90	880–740 cal BC (810 cal BC)
Niikkananlampi (Vuorela & Saarnisto 1997)				
Su-2742	392–396	–32.9	770 ± 40	cal AD 1230–1280 (cal AD 1260)
Su-2743	396–400	–32.3	1210 ± 50	cal AD 770–890 (cal AD 850)
Su-2744	448–456	–30.8	2390 ± 60	510–390 cal BC (420 cal BC)
Su-2745	499–505	–28.3	2750 ± 80	970–820 cal BC (880 cal BC)
Su-2746	505–511	–27.1	3170 ± 100	1530–1300 cal BC (1420 cal BC)
Skiitanlahti				
Ua-11209	648–652	–28.20	360 ± 70	cal AD 1473–1617 (cal AD 1546)
Ua-11210	680–684	–28.50	1060 ± 65	cal AD 903–1024 (cal AD 973)
Ua-11211	692–696	–28.38	1490 ± 70	cal AD 475–622 (cal AD 563)
Ua-12666	826–830	–27.73	3455 ± 70	1862–1685 cal BC (1769 cal BC)
Luostarinlahti (estimated; Fig. 3)				
	185		ca. 2100	ca. AD 100
	97		ca. 1500	ca. AD 600
	78		ca. 1200	ca. AD 800
	68		ca. 950	ca. AD 1100
	55		ca. 750	ca. AD 1250
	30		ca. 300	ca. AD 1600

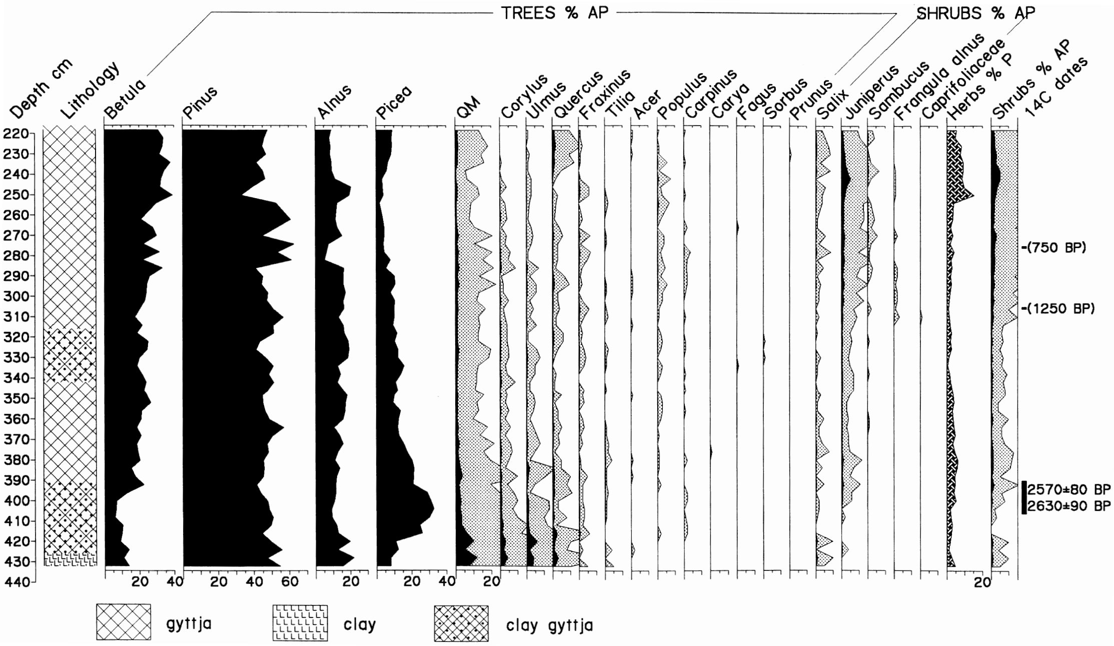

Fig. 4. Relative tree and shrub pollen frequencies (% AP) and radiocarbon dates of Lake Eastern Igumeeninlampi, Valamo.

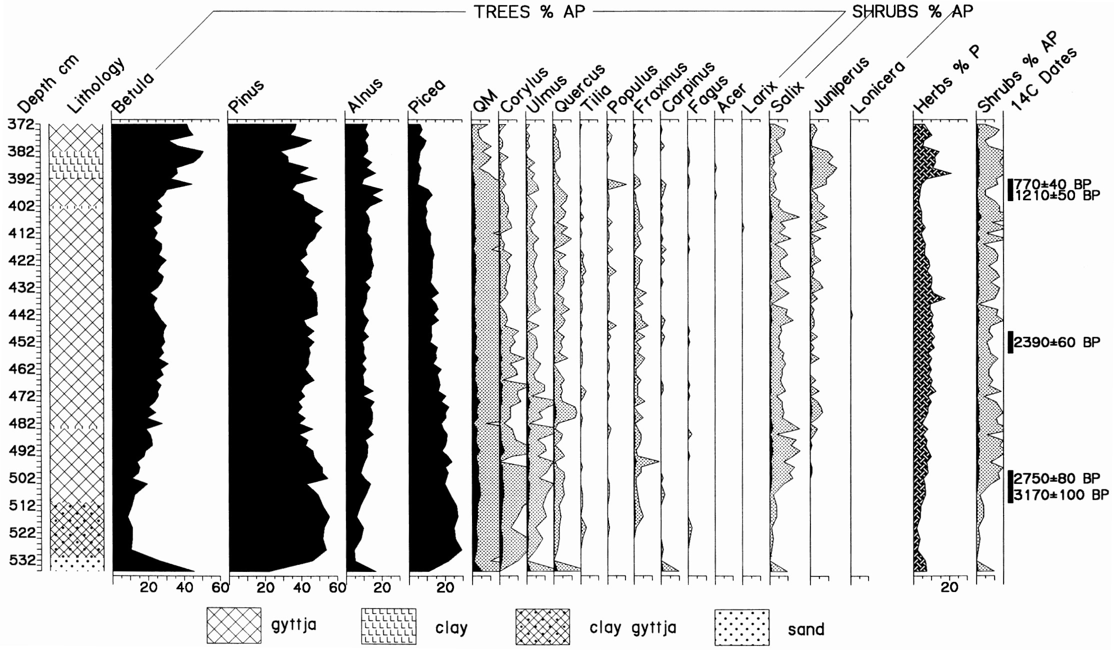

Fig. 5. Relative tree and shrub pollen frequencies (% AP) and radiocarbon dates of Lake Niikkananlampi, Valamo.

clay layer at the 482-cm level. *Salix* pollen frequencies decrease at the same level. At the 402-cm level, in connection with the second thin clay horizon, the increase in *Alnus,* and the decrease in the QM tree pollen frequencies, and in *Salix* and *Juniperus* are more distinct. In

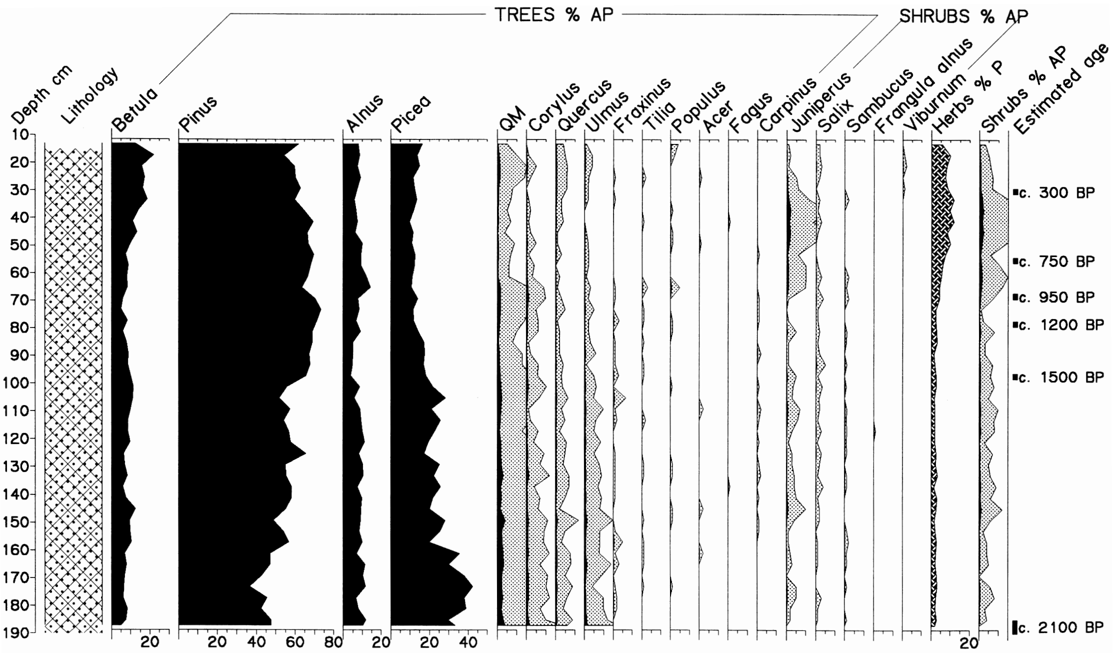

Fig. 6. Relative tree and shrub pollen frequencies (% AP) of Luostarinlahti, Valamo. Lithology: clay gyttja only.

connection with the more pronounced clay horizon at the 380–392-cm level, the herb pollen frequencies increase, together with that of *Juniperus*. In the topmost gyttja layer (380–372-cm) these indicators of human activity decrease towards the sediment surface.

Among other tree pollen types, *Populus* seems to occur mainly in connection with declining *Picea* frequencies, thus indicating deforestation. *Fagus* and *Carpinus* probably represent long-distance transport, *Acer* represents an opening landscape, and *Larix*, probably, planted trees.

The tree pollen frequencies of the bay sites, Luostarinlahti (Fig. 6) and Skiitanlahti (Fig. 7) are very similar to each other, differing somewhat from those of Lake Niikkananlampi and E. Igumeeninlampi.

The deposits of Luostarinlahti (Fig. 6) represent the last two millenia, showing a clear decrease in *Picea* pollen, most probably connected with the local human activity. The pollen frequencies of increasing *Betula* (7%–20% AP) and decreasing *Pinus* (70%–50% AP) and increasing *Juniperus* at the 65-cm level, in connection with the increasing human impact, correspond to those found in Skiitanlahti. Even though the frequencies of broadleaved deciduous trees increase close to the sediment surface, they hardly reflect the planted trees of the 1800s, as they seem to do in E. Igumeeninlampi. Among shrubs, *Salix* pollen was found evenly throughout the diagram, *Sambucus* on most levels, and *Frangula alnus* and *Viburnum* only sporadically.

In Skiitanlahti (Fig. 7) *Betula* pollen frequencies stay below 20% AP, and *Alnus* frequencies mainly between 10% and 15% AP. Coniferous trees are better represented, *Pinus* frequencies staying for most of the profile around 50% AP. In connection with the isolation at 870–860 cm, *Picea* increases from 20% to 30%–35% AP. The decrease in *Picea* pollen starts at the 750-cm level, where it reaches the maximum of 40% AP. At the onset of more intensive land use, indicated at the 696-cm level by an increase in *Rumex, Pinus* pollen frequencies increase to 60% AP. *Picea* pollen frequencies decrease simultaneously and rapidly from 30% to 10% AP, followed by decreasing *Salix* and increasing *Juniperus* and herb pollen frequencies. Among shrubs, *Sambucus*, *Myrica*, and *Hippophaë* pollen occurs sporadically. In *Betula* and among the broadleaved deciduous trees the short-lasting increase reflects reforestation (cf. Vuorela 1981).

