A Pollen Record of the Presence of Hunter-fisher Communities in the Vicinity of Lake Retsamo, Finnish Lapland

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A pollen profile from Lake Retsamo, Finnish Lapland, is presented. The entire Holocene vegetation history is illustrated from an open-land phase following the disappearance of the ice, through birch woodland to the pine dominated forest of today. Phases during which the vegetation surrounding the lake has been disturbed in some way are pinpointed. The longest, most destructive of these phases is dated from mid 15th *to mid 17*th *century and is interpreted as being related to a Sámi winter village, remains of which are visible on the lake shore. There is slighter evidence for up to four earlier disturbance phases but the interpretation of these is more controversial: they may be anthropogenic but could be in connection with naturally occurring fires. The slow rate of sediment accumulation (av. 0.034 cm year*$^{-1}$*) means that the temporal resolution of all phases is poor when compared with that of a peat profile adjacent to another winter village, Einehlammet. The interference phases are assessed relative to the overall picture of the advance of hunter-fisher populations into Lapland.*

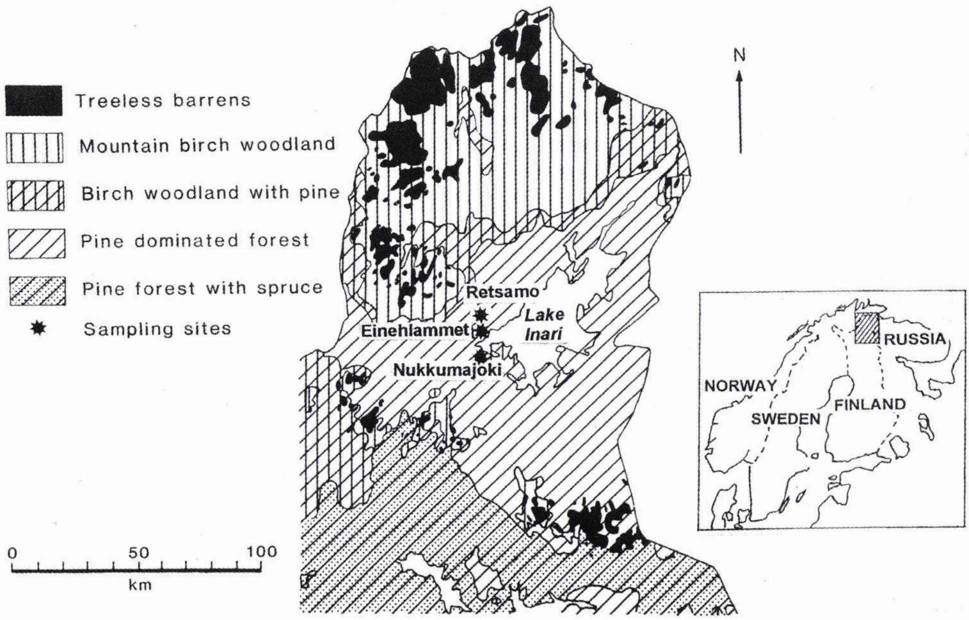
Key words

Sámi winter village, Finnish Lapland, pollen evidence, boreal forest, hunter-fishers

1. Introduction

The broad outlines of the vegetation history of Finnish Lapland are well documented (Hyvärinen 1975, 1976, 1993, 1996, Seppä 1996, Hicks & Hyvärinen 1997). Much of the area is today conserved as 'wilderness', giving the impression that these forests are close to their virgin state and that people are absent. Although, in comparison with the cultural landscapes of elsewhere in northern Europe, this is the visible impression one receives, the absence of people is a misconception. There is ample historical and archaeological evidence (Rankama 1989/90, 1996, Arkeologia Suomessa 1990 – 1992, Carpelan 1991, 1999, Carpelan & Kankainen 1990, Arponen & Hintikainen 1993, Halinen 1994, 1997, Torvinen 1999) to demonstrate that these northern boreal wilderness areas have been the homes of hunter-fisher communities for thousands of years, although the population density has been very low and the family groups nomadic. Historical evidence (Itkonen 1948) reveals that pine was also important in the economy, being used as a source of food (the inner cambium: Itkonen 1911, Hansson 1996, Zackrisson *et al.* 2000), as fuel, as building timber and to erect fences to direct wild reindeer towards pitfall traps (Zetterberg *et al.* 1994).

The challenge to palaeoecologists (using the most commonly available technique of pollen analysis), is to demonstrate the nature, duration and spatial extent of the changes that



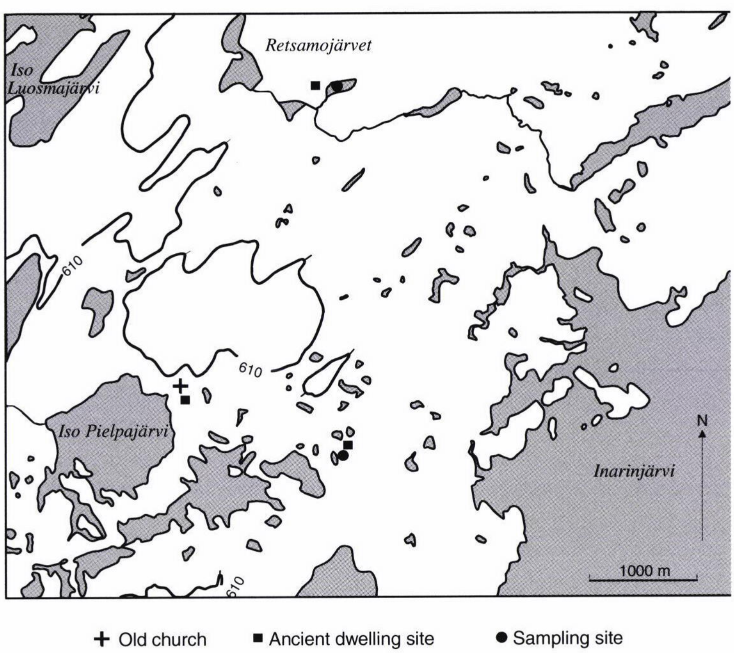


Fig.1. Northern Finland showing the major vegetation belts, the sampling site at Retsamojärvi and the location of Nukkumajoki and Einehlammet, the Sámi winter village sites to the west of Inarijärvi.

such groups of people have made to the natural forest vegetation. Investigations carried out so far (Carpelan & Hicks 1995, Hicks 1993, 1995, Aronsson 1991, Turner *et al.* 1993, Simmons & Innes 1996) have shown that continued seasonal settlement can be detected by pollen analysis if the sampling site is within 50 – 100 m of the occupation site. The extremely local nature of the evidence is supported by recent empirical studies on pollen dispersal and the relevant source area of the pollen analysed in a fossil assemblage (Jacobson & Bradshaw 1981, Sugita 1994, Calcote 1995, Sugita *et al.* 1997, Davis 2000, Hicks 2001).

