Sheila Hicks

PROBLEMS AND POSSIBILITIES IN CORRELATING HISTORICAL/ARCHAEOLOGICAL AND POLLEN-ANALYTICAL EVIDENCE IN A NORTHERN BOREAL ENVIRONMENT: AN EXAMPLE FROM KUUSAMO, FINLAND

Abstract

The problems involved in correlating the relative chronologies based on biostratigraphy on the one hand and archaeological artifacts or historical records on the other are considered. It is recognized that the problems increase in peripheral areas such as the northern boreal forest zone where the impact of man is slight and where the number of plant species present is highly restricted. Not only that but these forest types with a few high-pollen producing species present quite a different pollen sedimentation environment from those further south. In an attempt to clarify the situation the historical records for the past 350–400 years for Kuusamo are analyzed and the period is divided into 5 distinct phases on the basis of the type of settlement and the means of livelihood practised. Working from the vegetational changes which these means of livelihood are known to produce predictions are made as to how each would be represented in pollen terms. These predictions, which involve groups of indicator species, form the basis of a pollen key which can be used to locate and interpret different types of human activity in pollen diagrams from this area.

The validity of the predicted pollen representation as expressed in the key is tested by looking at the present day situation in comparison with modern pollen rain results. It is seen that the predictions hold good but that the pollen representation is at an unexpectedly small scale and largely reflects the regional rather than the local situation. Pollen influx results suggest that an event is recorded distinctly only within c. 200 m of its occurrence. Five pollen diagrams are then presented which between them cover a range of sampling sites and sediment types and an attempt is made to distinguish the 5 historical phases in them using the pollen key. Not all the phases are distinguishable in all the diagrams but the degree of pollen representation correlates with the distance of the sampling site from the scene of the activity and also with the nature of the sampling site itself. The results are sufficiently encouraging that, given a certain amount of refinement, this approach could well be used to interpret pollen diagrams representing this type of environment but covering earlier less well documented periods.

Sheila Hicks, Department of Geology, University of Oulu, Linnanmaa, SF – 90570 Oulu.

Introduction

Pollen analysis is of invaluable help to archaeologists in that it enables a reconstruction of environmental conditions at the time when the people who used the objects now surviving as archaeological artifacts lived. Conversely, archaeological data can be of great importance to pollen-analysts in explaining changes in pollen diagrams that result from human interference. This is relatively straight-forward when the contemporanity of both the pollen evidence and the artifact is reliably established, either through both having been dated independently to the same age or through both having been intimately associated in their place of origin. In many cases, however, and especially in areas beyond the main settlement centres, such a close relationship does not exist. The whole range of situations are encountered from having artifacts and no biostratigraphical control to having pollen evidence for the presence of man but no archaeological evidence. Generally for any one particular area two independent relative chronologies can be established, one based on artifacts and historical records and the other based on biostratigraphy, largely pollen evidence but supplemented perhaps by plant macro fossil and/or diatom and even chemical evidence. The correlation of these two offers exciting possibilities for explaining the interaction between man and his surroundings but it also poses problems. Particularly where the available evidence is sparce there is a great danger of drawing conclusions which support preconceived ideas and both pollen-analysts and archaeologists may be guilty of this.

The present paper attempts to examine just what conclusions ought to be possible from the pollen-analytical point of view and to what degree it is possible to correlate the independent but sparce chronologies outlined above. All the evidence presented here refers to the historical period, a time for which knowledge of what was happening, at what scale, and at what location is good. This represents a control situation and therefore a firmer base from which to extrapolate backwards in time to just those periods for which detailed information is lacking. The study area chosen is that of Kuusamo in northern Finland which is in many respects a marginal area so that the number of factors involved is relatively few and therefore their inter-relationship less complicated.

The manner in which the problen has been considered so far

During the past ten years increasing attention has been paid in Finland to the evidence of prehistoric and historic farming activities in pollen diagrams. In contrast to the 16 examples cited by Vuorela in her review of Finnish settlement history and pollen analysis in 1977, there are now some fourty or fifty publications. Not only that but there has been much closer cooperation between palaeobotanists and archaeologists so that whereas Vasari mentioned in 1976 that he knew of only one case in which palaeoethnobotanical and archaeological investigations were combined, this type of joint project is now quite common. In the south of the country archaeological knowledge has expanded a great deal during this period and there it has been possible to relate the artifact-based and pollen-based chronologies with a fairly high level of reliability (Vuorela 1978, Núnèz and Vuorela 1979, Tolonen, M 1979, Tolonen, K et al. 1979, Aalto et al. 1981, Huttunen 1980, Salonen et al. 1981, Vuorela 1982, 1983). In the north, in contrast, both the archaeological material and the pollen evidence is much sparcer and investigations which have attempted to relate the two have, for that reason, sometimes been less convincing. A closer look at the problems and possiblities of this area would, therefore, be useful.

When looking for evidence of man and his activities in pollen diagrams most workers have referred in general terms to a group of pollen types which can be considered as 'cultural indicators'. Some distinction is usually made, at least in the interpretation of the pollen evidence, between indicators associated with cultivation, grazing and settlement, while the features associated specifically with slash-and-burn cultivation have often been separately described (Huttunen 1980). However, the number of workers who have attempted to rigorously classify individual pollen types as indicators of a specific type of activity, or to construct any index in quantitative terms is far fewer. One example, of this type of approach has resently been provided by Behre (1981) in north Germany but his groupings are less applicable in Finland since he deals with a region in which the ecologial situation is quite different: the climax forest being mixed oak as opposed to boreal, and in which the impact of man has been highly intensive over a long period of time. With such a constructive treatise available it is tempting to apply his indicators in Finland but this would be wrong, particularly the further north one goes. They cannot be used as indicators because even at the climatic optimum they simply could not grow there. In this respect there is a similar difference between south and north Finland. There is no point looking for a rise in hazel pollen values following slash-and-burn cultivation, for example, if hazel is incapable of growing naturally in the area. For this reason, too, it is useful to take a closer look at plants associated with man's different activities in just this particular northern Finnish environment.

Another change which has taken place during the past decade is an increase in the attention paid to the possibility of calculating pollen influx. A knowledge of the actual quantity of an individual pollen type falling on cm^{-2} $year^{-1}$ allows changes in vegetation to be followed in a much more detailed way than by using pollen percentages. Influx values come into their own particularly in the situation where one (or several) low pollen producers are joined by one (or more) high pollen producers or conversely where a high pollen producer is removed from an assemblage. The classic example is seen in the late Weichselian (e.g. Pennington and Bonny 1970) where low-pollen producing tundra plants are joined by the high pollen producer birch, not replaced by it as the percentage diagrams would suggest. The converse situation can occur where man destroys the forest to grow crops. The high pollen producers, the trees, are partly (or maybe even entirely) reduced and the low-pollen producers, the crops and associated weeds, expand. If this happens on a vast scale the percentage method of expressing results will overemphasize the extent of the change. If, however, the clearance is small scale there will still be enough high-pollen producing forest in the vicinity to swamp out the changes in the low-pollen producers so that in percentage terms the record will be of a smaller change than actually took place. However, if the pollen influx of the crops and weeds is followed in isolation the real degree of change can be seen. This is a particularly significant aspect in the Kuusamo region where the forests have a high proportion of spruce which is a notoriously poor pollen producer (Hicks 1986). Nevertheless, at least in historical times, it has been just the spruce forests which have been primarily burnt for grain growing. Here, then, one is dealing with the interaction of two low-pollen producing groups against a background which is constantly being swamped by the high pollen production of birch and pine. The potential of this aspect has been relatively little explored. Earlier pollen influx diagrams from Finland (Donner 1972, Hicks 1975, Vuorinen and Tolonen 1975, Donner et al. 1978) concentrated more on major vegetation changes during the Flandrian and only a few have applied this method specifically to the investigation of cultural changes (Hicks 1976, Tolonen, M. 1978, Huttunen 1980). This approach, too, can provide a useful tool in investigating human interference in marginal areas.

The northern boreal forest environment, therefore, presents special problems in that any pollen evidence of human interference is likely to be obscured by the abundant pollen of two out of the three major tree species, and the degree of human inpact is in any case slight or relatively recent. On the other hand it is just this modest scale of the interference and its discrete location, even at the present day, which allows potentially far more precise conclusions to be drawn about distance from the site of the activity to the pollen sampling site and the scale of that activity, because the whole impact is much simpler and less complicated than in even southern Finland, let alone further south in Europe.

A very few attempts have been made at calculating these sorts of factors. Vuorela (1973) has looked at the modern pollen rain around cultivated fields in terms of percentage representation and Huttunen (1980) has also used modern pollen rain values to interpret human interference in his fossil diagrams. In addition Núnèz and Vuorela (1979) have made an initial attempt at calculating the relationship between the appearance of a pollen indicator and the distance from the site of growth to the sampling site and also the quantity of a pollen type compared with the known sown area of the crop. It is in these two fields that more progress should now be made. By combining pollen influx values, modern pollen rain values, and detailed historical/archaeological records it ought to be possible to start producing actual values for different types of cultural impact taking into account such factors as scale of impact, distance from sampling site, and nature of the evidence in different sediment types. An attempt of this kind is underway with reference to the island of Hailuoto (Hicks 1985a) which lies in the middle boreal zone and has a vegetation of dry pine forest and moist transitional birch woodland. Similar thoughts and an altogether new approach will be developed in this paper with reference to the northern boreal spruce dominated region.

Study area

The chosen study area, Kuusamo, is situated in the east of Finland some 30–60 kms south of the Arctic Circle and is bounded on the east by the border with the Soviet Union. The relief of the region is varied, with some hills (tunturi) rising to nearly 500 m but with the lower areas at 220–250 m a.s.l., and there are numerous lakes and stretches of mire. The climate is continental compared with the rest of Finland but maritime in the hygric sence (Koutaniemi 1983). It represents the slightly oceanic section of the northern boreal zone as defined by Ahti et al. (1968). Most of the area is forested with spruce-dominated forests being important on the moist, edaphically more favourable areas and pine dominated ones on the drier, sandier soils. The area of farmed land is relatively small and the fields scattered (Figs. 1 and 13).

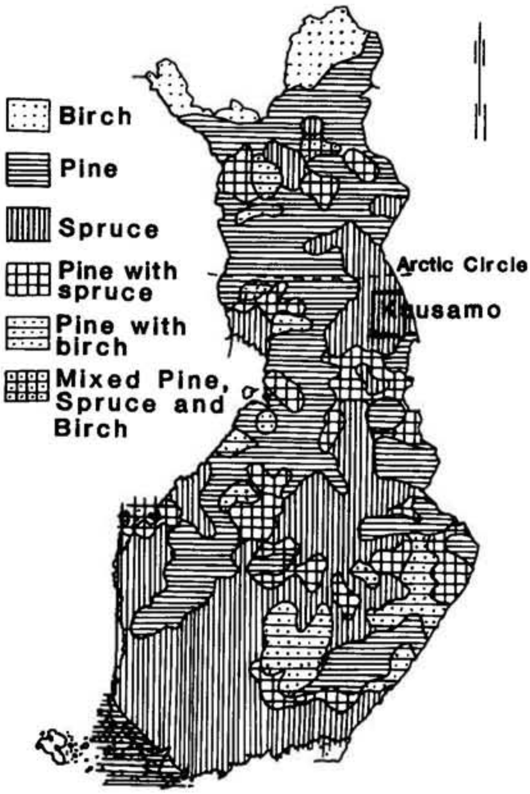


Fig. 1. Distribution of the main forest types in Finland after Salminen 1973, and location of the Kuusamo region.

Very little has been published about the archaeology of this region but the historical period, which really covers only the last 350 years or so, is extremely well documented (Kortesalmi 1975, Ervasti 1978). Pollen analytical studies which cover the whole of the period from the retreat of the Weichselian ice c. 9500 BP up to the present have been carried out on both mire and lake sediments and soils at a large number of sites. The majority, which provide the basic picture of vegetational development in the area as a whole were undertaken by Vasari in the 1960's (Vasari 1962, 1965a, 1965b). These were added to by Hicks in 1970's (Hicks 1974, 1975, 1976). The overall coverage in pollen analytical terms is therefore good.

Historical data

The farming methods employed in Kuusamo during the historical period have been recorded in detail by Kortesalmi 1975 and Ervasti 1978 and also earlier in broad outline by Ahti and Hämet-Ahti (1971). Only the main points are reiterated here but the detailed trends and changes are illustrated in Figs. 2–11 and in Table 1.

In the early 17th century there were two Lapp winter villages in the area (Fig. 3). The Lapps lived by hunting and fishing and kept a few sheep and a few domestic reindeer which they used as a lure for the wild reindeer which they hunted. As the number of wild animals decreased towards the end of 17th beginning of 18th centuries so the number of domestic reindeer increased. The Lapps were nomadic and their summer fishing places were important. These were on lake shores with good natural meadows which could provide pasture for their sheep.

By the middle of 17th century Finns from further west began increasingly to move into the region during the summer months to fish, and from 1676 several moved permanently to Kuusamo. In this they incurred great ill feeling from the Lapps who began to lose their means of livelihood. Although the law encouraged new settlers to clear permanent fields in reality they practised slash-and-burn agriculture (huuhtaviljely). This gave them high grain yields and was therefore particularly attractive but at the same time severely damaged the Lapp hunting grounds. Within about 30 years the game reserves had been destroyed to the extent that hunting as the sole means of livelihood was no longer possible. By 1720 the Lapps had disappeared completely from south Kuusamo and by 1767 neither of the two Lapp winter villages remained. The areas subjected to slash-and-burn were the mature spruce forests and the grain sown was rye (*Secale cereale*), while turnips (*Brassica rapa*) were also grown to some extent. Grain yields were high at first but the land was quickly exhausted and even with virgin forest only one grain crop could be obtained from each clearing. Although legal attempts were made to regulate the practice, enforcement of the law was virtually impossible, particularly during famine years. From the mid 18th century the population increased steadily and slash-and-burn cultivation was practiced widely so that by the latter half of the century virgin spruce forests were hard to find. It was only when the yields of rye from these temporary clearings began to fall and became consistently poor that any real incentive was provided for the clearing of permanent fields. These fields were in any case small, often stoney and sensitive to frost so that farm-