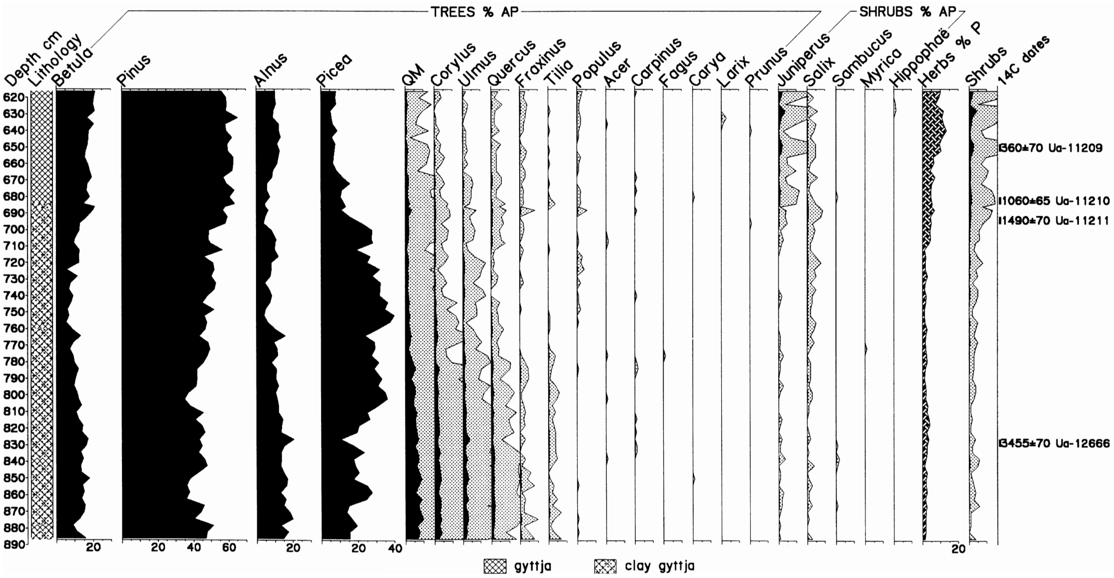

Fig. 7. Relative tree and shrub pollen frequencies (% AP) and radiocarbon dates of Skiitanlahti, Valamo.

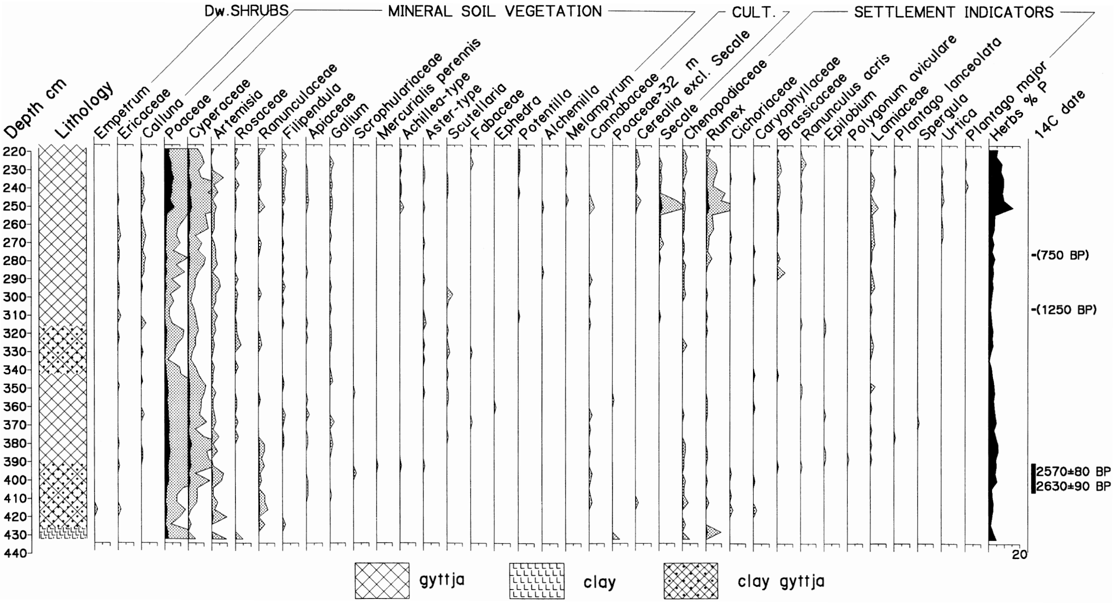

Fig. 8. Relative pollen frequencies (% P) of dwarf shrubs, mineral soil herb vegetation, cultivated plants, and settlement indicators of Eastern Igumeeninlampi, Valamo.

Mineral soil vegetation

In the deposits of E. Igumeeninlampi (Fig. 8) dwarf shrub pollen are very few. The mineral soil vegetation, which includes 18 pollen types, is dominated by Poaceae, Cyperaceae and *Artemisia*, all showing a clear division into two maxima divided by the clay gyttja horizon at the 317–340-cm level, dated to approximately 1450–1800 BP. This division cannot, however, be seen in the pollen frequencies of the rest of mineral soil vegetation. The pollen taxa found in

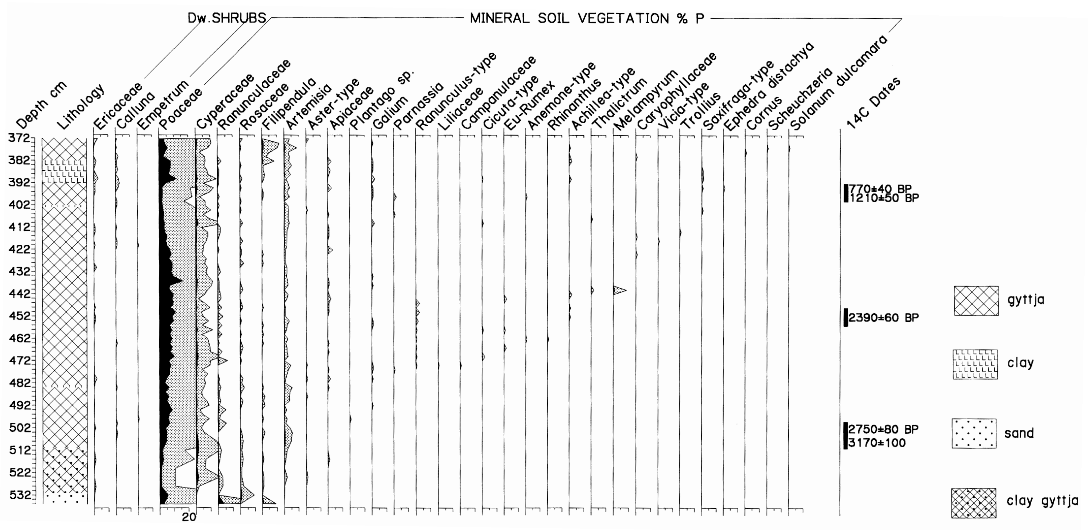

Fig. 9. Relative pollen frequencies (% P) of dwarf shrubs, mineral soil herb vegetation, and radiocarbon dates of Lake Niikkananlampi, Valamo.

the bottom clay (Poaceae, Cyperaceae, *Artemisia* and Rosaceae) increase in connection with the isolation. These include Ranunculaceae (the maxima of which at the 375–422-cm level could, in the land use history, correspond to that found at the 450–470-cm level at Niikkananlampi), *Filipendula*, Apiaceae, *Galium*, Scrophulariaceae, *Mercurialis perennis* as well as *Achillea* and *Aster* types. They are followed from 365-cm level by *Scutellaria* and, later, by Fabaceae. *Potentilla*, *Alchemilla* and *Melampyrum* were found only in the agrarian period. The pollen grain of *Ephedra* at the 310-cm level is of long distance transport origin.

The herb pollen data of Lake Niikkananlampi (Fig. 9) were described in detail by Vuorela and Saarnisto (1997). A two-phase division of Poaceae is also seen, the division horizon being related to the thin clayey horizon at the 402-cm level, dated to approximately 1350 BP. The total herb pollen sum which, in E. Igumeeninlampi, remains between one and five percent of P for most of the deposits, reaches ten percent of P at the 426–466-cm level of the pre-agrarian period presented in Lake Niikkananlampi. The rich herb vegetation is represented by 28 evenly increasing pollen taxa. The pollen types adding to the pollen taxa of E. Igumeeninlampi are as follows: *Potentilla*, *Plantago* sp., *Parnassia*, Liliaceae, Campanulaceae, *Cicuta*, *Rumex*, *Anemone-type*, *Rhinanthus*, *Thalictrum*, *Vicia*-type, *Saxifraga*-type, *Cornus*, *Scheuchzeria*, and *Solanum dulcamara*, long-transported *Ephedra* being present at both sites. The herb pollen taxa increase considerably at the 472-cm level, corresponding to ca. 2500 BP, increasing thereafter more evenly.

The pollen data of Luostarinlahti (Fig. 10) show an even pollen sequence very similar to that found in Skiitanlahti. The pollen taxa consist of Poaceae, Cyperaceae, *Artemisia*, *Galium,* and *Thalictrum* (the pollen of which occurs throughout the diagram) and of Apiaceae, Scrophulariaceae, *Melampyrum*, Liliaceae, *Mercurialis perennis*, Ranunculaceae, *Filipendula*, Fabaceae, *Scheuchzeria* and *Aster*-type, which appear in the lower part of the profile investigated. They are then accompanied by Rosaceae and *Trifoliu*m, and from the 78-cm level onwards also by *Scutellaria, Achillea*-type, *Ambrosia*-type and *Trientalis europaea*. This level, dated to ca. 1200 BP, carries evidence of human activity, especially by increasing Poaceae pollen frequencies (the other herb pollen types showing very weak reactions only). The dwarf shrub pollen (Ericaceae and *Calluna*) also increases in the upper part of the diagram.

In the pollen data of Skiitanlahti (Fig. 11),

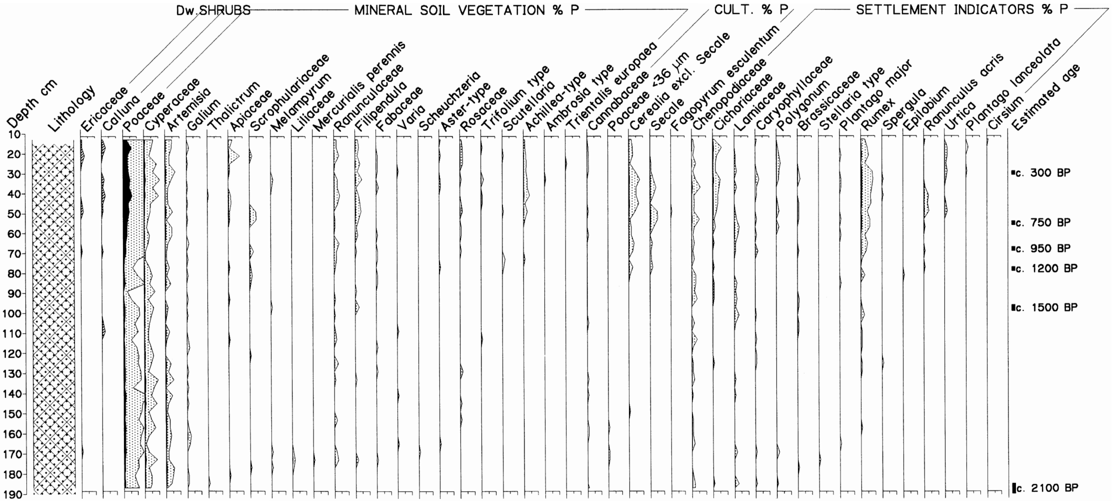

Fig. 10. Relative pollen frequencies (% P) of dwarf shrubs, mineral soil herb vegetation, cultivated plants, and settlement indicators of Luostarinlahti, Valamo. Lithology: clay gyttja only.

