Laborativ Arkeologi 12, pp. 11–24 (1999)

Vegetation history and land use in the Vendel area, Uppland, eastern Sweden

Sven Karlsson

In connection with current archaeological excavations in the Vendel area in Uppland, a pollen analysis has been conducted on a peat sequence from a fen called "Hovgårdsberg fen", situated c. 700 m N of the church at Vendel. The vegetation history of the area has been reconstructed from the present investigation combined with earlier pollen analyses of sediments and peat from Lake Vendel basin and cartographical material. Vegetation maps constructed for time slices 4000 BP, 1600–1200 BP, 200 BP and recent times (1979) illustrate the vegetational changes and expanding land use. The results show that cultivation and grazing have been sporadic from the Bronze Age to the Early Iron Age and continuous from the Late Iron Age (Vendel time) onwards. The immigration of spruce (*Picea*) is estimated at around 2500 BP ^{14}C-years or slightly earlier.

Introduction

A four year research project called "SIV" – Svealand during the Vendel and Viking Age – was started in 1996 by the Archaeological Research Laboratory, Stockholm University (Arrhenius & Eriksson 1997, Arrhenius 1998b).

The large scale project focuses on basic economy and the use of natural resources during the Late Iron Age (c. 2000–900 BP) where a study in which Vendel is included (figs. 1–2). Vendel has been regarded as a place of transhipment for goods such as iron and furs during the Late Iron Age, situated on a major trading route that lead north from the Mälar basin and connecting Lake Mälaren (then a part of the Baltic Sea) with northern Sweden (Hyenstrand 1996). Later research indicates that, geographically, the Vendel farmlands have a position in a blind alley with its entrance facing towards the south. A more realistic route for transporting goods from the north may have been located west of Vendel (Isaksson & Seiler 1998). Vendel is situated close to Old Uppsala where the centre of power (Svеariket) was located. Vendel has a key position in the SIV project due to the presence of a boat grave cemetery and large mounds in the area. The richness of archaeological finds, especially in the boat graves, gives an indication of a upswing of the area during the Vendel and Viking Periods (c. 1500–900 BP). The potential for cattle breeding on a large scale basis may have been one of the reasons for the colonisation and importance of the area during the Vendel and Viking Periods (Seiler 1998).

Concerning the spread of the Iron Age settlements before the Migration Period in central Sweden, it is clear that there were extensive settlements in the Mälar Valley and around Old Uppsala. So far, however, evidence for continuous farming in the Vendel area before the Migration Period is lacking (Seiler 1997, Arrhenius 1998a). Several Stone Age sites have been found in the area.

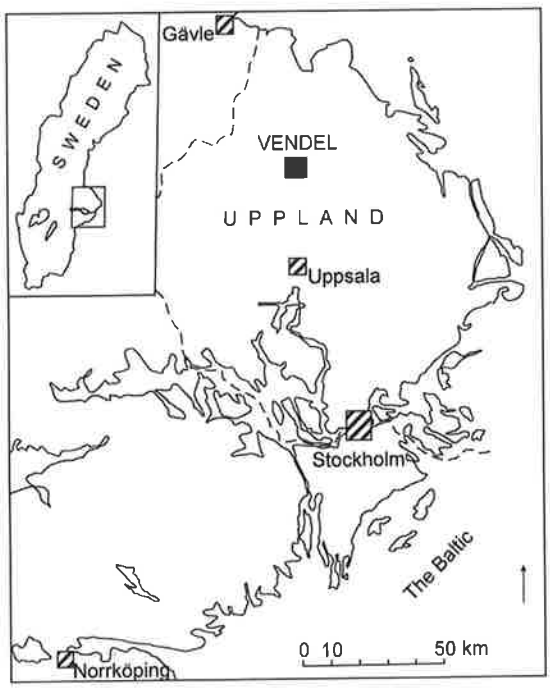


Figure 1. The Vendel area is situated in the county of Uppland c. 40 km N of Uppsala