Some of the most visible remains of

seasonal occupation, certainly some of the most recent, are provided by the Sámi winter villages, many of which are marked on the basic maps and some of which have been investigated and dated (Carpelan & Kankainen 1990, Carpelan *et al.* 1992). The question often arises of the length of time for which these village sites were used, how frequently they were abandoned and then later taken back into use and whether it is possible to see population movements such that the abandonment of one site is followed by the use of another within the same administrative area. A step towards illuminating this question was taken through the analysis of one of the Nukkumajoki villages alongside that of Einehlammet, some 12 km to the north-east of Nukkumajoki (Carpelan & Hicks 1995, Hicks 1993, 1995). From this it could be demonstrated that the occupation phase at Einehlammet was between AD 1670 and AD 1815, i.e. after the second phase at Nukkumajoki and not between the two Nukkumajoki phases (AD 1400 - 1500 and AD 1600 - 1670) as was originally hypothesized. The present investigation represents a second step in this same series by looking for pollen evidence of occupation in the vicinity of a third winter village site at Retsamo, 3.5 km north of Einehlammet (Fig. 1). The hypothesis is, again, that this village was used in the period AD 1500 – 1600 or after 1660 (contemporaneously with Einehlammet) when the Nukkumajoki villages were abandoned. At the same time the investigation aims to throw light on the possible presence of earlier hunter-fisher populations in the same area, thus evaluating whether those sites chosen for Sámi winter villages had frequently been desirable settlement sites throughout the Holocene.

2. Materials and methods

2.1 The area of investigation

The Retsamo lakes, which flank the southern foot of the highland area, Retsamovaara, lie within the pine dominated section of the northern boreal forest zone i.e. north of the spruce forest limit and south of the area of mountain birch woodland (Fig 1). The lake chosen for sampling is the easternmost of this group of lakes (68° 58´ N 27° 09´ E, 152 m a.s.l.), and the Sámi winter village remains are found on its western shore. The lake itself is 320 x 110 m, it has a very short stream flowing into its northeastern end and it is drained in the south by another small stream which eventually flows into Lake Inari. The highest shoreline in this area lies at 130-140 m a.s.l. which means that the lake basin was not submerged during the postglacial period. Investigations by Hyvärinen at Akuvaara 26 km to the north-east (Hyvärinen 1975, 1976) have demonstrated that the area was deglaciated some 9000 ^{14}C years ago. The direction of ice retreat was to the south-west, as can be seen from the drumlin orientation in this region.

2.2 Field sampling

Sediment samples were taken in April 1992. Sampling was by means of Livingstone and Russian type corers operating through the ice. The sampling point was in the western part of the lake basin, c. 40 m eastwards of the winter village remains and relatively close to the shore. The water depth at this point was 185 cm. The total core length was 324 cm and the sediment comprised a surface of gelatinous, green algal gyttja (0 - 5 cm depth) below which (5 - 240 cm depth) there was detritus gyttja with irregularly occurring laminae. Beyond this depth the sediment had an increasing mineral content. The following sections were distinguished: 240 – 305 cm depth, clay gyttja with irregularly occurring laminae, 305 - 310 cm depth silty gyttja and 310 -324 silt with a small amount of organic material.

2.3. Laboratory analyses

Samples for pollen analysis were taken in the laboratory. These were of a standard size of 1cm^3 and taken at every 2nd cm between 6 and 38 cm and 98 and 128 cm depth and at every 4th cm between 38 and 98 cm and 128 – 324 cm, except for the section 144 – 152 for which every consecutive cm was sampled. The sampling procedure followed a commonly applied strategy whereby the profile was first sampled evenly at 4 cm intervals and a preliminary pollen diagram produced. On the basis of this, sections which showed some disturbance in the vegetation were sampled at closer intervals in an attempt to locate the limits of the disturbance feature more exactly. Preparation consisted of adding a single *Lycopodium* tablet dissolved in water (Stockmarr 1971), boiling in 10% KOH, followed by sieving and acetolysis, with the addition of hot HF treatment for the mineral-rich samples (Faegri & Iversen 1989). For each sample the aim was to count a minimum of 500 AP (which was achieved in all but the basal sample) but in every case a whole preparation was counted so that the pollen sum per sample varies between 381 and 1347.

In identifying the pollen and spores, reference was made to various literature sources (primarily Faegri & Iversen 1989, Moore *et al.* 1991, Reille 1992) and to the pollen reference collection at the Department of Geology, University of Oulu. Pollen nomenclature follows Moore *et al.* 1991. The *Betula* pollen grains were separated into two groups: tree *Betula* type and *Betula nana* type, on the basis of a combination of size and morphology (small thin-exined grains with an almost circular polar view and very shallow pores were designated as *Betula nana*). Charcoal was counted in two size classes < 40 µm and > 40 µm and the results are given as percentages of TP (terrestrial pollen) +n. An additional 9 samples c. 2 cm^3 in volume and each covering 3 cm vertical depth of the core were taken at regular intervals throughout the core for loss-on-ignition calculations.

Six samples were taken for radiocarbon dating at the Dating Laboratory of Helsinki University. Five of these were bulk samples which were dated by conventional methods while the 6th (RS3), consisting of a single seed, was dated by AMS. The dates have been calibrated using the program Calib 4.3 (Stuiver & Reimer 1993). Details of these dates are summarized in Table 1 and Fig.2.

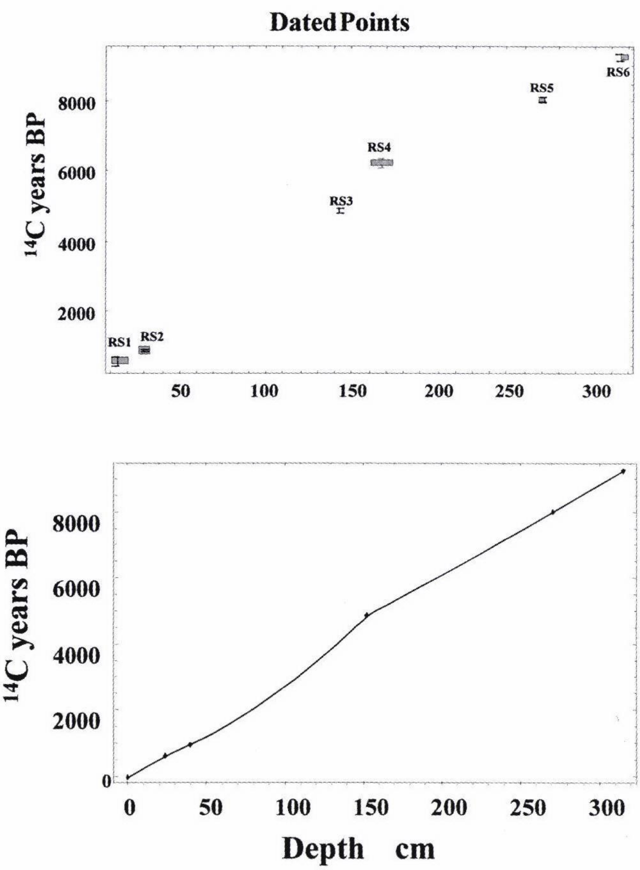


Fig. 2. The position and age range of the six radiocarbon dated samples listed in Table 1 (upper diagram). The lower diagram shows the sediment accumulation rate as illustrated by a 2nd degree polynomial (Maher 1992) based on 5 of the radiocarbon dates and taking the surface lake sediment (0 depth) as -42 ^{14}C BP.