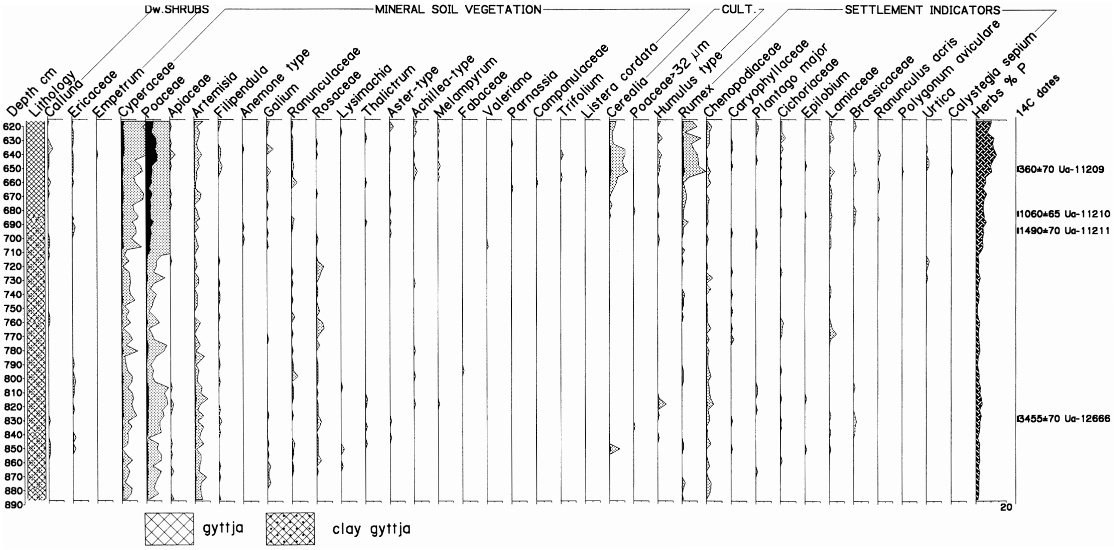

Fig. 11. Relative pollen frequencies (% P) of dwarf shrubs, mineral soil herb vegetation, cultivated plants, settlement indicators, and radiocarbon dates of Skiitanlahti, Valamo.

dating back to the pre-isolation phase, dwarf shrubs are modestly represented. No new pollen types were, however, found between the 792 and 708-cm levels, dating to approximately 2900–1700 BP, which was the period shortly after the opening of the River Neva. This was also the period of the lowest herb pollen representation and the lowest loss-on-ignition values. The exposed shores resulting from the opening of the Neva River, 3100 BP, seem not to have caused any major changes in the vegetation growing around the bay. The same pollen taxa (Poaceae, Cyperaceae and *Artemisia*) as in the lakes dominate the herb pollen data, which also consist of more sporadically occuring pollen grains of *Filipendula*, *Anemone*-type, *Galium*, Ranunculaceae, Rosaceae, *Lysimachia*, *Thalictrum*, *Aster*-type, *Achillea*-type, *Melampyru*m, Fabaceae, *Valeriana, Parnassia,* Campanulaceae, and *Listera cordata*. The increase in pollen taxa during the pre-

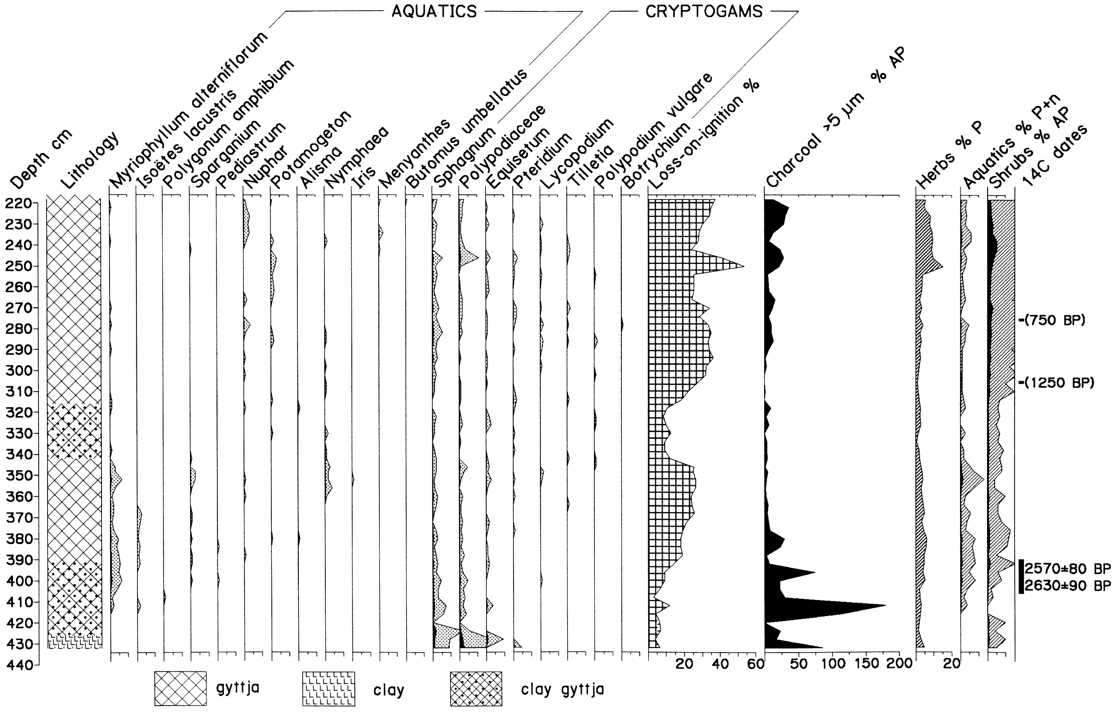

Fig. 12. Relative pollen and spore frequencies of aquatics and cryptogams, loss-on-ignition, charcoal frequencies (% AP), total herb, aquatic and shrub pollen frequencies, pollen concentration, and radiocarbon dates of Eastern Igumeeninlampi, Valamo.

isolation time was very uniform, the main increase in herb pollen frequencies taking place in the upper part (708–620 cm) of the diagram, especially in the uppermost 30 cm.

Cultivated plants and settlement indicators

In E. Igumeeninlampi (Fig. 8) a sporadic pollen grain of Poaceae exceeding 32 µm was found in the bottommost sample of the diagram, followed by a Cerealia pollen grain at the 410-cm level, this latter being the absolute Cerealia limit (C° ; cf. Vuorela 1986) for all the Valamo sites. The cereal pollen is accompanied by an increase in charcoal (Fig. 12) and a decrease in QM pollen, and followed by an increase in *Juniperus* and a decrease in *Picea*. The radiocarbon age of this limit antedates 2630 ± 90 BP. Even though the sedimentation at this level may still have been affected by the isolation process, it is unlikely that all these indicators could have been transported to the site by the waters of Lake Ladoga.

The earliest pollen grain of *Secale* type was found at the 312-cm level, immediately above the clay gyttja horizon, dating, according to the depth/age curve, to approximately 1350 BP. Only a sporadic *Rumex* pollen grain and an increase in *Juniperus* support the indication of local human activity. Herb pollen frequencies show a decline at this level.

The next *Secale* pollen grain was recorded at the 280-cm level, dating to approximately 800 BP (ca. 1250 cal AD) and representing the empirical Cerealia limit (C$^+$). This level is characterized by a peak in Poaceae pollen frequencies, by the start of the smooth *Rumex* curve, and by pollen grains of settlement indicators, such as Cichoriaceae, Brassicaceae and Lamiaceae. At the same level loss-on-ignition starts to decrease, and it is preceded by a clear increase in charcoal values (Fig. 12).

It was not until at the 246-cm level that the first Cerealia pollen grain (excluding *Secale* type) was found, in connection with shortlived *Secale* and *Rumex* maxima. At the same level loss-on-ignition decreases and charcoal frequencies show one of the most distinct maxima. The

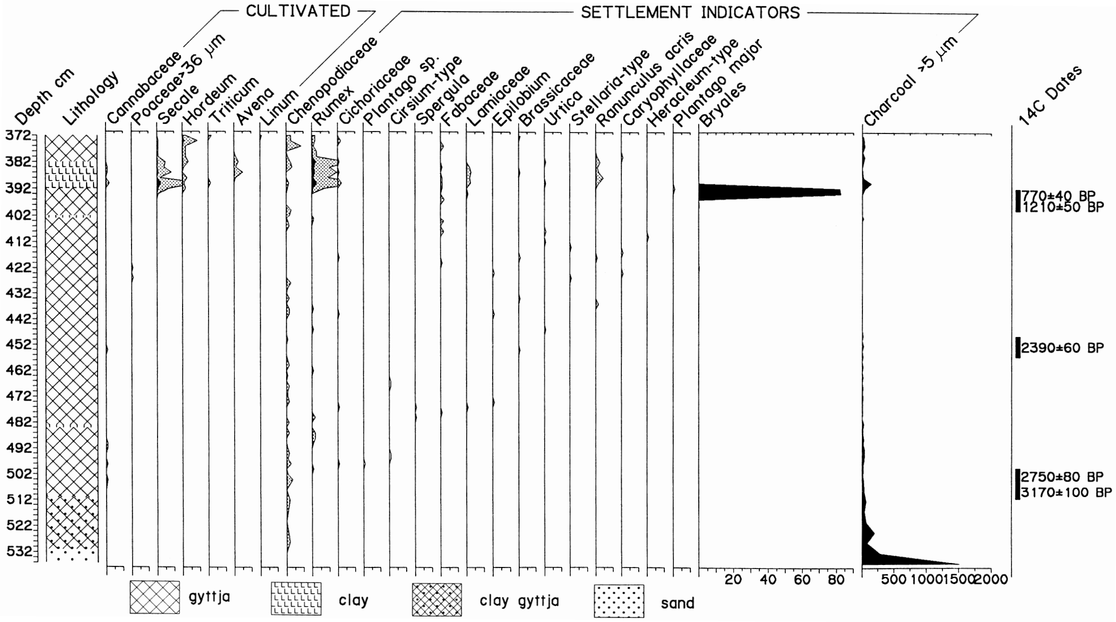

Fig. 13. Relative pollen frequencies (% P) of cultivated plants, settlement indicators, and radiocarbon dates of Lake Niikkananlampi, Valamo.

cultivation period seems to have remained short, or the activity was removed further from E. Igumeeninlampi. In the uppermost 20 cm of the diagram Cerealia pollen frequencies remain at 0.1%–0.3% P and *Rumex* pollen frequencies decrease, representing only 0.1% and 0.2% P in the uppermost subsamples. Cannabaceae pollen grains of *Humulus*-type most probably represent natural vegetation.