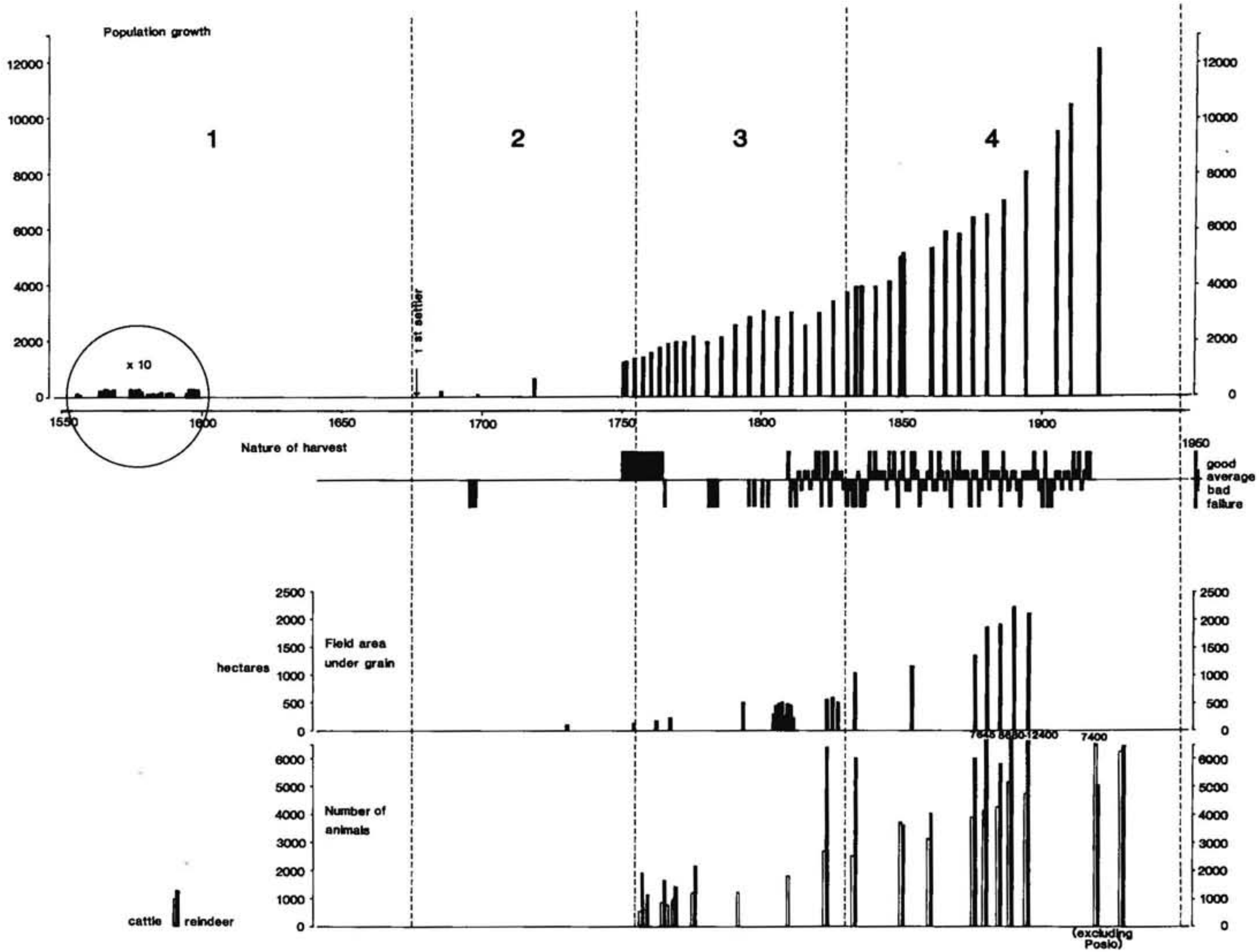
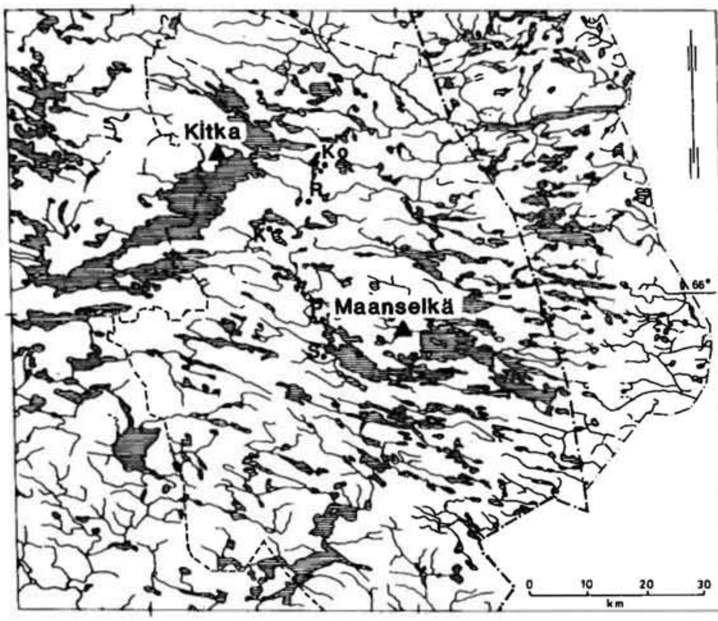
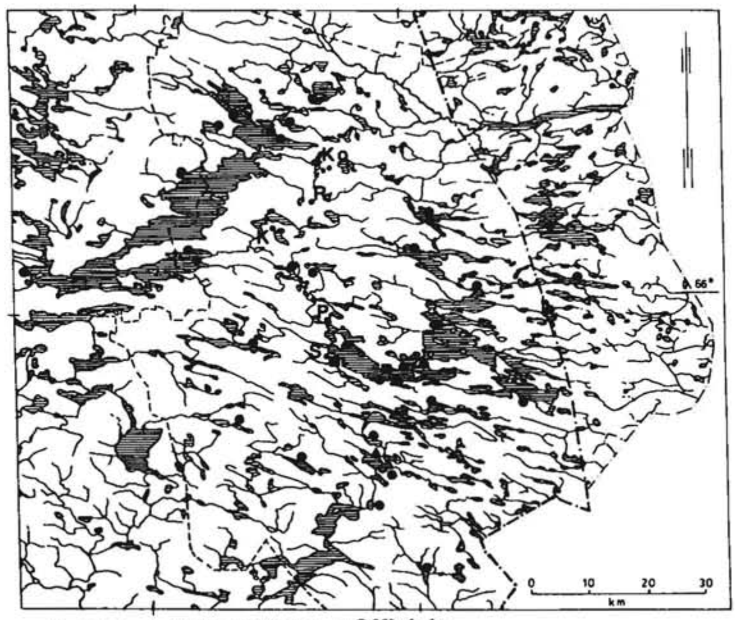


Fig. 2. Population growth in Kuusamo from mid 16th century to early 20th century together with the nature of the harvest, the field area under grain, and the number of cattle and reindeer kept. Information from Kortesalmi 1975 and Ervasti 1978. The large numbers refer to the different historical phases mentioned in the text and indicated in Table 1.



• Sites of pollen diagrams
Ko: Konttainen K: Kangerjoki S: Särkikangas
R: Rukatunturi P: Perälampi

Fig. 3. Location of Lapp winter villages in 16th century after Ervasti 1978, together with the location of the sites of the pollen diagrams. Maanselkä was no longer occupied by Lapps after AD 1720 and Kitka after AD 1767.



▲ Lapps • New settlers (Finns) ■ Officials

Fig. 4. Distribution of dwellings in AD 1730 after Ervasti 1978.

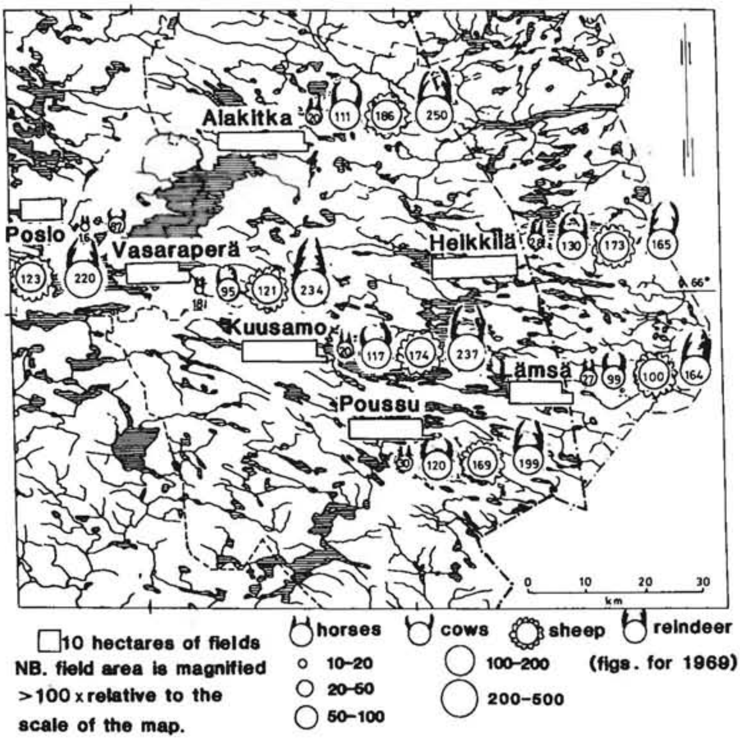


Fig. 5. Field area sown with grain and number of animals kept, by village, in AD 1767. Information from Ervasti 1978.

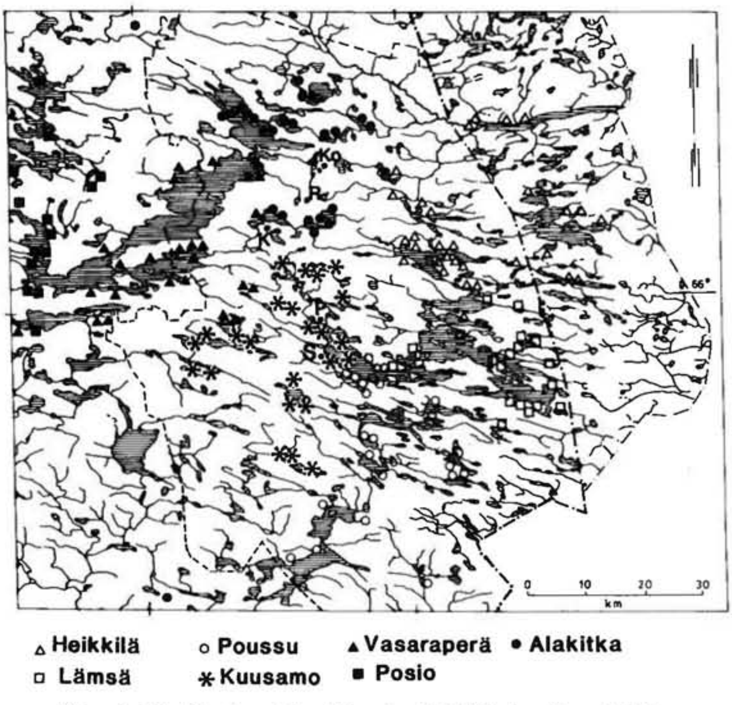


Fig. 6. Distribution of dwellings in AD 1790 after Ervasti 1978.

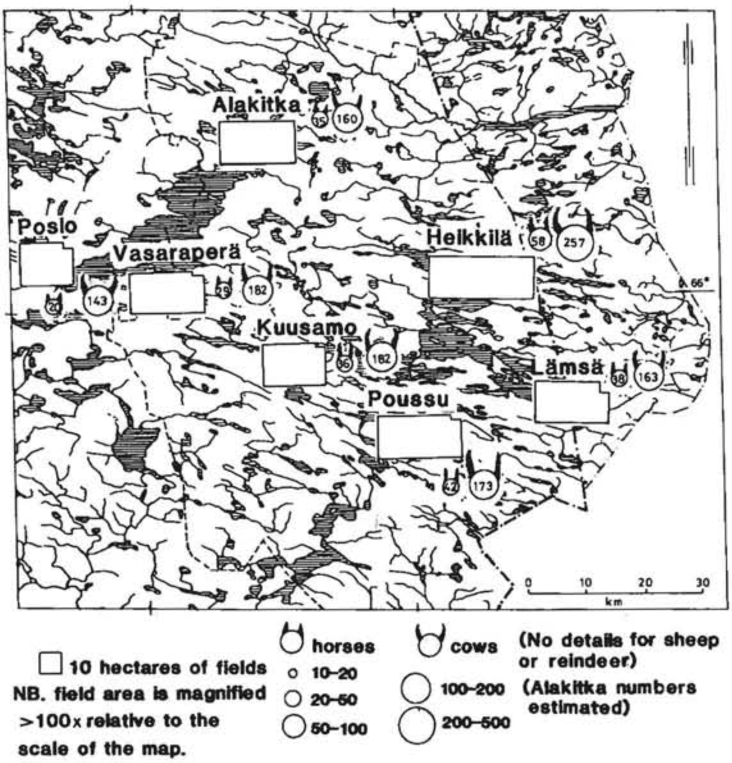


Fig. 7. Field area sown with grain and number of horses and cattle kept, by village, in AD 1793. Information from Ervasti 1978.

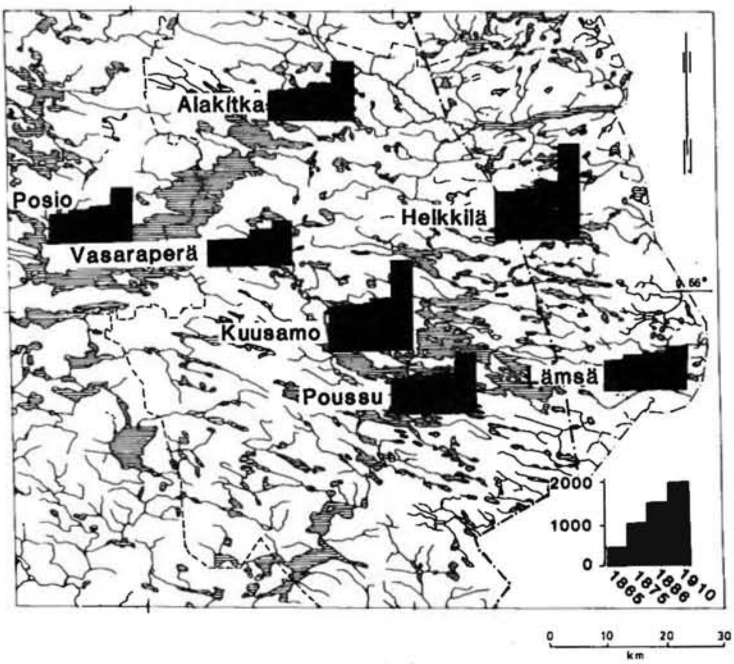


Fig. 8. Population growth over the period AD 1865 – 1910, by village. Information from Ervasti 1978.

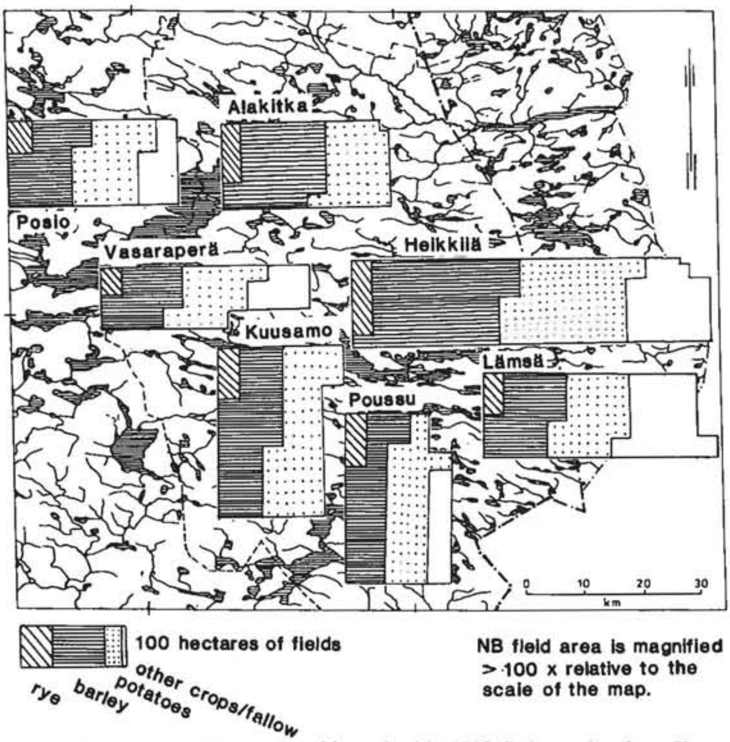


Fig. 9. Cultivated field area, by village, in AD 1882. Information from Ervasti 1978. A conversion of 1 tynnyrinala = ½ hectare has been used (Kortesalmi 1975).

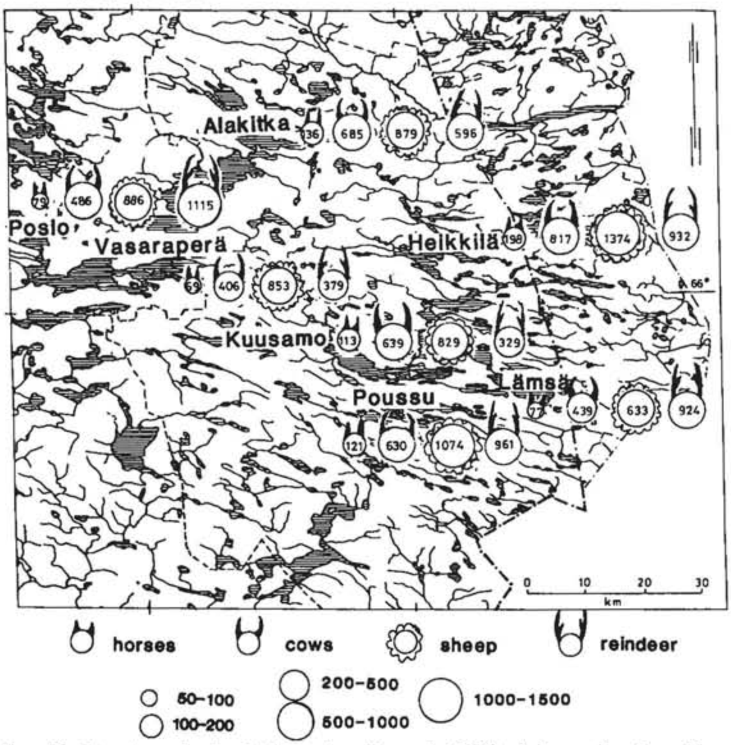


Fig. 10. Number of animals kept, by village, in 1880's. information from Ervasti 1978.