Lab. no.	Sample no.	Depth in sediment	14C years BP	Calibrated age (one sigma)	Sediment type
Hel-4014	RS1	20-28 cm	600±110	AD 1287-1430	detritus gyttja (partly laminated)
Hela-168	RS2	36-44 cm	910±60	AD 1028-1213	
Hela-169	RS3	152.7 cm	4855±70	3701-3633 BC 3556-3540 BC	
Hel-4015	RS4	170-184 cm	6230±120	5318-5035 BC 5011-5002 BC	
Hela-170	RS5	269-273 cm	8005±80	7063-6798 BC 6792-6768 BC 6759-6753 BC 6717-6711 BC	partly laminated detritus gyttja with much mineral material
Hela-171	RS6	312-319 cm	9245±95	8608-8292 BC	silty gyttja

Table 1. Radiocarbon dates obtained from the Retsamo lake sediment sequence.

2.4. Illustration of results

The pollen analyses results are illustrated in three diagrams (Figs.3 – 5). The first shows the main vegetation development in terms of pollen accumulation rates. The second two are more classical percentage based diagrams (% of a pollen sum including AP and terrestrial NAP but excluding mire and aquatic species, exotic taxa and spores). Fig. 5 illustrates selected curves from the percentage diagram in Fig 4. but at an exaggerated scale and for two separate time windows. The pollen accumulation diagram in Fig. 3 is presented in the same format as Hyvärinen's Akuvaara diagram (Hyvärinen 1975) in order to facilitate comparison with it (in this *Betula nana* is included within *Betula*). The PAZ's delimited on this diagram have been drawn in by eye and correspond with those delimited by Hyvärinen. In the other diagrams the order of the pollen taxa follows an ecological grouping with relevance to anthropogenic interference with the vegetation (Suominen 1975, Aronsson 1991, Carpelan & Hicks 1995, Hicks 1993) and the diagrams are not divided into PAZ's but, instead, phases of disturbance in the natural vegetation which may possibly be connected with human activity, are indicated by shaded horizontal bars. All diagrams have been drawn using the Tilia. Graph program (Grimm 1992).

2.5. Numerical treatment

The samples were treated by detrended correspondence analysis (DCA, ter Braak 1987-92) with untransformed data in order to identify the major compositional gradients in the pollen data (Fig. 6). By this method, interruptions in an otherwise smooth development of the vegetation can be detected in an objective way.

3. Results

3.1. Dating and calculation of an age-depth model

The basal date of 9245±95 ^{14}C years BP indicates that the sediment sequence covers the whole of the Holocene. Because of the very low organic content, one of the dated samples (RS4, Table 1) covered an undesirably long section of the core (14 cm of depth). This sample also had the greatest standard deviation (±120 years) and, when

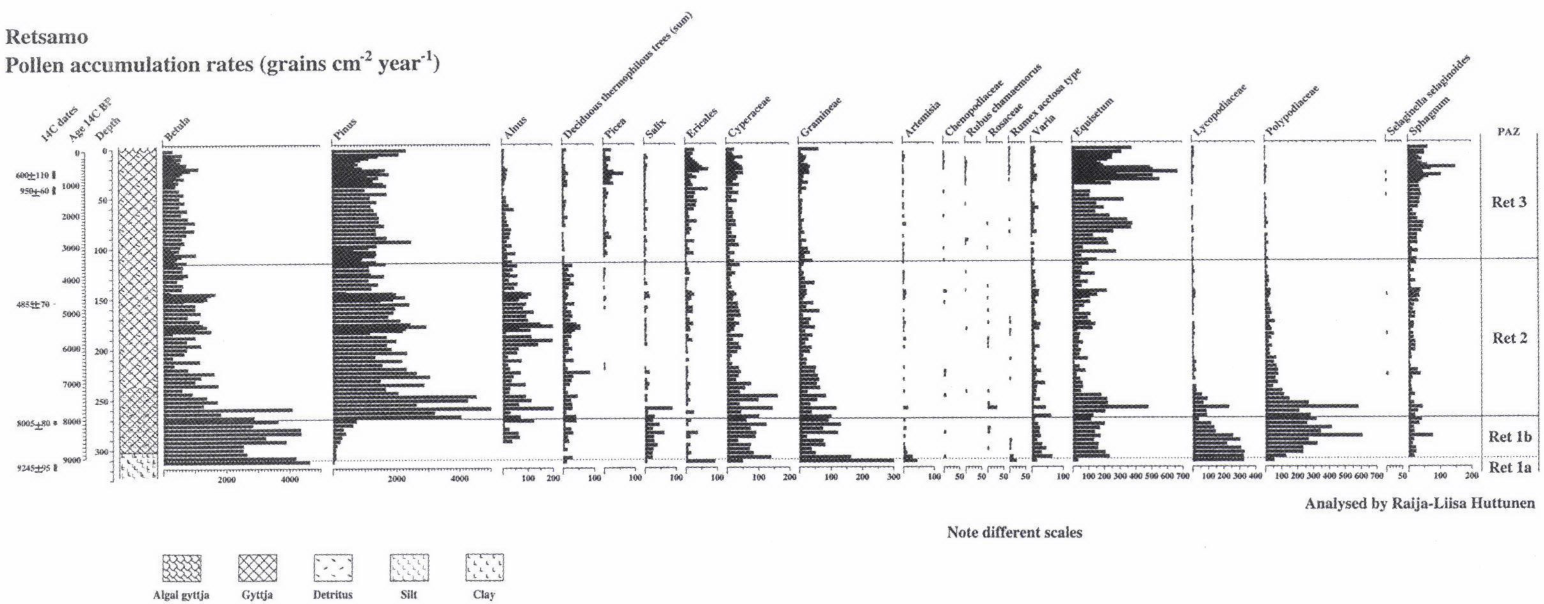


Fig.3. Pollen diagram from the Retsamo lake sediment expressed in pollen accumulation rates using the sediment accumulation rate illustrated in Fig. 2. The age scale is based on uncalibrated ^{14}C dates and the basal three samples have been omitted. The order of taxa compares with that of Hyvärinen's Akuvaara diagram (Hyvärinen 1975). In order to improve comparability the *Betula nana* pollen are, in this diagram, included in the *Betula* curve.