Pollen data of cultivated plants in Lake Niikkananlampi (Fig. 13) are, with the exception of *Humulus*-type pollen, strictly concentrated on the uppermost 20 cm of the profile dominated by the gyttja–laminated clay horizon at the 380–392-cm level. The earliest *Secale* pollen grain was found at 394 cm, dated to 770 ± 40 BP, i.e. ca. cal AD 1250, immediately followed by the first pollen grain of *Hordeum* type. *Secale* cultivation seems to have covered mainly the most intensive period reflected in the clay, while *Hordeum* pollen grains were found in lower, but more even, frequencies up to the surface layer, where they increase. *Triticum* pollen was found once in the oldest part of the eroded clay sediment and once on the sediment surface, while *Avena* was found at five levels in the upper part of the clay horizon, distinction of these two pollen taxa being based on the grain size (Beug 1961).

The strong but short-lasting maximum of Bryales at the 394-cm level, followed by a modest charcoal maximum, is simultaneous with the pollen signal of *Secale*. Among settlement indicators, *Rumex* pollen increases distinctly in connection with the cultivation, the maximum phase covering the whole erosion layer. Among other weeds, Lamiaceae and *Ranunculus acris* increase clearly. A sporadic pollen grain of *Plantago major* on the 394-cm level is an additional indicator of local settlement.

In the uppermost layers, after the decrease in settlement indicators, *Hordeum* seems to have gained a dominant position among the cereals, the most frequent weed pollen being Chenopodiaceae. Even though e.g. *Filipendula,* in the uppermost gyttja layer, may indicate partly abandoned fields, low but distinct charcoal values simultaneously indicate fire. One pollen grain of *Linum* was found in the topmost sample.

In the Luostarinlahti profile (Fig. 10) cereals excluding *Secale* have not been separated to the species level. The absolute Cerealia limit was determined at the 78-cm level, dated to approximately 1200 BP, that also being the date of the introduction of local *Secale* cultivation. Among the settlement indicators, Chenopodiaceae and *Rumex* are in particular evenly represented during the last millenium, with a somewhat scarcer appearance of Cichoriaceae, Lamiaceae, Caryophyllaceae, Brassicaceae and *Polygonum*, and with sporadic occurrences of *Stellaria* type and *Spergula*. Pollen of *Epilobium* was found at the absolute Cerealia limit together with the start of the *Ranunculus acris* curve. Most settlement indicators increase from that level onwards, reaching maximum values at the 60–30-cm level, which corresponds to the late Iron Age and the Middle Ages.

The sporadic pollen grain of *Fagopyrum* at the 48-cm level, corresponding to ca. cal AD 1300, is simultaneous with the short-lasting decrease in *Secale* frequencies. This level, however, carries evidence of increasing human activity by increasing pollen frequencies of Cerealia excl. *Secale*, Cichoriaceae, *Rumex*, *Ranunculus acris* and *Urtica*, and by relatively high frequencies of Chenopodiaceae. The increase in Cichoriaceae pollen should be emphasised, this pollen type being a most reliable indicator of intensive habitation. Within the mineral soil vegetation this was also the level where e.g. Poaceae, Cyperaceae, *Artemisia*, Apiaceae, Ranunculaceae, *Filipendula* and *Achillea*, and, among the shrubs, *Juniperus* pollen frequencies increase, thus confirming the interpretation of more intensive local habitation by Linkola (1916). In the uppermost part of the diagram, slight decreases in the settlement indicators, including also total herb pollen and *Juniperus*, can be seen. Pollen of *Urtica*, *Plantago lanceolata* and *Cirsium,* as well as macroremains of cereals were, however, concentrated in this part of the diagram, i.e. the last 300 years.

At the 694-cm level of the Skiitanlahti profile (Fig. 11), dated to 1490 ± 70 BP, a distinct decline of *Picea* takes place and a continuous *Rumex* curve starts, preceded, however, by the start of the Lamiaceae pollen curve and an increase in Poaceae and Cyperaceae. Cereal pollen was found at the 684-cm level, dated to 1060 ± 65 BP (antedating cal AD 1000), now indisputably reflecting local cultivation. The empirical Cerealia level was determined to the 668-cm level and the rational level to the 650-cm level, dated to 360 ± 70 BP. Even though the pollen frequencies of the settlement indicators, excluding those of *Rumex*, remain very low and scarce, they confirm the interpretation of intensive settlement in the area since cal AD 500–600 and cultivation since the 10th century cal AD. The strongest evidence of habitation is restricted to the last 500 years.

Aquatics and hygrophytes

In the deposits of Eastern Igumeeninlampi (Fig. 12), aquatics and hygrophytes are represented by eleven pollen types and spores of *Isoëtes*. In the clay deposited in the Lake Ladoga stage no aquatics were present, indicating deep water off the coast at that time. Immediately after the isolation, pollen of *Myriophyllum alterniflorum* and spores of *Isoëtes* appear, followed by *Polygonum amphibium*, *Sparganium*, *Pediastrum*, *Nuphar*, *Potamogeton* and *Alisma* in the gyttja layer preceding the clay gyttja horizon at the 317–340-cm level. The succession described reflects increasing eutrophy, which was interrupted by a distinct decrease in *Myriophyllum alterniflorum,* and a disappearance of *Isoëtes*, *Polygonum amphibium*, *Sparganium* and *Pediastrum*. An appearance of pollen of *Nymphaea* and *Iris*, however, precedes the clay–gyttja horizon, dated approximately to 1500–1600 BP, i.e. ca. cal AD 400. In the upper part of the sediment core, pollen of *Menyanthes* and *Butomus umbellatus* appeared together with *Nuphar* and P*otamogeton,* thus indicating again an increasing nutrient stage.

In Lake Niikkananlampi (Fig. 14), the pollen taxa are very much the same as in E. Igumeeninlampi consisting, in a chronological order, of *Nymphaea*, *Myriophyllum alterniflorum*, *Isoëtes lacustris*, *Sparganium*, *Menyanthes*, *Elatine*, *Alisma*, *Typha*, *Nuphar*, *Potamogeton*, *Myriophyllum spicatum/verticillatum*, *Ruppia,* and *Polygonum amphibium*. The maximum phase of *Myriophyllum alterniflorum*, in the early stage of the isolated small lake, seems to correspond to that in E. Igumeeninlampi. The maximum phase ends at a clay horizon at the 482-cm level, after which the nutrient stage seems, according to the evenly increasing pollen taxa, to regain and improve. This can also be seen in the steadily increasing

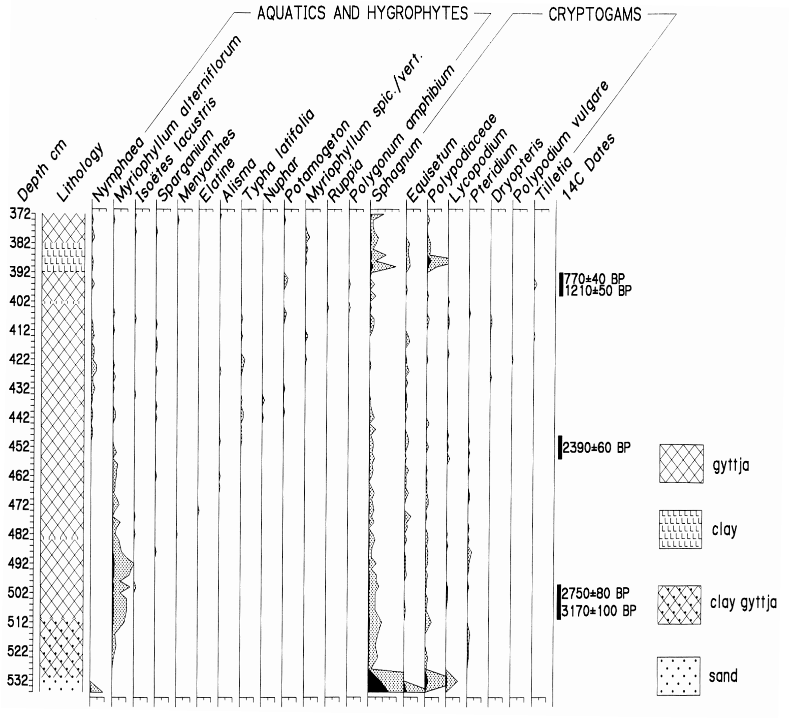

Fig. 14. Relative pollen and spore frequencies (% P) of aquatics, hygrophytes and cryptogams, and radiocarbon dates of Lake Niikkananlampi, Valamo.

loss-on-ignition value of the sediment (Fig. 2). The thin clay layer at the 402-cm level, dated to the 14th century BP, seems to be a turning point where the nutrient stage decreases. On the sediment surface there can again be seen slight evidence of recovering eutrophy, reflected in increasing aquatic pollen taxa.

The aquatic pollen data of Luostarinlahti (Fig. 15) consist of nine pollen taxa, which, in a chronological order, are as follows: *Myriophyllum alterniflorum*, *Sparganium*, *Isoëtes*, *Alisma*, *Potamogeton*, *Nuphar*, *Typha*, *Elatine*, and *Menyanthes*. Of these, *Myriophyllum* and I*soëtes* are the only ones occurring throughout the diagram, which covers the period following the lowering of the water level of Lake Ladoga in 3100 BP. The even occurrence of these species and the sporadic occurrence of the rest of the aquatics do not reflect major ecological changes during these millenia. However, the short-lasting maxima of *Isoëtes* at the 88–80-cm and 68–60-cm levels most probably correspond to the local settlement history (Vuorela 1980), as described above.

The ecosystem of Skiitanlahti (Fig. 16) has changed considerably in connection with the opening of the River Neva, when the strongly lowering water level closed the former strait. This phase is reflected in the loss-on-ignition values at the 790-cm level. It is preceded by sporadic pollen occurrences of *Polygonum amphibium*, *Typha*, *Myriophyllum alterniflorum*, *Elatine* and *Sparganium,* algae of *Pediastrum*, and spores of *Isoëtes lacustris*. After the formation of the bay new pollen taxa appear very slowly. It is not until from the 726-cm level onwards that spores of *Isoëtes echinospora* were found, followed by *Nuphar*, which indicates an increased nutrient stage. The final increase in eutrophication starts at the 690-cm level, dated to 1490 ± 70 BP, which corresponds strongly to the local settlement history, as seen above. Increased human activity led to the eutrophication of Skiitanlahti as reflected by the rising LOI value and the increasing pollen taxa of aquatics, the new pollen types being *Myriophyllum spicatum/verticillatum*, *Menyanthes*, *Nymphaea*, *Alisma*, and *Potamogeton*. Simultaneously the spore frequencies of *Isoëtes echinospora* exceed those of *I. lacustris*.