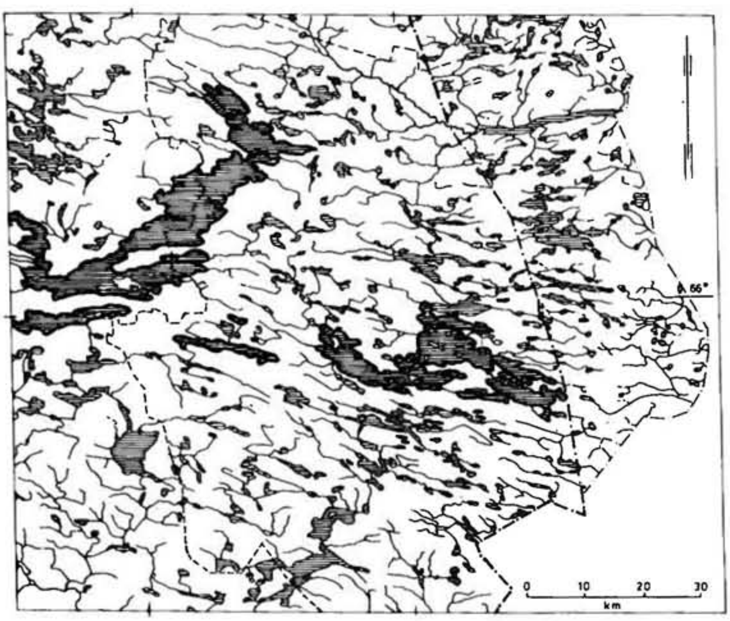


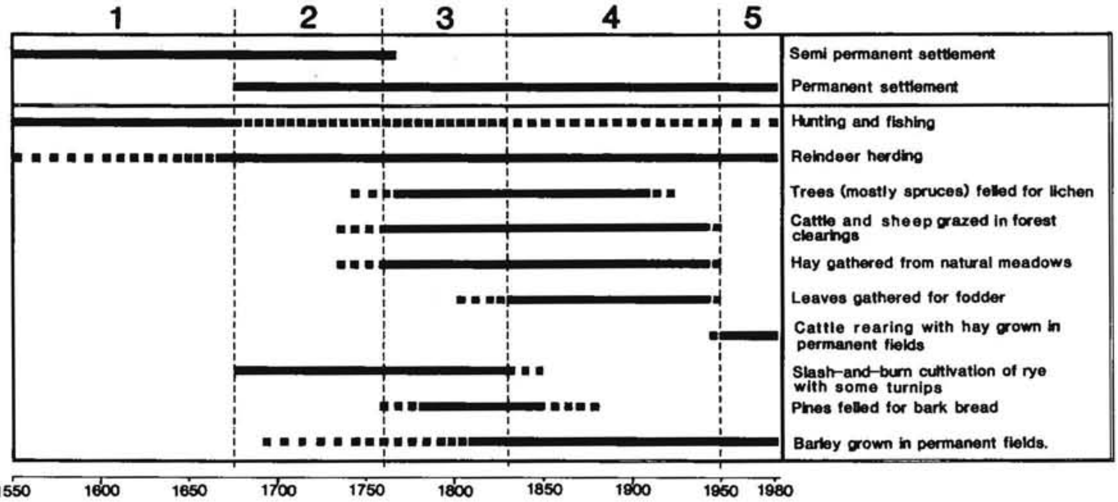
Fig. 11. Lakes where the water level was lowered to increase the area of natural meadows for hay in 19th century. Kuusamojärvi and associated lakes were lowered in 1806, Heinäjärvi in 1800–1, Kurkijärvi sometime after 1842 and Kitka and Posiojärvi 1841–1872. Information from Kortesalmi 1975.

ing them was not particularly remunerative. The main crop of the permanent fields was barley (*Hordeum vulgare*) but a little hemp (*Cannabis sativa*) was also grown. The distribution of dwellings and the size of the field area during this phase can be seen in figures 4–7.

During 19th century population expanded more rapidly (Figs, 2 and 8) and field cultivation was established but nevertheless was sufficiently difficult that grain production always fell short of local needs. Right up until the latter half of 19th century pine trees were regularly felled to provide bark for bark bread. Rye continued to be grown in slash-and-burn clearings even though the yields were very much lower than from the virgin forests, the practice finally being discontinued in 1850's when the law effectively prevented it. Hemp was no longer grown by the end of the 1800's and potatoes replaced turnips from the mid 1830's. Onions were grown in quantity from 1860's until the early 1900's and even tobacco in 1860's and 1880's. Peas were also cultivated. Oats were occasionally grown for fodder but with little success. The distribution of fields during this period is illustred in figure 9.

During the early decades of settlement few cows were kept but the practice of reindeer herding which the early Finnish settlers had taken over from the Lapps continued to be important. Hunting and fishing were also significant. From the early 19th century onwards animal husbandry increased in importance (Figs. 5, 7 and 10). At first hay was collected from natural meadows and animals continued to be pastured in the burnt clearings but as numbers increased so artificial means were employed to produce and increase meadows. These included damming streams, lowering lake levels (Fig. 11) and burning shores. During this period animal fodder was often supplemented by leaves, mostly birch but also willow and alder, while spruces were felled to make the lichen (*Usnea*) growing on them available to the reindeer during the hardest part of the winter. Spruce forest felled in this way was frequently later burnt for huuhtaviljely. Pine forests also came under human influence as trees were not only felled for their bark (for bread) but also for tar. However, tar was produced only for immediate local use and not on a wide scale for export as it was in the Kainuu area further south. The production of hay in permanent fields began on a very small scale near the village of Kuusamo in 1870's but did

Table I Time of dominance of different means of livelihood and settlement. Information from Kortesalmi 1975 and Ervasti 1978. The large numbers refer to the different historical phases mentioned in the text and indicated in figure 2.



not become significant until after World War II when peatlands were extensively drained to provide hay fields.

In summary, therefore, (Fig. 2, table 1) five distinct phases can be recognized:

1) Pre AD 1676. Hunting and fishing and a very small amount of reindeer herding and sheep pasturing. Population small and semi-nomadic.
2) AD 1676–1750/60. Slash-and-burn cultivation of rye supplemented by hunting, fishing and reindeer herding. Settlement becoming increasingly permanent and population gradually increasing in size.
3) AD 1750/60–1820/30. Slash-and-burn cultivation of rye with some turnips and increasing cultivation of barley and occasionally hemp in permanent fields. Reindeer herding continues to be important. Increasing numbers of cows and sheep kept. Hay gathered from natural meadows. Spruces felled for lichen and pines for bark. Permanent settlement with increasing population. In some respects a transitional phase between phases 2 and 4.
4) AD 1820/40–1950. Permanent field cultivation of barley and a small amount of rye, with potatoes, onions and occasionally hemp. Animal husbandry important with increasing use of natural and artificially produced meadows. Animal fodder supplemented by leaves and lichen. Permanent settlement with rapidly increasing population.
5) AD 1950 onwards. Cattle-rearing dominant. Hay grown in permanent fields on drained peatlands. Some cultivation of barley. Reindeer herding continues.

Much attention has been paid to the destructiveness of slash-and-burn cultivation and it is true that its practice was felt throughout the whole region. As early as 1773 Lagus (Kortesalmi 1975) wrote that the forests of Kuusamo have suffered badly. However, it would seem that the huuhtaviljely of the north, although it undoubtedly ultimately affected all the forests, may, nevertheless, not have been as destructive in the long term as the kaskiviljely practiced further south. Heikinheimo (1915) made calculations of the extent of kaskiviljely in southern Finland which have been reported both by Lampimäki (1939) and more recently by Huttunen (1980) and are repeated here for compasion. The land was burnt on a 25 year rotation and at each burning it was ploughed, harrowed and sown for three crop yields after which the abandonned clearing was cut for hay and then used as grazing land. Therefore, in the space of 100 years it will have been felled, burnt and used for crops for 20 years (4 fellings, 4 burnings, 12 crops), for hay making for 12 years and for pasture for 68 years, and all this for a period of between 500 and 1000 years. In contrast, the

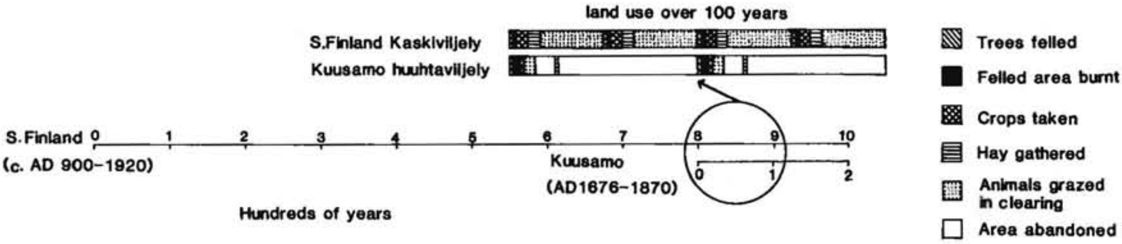


Fig. 12. A comparison of the intensity and duration of slash-and-burn cultivation in southern Finland and Kuusamo after Heikinheimo 1915 and Kortesalmi 1975 respectively.

huuhtaviljely of Kuusamo could be repeated on the same forest only every 50 years. The production of grain took longer (4–5 years) since the trees were felled and then the area was burnt twice before the crop was sown, and only one crop could be taken. The land was not ploughed or harrowed but the seeds were merely raked in among the ashes. The burnt clearings were used for pasture and some hay was cut from them, often after they had been left for 10 years or so. Over 100 years, then, the land will have been felled, burnt and used for crops for 8–10 years (2 fellings, each with 2 burnings, 2 crops) as grazing for cattle and sheep for about 6 years as a source of hay for 2–4 years and as intermittent grazing for reindeer for anything up to 80 years during which time the forest was regenerating, with this continuing for only 200 years at the most. Obviously the impact is on quite a different scale from further south (Fig. 12). Of course, partly this was because the land was too poor to allow any more intensive use. It is interesting to note, however, that the work of Sirén (1955) has shown that the northern spruce forests regenerate more quickly and more vigorously in burnt areas than in mature untouched spruce stands because the burning has the effect of breaking up the tight ground vegetation cover and providing suitable spaces for the spruce seeds to germinate and the young saplings to grow. Similarly Lampimäki (1939) has demonstrated that whereas intensive longterm grazing of forest clearings will have a detrimental effect on forest regeneration a limited amount of grazing may actually be beneficial in that the animals disturb the soil sufficiently to provide a good seed bed and also provide valuable fertilizer. Therefore, whereas Ahti and Hämet-Ahti (1971) were obviously right in saying that 'the influence of man on the environment was probably greater at that time than now, though the population was much smaller' nevertheless the influence was not really very great if one makes a comparsion with areas further south.

Expected expression of the different historical phases in the pollen records

The means of livelihood and types of settlement listed in Table 1 can each be considered separately in terms of their effect on the vegetation, the characteristic features of which are summarized in Table II together with the relevant literature sources. On the basis of this it is then possible to predict how these individual vegetation changes would be recorded in the pollen record and these predictions are listed in the right hand column of Table II. The changes mentioned are with reference to the close vicinity (< 0.5 km) of the activity concerned. A close scrutiny of the table shows that a large majority of the different means of livelihood should be distinguishable in pollen terms. Taking groups of indicator species and the NAP (particularly herb rather than drawf shrub)/AP ratio it should be possible to distinguish permanent and semi-permanent settlement and the following means of livelihood: slash-and-burn cultivation of rye (huuhtaviljely), sown hay fields, grain crops grown in permanent fields, grazing in forest clearings and the presence of natural meadows.

It is significant that several of the classical cultural indicators are not included. Noticeably absent are *Plantago lanceolata, Pteridium* and *Artemisia.* These species can occur sporadically in the area but are really at the limit of their distribution so their presence is not diagnostic here. Where they occur in the pollen diagrams they are more likely to reflect long-distance transportation from areas further south.

Using the right hand column in Table II as a basis, a dichotomous key has been constructed by means of which any pollen diagram from this region can be investigated and possibly interpreted (Table III). The key follows the same principle as that employed in identifying plants, for example, so that at each point two alternatives are given and by choosing always the alternative which best fits the evidence one is gradually led on to one specific conclusion.

This is slightly simplistic in that, as can be seen clearly from Table I, for certain periods several differing means of livelihood were being practised at the same time. Also the key refers to the activity taking place in the immediate vicinity and yet a pollen sampling site may be close to one activity but distant from another. These considerations will be enlarged on later but the key provides a starting point by means of which pollen diagrams can be looked at in a new, much more precise manner.

The pollen evidence: to what extent are the predicted changes actually recorded?

Having produced a key for interpreting pollen changes which result from human interference with the vegetation it is then necessary to test its validity. One means of doing this is to look at the present day situation and its expression in terms of modern pollen rain. At present Kuusamo is in phase 5 of those distinguished in Table I so the dominant features should be those associated with permanent settlement, hay grown in permanent fields, mostly on drained mires, and the cultivation of moderate amounts of barley and potatoes. All these three categories should, therefore, be recorded in the modern pollen rain, either individually or in any combination, depending upon the relative positions of the activities and the sampling sites. The present distribution of fields is shown in Fig. 13 together with the major areas (Oulanka, Riisitunturi, Konttainen, Rukatunturi, Naatikkavaara and Iivaara) in which pollen traps sampling the modern pollen rain have been located. The pollen spectra themselves are illustrated in Fig. 14, the values being the mean of a two-year period from October 1969–October 1971. The trap situation, in broad terms, is indicated at the right hand side of the figure. More detailed information of the exact position of the traps and the nature of the modern pollen rain material is discussed in detail in Hicks 1985 and 1986 and only those species regarded as significant in terms of human presence are considered here. Not all pollen and spore types identified are illustrated in the diagram but those which have been omitted are unrelated to the present problem.

The dominant vegetation type in Kuusamo is forest and the traps are placed primarily within forested areas (exceptions being those of the open summits). As expected, therefore, AP is overwhelmingly dominant. Of the NAP the dwarf shrubs and forest plants, basically those in category 'i' in the diagram, are well represented. A wide range of those cultural indicator species expected on the basis of the known means of livelihood are present but at very low values, frequently $< 0.5\ \%\ \Sigma P$. As a rough guide those species thought to be associated more with settlement are grouped under category 'ii' and those with field cultivation (hay and grain crops are not specifically differentiated) under category 'iii'. As is obvious from Table II several pollen types appear as indicator species of more than one type of activity and many pollen types (those indicated with an asterisk) include species which could grow in the area but are not specific indicators. Consequently, the groupings 'i'–'iv' in the pollen diagram should not be considered as binding but rather as a device for simplifying discussion. It is noticeable that pollen representing all the expected categories of livelihood are recorded at all the sites so that one can conclude that the present density of settlement and cultivation is recorded in the regional pollen rain. Of the predicted indicators *Rumex acetosa* type and *Urtica* are most consistently present within the permanent settlement group (Table III) but all indicators, with the exception of *Polygonum aviculare* and *Carduus* are recorded somewhere. Whithin the field cultivation group (sown hay fields or grain crops, Table III) Cerealia, Chenopodiaceae, Compositae *Achillea* type and *Ranunculus* are most consistently represented, and only *Polygonum aviculare* and *Spergula* type are missing from the expected pollen indicators. No attempt was made to identify *Elymus repens* and unfortunately the Cerealia pollen has not been any more precisely identified. Species which are recorded but which were not expected are *Plantago lanceolata* and *Artemisia* and, as indicated earlier, these are regarded as representing long distance transport. The natural meadow category is illustred by group 'iv' where the highest values $40\ \%\ \Sigma P$ are from a site directly within a sloping fen: in practice a natural meadow. The Gramineae curve has not been placed in any of these rough groups since some species of Gramineae are associated with virtually every kind of activity. As expected, however, Gramineae is recorded at every site.