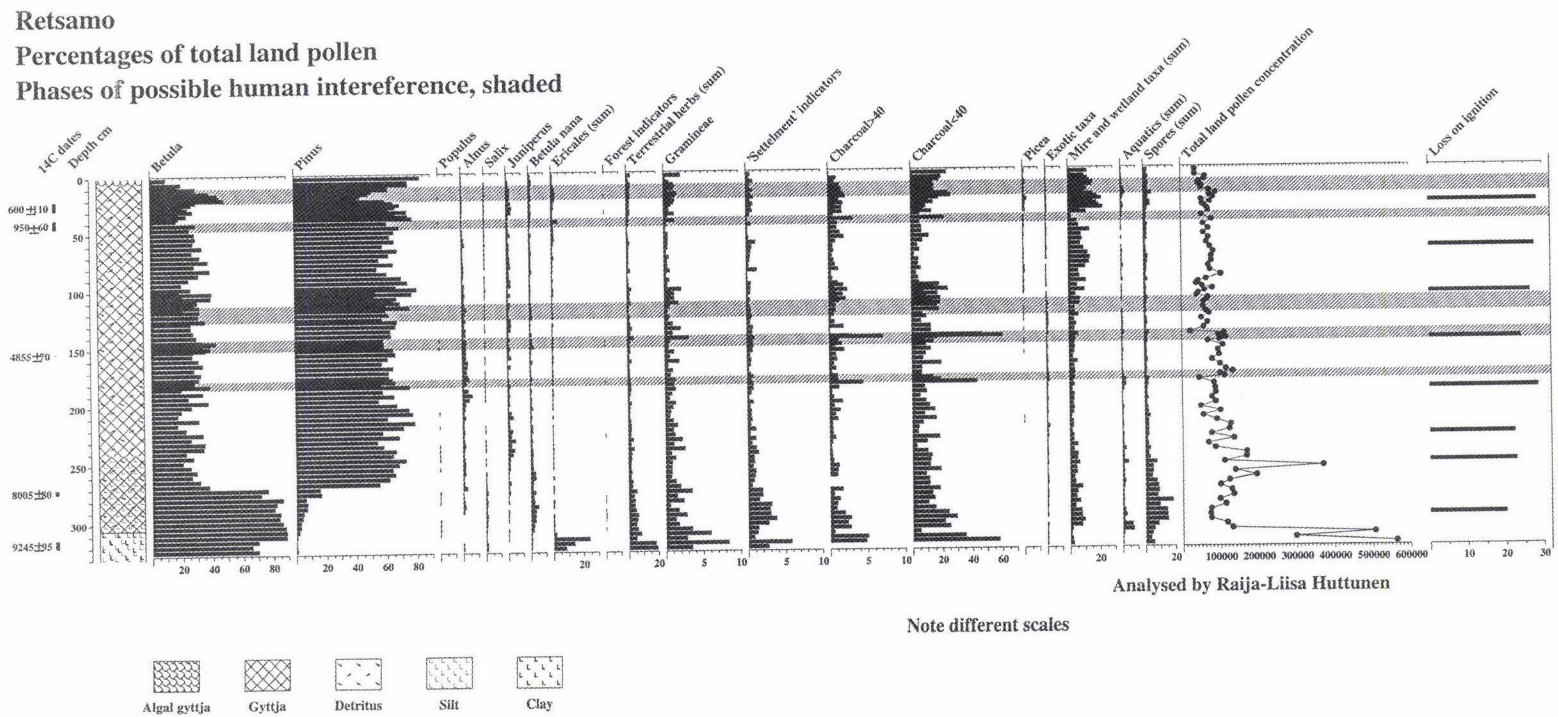


Fig.4. Pollen diagram from the Retsamo lake sediment with taxa expressed as % of total land pollen and grouped ecologically to best show possible phases of interference with the natural vegetation. The shaded horizontal bars indicate possible periods of interference/occupation as characterized in Table 3. These are shown at an enlarged scale in Fig. 5.

Retsamo (upper 50cm of sediment)
Percentages of total terrestrial pollen (selected taxa)
Disturbance phases possibly related to human interference shaded

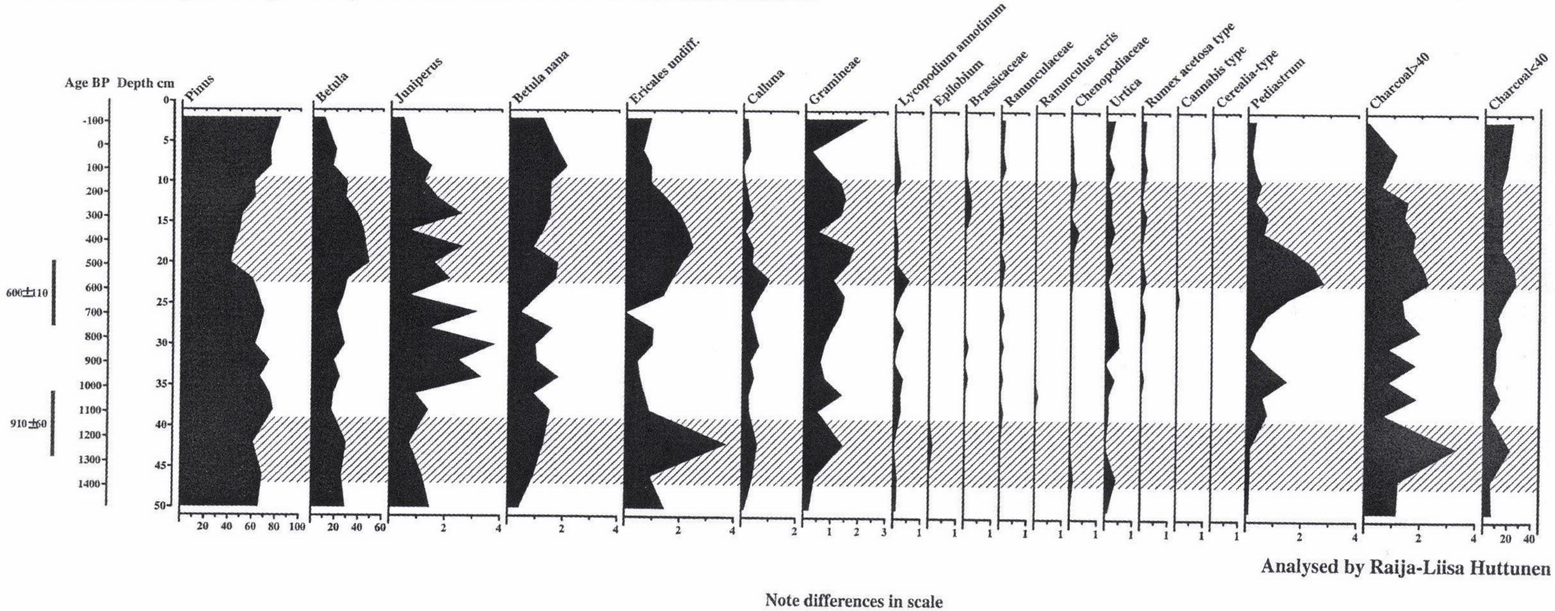
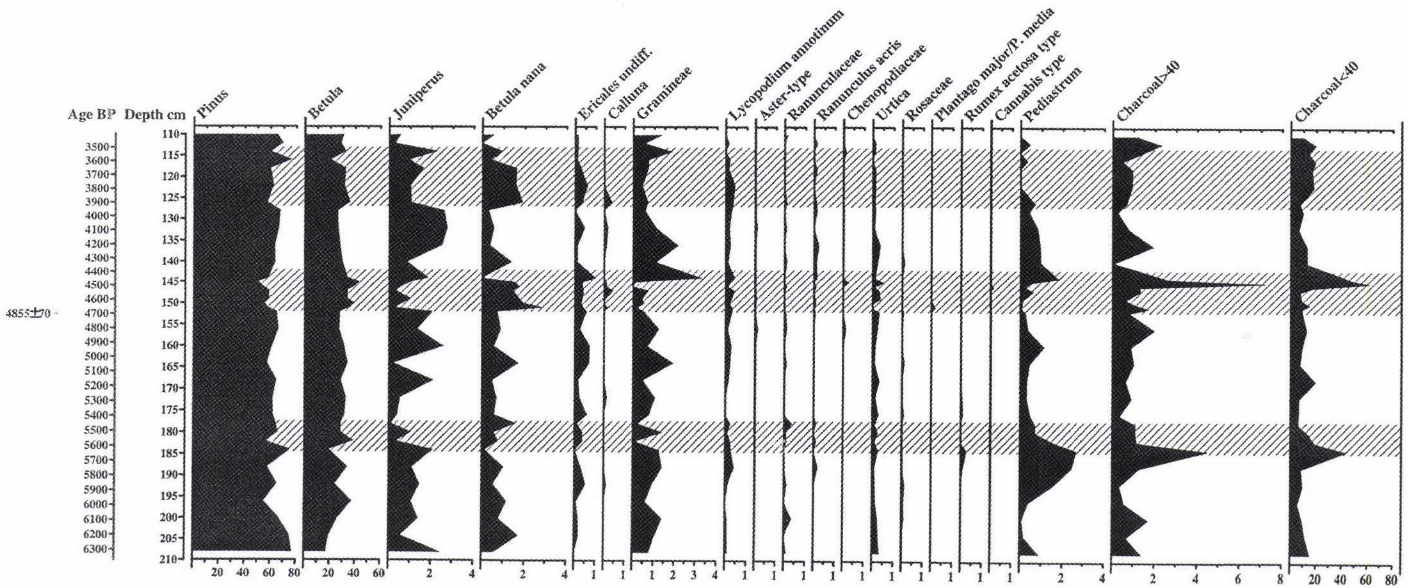