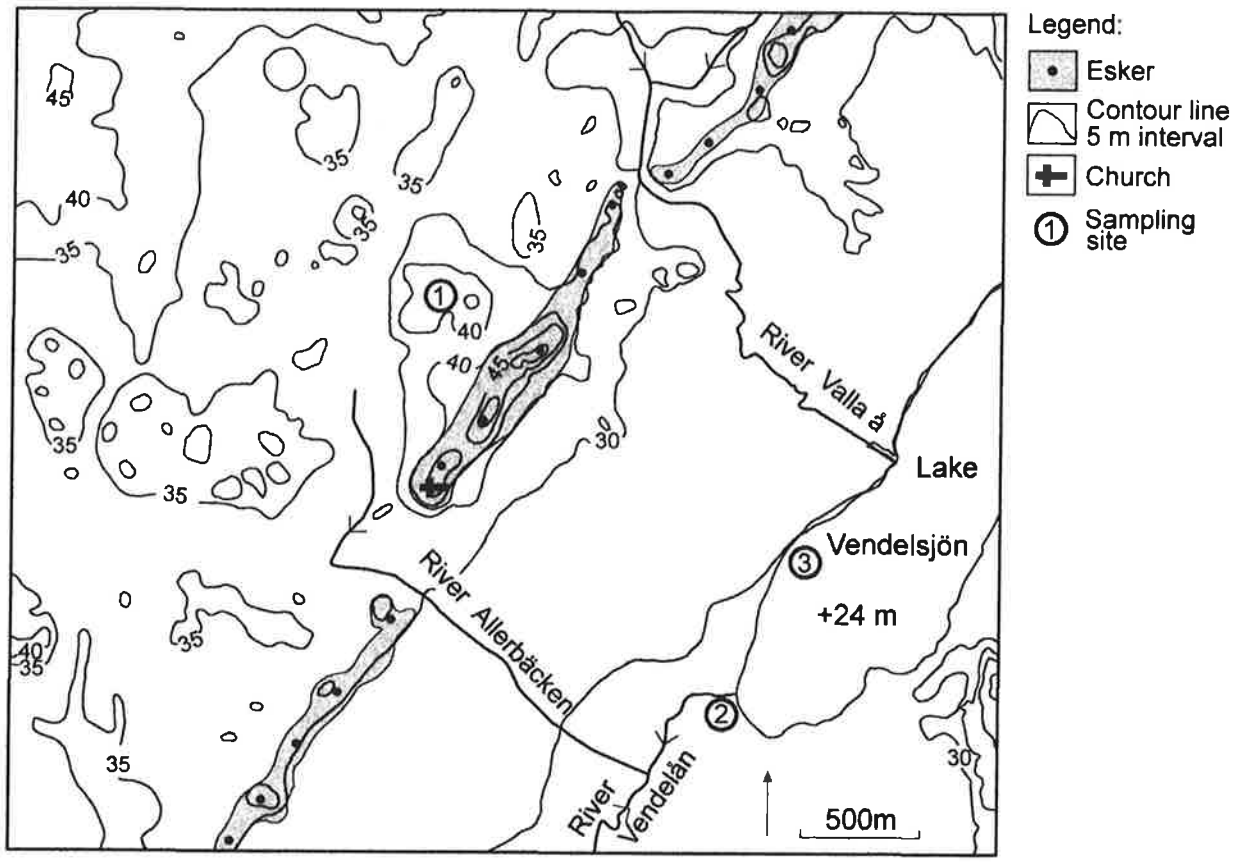


Figure 2. The fen investigated, Hovgårdsberg fen (1), is situated c. 700 m N of Vendel church. Earlier pollen investigations in the area have been carried out on a peat sequence from the outlet of Lake Vendel (2) and on the lake sediments (3) (Atkinson 1990, 1998). Topographically the Vendel area is situated at altitudes between 50 and 25 m above present sea level.

During the current archaeological excavation traces have been found of a Middle Neolithic settlement in close connection with Vendel church. Interestingly the cultural layer of the Iron Age settlement is situated directly above the Stone Age layers without traces of any Bronze Age settlement in between. There are several questions which need an answer, e.g:

1) Was the area (settlement?) abandoned during the Bronze Age?
2) While archaeological finds and, for later centuries, written sources and maps suggest that the land around Vendel was continuously farmed from the Migration Period onwards, what of the situation before this time?
3) When was the area first deforested, and when did the change from a hunter-gatherer culture to one of grazing and cultivation take place?

To answer questions about vegetation and cultivation history in the Vendel area a pollen analysis investigation has been carried out on a peat sequence from a fen in the area (fig. 2).

The Vendel area is geographically defined in the following text, see figs 1–2.