Those means of livelihood which are no longer practiced include slash-and-burn cultivation and grazing of animals in forest clearings

Table II Vegetational changes connected with different means of livelihood and settlement and their expected expression in pollen-analytical terms.

Means of livelihood Type of settlement	Known vegetational changes in the northern boreal zone	References	Expected pollen evidence in vicinity of happening
Semi-permanent settlement (Lapp winter villages)	No destruction of existing vegetation but an increase in the following species: Juniperus — Festuca ovina, F. rubra Betula pubescens — Deschampsia flexuosa, D. caespitosa Calamagrostis lapponica Trientalis europaea — Poa spp. Linnaea borealis Achillea millefolium — Polygonum aviculare Stellaria media — Rumex acetosella Epilobium angustifolium — Lycopodium annotinum The changes are relatively long-lasting.	Ahti & Hämet-Ahti 1971 Suominen 1975.	Not necessarily any change in AP influx, but Betula values may be higher. Definite increase in Gramineae* Possible increase in Juniperus Possible occurrence of: Trientalis, Linnaea, Compositae Achillea type*, Caryophyllaceae*, Epilobium*, Polygonum aviculare, Rumex acetosa type and Lycopodium annotinum
Permanent settlement	Some local clearing of trees. An increase in, or appearance of, the following species: Populus tremula — Urtica dioica Sorpus aucuparia — Plantago major Poa trivialis — Polygonum aviculare Alopecurus arundinaceus (less common) — Stellaria media Trifolium pratense, T. repens — Ranunculus repens Rumex acetosa, R. longifolius — Capsella bursa-pastoris Carduus crispus — Anthriscus sylvestris	Linkola 1917 Ahti & Hämet-Ahti 1971	Not necessarily any change in AP values. Populus and Sorbus may appear. The presence of several (but not necessarily all) of the following at the same time: Gramineae* — Polygonum aviculare Trifolium type — Caryophyllaceae* Rumex acetosa type — Ranunculaceae* Carduus* — Cruciferae* Urtica — Umbelliferae* Plantago major/media
Hunting and fishing	No changes		Not recorded.
Reideer herding	No changes which result from the animals grazing freely in the forest (see following)		Not recorded.
Trees felled for lichen	Area of spruce forest felled and the trees left so that reindeer can feed on the Usnea during the hardest part of the winter. These clearings then burnt for slash-and-burn cultivation.	Kortesalmi 1975	Decrease in Picea influx. Probably followed or accompanied by the same features as for huuhtaviljely.
Cattle grazed in forest clearings	A decrease in Vaccinium myrtillus and an increase in grasses especially Agrostis and Festuca spp. A spread of the following species: Pteridium aquilinum, Fragaria vesca, Veronica chamaedrys, V. officinalis — These are close to the limit of their range in Kuusamo — Leontodon autumnalis, Ranunculus acris As regeneration proceeds Rubus idaeus, Juniperus, Alnus and eventually Picea increase.	Hertz 1934 Lampimäki 1939	Decreased AP influx. Definite increase in Gramineae* Possible occurrence in small quantities of: Compositae Taraxacum type* Ranunculaceae* followed later by Rubus type*, Juniperus, Alnus, and an increase in Picea.
Hay gathered from natural meadows	No changes in the forest vegetation. Meadows characterized by: Juncus — accompanied by Carex — Thalictrum flavum, T. simplex (neither very common) Equisetum — Filipendula ulmaria Gramineae — Veronica longifolia Ranunculus spp.	Linkola 1922 Kortesalmi 1975	High valus of: Gramineae* Cyperaceae* Equisetum* with possible presence of Thalictrum, Filipendula, Rhinanthus type*, Ranunculus*. Since these meadows exist naturally it is not really possible to distinguish those which were cut from those which were not. New meadow areas resulting from flooding or from lowering lake levels should, however, be distinguishable.
Leaves gathered for fodder	Primarily Betula was collected but also Alnus and Salix spp. Populus was avoided. Whole trees were felled.	Kortesalmi 1975	Decrease in Betula influx, possibly also in Alnus and Salix.
Hay grown in permanent fields	Plants characteristic of sown hay fields are: Phleum pratense — Achillea millefolium Elymus repens — Taraxacum spp. Agrostis tenuis — Tripleurospermum maritimum Chenopodium seucicum — Stellaria media Ranunculus repens — Trifolium pratense Rumex acetosella	Suominen & Pohjakallio 1964 Ahti & Hämet-Ahti 1971 Raatikainen et al. 1972 Jukola-Sulonen 1983	NAP important and Gramineae*, including Elymus repens, dominant. A selection of the following present: Chenopodiaceae — Caryophyllaceae* Ranunculaceae* — Trifolium Rumex acetosa type Compositae Achillea and Taraxacum types*.

Slash-and-burn cultivation of rye huuhtaviljely	Picea removed and the typical ground flora destroyed so that Linnaea and Melampyrum disappear. Secale and Brassica rapa are sown in the clearing. Later the following species spread: Epilobium angustifolium (reaches its greatest abundance in 10-15 years) Trientalis europaea Euphrasia stricta group Calluna vulgaris Antennaria dioica Solidago virgaurea Diphasiastrum complanatum The following may also spread after fire Deschampsia Vaccinium vitis-idaea Empetrum Betula will first colonize the clearing in the succession back to forest.	Kujala 1921 Kortesalmi 1975	Decrease in Picea influx. Presence of charcoal. Disappearance of Linnaea and Melampyrum. Appearance of Secale and possibly Cruciferae* Presence of some of the following: Epilobium* (may occur later) Trientalis Rhinanthus type*• Calluna Compositae Solidago type* Diphasiastrum complanatum Later also Gramineae* Vaccinium type* Empetrum and still later increased Betula values.
Pines felled for bark bread	Areas of pine forest felled.	Kortesalmi 1975	Decrease in Pinus influx followed by the type of indicators associated with grazed forest clearings (see above).
Barley and associated crops grown in permanent fields	Plants characteristic of the barley fields are: Tripleurospermum maritimum Taraxacum Achillea millefolium Ranunculus repens Rumex acetosa, R. acetosella Trifolium Stellaria media Together with various grasses. Galium spurium Chenopodium suecicum, C. album (less common) Spergula arvensis Galeopsis speciosa Capsella bursa-pastoris Erysimum cheiranthoides Polygonum spp. Other species which are or have been cultivated in fields include: Secale, Avena, Brassica. Solanum, Cannabis and Allium.	Parvela 1923 Mukula 1964 Suominen & Pohjakallio 1964 Ahti & Hämet-Ahti 1971 Raatikainen et al. 1972 Kortesalmi 1975	NAP important. Absolute indicators Hordeum, Avena, Cannabis. Strong representation of a number of the following: Compositae Taraxacum & Achillea types* Ranunculaceae* Rumex acetosa type Trifolium Caryophyllaceae* Galium* Chenopodiaceae Spergula type• Stachys type*• Cruciferae* Polygonum aviculare Gramineae*

* Pollen types which could include species other than those regarded as characteristic

• Definition after Moore and Webb (1978)

Table III Provisional key for distinguishing different types of human interference in pollen diagrams from the northern boreal forest zone.

1\. a) AP values high. Herb pollen values not especially significant but some of the following appear or are present in slightly increased values, Gramineae, Juniperus, Rumex acetosa type, Compositae Achillea and Taraxacum types, Ranunculus, Urtica, Plantago major/media.

.... 2

1\. b) AP values lower, either consistently or because of a definite fall, and either for all species together or one selectively. Herb pollen values consequently relatively significant, and may be quite varied.

.... 3

2\. a) Gramineae important among the herbs. Some of the following present: Rumex acetosa type, Compositae Achillea and Taraxacum types, Ranunculus type. Juniperus values may be higher.

.... 4

2\. b) Plantago major/media present accompanied by some of the following: Urtica, Rumex acetosa type, Gramineae, Carduus, Caryophyllaceae, Trifolium, Polygonum aviculare, Ranunculaceae, Cruciferae and Umbelliferae.

...........Permanent settlement

4\. a) Possibly increased Juniperus values. Herb pollen includes a selection of the following: Rumex acetosa type, Compositae Achillea type, Epilobium, Polygonum aviculare, Caryophyllaceae, Linnaea, Trientalis and Lycopodium annotinum.

.......Semi-permanent settlement

4\. b) Herb pollen includes a selection of the following: Compositae Taraxacum type, Ranunculaceae, Rubus type.

....Grazing in forest clearings,

3\. a) Only one tree species, Picea, has lower values. Herb pollen values remain relatively modest. Presence of Secale. Possible disappearance of Melampyrum and Linnaea and appearance of Epilobium. Some of the following may also be present: Trientalis, Rhinanthus type, Diphasiastrum complanatum.

......Slash-and-burn cultivation (Huuhtaviljely)

3\. b) All AP values lower. Herb pollen values may be quite high (up to 80 % ΣP)

.... 5

5\. a) Hordeum and/or Avena and/or Cannabis present. Great variety of herb pollen types including several of the following: Gramineae, Compositae Achillea and Taraxacum types, Rumex acetosa type, Polygonum aviculare, Spergula type, Stachys type, Cruciferae, Chenopodiaceae, Trifolium, Galium, Ranunculaceae.

..........Grain crops grown in permanent fields.

5. b) Herb pollen values with a very high proportion of Gramineae

.... 6

6. a) Gramineae accompanied by high values of Cyperaceae and/or Equisetum. Filipendula, Thalictrum, Rhinanthus type and Ranunculaceae may be present.

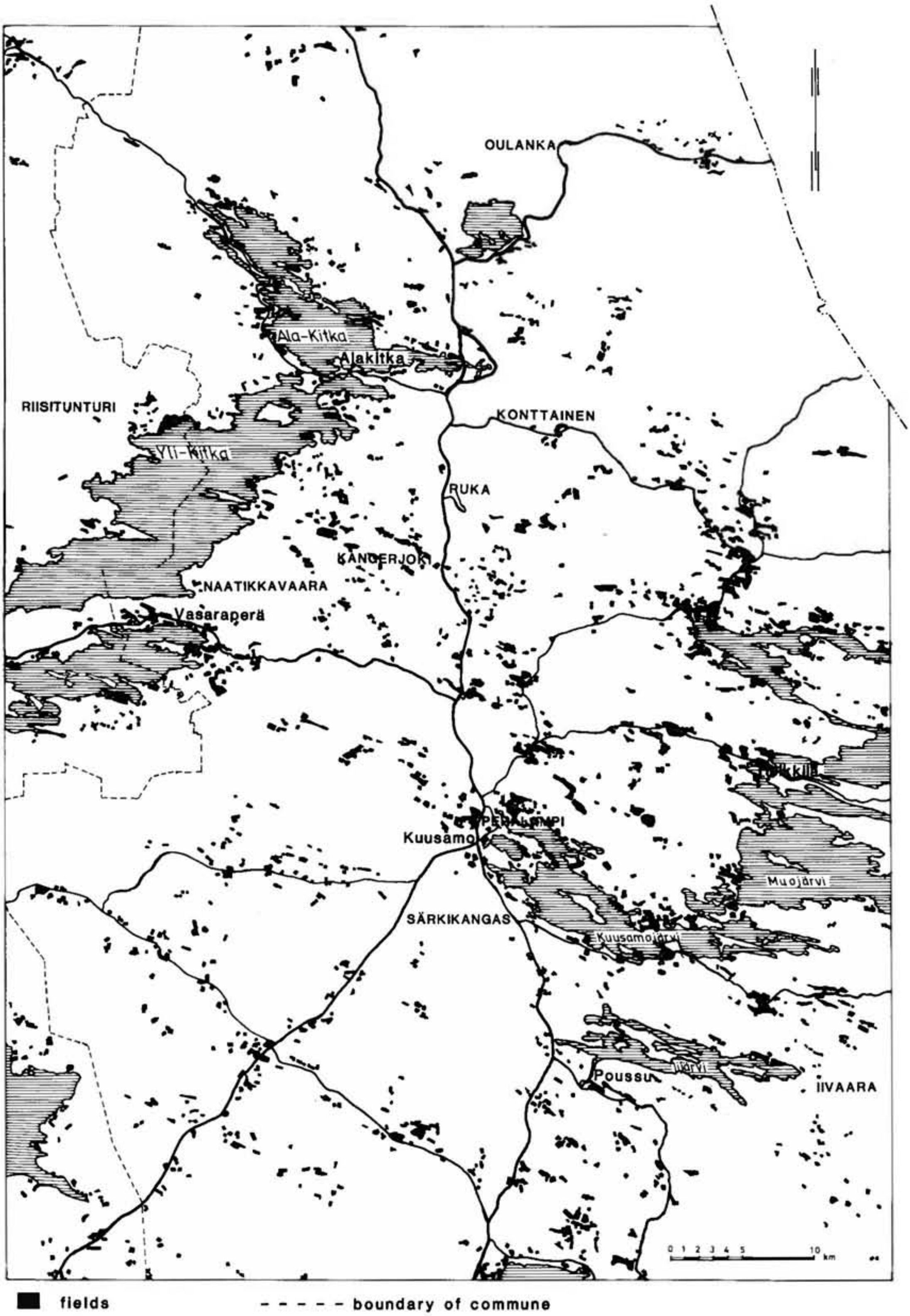
..............Natural meadows.

6. b) Gramineae not accompanied by Cyperaceae or Equisetum, instead a range of herb pollen types (but not as varied as in 5a) including a selection of the following: Elymus repens, Rumex acetosa type, Compositae Achillea and Taraxacum types, Trifolium, Chenopodiaceae, Caryophyllaceae and Ranunculaceae.

..............Sown hay fields.

---

together with semi-permanent settlement so one would expect that indicators specific to these activites would be lacking. Pollen types which are mentioned in connection with these rather than any other activity include *Epilobium*, *Trientalis*, (admittedly rarely identified in pollen diagrams at all), *Rhinanthus* type and *Rubus* type and certainly none of these appear in the trap collections. It would appear, therefore, that the pollen record fairly truthfully reflects the type of activities being practiced in the region and there are no obvious inconsistencies between the predicitons and the real situation. In order to look at this in a little more detail the influx values cm^{-2} $year^{-1}$ of just these indicator species are illustrated in Fig. 15. Those species on the left are ones which can be regarded as reflecting forests and those on the right are species of natural meadows. The species in the central part of the diagram, in contrast, are those associated with settlement and cultivation. With the exception of Gramineae and Cyperaceae the values involved are very low, very few species being recorded at more than 20 grains cm^{-2} $year^{-1}$. As has been stressed in an earlier publication (Hicks 1985b) the open hill summits (tunturi) and the vegetation types at the forest limit on these hills (including the birch important zone) tend to be characterized by higher pollen influx generally because they function as open elevated 'trapping' areas within the sea of forest. As Fig. 15 shows, this feature is also seen for the cultural indicators. However, there are some exceptions the most obvious of which is the pine dominated site Ii IX which has highest values of a number of indicator types. Knowing the exact location of the pollen traps the pattern of influx values recorded in Fig. 15 suggests that there is a correlation between pollen influx and the distance from source and certainly this is what one would expect. To test this the values are redrawn such that the total influx of indicator species recorded at each site is plotted against the distance of that site from the source of the activity (Fig. 16). Two aspects which are very easily measured from the basic maps are considered, namely settlement and fields. The measurement is a crude one in that the distance is that to the nearest dwelling or field in a direct line and does not take into account the intervening terrain or vegetation neither does it distinguish between a site which is a set distance from one single house or field and one which has a large number of houses or fields at the same set distance. The pollen types included in each calculation are divided into two groups, the first, that which is shaded black, comprises species which, on the basis of table II, are associated only with field cultivation or settlement respectively. The second group includes all pollen types which fall into both categories and are therefore 'ambiguous' as indicators. The length of this part of the column for any trap locality is therefore the same in both of the diagrams in Fig. 16. This column is, however, shaded so that for the settlement diagram the amount of *Rumex acetosa* type is shown and for the field diagrams the amount of *Ranunculus*. These are the two major pollen producers in the 'ambiguous' group and it is felt that *Rumex acetosa* type is perhaps more indicative of settlement and *Ranunculus* of fields but this is a subjective assumption.