Fig.5a. The upper section of the precentage pollen diagram illustrated in Fig.4. showing selected terrestial taxa.

Retsamo (sediment section 110- 205 cm depth)
Percentages of total terrestrial pollen
Disturbance phases possibly related to human interference shaded



Analysed by Raija-Liisa Huttunen

Note differences in scale

Fig.5b. The middle of the percentage pollen diagram illustrated in Fig.4. showing selected terrestial taxa.

calibrated covers age ranges of 5472 – 4898, 4892 – 4846 and 4817- 4812 cal BC (2 sigmas) and lies outside of the other dates by more than 2 standard deviations. On all these scores this sample contains a much greater uncertainty than the other 5 dated samples and so it was not included when calculating an age-depth model for the sediment sequence (Fig. 2).

Using the remaining 5 radiocarbon dates in their raw form (i.e. uncalibrated) two age-depth models were experimented with: linear interpolation between the dated points and 2nd degree polynomial (Maher 1992). The linear interpolation between the dated points produces sediment accumulation rates which vary between 0.031 and 0.057 cm $year^{-1}$ and the 2nd degree polynomial gives varying sediment accumulation rates ranging between 0.0295 cm $year^{-1}$ near the surface and 0.0389 cm $year^{-1}$ at the base of the profile (Fig. 2). The 2nd degree polynomial has been used here to date specific points in the sediment sequence and to convert pollen concentration values to pollen accumulation rates. It is appreciated, however, that this choice affects the results.

3.2. Regional vegetation and climate history

The regional vegetation and climate history are illustrated by the pollen accumulation diagram in Fig. 3. The basal three pollen samples have been omitted from this diagram because they fall beyond the range of the age-depth model. The pollen concentration in these samples is surprisingly high (300 000 – 600 000 grains cm^{-3}) so it would seem reasonable to conclude that either each sample represents a longer period of time (i.e. has a considerably slower accumulation rate) than the overlying samples and/or is subject to allochthonous inwash. The samples themselves are highly minerogenic so the latter is the more probable.

The main features of the vegetational development and their dating correspond very closely with those described by Hyvärinen for Akuvaara (Hyvärinen 1975). The diagram is divided into three pollen assemblages zones (PAZ Ret1 – Ret3) the characteristic features of which are summarized in Table 2. The interpretation of these zones is given below.

PAZ	Depth range and ^{14}C date	Dominant pollen feature	Other pollen characteristics
Ret 3	**0 – 115 cm** **3270 to -45 BP**	*Pinus* pollen dominates at values between 1500 and 2000 grains cm^{-2} $year^{-1}$. *Betula* values are slightly over 500 grains cm^{-2} $year^{-1}$.	*Picea* is continuously present. *Alnus* and the deciduous thermophilous trees virtually disappear. *Equisetum* and *Sphagnum* increase, also Ericales.
Ret 2	**115 – 270 cm** **7980 to 3270 BP**	*Pinus* pollen dominates at values between 2000 and 3000 (4000) grains cm^{-2} $year^{-1}$. *Betula* is present at values around 1000 grains cm^{-2} $year^{-1}$.	*Alnus* and the deciduous thermophilous trees increase, particularly in the second half of the zone, while Cyperaceae, Gramineae, *Equisetum*, Lycopodiaceae and Polypodiaceae decrease
Ret 1 subzone 1b	**270 – 310 cm** **9090 to 7980 BP**	*Betula* pollen dominates at values between 2000 and 4000 grains cm^{-2} $year^{-1}$	Ericales, Gramineae, *Artemisia* and *Rumex acetosa* type decrease while *Salix* and Cyperaceae increase and the spores of *Equisetum* and Polypodiaceae become abundant
Ret 1 subzone 1a	**below 310 cm** **before 9090 BP**	*Betula* pollen dominates at values around 4000 grains cm^{-2} $year^{-1}$	High values of Ericales, Gramineae, *Artemisia* and *Rumex acetosa* together with spores of Lycopodiaceae

Table 2. Summary of pollen features in the Retsamo Pollen Assemblage Zones (the dates are based on the 2nd degree polynomial age-depth reconstruction).

PAZ Ret 1

During this zone the local vegetation was dominated by birches. The pollen accumulation values for this species suggest a dense woodland (Hicks 2001). However, the herbs which accompany the birches in zone 1a are those characteristic of an open-land, periglacial flora (Hyvärinen 1972, Bondestam *et al.* 1994). Because there is a distinct possibility that these basal samples contain inwashed allochthonous mineral material, this pollen assemblage is interpreted as representing a mixture from different time periods, with the periglacial floral elements originating from the exposed mineral sediments which surrounding the lake after ice retreat and the birch woodland elements originating from contemporary pollen deposition. There is no single obvious explanation for the large number of charcoal particles in the basal sediments, unless natural fires were more frequent during the dry periglacial phase. However, it is known (Sarjama-Korjonen 1992) that basal minerogenic lake sediments frequently contain opaque mineral particles (pyrite) which may easily be confused with charcoal and this possibility cannot be ruled out. The very high birch pollen accumulation values support the hypothesis of continued inwash of soil surface material during the period when birch was establishing itself in the area. By Ret 1b organic deposition had already started in the lake. The establishment of a dense birch woodland will also have greatly inhibited slope wash into the lake. For this reason, the pollen assemblages of Ret 1b are regarded as reflecting contemporary floras without any temporal mixing. The species most abundantly present indicate that shore vegetation communities of sedges and horsetails were becoming established and that there was a lush undergrowth of clubmosses (*Lycopodium*) and ferns (*Polypodiaceae*) in the birch woodland. This same succession is seen at Akuvaara although the *Betula* pollen accumulation rates are lower there. This could be interpreted as the birch woodland being denser at Retsamo than at Akuvaara but could equally well be due to factors inherent in the calculation of pollen accumulations rates (e.g. confidence limits on the pollen concentration values and on the age-depth model, see Bennett 1994). At Akuvaara the beginning of zone Aku 1b, regarded as representing the establishment of closed birch woodland with an undergrowth of clubmosses and ferns is dated to 8840 ±170 ^{14}C years BP. At Retsamo this same transition is dated to 9090 ^{14}C years BP. Given the standard deviation on the Akuvaara date and the range of uncertainty on the Retsamo age-depth model, these can be considered as contemporary.