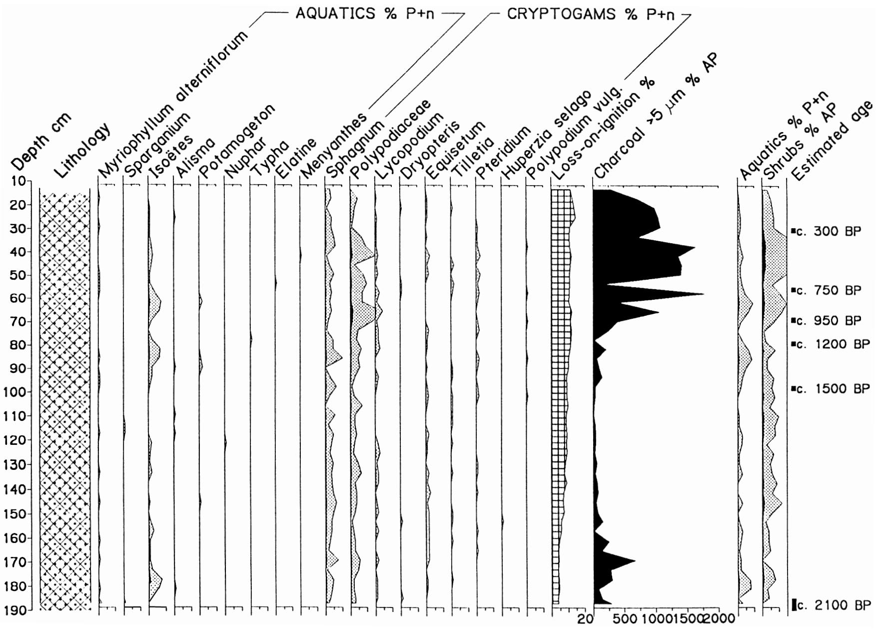

Fig. 15. Relative pollen and spore frequencies of aquatics and cryptogams, loss-on-ignition, charcoal frequencies (% AP), total pollen concentration, and palaeomagnetic dates of the Luostarinlahti sediments, Valamo. Litology: clay gyttja only.

Cryptogams

In the bottommost clay layer of E. Igumeeninlampi (Fig. 13), *Sphagnum*, Polypodiaceae and *Equisetum* spore frequencies exceed 1% P + n declining, in connection with the isolation, to a permille level. The other spore types, occurring, however, only sporadically, are: *Pteridium*, *Lycopodium*, *Tilletia*, *Polypodium vulgare* and *Botrychium*. Human activity seems to have increased the frequencies of *Sphagnum* and Polypodiaceae, which corresponds to the fluctuations in the charcoal frequencies.

In the deposits of Niikkananlampi (Fig. 14), the spore data corresponds to that found in E. Igumeeninlampi. Occasional spores of *Dryopteris* type add to the taxa.

In Luostarinlahti (Fig. 15), spore frequencies of *Sphagnum*, *Equisetum*, *Lycopodium, Equisetum, Tilletia* and *Pteridium* are evenly distributed, while those of Polypodiaceae seem to follow the pollen indicators of human activity and charcoal dust particles. Only occasional spores of *Dryopteris* type, *Huperzia selago* and *Polypodium vulgare* were found.

In Skiitanlahti (Fig. 16), spore frequencies dominated by *Sphagnum* and Polypodiaceae decline in connection with the opening of the Neva River, remaining at the permille level up to the surface layer. *Equisetum* spore frequencies remain very even throughout the diagram, while those of *Pteridium* increase slightly in the gyttja layer corresponding to the most active human interference. *Pediastrum* algae were represented sporadically.

Charcoal dust particles

The relative charcoal frequencies in lake deposits, calculated as % AP, reflect natural fire or the use of fire, probably in the vicinity of the basin. In connection with isolation, the charcoal frequencies are usually high, as a result of the accumulation of floating material in a closing bay.

In E. Igumeeninlampi (Fig. 12), charcoal frequencies are temporarily high at the 380–430-cm level, the maxima fluctuating between 25% and 175% AP in connection with the isolation from Lake Ladoga. After that they decrease up to the 285-cm level to frequencies of 1%–5% AP. In the uppermost part of the diagram, at the 240–250-cm level, charcoal values reach 25% AP and at the 222–230-cm level 30% AP, remaining otherwise at 10%–12%.

In the pre-isolation deposits of Lake Niikkananlampi (Fig. 13), charcoal frequencies reach 1500% AP decreasing, however, rapidly

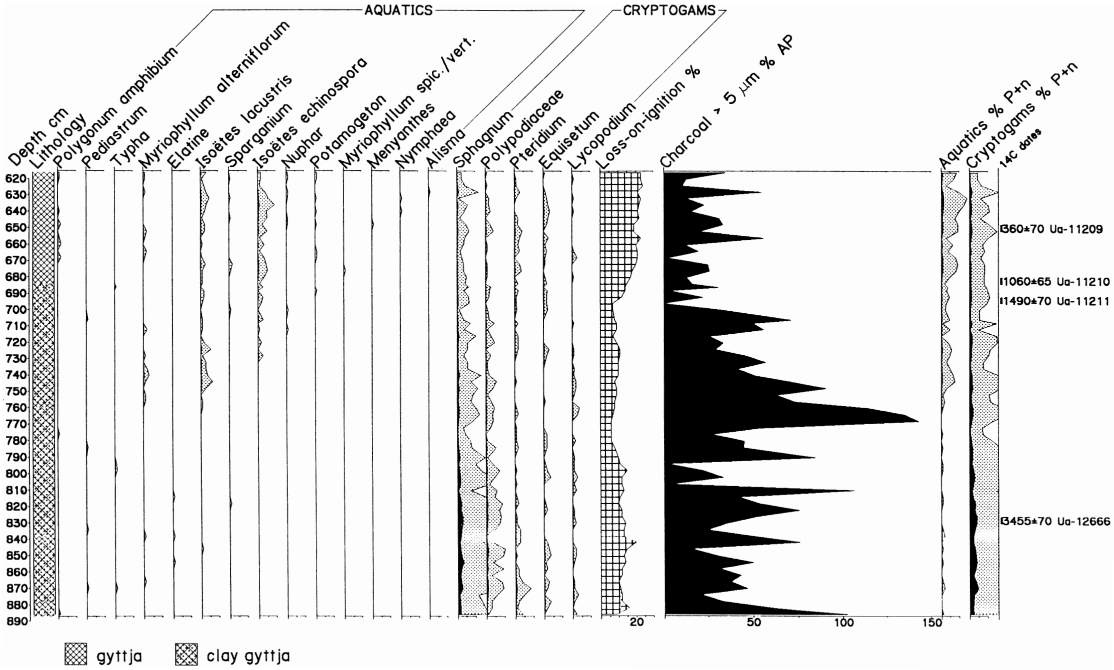

Fig. 16. Relative pollen ans spore frequencies of aquatics and cryptogams, loss-on-ignition, and charcoal frequencies in Skiitanlahti, Valamo.

to less than 10% AP for most of the diagram. It is not until at the 386-cm level where the frequencies increase temporarily to 200% AP in connection with other indicators of land use.

In the pre-agrarian part of the Luostarinlahti diagram (Fig. 15), after a short maximum phase (reaching 700% AP at the 168-cm level), relatively low charcoal frequencies (mainly between 25% and 250% AP) could be found. The increase starts at the 92-cm level, first from 15% to 200%, and from the 70-cm level upwards to 1700% AP. The maximum stage remains at the 62–36-cm level, decreasing thereafter towards the sediment surface to 250% AP.

In the bay deposits charcoal values exceed those found in the sediments of the small lakes.

In Skiitanlahti (Fig. 16), where the frequencies fluctuate very strongly, there is an increasing tendency from ca. 50% to 145% AP starting from the deposits antedating the opening of the Neva River and reaching the maximum at the 760-cm level, where lithological evidence of ecological changes can be seen. From this level upward, relative charcoal values decrease, reaching only approximately 25% AP in the gyttja layer (620–692 cm).

Plant macrofossils

The identified macrofossil finds numbered 603 in E. Igumeeninlampi (Table 3), 103 in Lake Niikkananlampi (Table 4), 276 in Luostarinlahti (Table 5) and 1226 in Skiitanlahti (Table 6). Pieces of unidentified species that were, however, clearly identifiable as plants or mosses, were not counted.

In the samples of E. Igumeeninlampi, the remains of cultivated plants were very rare. One seed per species were found of *Cannabis sativa* from the layer 240–260 cm, of *Linum usitatissimum* from the layer of 320–340 cm, preceding the earliest *Secale* pollen grain, and of *Humulus lupulus* from the layer 380–390 cm. It is possible that *Humulus* grows in the area as a native plant.

At this site the most common remains were seeds, scales and pieces of inflorescence of *Alnus* spp. and *Betula* spp., with the species *Alnus glutinosa*, *A. incana*, *Betula nana*, *B. pendula*, *B. pubescens*, and also of a *Betula*-hybrid with two seeds. These remains occurred most frequently in the layers between 280–380 cm corresponding, according to the pollen ratio (AP/NAP), to the most forested period. Needles,

Table 3. Eastern Igumeeninlampi, Valamo, Russian Karelia. Macrofossils are seeds and fruits if not otherwise stated. l = leaf, * = charred, s = seeds, n = needle, f = flower, '–' = no finds, '+' = few finds, '++' = common, '+++' = very common.

Depth (cm)	220–	240–	260–	280–	300–	320–	340–	360–	380–	400–	420–	440–	Sum
Cultivated													
Cannabis sativa	–	1	–	–	–	–	–	–	–	–	–	–	1
Humulus lupulus	–	–	–	–	–	–	–	–	1	–	–	–	1
Linum usitatissimum	–	–	–	–	–	1	–	–	–	–	–	–	1
Trees and shrubs													
Alnus glutinosa	1	5	–	1	–	7	1	–	1	–	–	–	16
Alnus incana	–	–	–	–	1	3	3	7	3	–	–	–	17
Alnus sp./f	–	–	1	–	2	8	3	5	–	–	1	–	20
Betula nana	1	–	–	–	–	–	–	–	–	–	–	–	1
Betula pendula/s	24	34	26	8	23	46	47	70	25	5	–	–	298
Betula pubescens/s	–	–	–	–	–	–	32	6	–	–	–	–	38
Betula pubescens/l	+	–	–	–	–	–	–	–	–	–	–	–	–
Betula x (hybrid)	–	–	1	–	1	–	–	–	–	–	–	–	2
Picea abies/n	28	22	5	29	28	28+1*	3	5+3*	2	1	–	–	155
Picea abies/s	–	4	–	3	4	–	–	3	–	–	1	–	15
Picea abies/f	8	–	–	–	1	–	–	–	–	–	–	–	9
Pinus sylvestris/n	–	5	13+1*	–	4	28	27	9	–	3	–	–	90
Pinus sylvestris/f	–	–	–	–	–	–	4	–	–	–	–	–	4
Pinus sylvestris/s	–	–	3	–	–	9	–	3	–	7	–	–	22
Settlement indicators													
Fumaria officinalis	–	–	–	–	–	–	–	–	–	–	1	–	1
Galeopsis speciosa	–	–	–	–	–	–	–	–	–	–	1	1	2
Potentilla anserina	–	–	–	–	–	–	–	–	1	–	–	–	1
Ranunculus acris	–	–	–	–	–	–	–	1	1	–	–	–	2
Ranunculus repens	–	–	–	–	–	1	1	2	–	3	–	–	7
Rubus idaeus	–	–	–	–	–	2	–	–	–	2	8	–	12
Stellaria graminea	–	–	–	–	–	–	–	–	–	–	–	1	1
Trifolium repens/f	–	–	–	–	–	–	1	–	–	–	–	–	1
Urtica dioica	–	–	–	–	–	–	–	1	–	–	–	–	1
Natural vegetation													
Fragaria vesca	–	–	–	–	–	1	1	–	–	–	–	–	2
Vaccinium vitis-idaea	–	–	–	1	–	–	–	–	–	–	–	–	1
Vicia sp.	–	–	–	–	–	–	–	–	–	–	–	1	1
Viola riviniana	–	–	–	–	–	–	–	–	–	1	–	3	4
Wet meadows, shores and marshes													
Cardamine amara	–	–	–	–	–	–	–	1	–	–	–	–	1
Carex acuta	–	–	–	–	–	1	2	2	–	1	1	2	9
Carex canescens/ brunnescens	–	–	1	–	–	–	–	–	1	1	–	–	3
Carex leporina	–	–	–	–	–	–	–	–	–	1	–	–	1
Carex nigra	1	7	2	–	–	11	–	1	9	–	–	1	32
Carex sp.	–	–	–	–	–	1	2	8	–	–	–	–	11
Chara sp.	–	–	–	–	–	–	–	–	–	–	–	2	2
Cicuta virosa	–	–	–	–	–	–	–	1	–	–	–	–	1
Cirsium palustre	–	–	–	–	–	–	–	–	1	–	–	–	1
Comarum palustre	–	–	–	–	–	–	–	1	–	–	–	–	1
Juncus bufonius	–	–	–	–	–	–	–	2	–	–	–	–	2
Mentha arvensis	–	–	–	–	–	1	–	–	–	–	1	–	2
Menyanthes trifoliata	1	–	–	–	–	–	–	–	–	–	–	–	1
Phalaris arundinacea	–	–	–	–	–	–	–	–	1	–	–	–	1
Polygonum persicaria	–	–	–	–	–	–	–	–	3	–	–	–	3
Potentilla erecta	–	–	–	–	–	–	–	–	–	1	–	–	1
Ranunculus flammula	–	–	–	–	–	2	–	–	1	1	–	–	4
Sagina nodosa	–	–	–	–	–	–	–	–	2	–	–	–	2
Schoenoplectus tabernaemontani	–	1	–	–	–	–	–	–	–	–	–	–	1