■ fields - - - - - boundary of commune

Fig. 13. Central part of the Kuusamo area showing the present distribution of fields and the general location of the pollen traps and the sites of the pollen diagrams.

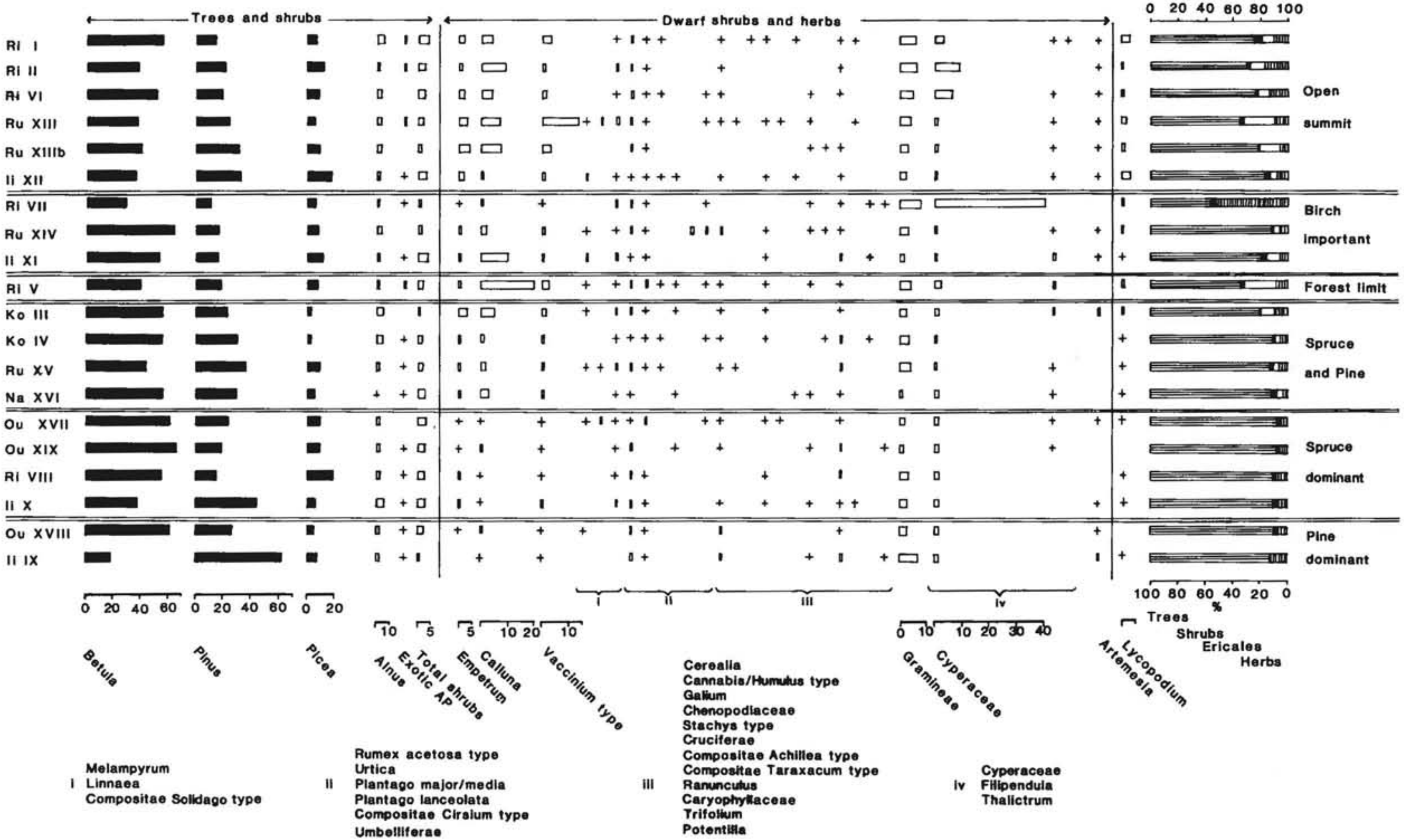


Fig. 14. Modern pollen rain values for the 20 traps located in different vegetational situations within the Kuusamo region. The values are the mean of two years from October 1969 to October 1971 and are expressed as % Σ P (see Hicks 1986).

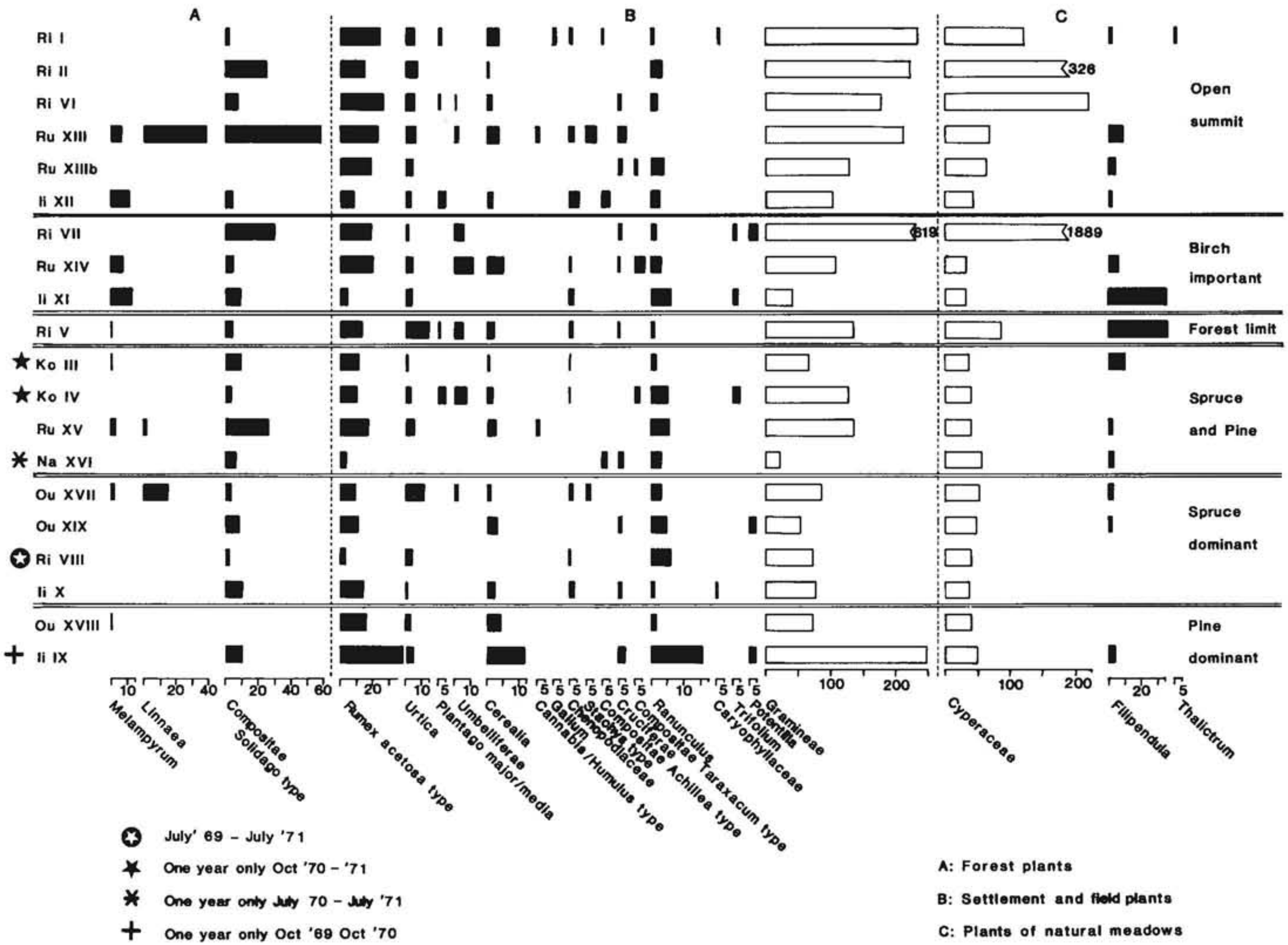


Fig. 15. Annual pollen influx cm^{-2} of selected indicative species for the 20 pollen traps, based on the mean of two years from October 1969 to October 1971.

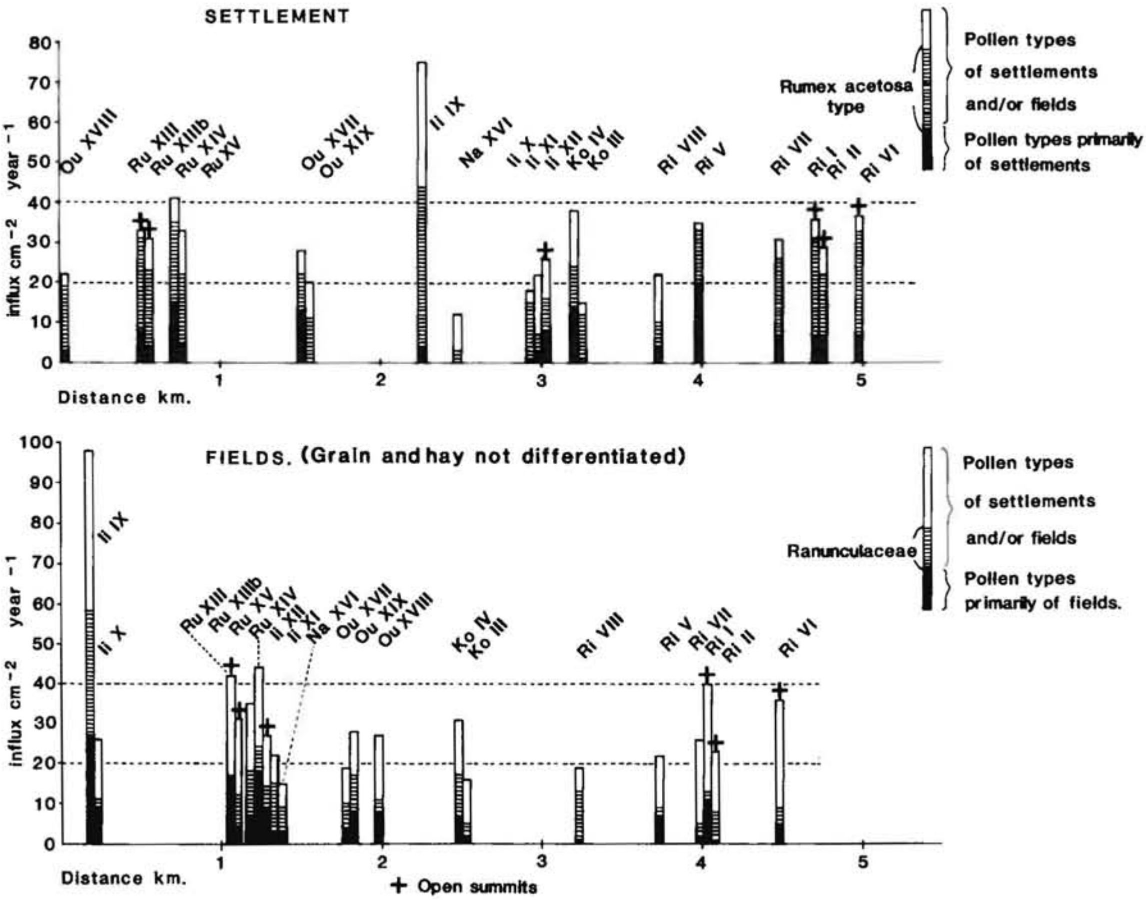


Fig. 16. Pollen influx cm^{-2} $year^{-1}$ of indicative species plotted against distance from settlement (upper diagram) and cultivated fields (lower diagram).

The pollen types concerned are:

Settlement: *Urtica, Plantago major/media*, Umbelliferae.

Fields: Cerealia, *Cannabis/Humulus*, Compositae *Achillea* and *Taraxacum* types, Chenopodiaceae, *Stachys* type, Galium.

Both fields and settlement 'ambiguous': *Rumex acetosa* type, *Ranunculus*, Caryophyllaceae, *Trifolium*, Cruciferae.

The settlement indicators do not show any correlation with distance from sampling site. With the exception of trap Ii IX total values remain below 45 grains cm^{-2} $year^{-1}$ and for the pollen types primarily associated with settlement below 20 grains cm^{-2} $year^{-1}$. All sites except Ou XVIII are more than 0.5 km from the nearest dwelling and Ou XVIII itself is situated in dry pine forest in the Oulanka valley on a terrace above the university field station which represents a slightly different type of settlement from the farms of the area. It would seem, therefore, that these indicators are part of the general regional pollen rain and are in quantities too low to pinpoint the location of any particular dwelling.

The field indicators suggest a slightly better relationship with distance. Given that neither the pollen types nor the fields have been categorized with respect to hay or grain production so that the relationship is a crude one, if only the field pollen types (black in the columns) are considered, and if the open summit sites, which as indicated form a special situation, are discounted then the overall trend is one of decreasing values with distance. More significant, however, are the relatively high values for trap Ii IX. This trap is situated in pine forest but within 200 m of a large field and has a similarly large field within 400 m on the other side, in contrast to Ii X which is 250 m upslope of a large field but in denser spurce forest with no other fields nearby. Both the field indictors and the field/settlement indicators at Ii IX are greater then at any other trap. Since the settlement indicators for this trap are very low it seems reasonable that the 'ambiguous' indicators represent field rather than settlement in this case. Certainly the nearest dwelling is 2.5 km distant. This would also explain the anomolous representation of Ii IX in the settlement diagram in Fig. 16.

The material is scanty but would suggest that pollen influx of the group of species representing cultivated fields at 80 grains cm^{-2} $year^{-1}$ or more would suggest the presence of fields within 200 m but that values of around 20–40 grains cm^{-2} $year^{-1}$ represent the general regional pollen contribution.

This assessment of the pollen trap results suggests that the grouping of pollen types given in Table II and in the key in Table III is significant but that the quantity of pollen involved is very small and any major expression in the pollen assemblage is only achieved at distances of a few hundred metres at the most from the site of the activity. This is in keeping with the calculations of Tauber (1977). Bearing those facts in mind it is then possible to look at the fossil pollen diagrams to see if all 5 phases distinguished in table I can be seen.

Five different pollen diagrams are presented (Figs. 17–21), two from relatively low-lying mires, one from a small pond and two from hill summits. Between them they cover both a range of situations and a range of sediment types. Three of the diagrams have been published previously but in a different form and a different connection (Hicks 1974, 1975, 1976) and two are presented here for the first time. All are furnished with ^{14}C dates and so, with the exception of Perälampi for which the ^{14}C dating is obviously inconsistent (see the author's comments in Jungner and Sonninen 1983), only the upper parts of the diagrams covering the historical period considered here are illustrated. The location of the various sites is shown in Fig. 13 and a brief discription of each follows.

Kangerjoki
This is a small mire at c. 288 m a.s.l. formed in a depression between drumlins. It has been partially drained by ditching. The surface vegetation is dominated by cotton grass, sedges and horsetails with juniper and dwarf shrubs. The surrounding forest contains a fair proportion of spruce but a ridge covered with pine and a strip of birch and alder along the stream, Kangerjoki, also border onto the mire. At present fields occur on all sides the nearest being some 300 m away. In 1730 there was a dwelling 7 km to the S.S.E. (Fig. 4) and by 1790 three dwellings about 2.5–3.0 km to the N. (Fig. 6). Now the nearest dwelling is 600 m to the N.W.. The pollen diagram is illustred in Fig. 17.

Särkikangas
This strip of mire lying at c. 260 m a.s.l. is part of a larger mire complex to the west of Kuusamojärvi. It has not been drained and supports a surface vegetation of cotton grass, sedges and dwarf shrubs. It is surrounded on three sides by young pine forest with spruce being present in the forest further away. At present fields occur to N.E.E. and S.E. but not at all on W.. The nearest is 0.5 km away. In 1730 the house of the local officials was situated within 2 km to E. (Fig. 4) and in 1790 there were additional dwellings further south along the shore of Kuusamojärvi about 2.5–4.0 km distant (Fig. 6). Now the nearest dwelling is 700 m to N.N.W.. The pollen diagram is illustrated in Fig. 18.