Area description

Geology

The bedrock in the Vendel area mainly consists of medium- to coarse grained granite and gnejss granites. In the southern part of Lake Vendel there is a belt of hälleflinta and leptite, which are more fine grained than the granites and are supposed to orginate from old vulcanic ash deposits. The colours of the rock types mentioned vary, from grey through red-grey to red. Massive greenstones also occur, although not in direct connection to the lake. The greenstones are all dark colored due to a high content of dark basic minerals, such as hornblende, pyroxene and biotite (Persson 1982, 1984).

The soil deposits that dominate in the area are till, mainly sandy-silty, and clay (fig. 3). The thickness of the till varies, but in the south-eastern part of Lake Vendel is 3–5 m (Persson 1982, fig. 5, p. 29). A glacifluvial deposit runs through the area in a SW–NE direction west of Lake Vendel. The deposit is a feeding esker to the Uppsala esker and is about 3 to 8 m high with a pronounced ridge. The esker contains mainly

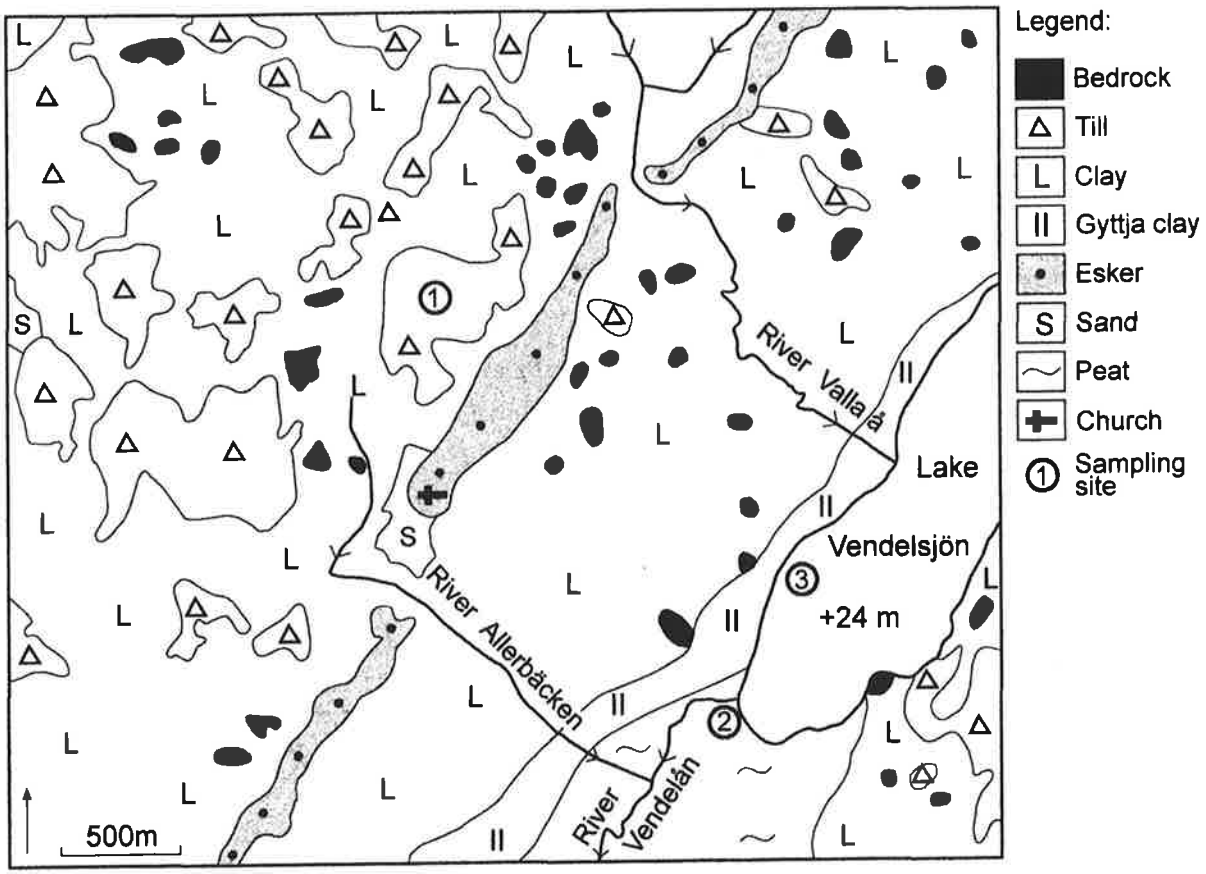


Figure 3. Simplified map showing the Quaternary deposits in the Vendel area. An esker runs through the area in a SW–NE direction. West of the esker the Quaternary deposits are dominated by till and clay, east of the esker mainly by clay. An extensive area south of Lake Vendel is covered by peat.