PAZ Ret 2

During this zone, pine replaces birch as the dominant forest tree in the area surrounding the lake. The rise in *Pinus* pollen at the beginning of the zone is particularly abrupt and the pollen accumulation rates for *Pinus* in the early part of this zone are very high (>4000 grains cm^{-2} year^{-1}). There is a change in sediment stratigraphy at a depth of 240 cm. Below this depth there is much more clay and the sediment is irregularly laminated, above this the sediment is a more uniform detritus gyttja. This indicates that the sediment accumulation rate was still varying in the early part of this zone and only became stabilized later. The actual numerical values for *Pinus* in this early section, therefore, may not be valid. The dramatic spread of *Pinus* is dated to 8005 ± 80 radiocarbon years BP (7980 from the age-depth chronology) and at Akuvaara to 7770 ± 220. Throughout the major part of the zone *Pinus* pollen accumulation rates are around 2000 grains cm^{-2} year^{-1} which is very slightly higher than at Akuvaara and, on the basis of Hicks' modern pollen deposition results (Hicks 2001), indicates closed pine forest. *Betula* pollen accumulation rates at around 1000 grains cm^{-2} year^{-1} are also comparable to those at Akuvaara and demonstrate that birch was still present in the forest but occurred only sparsely (Hicks & Hyvärinen 1999, Hicks 2001). The presence and maximum occurrence of both *Alnus* pollen and the pollen of the thermophilous deciduous trees (*Quercus, Tilia* and *Ulmus*) in this zone indicates climate conditions warmer than the present. The pollen of the thermophilous deciduous trees is all long distance transported and merely reflects the fact that these trees were more abundant and/ or extended further north in the southern part of the country during this period than they were previously or later. The *Alnus* pollen is, in all probability, coming from local sources and may be highly local in origin. *Alnus*, at the present day, is more or less restricted to wet habitats and, if its ecological requirements were the same in the past, then the *Alnus* pollen here may simply reflect the presence of a narrow band of alder at the shore of the lake. All Lapland pollen diagrams (both those from lake sediments and from peats) have greater amounts of *Alnus* pollen during this period than in more recent times, indicating that the tree was more common then than it is now. It is possible that alder replaced the willows that were more abundant in the previous zone. With the establishment of the pine forest the undergrowth changed and the ferns, clubmosses, horsetails, grasses and sedges which were an integral part of the birch woodland became far less common. Taken as a whole the evidence suggests that this period was not only warmer but relatively dry. This is supported by the lake-level evidence (Hyvärinen & Alhonen 1994, Eronen *et al.* 1999). It is towards the end of this zone, when humidity is increasing and temperature falling, that the first signs of possible disturbance in the vegetation are found (see below).

PAZ Ret3

During this zone, commencing at around 3270 radiocarbon years BP, the composition of the regional forest remained much the same as it was earlier, a mixture of birch and pine.

However, the forest itself must have become much more open as witnessed by the lower pollen accumulation rates of these two taxa. In keeping with this, Ericales species become more abundant. There is also an indication of wetter edaphic conditions in terms of bigger expanses of mires shown by the increase in *Sphagnum* and the more consistent presence of *Rubus chamaemorus*. The dramatic increase in *Equisetum* might also reflect this, though this abundant growth of horsetails is probably highly local, along the shores of the lake. It could be imagined that this increase in wet habitats would also have favoured *Alnus* but the pollen of this taxon decreases rather than increases during this period. Either its earlier presence was truly in response to warmer conditions or during this phase edaphic conditions deteriorated to the extent that there were fewer suitable habitats for the more nutrient demanding *Alnus*.

The nature of the long distance pollen component also changes at the beginning of this period. There is far less pollen of the thermophilous deciduous trees but a distinct increase and continuous presence of *Picea* pollen. There is ample evidence that *Picea* was spreading westwards and northwards into the pine forests of northern Finland (Aartolahti 1966, Moe 1970, Tolonen 1983, Huntley & Birks 1983) and a date of around 3300 BP for the start of a continuous curve of *Picea* pollen is in keeping with that which is generally accepted for its achieving its most northerly limit in Finnish Lapland (Hicks & Hyvärinen 1997). At Akuvaara the boundary between PAZ's Aku2 and Aku3, which is close to the point of the continuous curve of *Picea* pollen is also dated to c. 3300 BP. *Picea* pollen accumulation rates of < 50 grains cm^{-2} $year^{-1}$ at Retsamo indicate that it was not present locally (Hicks 2001).

The impression is of cooler and wetter conditions and much more open forests interspersed with patches of mire. This is in keeping with the findings of Hyvärinen & Alhonen (1994) and Eronen *et al.* (1999) of greater humidity and higher lake levels from 4000 ^{14}C BP onwards. Although the general sequence of events at Retsamo are the same as at Akuvaara, during pollen zone Ret 3 small-scale vegetation changes occur, some of which might be attributed to human presence (see below). The fact that these are not

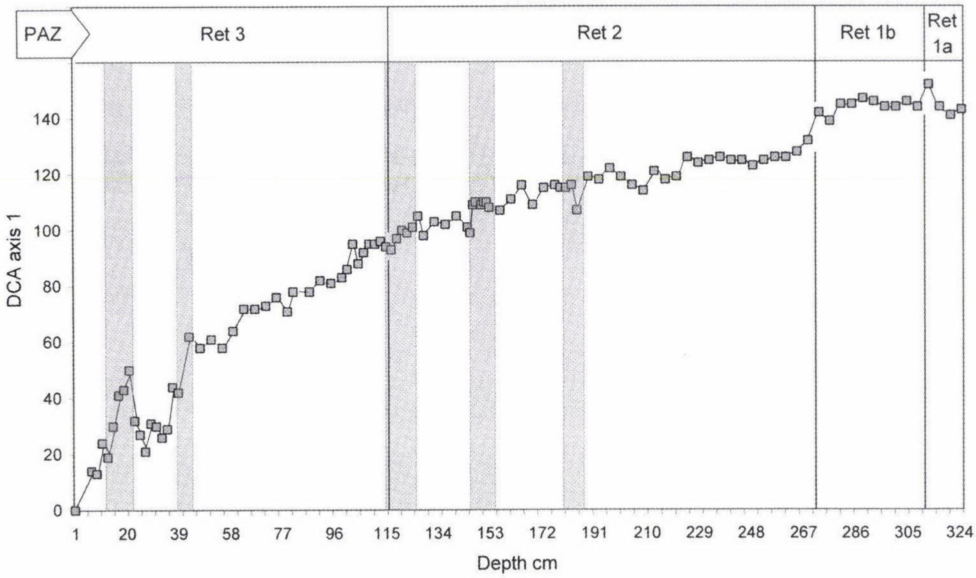


Fig. 6. Detrended correspondence analysis (DCA) on intransformed data. Axis 1 versus depth. The diagram has been annotated to facilitate comparison with the pollen diagram. The single vertical lines indicate the position of the PAZ boundaries and the shaded lines the position of postulated disturbance phases which may be due to human interference with the natural vegetation.

recorded at Akuvaara supports the interpretation that they are local to Retsamo and not of wide regional extent.