continued

Table 3. Continued.

Depth (cm)	220–	240–	260–	280–	300–	320–	340–	360–	380–	400–	420–	440–	Sum
Aquatics													
Alisma plantago-aquatica	–	–	1	–	–	–	1	1	–	–	–	–	3
Calla palustris	–	–	–	–	1	–	–	–	–	–	–	–	1
Callitriche sp.	–	–	–	–	–	–	10	–	–	–	–	–	10
Hippuris vulgaris	–	–	1	–	–	–	–	–	–	–	–	–	1
Ranunculus peltatus	–	–	–	–	–	–	–	7	5	1	–	–	13
Cryptogams													
Thelypteris palustris/l	–	–	–	2	–	–	–	–	–	–	–	–	2
Total	64	79	55	44	65	151	138	139	57	28	14	11	845
Other remains													
Bryophyte stems/leaves	+++	+++	+	+++	+	+	+++	+++	+++	+	–	–	–
Mnium sp.	+	–	–	–	–	–	–	–	–	–	–	–	–
Sphagnum spp.	+++	–	–	–	–	–	–	–	–	–	–	–	–
Fungi/sclerotia	–	–	–	4	2	12	1	–	2	2	12	14	49
Plant remains/indet.	+++	+++	+	+++	++	+	+++	+	+	+++	+++	–	–
Charcoal	–	–	–	–	–	+++	–	–	–	++	+++	+++	–
Wood													
Cristatella mucedo	1	1	2	–	61	121	56	70	59	92	31	20	514
Insecta	–	–	–	10	2	–	2	2	22	–	–	2	40

seeds and pieces of flowers of *Picea abies* and *Pinus sylvestris* were also common in the same layers as *Betula* and *Alnus*.

The remains of settlement indicators were concentrated to the layers between 320–440 cm. The species were *Fumaria officinalis*, *Galeopsis speciosa*, *Potentilla anserina*, *Ranunculus acris*, *R. repens*, *Stellaria graminea*, *Trifolium repens*, and *Urtica urens*. A few seeds of *Rubus idaeus* were also found. It grows everywhere with humans but also on wasteland. *Fragaria vesca*, *Vaccinium vitis-idaea*, *Viola riviniana* and also *Vicia* sp. belong to natural vegetation of sunny, open, or shadowed forest slopes (Hämet-Ahti *et al*. 1998).

The most common remains of these sediment samples represented plants of wet meadows and shores. The pure shore plants were *Carex acuta*, *C. nigra* and *C. canescens/brunnescens*, *Cicuta virosa*, *Comarum palustre*, *Menyanthes trifoliata* and *Schoenoplectus tabernaemontani*. *Cardamine amara*, *Cirsium palustre*, *Juncus bufonius, Polygonum persicaria* and *Ranunculus flammula* grow on wet but yet a little drier sites than the former plants.

Remains of five plant species growing on shallow shore water, or of pure aquatics, were found from the depth of 240–400 cm. They were *Alisma plantago-aquatica*, *Calla palustris*, *Callitriche* sp., *Hippuris vulgaris* and *Ranunculus peltatus*.

Pieces of leaves of *Thelypteris palustris* were found from the depth of 280–300 cm. Stems and leaves of mosses (Bryophyta), sclerotia of fungi and indetermined plant remains were very common in almost all layers, but they were not counted. The abundance of *Cristatella mucedo* was remarkable from depths of 440 cm to 300 cm and reflects polluted or very polluted water conditions (cf. Vuorela *et al*. 2001).

The samples of the Lake Niikkananlampi (Table 4) were rather poor in plant remains. The most common ones were the remains of trees, especially seeds of *Betula pendula*. They were found from all the depths studied. Few needles and pieces of flowers of *Picea abies* and *Pinus sylvestris* were found. Settlement indicators were *Brassica/Raphanus* and *Chenopodium album. Fragaria vesca* and *Rumex crispus* are plants of natural dry habitats. *Cardamine amara* thrives on wet shores, while only one aquatic species, *Ranunculus peltatus,* was encountered. Other remains were the same as in the samples of E. Igumeeninlampi. The most common remains were pieces of stems and leaves of mosses and the remains of *Cristatella mucedo*, from the depth of 412–532 cm.

The only remains of cultivated cereals were found from the samples of Luostarinlahti (Table 5). The remains of Cerealia-type and *Hordeum vulgare* were found from the depth of 10–30 cm. According to the dating (*see above*), they are from the 16th–18th centuries.

Betula spp. (mainly seeds of *B. pendula*), *Picea abies*, *Pinus sylvestris* were also in this material the most common tree remains. They were found at all depths.

Few settlement indicators were concentrated to the uppermost layers. They were *Polygonum persicaria, Potentilla anserina*, *Ranunculus repens, R. sceleratus*, *Rumex acetosella*, and *Trifolium repens*.

The remains of the plants growing in different natural habitats were all found from the uppermost 70 cm. Among these, *Agrostis* sp., *Alchemilla vulgaris*, *Alopecurus geniculatus*, *Fragaria vesca*, *Pimpinella saxifraga*, and *Poa pratensis*/*trivialis* come from dry or fresh meadows, and *Vaccinium vitis-idaea* from forest.

Remains of plants growing on wet shores, meadows and marshes were found throughout the core. The species were *Carex acuta*, *C. nigra*, *Juncus compressus*, *Phragmites australis*, *Ranunculus flammula*, and *Vaccinium oxycoccos*.

Other remains were the pieces of stems and leaves of mosses (Bryophyta), including *Sphag-*

Table 4. Lake Niikkananlampi, Valamo, Russian Karelia. Macrofossils are seeds and fruits if not otherwise stated. s = seeds, n = needle, f = flower, '–' = no finds, '+' = few finds, '++' = common, '+++' = very common.

Depth (cm)	372–	392–	412–	432–	452–	472–	492–	512–	532–	Sum
Trees and shrubs										
Betula pendula/s	–	20	5	4	7	24	2	4	–	46
Betula x hybrid	–	–	–	–	–	1	–	–	–	1
Picea abies/n	–	–	–	–	–	–	–	–	1	1
Pinus sylvestris/n	–	2	–	–	–	–	–	–	–	2
Pinus sylvestris/f	–	–	–	–	–	2	–	–	–	2
Settlement indicators										
Brassica/Raphanus	–	1	–	–	–	–	–	–	–	1
Chenopodium album	–	–	–	–	–	–	–	–	1	1
Natural vegetation										
Fragaria vesca	–	1	–	–	–	–	–	–	–	1
Rumex crispus	–	–	–	–	–	1	1	–	–	2
Wet meadows, shores and marshes										
Cardamine amara	–	–	–	–	–	–	–	1	–	1
Carex acuta	–	1	–	–	–	–	–	–	–	1
Carex nigra	–	–	–	–	–	3	1	–	–	4
Comarum palustre	–	1	1	–	–	–	–	–	–	2
Phalaris arundinacea	–	–	–	–	–	–	1	–	–	1
Aquatics										
Ranunculus peltatus	–	–	–	–	–	5	1	3	–	9
Total	–	26	6	4	7	16	46	8	2	75
Other remains										
Bryophyte stems/leaves	–	+	–	++	+	+++	+++	++	+	–
Sphagnum	–	+++	–	–	–	–	–	–	–	
Fungi/sclerotia	–	–	–	–	–	–	–	–	1	1
Plant remains/indet.	–	–	++	–	–	–	–	–	–	–
Charcoal	–	–	–	–	–	–	–	–	+	–
Cristatella mucedo	–	–	5	5	1	1	2	11	1	26
Insecta	–	–	2	–	–	–	–	+	–	2

Table 5. Luostarinlahti, Valamo, Russian Karelia. Macrofossils are seeds and fruits if not otherwise stated. l = leaf, s = seeds, n = needle, f = flower, '–' = no finds, '+' = few finds, '++' = common, '+++' = very common.