stony gravel with some boulders, petrographically originating from bedrock of Svecokarelian age, i.e about 2000 million years. There are elements of Cambrian and Jotnian sandstone together with Ordovician lime stone probably transported with the ice from the Gulf of Gävle. In close connection to the esker there are washed deposits of gravel, sand and silt. Glacial and postglacial clays cover a large area of the Lake Vendel depression, and such deposits also occur frequently west of the esker. Overgrowth at the outlet of the lake has lead to extensive peat accumulation around the Vendel river.

Topgraphy and recent vegetation

The Vendel area is situated in an agricultural district on altitudes between 25 and 50 m above present sea level (m a.s.l) (fig. 2). Lake Vendel, 9 km long, 0.5–1 km wide, occupies the depression east of the Vendel esker. The altitude of the lake is c. 24 m a.s.l. with an outlet to the south through the Vendelån river. The water depth of the lake is 2 m at the most (Brunberg and Blomqvist 1998, fig. 781, p. 830). Along the shores there are extensive reed belts (*Phragmites*) especially in the northern and southern parts. Behind the reed belts, willow, alder and birch (*Salix- Alnus- and Betula*) forest occupies the wetlands as a border to dryer areas. Along the outlet at the southern end of the lake there are extensive tussocks occupying the water meadows. On the western side of the lake coniferous forest and pasture land dominate. On the eastern side, pasture land is mixed with hazel and oak (*Corylus avellana, Quercus robur*).

Site description

The sampling site, a fen called Hovgårdsberg fen is located in a till area rich in boulders at Hovgårdsberg (fig. 2). The fen is situated about 700 m N of the Vendel church and c. 40–45 m a.s.l. The fen is c. 50×90 m in size, which area mainly has the character of a quagmire. A small part, c. 10×10 m, at the northern end has a continuous peat layer with a thickness of c. one metre. In connection to the fen, traces of anthropogenic activity, probably caused by ditching, were observed.

The tree vegetation in the fen is dominated by pine (*Pinus sylvestris*) and to a minor extent birch (*Betula*