Perälampi
This small pond which connects with the lake, Kuusamojärvi, and is within the delta area of the stream flowing from the lake, Kolvanki, to Kuusamojärvi is situated actually within the village of Kuusamo. At present it is fringed by reeds and sedges, birches and willows, and is rapidly infilling. It must have been affected by the lowering of lake levels carried out in 1800's (Fig. 11). Fields are situated on the N. and W. sides within 50 m of the lake shore. The nearest dwellings in 1730 were 8–9 km to N. (Fig. 4) but by 1790 there was a dwelling about 2.5 km to S. (Fig. 6) and now there are numerous houses within 100 m to N.. The pollen diagram is illustrated in Fig. 19.

Rukatunturi
This is a shallow peat deposit on the summit of one of the highest (tunturi) at c. 460 m a.s.l.. The hill rises above the forest limit and at the time of sampling (1969) the surface vegetation was dominated be dwarf shrubs. The Ru XIIIb pollen trap has its location at this site. The hill forms the centre of a famous winter sports area and summer hiking rendezvous and in recent years has come under such heavy use that the vegetation of the site and even the whole peat deposit have now completely disappeared. The nearest fields are 1.2 km to N.W. on the shore of the lake, Talvijärvi, at the foot of the hill some 180 m below the site. In 1730 the nearest dwellings were some 12 km away (Fig. 4) and by 1790 some 5 km to S. (Fig. 6). The nearest dwelling now is the hotel which is 0.5 km away but 110 m below the sampling site. The pollen diagram is illustrated in Fig. 20.

Konttainen
Like Rukatunturi this site is also a shallow peat deposit on the summit of a hill but at the other end of the same range. This summit is at 430 m a.s.l. but unlike Rukatunturi does not rise above the forest limit. The wet depression from which the samples came is dominated by dwarf birch and *Rubus chamaemorus* with sedges, cotton grass and dwarf shrubs, and is surrounded by an open forest of stunted pines, spruces and birches. This is also the site of pollen trap Ko III. The nearest fields are 2.2 km to E.S.E. and

some 110 m below. Dwellings existed some 8–9 km to N.W. in 1730 (Fig. 4) and within 5 km to N. in 1790 (Fig. 6). Today the nearest farms are over 3 km away. The pollen diagrams is illustred in Fig. 21.

By comparing the positions of the sampling sites and the dwellings in 16th–18th centuries (Figs. 3, 4 and 6) it is obvious that none were close enough to record evidence of settlement during those periods. It is unknown precisely where the slash-and-burn clearings were located at this time but with a total population of only 1571 in 1760, the end of phase 2 (Table 1, Fig. 2), it is unlikely that any effect of either settlement or cultivation will be recorded in the pollen diagrams at anything more than the regional level, and that only slightly. By the end of phase 3 the pressure on the land is much greater but probably still not in the vicinity of any one sampling site unless a slash-and-burn clearing chanced to be located close by. One would expect, however, that the lowering of the level of Kuusamojärvi and its associated small lakes and ponds in 1806 would be recorded at Perälampi which falls within this complex. Similarly the increasing pressure on natural meadows for hay during both phase 3 and the following phase 4 should show up clearly in the two mire sites, Kangerjoki and Särkikangas, particularly if they were areas which were either flooded by damming or burnt. Permanent field cultivation increases during phase 4 and, if it is assumed that the earliest fields were in similar positions to part of the present day fields, in that the field area has been expanded and added to rather than abandonned and new ones cleared in quite different places, then it is to be expected that phase 4 will show up much more clearly at Perälampi and Kangerjoki and perhaps Särkikangas and least well at the hill-top sites of Rukatunturi and Konttainen with the difference that Rukatunturi being a higher, more open summit will record the regional situation more clearly than Konttainen.

The situation in phase 5 is sufficiently different that it should be clearly distinguishable in all the diagrams at the same sort of scale as in the pollen trap results and in the case of Perälampi and possibly also Kangerjoki, in an obvious wasy. However, the time period involved is very short only some 20 years since the growing of hay on ditched peatlands began in 1950's and the pollen samples were collected in 1970's. Kangerjoki is just one of these mires which were ditched but in the process of ditching the surface layers of peat have naturally dried out so the most recent pollen assemblage may be lost. For the other mire sites the sediment has continued to grow up until the time of sampling but if the rate of accumulation is very slow then the size of sample (1 cm^3 in all cases) may be too large to distinguish such a short time interval. For all sites pollen concentration values are available but no attempt is made here to calculate either rate of sedimentation or pollen influx for the historical period because there are so many variables to be taken into account. Analysis will, therefore, for now be based on pollen percentages and the pollen influx aspect will be dealt with in a later publication.

With this framework in mind the pollen diagrams can be critically examined and the key outlined in Table III applied.

Kangerjoki (Fig. 17)

The ^{14}C date at 13–15 cms depth of 240 ± 70 B.P. (Hel-317) in its uncalibrated form gives a possible age to the 14 cm horizon of between A.D. 1640 and 1780 which provides a control point. From the details outlined above one would expect no evidence from phase 1 and little or no evidence from phase 2 but definite evidence from phase 3 which would include slash-and-burn cultivation of rye, some field cultivation of barley, the gathering of hay from natural meadows and permanent settlement. The first indicators appear at 14–15 cms depth with the presence of *Rumex acetosa* type and Cerealia and just perceptibly lower values of *Picea*. This could be the end of phase 2 or the beginning of phase 3 and the ^{14}C date suggests the former. One could interpret the *Rumex acetosa* type pollen as indicating settlement and the Cerealia as slash-and-burn cultivation somewhere in the region but at a considerable distance from the sampling site. By 12–13 and 9–10 cms depth the *Rumex acetosa* type is joined by *Urtica* and the Cerealia by *Cannabis/Humulus* type, *Galium*, Cruciferae and *Ranunculus* and after this horizon the forest indicator *Melampyrum* disappears. These represent more widespread settlement and cultivation of crops now also in permanent fields and must refer to phase 3. Most of these indicators are still present at 4–5 and 6–7 cms depth and Chenopodiaceae is additionally recorded but more significant are the high Cyperaceae values. An increase in this natural meadow indicator must reflect the flooding of the bog surface to produce better hay and therefore represent phase 4. In the topmost sample 0–1 cm depth all indicators are lacking and there is evidence for increased forest growth.

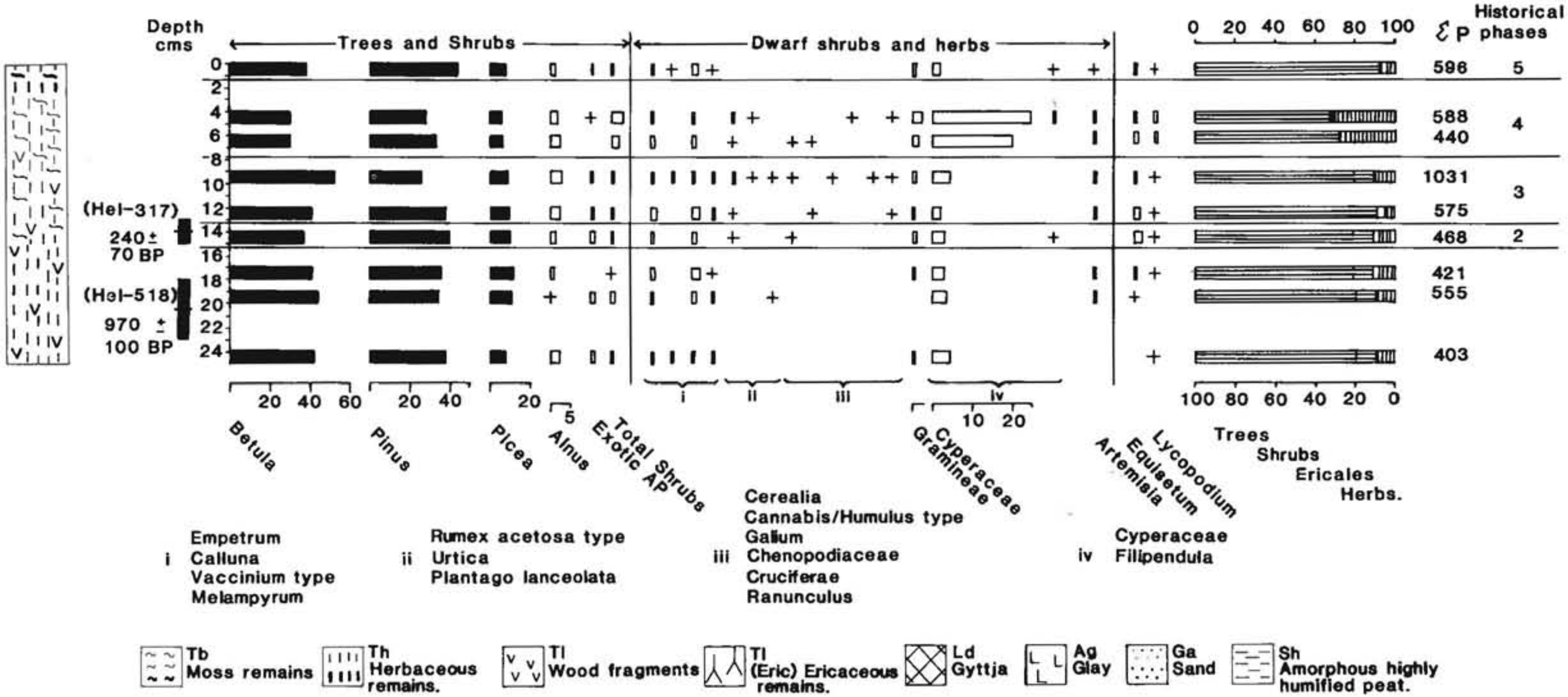


Fig. 17. Kangerjoki, relative pollen diagram, % Σ P.

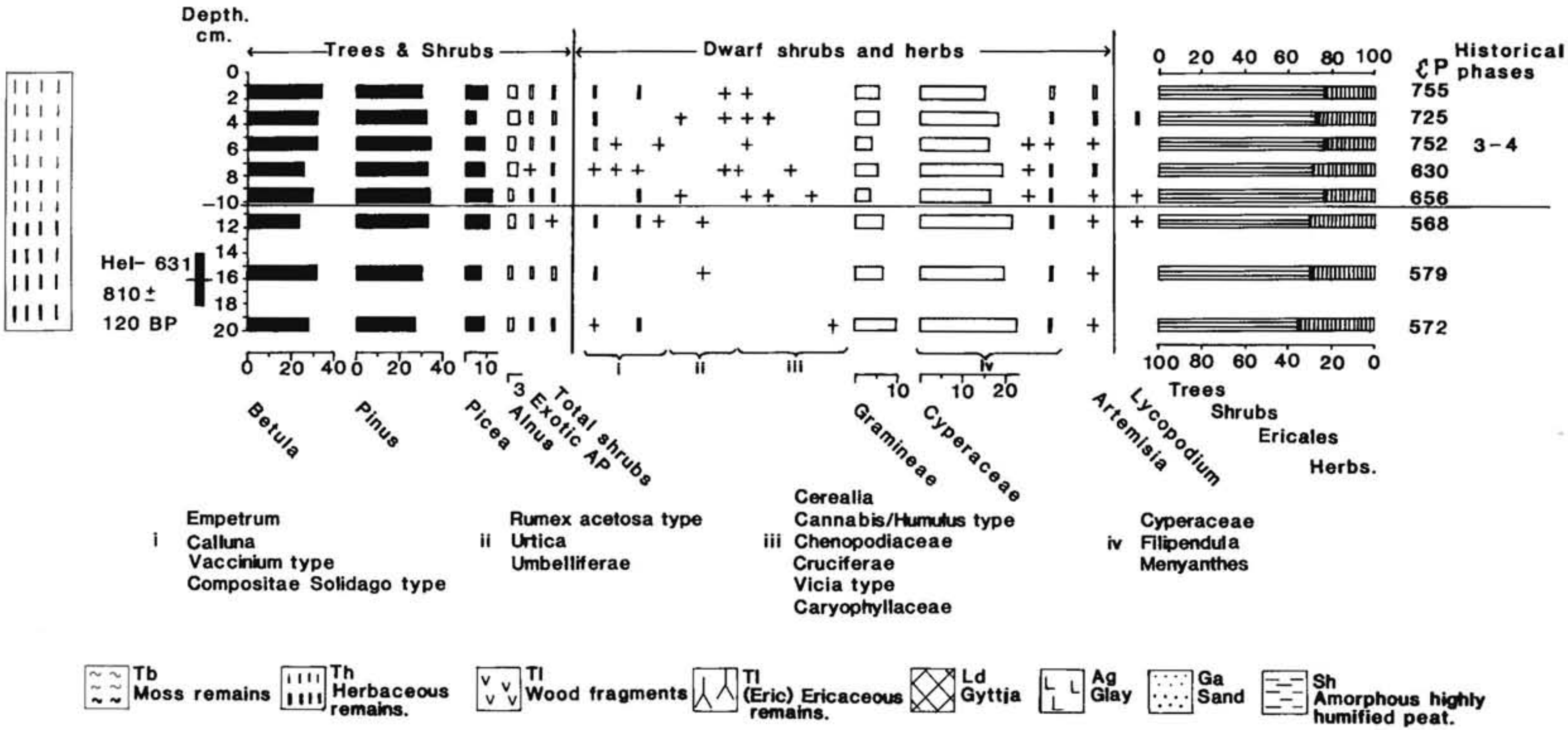


Fig. 18. Särkikangas, relative pollen diagram, % Σ P.

This must represent the most recent period with the ditching of the bog and the spread of pines onto the surface. The surface peat has been sufficiently affected by drying out that phase 5 is not in itself recorded. In an earlier publication (Hicks 1976), a line indicating the beginning of Finnish settlement was drawn at just below 10 cms depth, the point at which the greatest number of indicators are recorded. In the light of this new approach it is now obvious that this horizon represents the time by which settlement is becoming well established and the first farmers actually arrived some time earlier. In this way it has been possible to refine the earlier interpretation.

Särkikangas (Fig. 18)

This diagram has fewer indicators and their occurrence is more sporadic than in the Kangerjoki diagram which is in keeping with the site being more peripheral to the areas of activity. *Urtica* is present at an early stage, around A.D. 1140 on the basis of the uncalibrated ^{14}C date and occurs again at 11–12 cms depth, after which there are also occurences of *Rumex acetosa* type. These must indicate the presence of settlement somewhere in the general region. The only Cerealia grain is recorded at 7–8 cms depth but *Cannabis/Humulus* pollen appears before that (9–10 cms depth) and so one must conclude that this represents a period during which cultivation in permanent fields was practised. There are no records of *Melampyrum, Linnaea, Epilobium* or Cruciferae which could indicate slash-and-burn cultivation and fluctuations in the *Picea* curve are more in relation to fluctuations in the Cyperaceae curve than anything else. One can conclude that huuhtaviljely was not practised close to the site probably because the surroundings are largely mires. The continued presence of high values of Cyperaceae and relatively high Gramineae together with *Filipendula* and *Menyanthes* show that the site has always had a natural meadow vegetation and indeed the stratigraphy confirms this. Unlike Kangerjoki there has been no incentive to flood this mire, nor has it been drained and so the pollen representation remains constant throughout. It is not, therefore possible to say whether hay was gathered from here or not. The topmost sample is at 1–2 cms depth and so the most recent period corresponding to phase 5 is not illustred at all. In this diagram, therefore, only a general phase 3–4 can be distiguished. In the earlier publication mentioned above (Hicks 1976), on the basis of the ^{14}C date of 810 ± 120 B.P (Hel-631) and assuming a constant rate of peat accumulation between the dated horizon (16 cms) and the surface, a line indicating the arrival of Finnish farmers c. 300 years ago was drawn at a depth of 6 cms. Now, by looking at the pollen indicators in this more detailed manner and taking into account the fact that the upper 11 cms of the sediment is less humified than that be low 11 cms depth and consequently likely to have accumulated more rapidly, it is possible to refine the interpretation of this diagram, too, and show that 300 years B.P. level must be lower down.

Perälampi (Fig. 19)

This diagram is much more difficult to interpret. A wide range of pollen types are present and both settlement and cultivation indicators occur sporadically throughout with forest plants being represented in the central portion. The earliest Cerealia grain appears at a depth of 605.5 cms (the depths are measured form the surface of the pond ice at the time of sampling) and the ^{14}C date from the length of core from 598 to 609 cms is 1970 ± 140 B.P. (Hel-1238) i.e. 20 B.C. (uncalibrated). However, this date, like the one higher up the profile is considered unreliable and likely to be too old.