Depth (cm)	10–	30–	50–	70–	90–	110–	130–	150–	170–190	Sum
Cultivated										
Cerealia	1	–	–	–	–	–	–	–	–	1
Hordeum vulgare	1	–	–	–	–	–	–	–	–	1
Trees and shrubs										
Alnus glutinosa	–	–	1	–	–	1	–	–	–	2
Alnus incana	6	–	–	–	–	–	1	3	1	11
Alnus sp./l	–	–	–	–	–	–	–	–	+	–
Betula pendula/s	7	8	2	5	4	2	49	7	8	52
Betula pubescens/s	–	–	3	–	–	–	–	8	–	11
Picea abies/n	3	–	1	1	–	1	–	–	–	6
Picea abies/f	–	–	–	2	2	–	–	–	–	4
Picea abies/n	1	5	3	–	–	–	–	–	–	9
Picea abies/f	–	5	–	–	–	–	–	–	–	5
Pinus sylvestris/n	–	–	3	–	–	2	1	2	2	10
Pinus sylvestris/f	–	–	1	–	–	–	–	2	–	3
Pinus sylvestris/s	–	–	–	–	–	1	–	1	–	3
Populus tremula/l	–	–	–	–	–	–	–	–	+	–
Salix sp./l	–	–	–	–	–	–	–	–	+	–
Settlement indicators										
Polygonum persicaria	–	–	–	1	–	–	–	–	1	2
Potentilla anserina	–	–	–	–	–	–	–	1	–	1
Ranunculus repens	–	–	–	–	–	–	–	1	–	1
Ranunculus sceleratus	–	–	–	–	–	–	–	1	–	1
Rumex acetosella	–	1	–	1	–	–	–	–	–	2
Trifolium repens/f	2	–	1	–	–	–	–	–	–	2
Natural vegetation										
Agrostis sp.	3	–	–	–	–	–	–	–	–	3
Alchemilla vulgaris	–	2	–	–	–	–	–	–	–	2
Alopecurus geniculatus	1	–	–	–	–	–	–	–	–	1
Fragaria vesca	1	–	–	–	–	–	–	–	–	1
Pimpinella saxifraga	1	–	–	–	–	–	–	–	–	1
Poa pratensis/trivialis	–	–	1	–	–	–	–	–	–	1
Vaccinium vitis-idaea	3	–	–	–	–	–	–	–	–	3
Wet meadows, shores and marshes										
Carex acuta	–	1	1	2	–	–	–	–	–	4
Carex nigra	–	–	–	–	–	1	–	–	1	2
Juncus compressus	1	–	–	–	–	–	–	–	–	1
Phragmites australis	–	1	–	–	–	–	–	–	–	1
Ranunculus flammula	–	–	–	–	1	–	–	1	–	2
Vaccinium oxycoccos	1	–	–	–	–	–	–	–	–	1
Aquatics										
Alisma plantago-aquatica	–	–	–	–	–	1	–	–	–	1
Total	32	23	17	12	7	9	11	27	13	151
Other remains										
Bryophyte stems/leaves	+	+	+++	+	++	–	++	–	+	–
Sphagnum	+	+	–	–	–	–	–	–	–	–
Plant remains/indet	+++	+++	+++	+++	+++	+++	++	–	–	–
Charcoal	–	–	–	++	–	–	–	–	–	–
Cristatella mucedo	76	11	6	2	7	3	5	9	6	125
Insecta	+	–	–	+	–	–	–	+	–	–

Table 6. Skiitanlahti, Valamo, Russian Karelia. Macrofossils are seeds and fruits if not otherwise stated. st = stem, s = seeds, n = needle, f = flower, '–' = no finds, '+' = few finds, '++' = common, '+++' = very common.

Depth (cm)	620–	640–	660–	680–	700–	720–	740–	760–	780–	800–	820–	840–	860–	880–890	Sum
Trees and shrubs															
Alnus incana	–	–	2	–	3	2	12	1	–	3	5	2	1	–	27
Betula pendula/s	6	1	7	2	12	18	23	36	35	40	19	36	23	5	263
Betula pubescens/s	–	–	–	–	1	3	–	–	–	–	–	–	–	–	4
Picea abies/n	–	–	–	–	1	–	–	1	1	–	–	–	–	–	3
Picea abies/f	–	–	3	–	–	–	–	–	–	–	–	–	–	–	3
Picea abies/n	–	–	–	–	–	1	3	–	3	–	–	1	–	–	8
Pinus sylvestris/n	–	1	1	–	–	1	6	1	6	5	10 + 2*	10	4	2	49
Pinus sylvestris/f	–	–	–	3	–	–	2	–	–	–	–	–	–	–	5
Pinus sylvestris/s	–	1	–	2	9	1	–	2	3	3	–	2	1	–	24
Settlement indicators															
Ranunculus repens	–	–	–	–	–	1	–	–	–	–	2	–	–	–	3
Ranunculus sceleratus	–	–	–	–	–	1	–	1	–	–	–	–	–	–	2
Rumex acetosella	1	2	–	–	–	–	–	–	–	–	–	–	–	–	3
Natural vegetation															
Anemone nemorosa	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1
Calluna vulgaris/st	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1
Fragaria vesca	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1
Rubus fruticosus	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
Rubus idaeus	–	–	–	–	1	–	–	–	–	1	2	–	–	–	4
Vicia sp.	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
Viola riviniana	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1
Wet meadows, shores and marshes															
Carex acuta	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
Carex canescens/ brunnescens	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
Carex nigra	1	1	2	–	3	2	–	–	–	–	1	–	–	–	10
Eleocharis palustris	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1
Filipendula ulmaria	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
Juncus alpinoarticulatus	–	–	–	–	1	–	–	–	–	1	–	–	–	–	2
Juncus compressus	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Phragmites australis	–	–	–	–	–	–	–	2	–	–	1	–	–	–	3
Polygonum persicaria	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1
Scutellaria galericulata	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1
Aquatics															
Alisma plantago-aquatica	1	–	1	–	–	1	–	–	–	–	–	–	–	–	3
Potamogeton natans	–	–	–	–	–	–	–	–	–	2	–	–	–	–	2
Ranunculus peltatus	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
Total	10	7	16	7	33	31	47	45	49	56	44	43	31	7	426
Other remains															
Bryophyte stems/leaves	+	+++	–	++	++	–	–	+++	++	++	+++	+++	++	+++	–
Fungi/sclerotia	2	–	–	–	–	3	3	5	–	–	9	–	–	–	22
Plant remains/indet	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	++	++	+++	++	–
Charcoal	–	–	–	+	–	–	–	+	–	–	–	–	–	–	–
Cristatella mucedo	2	7	2	10	32	5	19	43	205	179	94	142	138	10	778
Insecta	–	+++	+	–	+++	–	–	–	+	+	–	–	++	–	–

num sp., some undetermined plant remains and charcoal. The remains of *Cristatella mucedo* were very common in the uppermost layers, from ten to 70 cm, corresponding approximately to the last 1000 years.

The samples of Skiitanlahti (Table 6) contained mainly seeds, needles and pieces of florescences of trees (*Alnus incana*, *Betula pendula, B. pubescens*, *Picea abies* and *Pinus sylvestris*). Seeds of *Betula pendula* were the most common ones. Settlement indicators (*Ranunculus repens*, *R. sceleratus, Rumex acetosella*) were very few, found between 620–820 cm. Remains of the plants growing in natural habitats were mostly those of forest plants (*Anemone nemorosa*, *Calluna vulgaris*, *Rubus idaeus*, *R. fruticosus*) or plants of dry meadows (*Fragaria vesca*, *Vicia* sp., *Viola riviniana*).

The most common remains also in this group were those of plants of wet meadows and shores. The *Carex* species were *C. acuta*, *C. canescens/brunnescens* and *C. nigra*. *Eleocharis palustris*, *Filipendula ulmaria*, *Juncus alpinoarticulatus*, *J. compressus*, *Phragmites australis*, *Scutellaria galericulata*, and *Polygonum persicaria* grow on wet meadows or shores. *Alisma plantago-aquatica*, *Potamogeton natans* and *Ranunculus peltatus* grow in shallow shorewater or as aquatics.

Among the most common remains, stem pieces of mosses, indeterminate plant remains and, again, *Cristatella mucedo*, very common between 780 cm and 860 cm, should be mentioned.

Discussion and summary

The palaeoenvironment of the Valamo islands changed considerably in connection with the formation of the Neva River 3100 BP (Saarnisto & Grönlund 1996). Then the water level of Lake Ladoga regressed several metres and the former small rocky islands, antedating that period, were united to form one island. In that connection, several small lakes were isolated and straits were closed to form long bays, the bottom sediments of which contain the pollen stratigraphy of the last three millenia. The pollen data of two lakes and two bays were presented, and special attention was paid to the anthropogenic indicators reflecting the settlement and agricultural history of the Valamo Island.

The pollen data of the Skiitanlahti cover ca. 4000 radiocarbon years, and those of E. Igumeeninlampi and Lake Niikkananlampi more than 3000 radiocarbon years, including the isolation phase ca. 3100 BP. The pollen diagram of Luostarinlahti covers ca. 2100 years. The fluctuations in the nutrient content of the basins, as a result of natural eutrophication, are reflected by increasing pollen frequencies and pollen taxa of aquatics which, however, are affected by soil erosion during the agricultural time.

Great similarities were observed between the tree pollen data of the bay sites, both Luostarinlahti and Skiitanlahti showing a strong domination of *Pinus* pollen and also relatively high *Picea* pollen frequencies, resulting partly from floating pollen material from the vast Lake Ladoga. In the lakes E. Igumeeninlampi and Lake Niikkananlampi, *Betula* and *Alnus* were considerably better represented. In the deposits of E. Igumeeninlampi, however, the planted *Quercus* stands, which form an oak alley, are represented by increasing pollen frequencies in the uppermost part of the diagram, probably also in that of Luostarinlahti. The *Larix* trees growing e.g. in the vicinity of E. Igumeeninlampi are reflected in the pollen taxa of Skiitanlahti and Niikkananlampi.

In the bottommost deposits of the Skiitanlahti sediments, antedating the formation of River Neva, broadleaved deciduous trees reach 10% AP. In the younger part of the profiles a clear decrease in the QM pollen frequencies can be seen first as a result of climatic deterioration, later also of human impact. At all sites, deforestation was reflected by increasing pollen frequencies of *Populus* and shrubs, especially *Juniperus* and *Salix*. Local differences could also be seen between the lake surroundings, the relatively high *Salix* frequencies of Lake Niikkananlampi indicating more humid conditions. As to the bays, the shores of Skiitanlahti have more *Salix*, while *Juniperus* dominates in Luostarinlahti, indicating the rocky shores.

In the lake deposits, the NAP/AP ratio was higher than that of the bays, thus reflecting more verdant and more site-specific vegetational conditions. The enlargement of the land area in connection with the regression of the water level ca. 3100 BP is reflected in increasing herb pollen taxa. This development was accelerated in connection with the local settlement, especially with the introduction of agriculture.