The tendency shown by the DCA ordination (Fig. 6) may be a reflection of several factors such as a coherent botanical composition between both the unstable conditions of the early Holocene and the recent successional trends possibly initiated by humans. The general trend of DCA axis-1 cannot be connected to an oceanicity/continentality change as described for further north in Fennoscandia (Seppä 1996). At the most it could be related to edaphic oligotrophication. The variation along axis-1 is only partly explained by the fluctuations in *Pinus* and *Betula* values. Taxa such as Lycopodiaceae, Polypodiaceae, Rosaceae, *Filipendula* and *Artemisia* have heavier loadings.

3.3. Evidence for the presence of people in the forests

On the basis of results from Nukkumajoki (Carpelan & Hicks 1995) and Einehlammet (Hicks 1993, 1995) it is possible to delimit a sequence of events which indicate an occupation/settlement phase (used only seasonally but repeatedly over a long period). These are summarized in Table 3. The percentage pollen diagrams in Figs. 4 and 5 have been constructed so that such a sequence of pollen events, if they occur, can be easily distinguished. On this basis, possible occupation phases are shaded.

The sequence of events outlined in Table 3 is most obvious in a zone from 20 – 22 cm depth through to 10 – 12 cm depth (Fig. 5a), where a fall in *Pinus* pollen is accompanied by a rise in Ericales, *Calluna* and *Lycopodium annotinum*, the appearance of Chenopodiaceae and the presence of *Urtica, Rumex acetosa* type and Ranunculaceae, and an increase in charcoal particles >40 μm in size. This disturbance stands out in the same way in the DCA curve (Fig. 6). Unlike the characteristics sequence recorded at Einehlammet, *Betula* and Gramineae pollen values rise contemporaneously and *Urtica, Rumex acetosa* type and Ranunculaceae have been present (even at higher values in the case

Order of changes	Pollen event (% presence)	Interpretation
1	Decrease in *Pinus* accompanied by a rise in Ericales and the presence of *Urtica*, Chenopodiaceae, *Lycopodium annotinum* and *Rumex acetosa* type	People arrive and create the settlement, felling some trees, opening up the canopy and allowing prolific flowering of dwarf shrubs
2	Slight fall in Ericales but presence of more herbs: *Ranunculus*, Charyophyllaceae, *Solidago* type, *Plantago major/media*. At the end of this phase slightly lower loss-on-ignition values	During the settlement phase dwarf shrubs become trampled out and a richer herb flora appears. The soil surface is disturbed causing mineral material to be blown into the sediment.
3	Peak in Poaceae, accompanied by *Epilobium* and a peak in charcoal	The settlement area is abandoned, some dwellings burn down and the area is invaded by grasses
4	Strong rise in *Betula* and possibly *Juniperus*	(Juniper) and birch invade in the natural succession
5	Rise in *Pinus* to return to original values	Pine forest is re-established.

Table 3. Pollen characteristics associated with settlement in pine dominated forest (Hicks 1993).

of *Urtica*) earlier, while no *Epilobium* is recorded. This phase cannot be dated precisely. A radiocarbon date for the sediment just below it gives a calibrated age of AD 1287 – 1430 (Table I). If the polynomial age-depth model used for calculating sediment accumulation rates is applied then this whole phase (from the fall in *Pinus* to its recovery) lasts from 490 to 220 ^{14}C years BP. If these ages are calibrated then dates of AD 1430 to AD 1660 are obtained for its beginning and end. Using the same interpretation as for Einehlammet, the first part of this phase represents the time of occupation and the second part the succession back to pine forest after abandonment. If this is the case, the time of occupation could be from AD 1430 to AD 1640. The range of error on the sediment accumulation rate combined with the possible range for the calibrated radiocarbon dates means that the uncertainty on the dating and on the duration of the occupation (200 years) is quite large. It would have been more correct to first calibrate the radio carbon dates and then, using the calibrated dates plus their ranges, calculate an age depth model and use that to obtain a date plus error range for a specific depth. This is a somewhat more difficult calculation and was not attempted but it is unlikely that it would have reduced the range of uncertainty.

Four additional earlier phases occur where the sequence set out in Table 3 can be detected (shaded bands in Figs. 4 and 5) at depths from 45 – 40 cm, 125 – 112 cm, 152 – 142 cm and 184 -178 cm respectively. The earliest phases show only very slight changes in the progression of the DCA curve but the more recent disturbance phase (45-40cm depth) is clearly recorded (Fig. 6). Not all the features are present in all of these phases and so it can be questioned whether they really do represent occupation. A dominant feature of them all is a peak in charcoal particles >40 µm in size. It can be argued that the charcoal results from natural fires and may not indicate the presence of people at all. For this reason it is important to look at the whole pollen assemblage associated with the charcoal peak (Table 3). Widespread natural fires would destroy the undergrowth as much as the trees. Increased values of Ericales and *Calluna*, therefore, could argue against a natural fire and in favour of local domestic burning or accidental burning of a dwelling place. However, it could equally well be argued that, following a fire, there is often a rapid and abundant growth of just these same dwarf shrubs, so that the sequence could be a natural one. Another feature is the increased abundance of apophytes (naturally occurring plants favoured by the presence of people) and the presence of anthropochores (plants introduced by people). It is the occurrence of a number of these taxa (Chenopodiaceae, Ranunculaceae, *Urtica*, *Rumex acetosa* type, *Plantago major/media*, *Ranunculus acris*) together and in association with increased dwarf shrubs at the same time as the charcoal which helps distinguish a phase of human interference from a natural fire. In this respect, however, *Urtica* is not a very sensitive indicator. Although the plant quickly becomes established on the nitrogen enriched soils surrounding settlements, it produces a large amount of very light pollen which is easily transported. For this reason *Urtica* is widely dispersed and almost universally encountered in pollen diagrams. It has already been mentioned (Table 3) that an increase in mineral material (revealed through lower loss-on-ignition values), indicating possible erosion, provides additional evidence of interference with the vegetation. In the same way, an increase in species richness provides evidence of interference. Other features can be considered. If clearings in the forest are extensive the amount of long-distance transported exotic pollen (*e.g.* of the southern thermophilous deciduous trees) may show higher percentage presence. If the impact of people is great then there may be changes in the lake flora in response to slight eutrophication. In this connection, one indicator of nutrient enrichment of the lake water is the alga *Pediastrum*.