The whole length of sediment is extremely poor in organic material so that in both cases the section dated covers an undesireably long length of core and therefore the dates are not specific to any precise horizon. In addition the high mineral content of the sediment and the presence of sandy bands, including a much thicker sandy band between 564 and 561 cms depth, indicates a high amount of inwash. Although at present the pond has no direct inflow it does lie within the delta area of the stream which flows from Kolvanki to Kuusamojärvi and may very well receive quite considerable amounts of material during spring flood conditions, for example. The small quantity of organic matter on which the ^{14}C dates were counted could, therefore, contain a fairly high proportion of organic material washed in from the surroundings and the pollen assemblages, too, could have a washed-in component. The samples were taken through the ice with a Livingstone borer and the topmost horizons, being water saturated, were too loose to be sampled. An unknown length of sediment in the region of 30–40 cms therefore exists above that illustrated in the diagram.

In interpreting the pollen diagram, therefore, various aspects of the sediment core and the

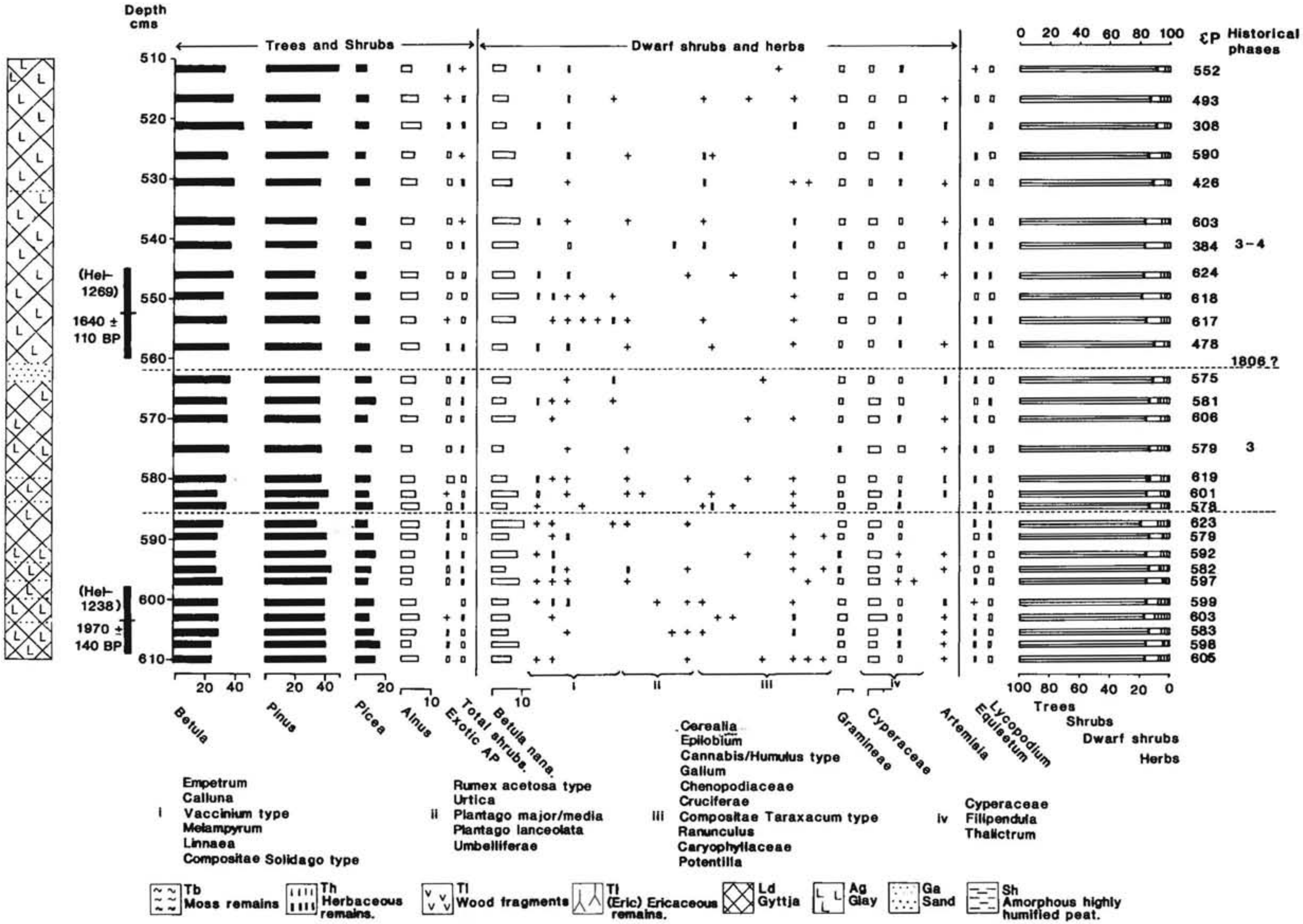


Fig. 19. Perälampi, relative pollen diagram, % Σ P.

sedimentary environment must be taken into consideration. Firstly that the top of the core is missing, secondly that the sediment may include older material inwashed from the surroundings, and therefore the ^{14}C dates are probably too old, and thirdly that the pollen concentration curve (not illustrated here) shows noticeably lower values from a depth of 580 cms upwards suggestive of more rapid sediment accumulation in the upper part of the diagram. This latter feature would be in keeping with the much sparcer incidence of indicators in this section of the diagram. That changes are taking place within the pond at around this time is also indicated by a distinct drop in the percentage presence of *Pediastrum* species at 570 cms depth.

If the key in Table III is applied then a fall in *Picea* pollen accompanied by the appearance of Cerealia is seen at 605.5 cms depth and this is quickly followed by *Cannabis/Humulus* type accompanied by *Galium* and *Ranunculus* suggesting cultivation in permanent fields. A second occurrence of *Cerealia* with *Epilobium, Galium* and *Ranunculus* is recorded at 584.5 cms depth which could partly be interpreted as indicating slash-and-burn cultivation but is not completely convincing. *Picea* values do not drop significantly at this point. *Plantago major/media*, as an indicator of settlement, is recorded at 600.5 cms depth, *Rumex acetosa* type from 597 cms and *Urtica* from 582.5 cms. Umbelliferae is consistently present from the lowermost samples but cannot alone be regarded as particularly indicative. The natural meadow pollen types are present at low values throughout. Though most of the lowering of lakes in the region took place towards the end of 19th century Kuusamojärvi was lowered much earlier, in 1806, and this lowering must also have affected Perälampi. One would expect this to be reflected in the pollen diagram in terms of increased Cyperaceae, Gramineae and *Equisetum* values. This is not the case but it is tempting to regard the thicker sandy layer at 564–561 cms depth as relating to the lowering of lake level, or at least to man disturbing the local environment.

One is forced to conclude that the pond is a poor site for recording the various phases of interference despite its ideal situation close to the centres of activity. Because of the sedimentary environment the pollen record is disturbed and it is not possible to distinguish different pollen assemblages and correlate them with different historical phases in the same way as it is at Kangerjoki, for example. Two tentative horizons are indicated in the diagram, one for the commencement of phase 3 and one for the lake lowering of 1806, but these are then completely at variance with the ^{14}C dates. If these horizons are in fact correct then the rate of sedimentation implied is very high.

Rukatunturi (Fig. 20)

This diagram has clear indications of slash-and-burn cultivation which, considering its hill top situation, shows that the incidence of huuhtaviljely had reached a sufficiently high density to be clearly recorded in the regional pollen rain. At a depth of 7–8 cms *Picea* values fall, the forest plants *Melampyrum* and *Linnaea* disappear, Cerealia appears and Gramineae values increase. At the same time *Rumex acetosa* type appears and Chenopodiaceae is also present. This horizon is, therefore, correlated with phase 3. The only indicators recorded just prior to this are *Plantago lanceolata* which is considered as being long-distance transported and Chenopodiaceae and *Taraxacum* type. Samples from 1–6 cms depth are likely to record phase 4 since *Cannabis/Humulus* type is present but phase 5 must fall within the very top cm since the wide range of pollen types associated with present day conditions is not recorded. It should, however, be borne in mind that their representation in the pollen trap at this site (Ru XIIIb) is far less pronounced than in the adjacent more exposed Ru XIII trap (Fig. 14). *Picea* values increase slightly at 1–2 cms depth which perhaps reflects the cessation of spurce felling in the latter half of 19th century. As in the case of the Kangerjoki diagram, in an earlier publication (Hicks 1976) the arrival of Finnish farmers in the Kuusamo area was marked on this diagram at a level which is now seen to correspond rather to the period of more intensive exploitation.

Konttainen (Fig. 21)

Pollen types indicative of human interference are particularly sparce in this diagram. This is due to a number of factors. Firstly the location is remote from the sites of activity and has always been so. Secondly, although a hill summit it is forest covered and, therefore, does not act as an open 'trapping' area in quite the same way as, for example, Rukatunturi and the sampling site itself is in a depression and well sheltered. Thirdly the sampling interval in this diagram is much wider for the period in question than in the other diagrams so that significant horizons may not be recorded. However, the appearance

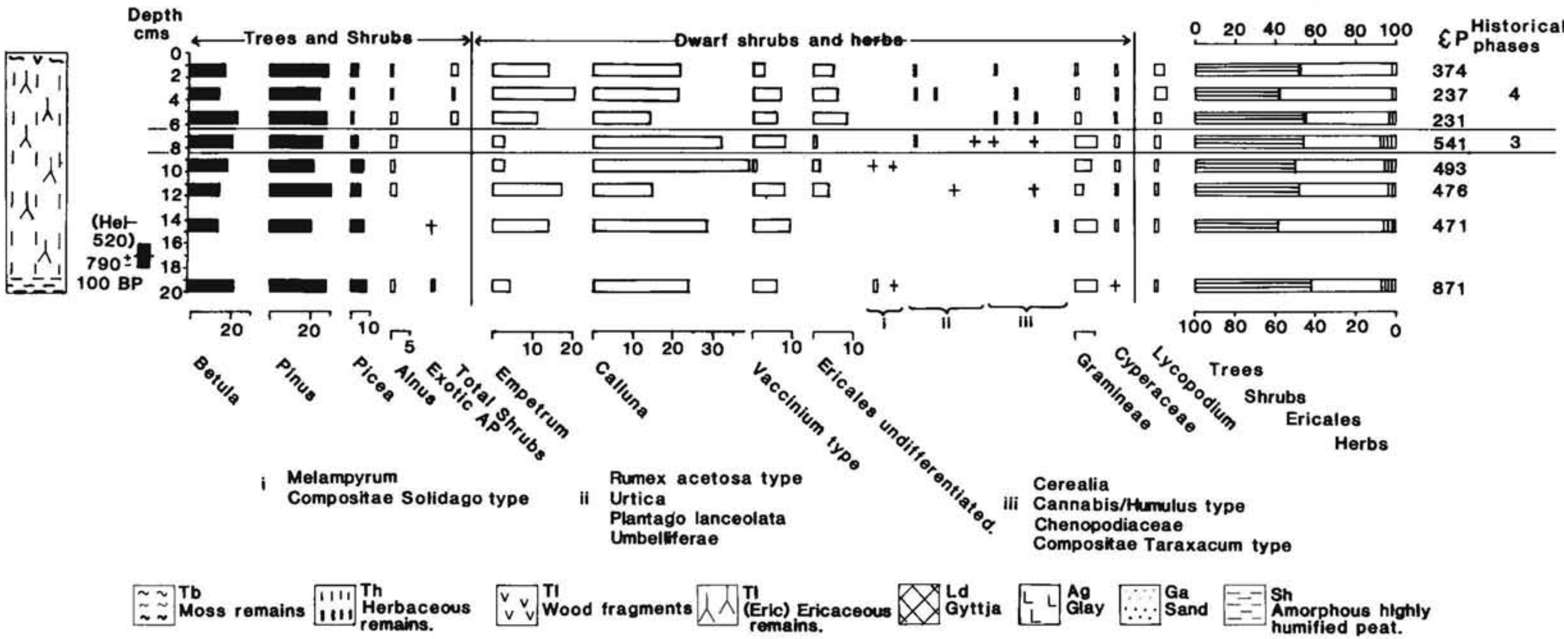


Fig. 20. Rukatunturi, relative pollen diagram, % Σ P.

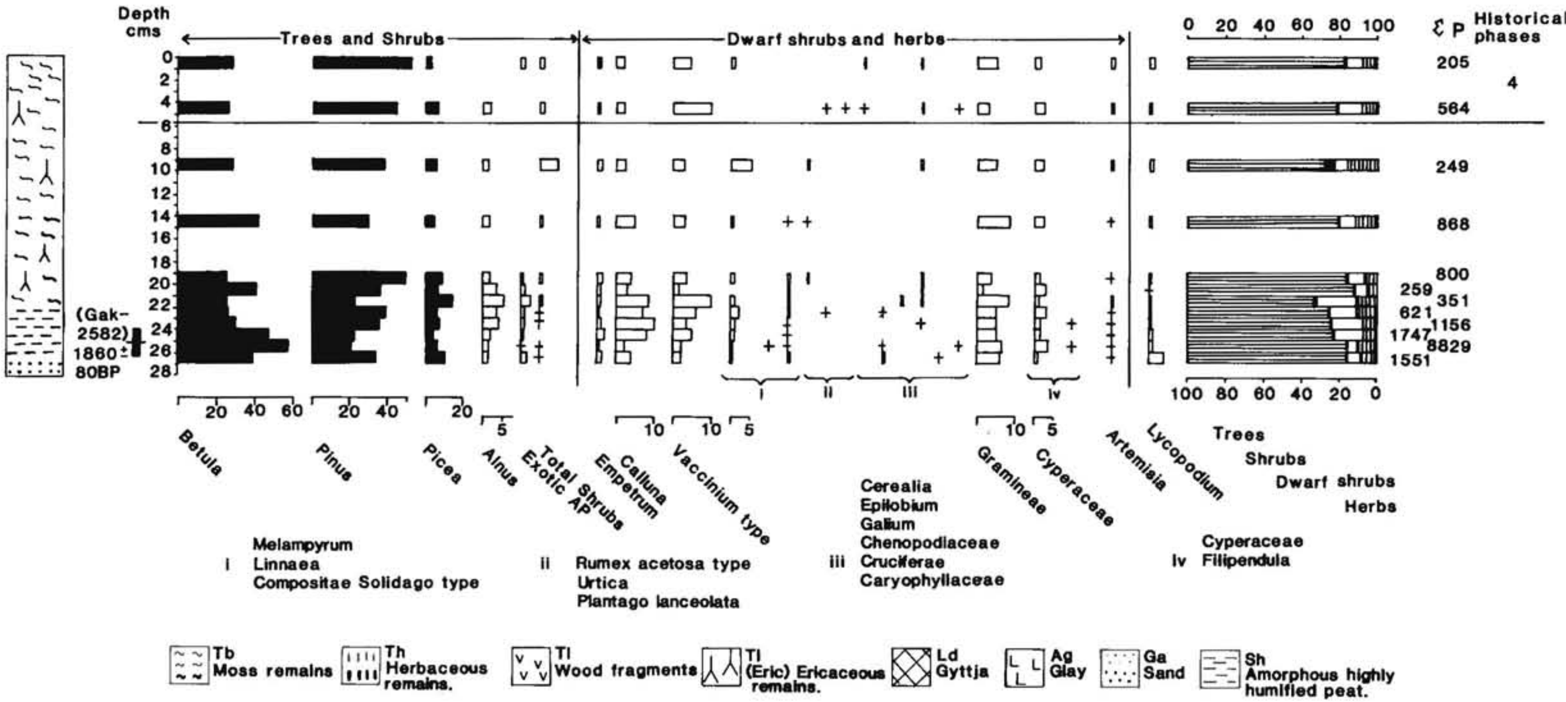


Fig. 21. Konttainen, relative pollen diagram, % Σ P.

Table IV Pollen representation of each of the historical phases indicated in figure 2 and Table I.