The early settlement history of Valamo Island, summarized in Fig. 17, can be deduced from an ensemble of several indicator groups. They include decreasing QM and *Picea* frequencies, an increase in charcoal particles and herb pollen frequencies, and an appearance of, or increase in, settlement indicators, such as *Rumex*, Chenopodiaceae and Lamiaceae. The oldest pre-

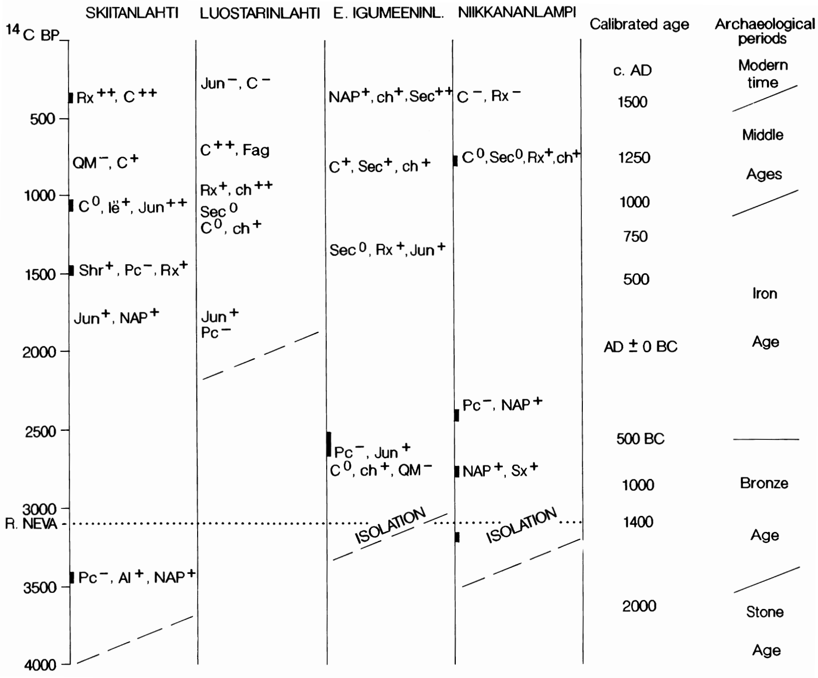

Fig. 17. Summary diagram of the most important levels in the pollen diagrams drawn in the time perspective. Abbreviations: Al = *Alnus*, C = Cerealia, ch = charcoal, Ië = *Isoëtes*, Jun = *Juniperus*, NAP = non-arboreal pollen, Pc = *Picea*, Rx = *Rumex*, Sx = *Salix*, shrubs = shr, QM = Quercetum Mixtum.

agricultural cultural phase, indicated by a decrease in *Picea* and an increase in *Alnus* and NAP, was recorded in Skiitanlahti ca. 3500 BP, i.e. the Stone Age–Bronze Age border. In Niikkananlampi pre-agricultural indication of human activity was recorded at 2750 ± 80 BP and 2390 ± 60 BP, the former representing Bronze Age and the latter, correspondingly, early Iron Age. In Luostarinlahti, weak, somewhat uncertain human impact was dated to ca. 1800 BP. Anthropogenic evidence, also lacking cereal pollen, was found in Skiitanlahti at ca. 1800 BP and later at 1500 BP. The results show that the date of the earliest indication of human activity varies considerably between the investigated sites. This can be explained by differences in local environments and by the small number of local inhabitants during the early centuries AD.

The most important agricultural phases, absolute (C°), empirical (C^+) and rational (C^{++}) levels (Tables 7 and 8; Vuorela 1986) were radiocarbon dated or estimated on an age/depth curve, the calibration being based on Stuiver and Kra (1986). The earliest pollen occurrence of Cerealia-type pollen was recorded from the lowermost part of the sediments of Lake E. Igumeeninlampi, preceding the 14C date of 2630 ± 90 BP and thus representing the Bronze Age. The local character of this indication was confirmed by a pronounced peak in the charcoal frequencies and a decrease in the QM frequencies, followed immediately by a decrease in *Picea* and an increase in *Juniperus*. Among the settlement indicators, *Rumex* and Chenopodiaceae pollen was present in the same subsample. After a “silence” of ca. 1500 radiocarbon years, agriculture was more evenly documented, the next Cerealia occurrence being the first pollen grain of *Secale*-type, that again in E. Igumeeninlampi. It was dated to ca. cal AD 650 (ca. 1400 BP) and accompanied by an increase in *Juniperus* and *Rumex*. The following Cerealia pollen, in chronological order, was found in Luostarinlahti ca. 1200 BP (ca. cal AD 800), which also seems to have antedated the start of more permanent *Secale* cultivation on the Valamo Island, and in Skiitanlahti in the Viking Age (1060 ± 65 BP). Around E. Igumeeninlampi and Niikkananlampi the corresponding stage was reached ca. 200 years later, ca. cal AD 1250 (770 ± 40 BP). In Niikkananlampi, however, that was the earliest indication of cultivation while, in E. Igumeeninlampi, it already indicated the increase in *Secale* cultivation. These results also correspond to the dates of the absolute Cerealia limit (1060 ± 60 BP; Ekman & Zuravlev 1986) in Säämäjärvi, Jessoila, the Ladoga–Onega isthmus, and in the northern Lake Onega region (790 ± 80 BP; Vuorela *et al*. 2001).

More advanced agriculture seems to have started from the surroundings of Luostarinlahti at ca. cal AD 1000. The same happened simultaneously on the nearby Kilpolansaari, close to the mainland, where the date of the empirical Cerealia limit is 1090 ± 90 BP (Taavitsainen *et al.* 1994), corresponding to the 10th century cal AD. The empirical Cerealia limits at Skiitanlahti (ca. 800 BP), E. Igumeeninlampi (ca. 850 BP) and at Niikkananlampi (770 ± 40 BP), all calibrated to ca. cal AD 1250, show that this activity was spread over Valamo island during the following 200–250 years. The dates of the foundation of the monastery given by the historians (AD 1160, Kirkinen 1963; AD 1329, Lind 1986; < AD 1400, Spiridonov 1992) vary approximately within the corresponding frames.

The rational Cerealia limit (C^{++}), i.e. the level of the start of the maximal Cerealia occurrence, usually consists mainly of *Secale* pollen. This was true especially in Niikkananlampi, where *Secale* pollen was also connected with the start of agricultural activity. According to the anthropogenic pollen data, the maximum Cerealia phases most probably also indicate the most intensive cultivation practised on the island.

Special attention should be paid to the settlement indicators in the upper part of the diagram of Luostarinlahti, where an increase in herb pollen taxa and, especially, in Cichoriaceae pollen frequencies reflect intensive habitation on the adjacent area ca. 750 BP. In the uppermost part of the diagram, the decline of this pollen group most probably reflects a regression of the activity from the 17th century onwards. A corresponding regression can be seen in the curves for Cerealia and settlement indicators in all the sites investigated, especially in the deposits of Lake Niikkananlampi. The macroremains of cereals in

Table 7. Age of cultivation in the Ladoga–Onega area (BP).

	C°	C^{+}	C^{++}
Luostarinlahti	ca. 1200 ca. 600 = *Fagopyrum*°	ca. 950	ca. 750
Skiitanlahti (^{14}C)	1060 ± 65	ca. 800	360 ± 70
Eastern Igumeeninlampi (^{14}C/tr)	> 2630 ± 90 ca. 1400	ca. 850	ca. 450
Niikkananlampi (^{14}C)	770 ± 40	770 ± 40	770 ± 40
Säämajärvi, Jessoila (^{14}C)	1060 ± 60		
Suuri Kokkolampi, Kilpolansaari (^{14}C)	ca. 1600	1090 ± 90	ca. 350
Pegrema Bay (N Lake Onega) (^{14}C)	790 ± 80		

Table 8. Age of cultivation in the Ladoga–Onega area (cal BC/AD).

	C°	C^{+}	C^{++}
Luostarinlahti	ca. AD 800 ca. AD 1350 = *Fagopyrum*°	ca. 1050	ca. 1250
Skiitanlahti	ca. AD 1000	ca. 1250	ca. 1500
Eastern Igumeeninlampi	> 800 BC ca. AD 650	ca. AD 1250	ca. 1450
Niikkananlampi	cal AD 1200–1310	1200–1310	1200–1310
Säämajärvi, Jessoila	cal AD 960 (1000) 1020		
Suuri Kokkolampi, Kilpolansaari	ca. AD 430	870(970)1020	ca. 1550
Pegrema Bay (N Lake Onega)	late 13th century (= *Fagopyrum*°) early 14th century (= *Secale*°)		

the upper part of the Luostarinlahti sediments, however, confirm continuous settlement on the island. The natural herb vegetation may have resembled that described by Prokki and Prokki (1997) on the Island of Mantsi, situated closer to the eastern shore of Lake Ladoga.

The Cerealia limit dates can be compared (Tables 7 and 8) with those obtained at Kilpolansaari Island, northwestern archipelago of Lake Ladoga (Taavitsainen *et al*. 1994), and at the village of Jessoila (Russian *Essojla*) located on the isthmus between Lake Ladoga and Lake Onega (Ekman & Zhuravlev 1986), and at the village of Pegrema at the northern shore of Lake Onega (Vuorela *et al*. 2001). It can be stated that small-scale cultivation was practised in the area from the Bronze Age onwards. This result is of great importance when searching for the source areas of cultivation in the present SE Finland (Tolonen & Ruuhijärvi 1976, Vuorela 1994, Vuorela & Hicks 1996). Iron Age cultivation has now been documented on Kilpolansaari and on Valamo Island. More advanced cultivation started on the mainland in the late Iron Age, around AD 1000, and it also migrated to Valamo Island at that time. The remote area around Lake Niikkananlampi, in the southwestern part of the island, was, however, not cleared for cultivation until ca. cal AD 1250. That is the date of the rational Cerealia limit (C^{++}), i.e. the date of increasing agricultural activity in the central part of the island, reflected also in the deposits of Luostarinlahti, Skiitanlahti and E. Igumeeninlampi. The 13th century was also the period of *Fagopyrum* cultivation, in the Lake Onega region as well as on the Valamo Island. At Kilpolansaari the rational limit was reached in ca. cal AD 1550.

When comparing the ^{14}C dates of agricultural history on the Valamo Island and the adjacent Lake Ladoga region, two periods seem to be of special importance. The first of these is around 1000 BP, i.e. the Viking Age when agriculture started around Luostarinlahti, Skiitanlahti and Säämäjärvi, and was strengthened on Kilpolansaari. The second period of great significance is ca. 800–900 BP, i.e. the Middle Ages cal AD 1150–1250, when agriculture increased around Skiitanlahti, E. Igumeeninlahti and Niikkananlampi. This is also the absolute Cerealia limit at Pegrema Bay (Lake Onega), as well as at Lake Ohalampi (Saksa *et al*. 1996) and at Lake Riekkalanlampi (Grönlund *et al*. 1997), both located in the western Lake Ladoga region. The dates for the increasing field cultivation vary between 770 BP (13th century) at Niikkananlampi, and ca. 350–400 BP (16th century) at Skiitanlahti, E. Igumeeninlampi and Kilpolansaari, that of Luostarinlahti being ca. 700 BP (mid 13th century cal AD).

Due to the small volume of the material available, the number of macrofossils was relatively few. However, they support the information provided by the species variation of the area. The remains of cultivated plants, *Hordeum vulgare*, *Cannabis sativa*, *Humulus lupulus* and *Linum usitatissimum* were found also in the pollen diagrams of Luostarinlahti and E. Igumeeninlahti. The remains of cereals were found rather near the surface. Instead, *Linum usitatissimum* was found from the layers of the Late Iron Age and *Humulus* from the Early Iron Age, or even earlier. *Humulus* may, however, have grown as a native in this area.

Conclusion

The lack of archaeological finds from the period preceding the formation of River Neva suggests that the Valamo Islands remained uninhabited till at least 3000 BP. Weak indication of Bronze Age activity can, however, be seen in the present pollen data. The theory of probable early settlement on the Islands of Mantsi, which were united when the water level dropped (Peiponen 1997), support this interpretation.

The results show that agriculture was practised in the western part of the Valamo Island already before the foundation of the monastery, ca. AD 1300 (Lind 1986), most probably first as early as Bronze Age. Later, a new introduction of agriculture took place between AD 650 and AD 800, increasing considerably shortly after AD 1000 in the vicinity of Luostarinlahti, and, in other parts of the island, around AD 1250. AD 1000–1250 seems to have been an important period of growing and developing settlement on the island.

The abundant remains of *Cristatella mucedo*, an indicator of polluted water, in the sediment layers lacking pollen evidence of agricultural activity may indicate more continuous early habitation on the Valamo Island than interpreted on the basis of microfossils. The settlement indicators concentrated in the uppermost layers of Lake Niikkananlampi also show continuous habitation in the area after the rapid decrease in agricultural activities in the 17th century.

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