Taking all these aspects into account, of the four earlier phases of disturbance in the vegetation mentioned above the most convincing is that between 152 and 142 cm where the presence or increased values of a number of the characteristic herbaceous species is coupled with a peak in charcoal, a contemporaneous peak in the *Pediastrum* curve and a rise in *Betula* values. The fall in *Pinus*, however, is only slight. Using the dating and calibration approach outlined above this whole phase is dated to 3650 – 3000 BC. One of the dated samples, Hela-169 (Table 1), falls within this phase and provides a calibrated age of 3701-3633 BC or 3556-3540 BC for the 152.7 cm depth.

Of the remaining three phases, that at 125 – 112 depth is the least convincing and the only one not accompanied by a peak in *Pediastrum*. Again, using the dating and calibration approach outlined above, these phases are dated (from the most recent to the oldest) to AD950 – 1150, 2150 – 1450 BC (least convincing) and 4500 – 4300 BC.

4. Discussion

The most obvious interference phase and the most recent one recorded in the diagram is that commencing at a depth of 22-20 cm and dated to around AD1430 – 1660. It would seem logical to relate this to the remains of the winter village nearby on the lake shore although the fall in the *Pinus* pollen accumulation rate to 1000 grains cm^{-2} $year^{-1}$ indicates such a dramatic removal of pine that one can question whether this is an even wider reaching disturbance than just in connection with the winter village. If the dating is correct then the Retsamo village must have been in use contemporaneously with those at Nukkumajoki and before that at Einehlammet. The Retsamo dates, as calculated here, cover the latter part of the first occupation phase at Nukkumajoki, the whole of the abandonment period and at least the early part of the second Nukkumajoki phase. Given the uncertainty on the dating it is possible that the Retsamo village was primarily in use in the period AD1500 to 1600 when the villages at Nukkumajoki were abandoned.

The earlier suggested disturbance phases are all much vaguer and the calculated duration of their use (200 – 700 years) is very long. This is seen more as a reflection of the range of uncertainty in the dating than a realistic figure for the length of any possible human presence. All that can be said is that there is some pollen evidence to suggest that human groups occupied the shores of lake Retsamo (probably only seasonally) around 3500-3000 cal BC and that people may also have been present as early as 4500 cal BC and at one or two other times between 3000 cal BC and AD 1430. It is quite likely that hunter-fisher groups following a nomadic way of life and returning seasonally to stay at particular localities will have affected the pine forest in very much the same way at each visit, irrespective of the date. The degree of pollen evidence that is preserved to record these visits depends very much on the number of people involved, the frequency with which they visit the site (every year, every 5 years *etc.*) and the closeness of the occupation site to the lake shore. Comparable pollen evidence can be seen in the diagrams of Ruuhijärvi (1963) from Ahmajänkä some 10 km to the NNE and of Sorsa (1965) at Virtaniemi (diagram XXXII) at the north eastern corner of Lake Inari, though neither of these authors interpreted the pollen evidence as such and the events are not dated. Further afield similar pollen evidence of long-term but seasonal occupation of a lake shore is seen in connection with Palaeolithic groups during the late glacial in The Netherlands (Bos & Janssen 1996) and at the Mesolithic site of Kunda in Estonia (Poska & Königsson 1996).

This raises questions about the temporal and spatial resolution of the evidence. Much has already been made of the dating uncertainty arising from calculating the sediment accumulation rate. What is strikingly evident in the lake sequence from Retsamo, compared with the peat sequence from Einehlammet, is the very much slower rate of accumulation in the former. At Retsamo each pollen sample (1cm of sediment) during the most recent occupation phase gives a composite picture of 34 years whereas at Einehlammet, during the obvious occupation phase, each cm of sediment represents only about 7 years. Inevitably, therefore, since the same sample size and comparable sampling interval were used, the temporal resolution of events at Retsamo is poorer than at Einehlammet. The Retsamo sequence covers the whole of the Holocene and, within it, a series of disturbances, several of which may be occupation phases are indicated. At Einehlammet the sequence does not go back quite so far, although the basal sample seems to represent the birch woodland phase comparable to that of PAZ Ret1. The very high pollen concentration of the basal samples at Einehlammet (600 000 – 800 000 grains cm^{-3}) indicates that, for this early part of the profile, the temporal resolution is even poorer than at Retsamo. That no earlier disturbance/ occupation phases were recognized at Einehlammet may be because of the wider sampling interval in the lower part of the profile. In such a situation short-lived human interference phases may be present but are recorded in parts of the sediment that were not sampled. There is also a difference in the way the evidence is recorded at Einehlammet and Retsamo. Einehlammet, being a mire, shows pollen deposition at just one point and the deposited pollen is not mixed through the profile in any way. In contrast the pollen incorporated in the Retsamo lake sediment can have been deposited on any part of the lake surface and the whole lake surface pollen will have been mixed in the water of the lake and then mixed again in the process of sedimentation (Davis 1968, 1973, Davis & Brubaker 1973, Davis & Ford 1982, Hicks & Hyvärinen 1999).

In terms of spatial resolution the distance between the winter village remains and the sampling site is approximately the same at both Einehlammet and Retsamo, 40 – 50 m. As models of pollen dispersal are increasingly showing (Sugita *et al.* 1997) any occupation or interference that may have changed the forest structure which took place at a distance of 100m or more from the sampling site is unlikely to be recorded. This means that those phases of interference which give a clear pollen signal must reflect events which took place very close to the lake. The 'less convincing' phases described above (shaded in Figs. 4 and 5) may represent the sum of several different phases which took place over the period of time represented by the sediment but at a greater distance from the lake.

5. Conclusions

Archaeological research (Arkeologia Suomessa 1990-1992, Arponen & Hintikainen

1993) has shown that people were present in the area from as early as 7300 cal BC. At the other end of the time scale the presence of Sámi winter villages from the 15th through to the 18th century is well documented. Throughout this whole period (7000 BC to AD 1800) the economic basis of the people was the same: hunting, small-scale gathering and fishing. Throughout this whole time, too, the vegetation of the area has been the same: pine dominated forest. In this type of species-poor vegetation and with a non-destructive economy, the only changes that human groups can make to the natural vegetation are those associated with the use of fire and with seasonal settlement repeated over several years. In terms of the pollen evidence for this presence the registration of an occupation event depends on it happening very close to the site being investigated and its intensity depends on the number of people involved and the period of time over which it continues.

On the basis of the results presented here it can be concluded that up until historical time the groups coming to Retsamo were small in number and their times of presence were at irregularly recurring intervals. The earlier phases of presence were after the time of most favourable climate when cooling and increased humidity trends had already commenced. It is not until the time of the Sámi winter villages that numbers increased and pressures became sufficiently great and of long duration to cause clearly visible changes. These more intensive phases happen during the period when mires have already become much more common in the landscape and the pine forest is, in any case, more open. The occupation of the winter village at Retsamo may have been for as along as 200 years but is more likely to have been during the period when the Nukkumajoki valley was uninhabited. Since this phase the forest has recovered so that all traces of the birch phase following the abandonment of the village have disappeared and the vegetation is dominated entirely by pine. This dominance is the result of the programme of forest management implemented in recent years.

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