<table>
<tr><th rowspan="2">Means of livelihood and intensity of land use (As in Fig. 2 and Table I)</th><th colspan="2">Example in pollen diagrams</th></tr>
<tr><th>within 200 m of scene of activity</th><th>>200 m from scene of activity</th></tr>
<tr><td>Phase 1
AD 1500 - 1676
Hunting and fishing. A few reindeer and sheep pastured. Semi-permanent settlement - only two winter villages (Fig. 3). Taxable population c. 25 persons.</td><td>-</td><td>-
(Expected records even in regional pollen rain are very slight.)</td></tr>
<tr><td>Phase 2
AD 1676 - 1760
Slash-and-burn cultivation of rye and reindeer herding. More permanent settlement, some 37 holdings (Fig. 4) by the end of the period with a population reaching 1571 in 1760</td><td>-</td><td>Kangerjoki 14-15 cms depth.</td></tr>
<tr><td>Phase 3
AD 1760 - 1830
Slash-and-burn cultivation of rye and reindeer herding continue accompanied by some field cultivation of barley and the keeping of cows and sheep (Figs. 5 and 7). Hay gathered from natural meadows, spruces felled for lichen and pines for bark.
Permanent settlement with at least 200 holdings (Fig. 6) and a population increasing to 3728 by 1830</td><td>Perälampi from c. 564 cms depth with respect to the lowering of lake, Kuusamojärvi, in 1806. The evidence is rather in terms of increased mineral influx and disturbance of the pollen rain.</td><td>Kangerjoki 8-14 cms depth
Särkikangas c. 7-10 cms depth
Rukatunturi 7-8 cms depth</td></tr>
<tr><td>Phase 4
AD 1830 - 1950
Barley grown in permanent fields and later also rye and potatoes (Fig. 9). Increasing numbers of cows and sheep kept and reindeer herded (Fig. 10). Hay gathered from natural meadows and the area of these artificially improved by either damming, burning or lower lake water levels (Fig. 11). Spruces still felled for lichen and birch leaves gathered for additional fodder. Population increasing to 10,500 by 1910 (Fig. 8).</td><td>Kangerjoki 4-7 cms depth, with respect to the artificial production of natural meadows by damming and flooding.</td><td>Kangerjoki 1-8 cms depth
Särkikangas c. 1-7 cms depth
Rukatunturi 1-7 cms depth
Konttainen 1-5 cms depth.</td></tr>
<tr><td>Phase 5
AD 1950's - present
Some barley grown. Hay cultivated in permanent fields, especially those drained from mires. Field area, however, <3 % of the total land (Fig. 13). Cows kept and reindeer herded. Population at its maximum of 20,913 in 1968.</td><td>Trap Ii IX with respect to cultivated fields</td><td>The pollen traps
Kangerjoki 0-1 cms depth.</td></tr>
</table>

and grouping of the pollen types is in keeping with both the site location and the historical records. Indicators of cultivation and settlement appear at 4–5 cms depth which is here taken to correspond to phase 4. As at all the mire sites the uppermost sample does not correspond in expected pollen terms to phase 5 nor are there as many indicators present as are recorded in the pollen trap for this site (Ko III, Fig. 14). One must conclude that the time resolution of this type of deposit is insufficient to record the most recent happenings.

The relationship between the 5 historical phases and their expression in the pollen diagrams is summarized in Table IV.

Conclusions

The material presented here demonstrates that various different types of human interference with the landscape can be distinguished in the pollen record but that the amount of evidence is very small. The pollen occurrences are in such tiny percentages that if these were diagrams from further south they would be discounted as unreliable and insignificant. That even these tiny percentages are significant, however, is shown by the modern pollen rain results. The extent of farming at the present day is available for anyone to observe and yet even this amount of farming (fields cover some 2.7 % of the land area), which is considerably more than was practised in the past (though, admitedly being quite different in character from huuhtaviljely), is recorded in the regional pollen rain at values of 0.5–1 % Σ P or even less for individual pollen types. The northern boreal forests with their high-pollen producing species (primarily birch and pine), present a distinctly different environment in terms of pollen sedimentation. This should be remembered when interpreting pollen diagrams from further south which contain boreal phases.

Given that the pollen representation of indicative species is on a very small scale it is nevertheless possible to distinguish different types of activity. These can rarely be characterized by one pollen type alone but rather by a grouping of pollen types. Although Cerealia pollen gives an indisputable indication of cereal cultivation other activities such as permanent settlement or growing hay in fields can only be deduced if a selection of key species are recorded. It is, however, unusual to find that every indicator type of a particular activity is present. Representation is primarily at the regional level since it appears that a sampling site must be within c. 200 m of a particular activity for it to be strongly recorded in a pollen diagram. Since it is the regional pollen rain which is being recorded and since this may represent the area within a 10–20 km radius of the sampling site the pollen indicators rarely represent just one type of activity but rather all the acitivities which are being practised in the region at that point in time. For this reason one cannot expect to be able to distinguish closely related activities at this level (e.g. cereal fields from hay fields). Again such a distinction is only possible if the sampling site is very close to the activity in question. Conversely, of course, if one activity is unambiguously and strongly represented in a pollen diagram one can be fairly certain that it was practiced within c. 200 m of the site. Because the record is generally in terms of the regional pollen rain it is also true that the intensity of any activity within the region will have to reach a certain level before it is recorded at all. Something of this is seen in the difference between the records of phases 2 and 3 in the pollen diagrams presented here. This question of scale is quite significant.

In contemplating the scale of an activity and the distance between it and the sampling site pollen influx values can be of great use. Although this aspect is only lightly touched on here it does seem clear that there is an obvious threshold in pollen influx which is exceeded if the activity is local but not if it is regional and this is often obscured in the percentage presentation of results.

Another factor which will affect the way in which the indicator pollen types appear in the pollen assemblages is the nature of the sampling site and the type of sediment. The sampling site will affect the pollen record such that small sheltered sites will receive much less regional pollen than larger, exposed or elevated ones. The sediment type is significant in that peat frequently gives a clear record, and occasionally a highly local one if the mire itself has been utilized by man, but the time resolution of peat samples may not be sufficient to distinguish phases which are of very short duration. On the other hand lake sediment has the potential for giving a more detailed time-scale, as would be the case with a lake containing annually laminated sediments, but is more susceptible to factors which completely disturb the pollen record, such as inwash. Frequently, too, as human activity in the vicinity of a lake increases so does the inwash of material from the surroundings.

The examples used here all come from the historical period which means that a strong control can be exercised on the interpretation of the pollen record. The time of occurrence, intensity and distribution of activities is known and can be verifed and, therefore, the conclusions drawn in terms of indicator species, degree of pollen representation etc. have a fairly strong base. In an area where evidence is sparce it is only by setting out from this type of indisputable starting point that any confidence can be gained for interpreting earlier, unknown periods.

The suggestions outlined here can be further refined. More precise details could be obtained by having pollen traps sampling the pollen influx within the man-made environments (as far as they exist today), by applying the suggested key (Table III) to sites carefully chosen to be located close to specific past activities and by sampling with great precision, counting to high pollen sums, indentifying individual pollen types to the most detailed level and calculating pollen influx.

Once the features of the pollen key are confirmed or refined it can be applied to the unknown sections of pollen diagrams with the proviso that at periods in the past the climate has been more favourable than for the historical period considered here and at those times other plant species, which today are at their ecological limit, may have been able to grow quite happily in the area. It should also be valid to apply the same key to other regions having a similar ecology i.e. spruce dominated forest areas at similar latitudes or similar forests at slightly more southerly latitudes but higher altitudes. Only by using this sort of controlled approach, however, will pollen analysts be able to gain the confidence of their archaeological colleagues.

BIBLIOGRAPHY

Aalto, M. Taavitsainen, J.-P. & Vuorela, I. 1981, Palaeobotanical investigations at the site of a sledge runner find, dated to about 4900 B.P. in Noormarkku, S.W. Finland. *Suomen Museo* 1980, 41–65.

Ahti, T. Hämet-Ahti, L. & Jalas, J. 1968, Vegetation zones and their sections in northwestern Europe. *Annales Botanici Fennici* 5, 169–211.

Ahti, T. & Hämet-Ahti, L. 1971, Hemerophilous flora of the Kuusamo district, northeast Finland, and the adjacent part of Karelia, and its origin. *Annales Botanici Fennici* 8, 1–91.

Behre, K.-E. 1981, The interpretation of anthropogenic indicators in pollen diagrams. *Pollen et Spores* XXIII: 2, 225–245.

Donner, J.J. 1972, Pollen frequencies in the Flandrian sediments of Lake Vakojärvi, S. Finland. *Commentationes Biologicae* 53, 3–19.

Donner, J.J. Alhonen, P. Eronen, M. Jungner, H. & Vuorela, I. 1978, Biostratigraphy and radiocarbon dating of the Holocene lake sediments of Työtjärvi and the peats in the adjoining bog Varrassuo west of Lahti in southern Finland. *Annales Botanici Fennici* 15, 258–280.

Ervasti, S. 1978, *Kuusamon historia* I. Kuusamo. 999 pp.

Heikinheimo, O. 1915, Kaskiviljelyn vaikutus Suomen metsiin. *Acta Forestalia Fennica* 4: 2, 1–264.

Hertz, M. 1934, Tutkimuksia karjan vaikutuksesta hakkausalojen kasvillisuuteen. *Acta Forestalia Fennica* 40, 1–25.

Hicks, S. 1974, A method of using modern pollen rain values to provide a timescale for pollen diagrams from peat deposits. *Mem. Soc. Fauna Flora Fenn.* 49, 21–33.

Hicks, S. 1975, Variations in pollen frequency in a bog at Kangerjoki, N.E. Finland during the Flandrian. *Commentationes Biologicae* 80, 1–28.

Hicks, S. 1976, Pollen analysis and archaeology in Kuusamo, north-east Finland, an area of marginal human interference. *Trans. I.B.G. New Series* 1: 3, 362–384.

Hicks, S. 1985a, Pollen values and field size: an experimental example from Hailuoto. Proceedings of the third Nordic conference on the application of scientific methods in Archaeology. *Iskos* 5, 101–103.

Hicks, S. 1985b, Modern pollen deposition records from Kuusamo, Finland. I. Seasonal and annual variation. *Grana*. In press.

Hicks, S. 1986, Modern pollen deposition records from Kuusamo, Finland. II. The establishment of pollen: vegetation analogues. *Grana*. In press.

Huttunen, P. 1980, Early land use, especially the slash-and-burn cultivation in the commune of Lammi, southern Finland, interpreted mainly using pollen and charcoal analyses. *Acta Botanica Fennica* 113, 1–45.

Hämet-Ahti, L. Suominen, J. Ulvinen, T. Uotila, P. & Vuokko, S. 1984. *Retkeilykasvio*. Suomen Luonnonsuojelun Tuki Oy. Helsinki. 544 pp.

Jukola-Sulonen, E.-L. 1983, Vegetation succession of abandoned hay fields in Central Finland. A quantitative approach. *Comm. Inst. Forestalia Fenniae* 112, 1–85.

Jungner, H. & Sonninen, E. 1983, *Radiocarbon Dates* II. Radiocarbon Dating Laboratory, University of Helsinki. Report No. 2.

Kortesalmi, J.J. 1975, *Kuusamon talonpoikaiselämä* 1670–1970. Helsinki. 705 pp.

Koutaniemi, L. 1983, Climatic characteristics of the Kuusamo uplands. *Oulanka Reports* 3, 3–29.

Kujala, V. 1921, Havaintoja Kuusamon ja sen eteläpuolisten kuusimetsäalueiden metsä- ja suotyypeistä. *Acta Forestalia Fennica* 18: 5, 1–65.

Lampimäki, T. 1939, Nautakarjan laiduntamisesta metsämailla. *Silva Fennica* 50, 1–106.

Linkola, K. 1917, Vanhan kulttuurin seurannaiskasveja maamme ruderaatti- ja rikkaruohokasvistossa. *Terra* 29, 125–152.

Linkola, K. 1922, Niityt ja viljelysmaat. *Oma Maa* 3, 1012–1031.

Moore, P.D. & Webb, J.A. 1978, *An illustrated guide to pollen analysis*. Hodder and Stoughton, London.

Mukula, V. 1964, *Rikkaruohot ja niiden torjunta*. Helsinki. 128 pp.

Núnèz M.G. & Vuorela, I. 1979, A tentative evaluation of cultural pollen data in early agrarian development research. *Suomen Museo* 1978, 5–38.

Parvela, A.A. 1923, Tietoja Kuusamon viljelyskasvistosta. *Luonnon Ystävä* 27, 11–18.

Pennington, W. & Bonny, A. 1970, Absolute pollen diagram from the British Late-glacial. *Nature* 226, 871–873.

Raatikainen, M. & Raatikainen, T. 1972, Weed colonization of cultivated fields in Finland. *Ann. Agric. Fenn.* 11, 100–110.

Salminen, S. 1973, Tulosten luotettavuus ja karttatulostus valtakunnan metsien V inventoinnissa. *Comm. Inst. Forestalia Fenniae* 78: 6.

Salonen, V-P., Ikäheimo, M. & Luoto, J. 1981, Rautakautisen ja historiallisen asutuksen ilmeneminen paleontologisin ja arkeologisin keinoin Piikkiön Kuoppajärven ympäristössä Lounais-Suomessa. *Turun yliopiston maaperägeologian osaston julkaisuja* 44.

Sirén, G. 1955, The development of spruce forest on raw humus sites in northern Finland and its ecology. *Acta Forestalia Fennica* 62: 4, 1–408.

Suominen, J. 1975, Kasvipeitteestä saamelaisten muinaisilla talvikylän paikoilla. English summary: On the plant cover at sites of ancient Lapp winter villages. Finnish Lapland. *Luonnon Tutkija* 79, 92–94.

Suominen, J. & Pohjakallio, K. 1964, Kuusamon Juuman kylän rikkaruohoista. *Molekyyli* 4, 60–63.

Tauber, H. 1977, Investigations of Aerial Pollen Transport in a Forested Area. *Dansk. Botanisk Arkiv* 32: 1, 1–121.

Tolonen, K., Siiriäinen, A. & Hirviluoto, A.-L. 1979, Iron Age cultivation in SW-Finland. *Finskt Museum* 1976, 5–66.

Tolonen, M. 1978, Palaeoecology of annually laminated sediments in Lake Ahvenainen, S. Finland. I. Pollen and charcoal analyses and their relation to human impact. *Annales Botanici Fennici* 15, 177–208.

Tolonen, M. 1979, On the prehistoric agriculture in Sääksmäki, S. Finland. *Finskt Museum* 1976, 67–84.

Vasari, Y. 1962, A study of the Vegetational History of the Kuusamo District (N.E. Finland) during the Late-Quaternary Period. *'Vanamo'* 33: 1, 1–140.

Vasari, Y. 1965a, A Study of the Vegetational History of the Kuusamo District (N.E. Finland). III. Maanselänsuo, a Late-Glacial site in Kuusamo. *Annales Botanica Fennici* 2, 219–235.

Vasari, Y. 1965b, A Study of the Vegetational History of the Kuusamo District (N.E. Finland). IV. The age and origin of some present day vegetation types. *Annales Botanici Fennici* 2, 248–273.

Vasari, Y. 1976, The state of palaeoethnobotanical research in Northern Finland. *Folia Quaternaria* 47, 89–95.

Vuorela, I. 1973, Relative pollen rain around cultivated fields. *Acta Botanica Fennica* 102. 27 pp.

Vuorela, I. 1977, Suomen asutushistoria ja siitepölyanalyysi. *Luonnon Tutkija* 81, 134–138.

Vuorela, I. 1978, Local settlement history of the Lahti area as shown by pollen analysis. *Bull. Geol. Soc. Finland* 50, 45–57.

Vuorela, I. 1982, Pollen stratigraphy and chemical analyses of a mineral soil profile at a Corded Ware dwelling site in Southern Finland compared with those of local organic sediments. *PACT* 7, 175–193.

Vuorela, I. 1983, Vohtenkellarinsuo, a bog in Paimio, S.W. Finland with a cultural origin. *Bull. Geol. Soc. Finland* 55: 1, 57–66.

Vuorinen, J. & Tolonen, K. 1975, Flandrian pollen deposition in lake Pappilanlampi, Eastern Finland. *Publications of the University of Joensuu* B_{II}: 3, 1–12.