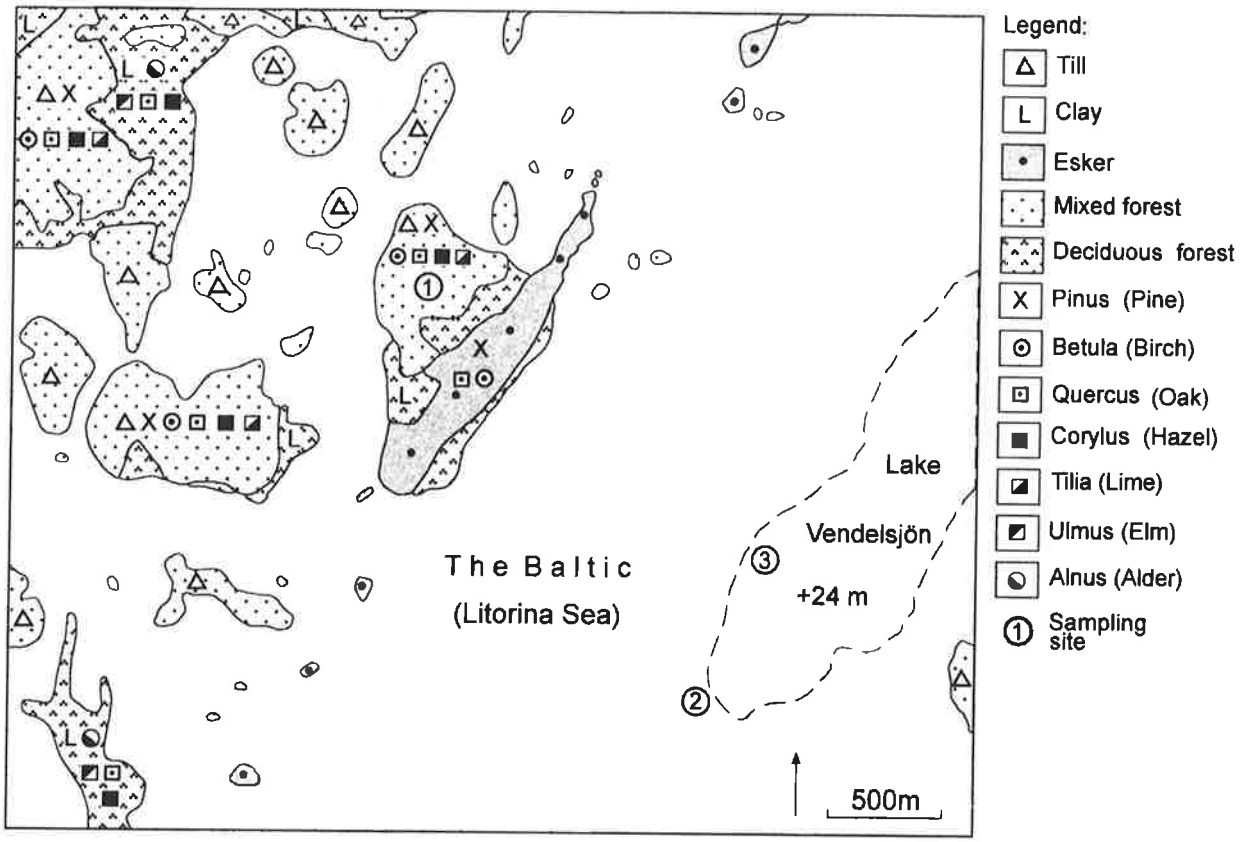


Figure 4. (4000 BP). The shoreline was located c. 35 m above present sea level. The vegetation in the area covered with till consisted mainly of pine, birch, lime and hazel (Pinus, Betula, Tilia and Corylus). Clayey, wet areas were dominated by alder and willow (Alnus and Salix) while clayey dry areas were covered by mixed deciduous forest.

pubescens). Brushwood, especially wild rosemary (*Ledum palustre*), is abundant together with cowberry, bilberry and bog whortleberry (*Vaccinium vitis-idaea, V. myrtillus, V. uliginosum*). Occasional cloudberry, bog rosemary and tussocks of harestail cotton-grass occur (*Rubus chamaemorus, Andromeda polifolia, Eriophorum vaginatum*). Along the edges of the fen especially in the northern part, birch is abundant. The fen's surroundings are occupied by spruce (*Picea abies*).

Previous pollen investigations

A pollen analysis has been carried out on material from the peaty area south of Lake Vendel (fig. 3) just south of the outflow, and at another sampling site in the south-western part of the lake (Atkinson 1990, 1998, Arrhenius et al. 1990). In time both analysed cores comprise probably the last 5000 years.

The analysed core from the lake indicates an increased anthropogenic influence in the area from 2000–1500 BP. A hiatus in the sediment between clay gyttja and gyttja clay at 80 cm depth makes the dating somewhat uncertain.

Material and methods

Fieldwork

Sampling was carried out with a so called Russian corer, one metre in length, 4.5 cm in diameter (Jowsey 1966). An attempt was made to take corings along the whole fen to get an understanding about possible differences in the lithostratigraphy between different sampling points. The small part of the fen (c. 10×10 m) which had a continuous sequence and was not of quagmire character appeared to have a similar lithostratigraphy. For that reason the lithostratigraphy only is descibed for the sampling site (Table 1).

Table 1. Lithostratigraphy in the Hovgårdsberg fen

Depth (cm)	Lithological description
0–5	*Carex* peat, highly humified
5–20	*Carex-Phragmites* peat, low degree of humification. Charcoal layer at 41cm
20–100	*Carex* peat, high degree of humification
100	Bedrock or till

Laboratory work

Subsampling for pollen analysis was carried out by cutting the sediment core in 1 cm thick slices with 2.5 cm intervals. From the subsamples 0.2–0.3 g peat has been concentrated for pollen by standard methods according to Berglund & Ralska-Jasiewiczowa (1986).

In principle this means dispersal in sodium hydroxide (NaOH), removal of possible calcium carbonate ($CaCO_3$) with hydrocloric acid (HCL), removal of cellulose with mixture of one part concentrated sulfuric acid (H_2SO_4) to nine parts acetic anhydride [$(CH_3COO)_2O$] (acetolysis) and mounting in glycerol. Spores of *Lycopodium* in tablets, each containing 12,542 spores in average, have been added to the samples, for calculation of the pollen concentration/g dry weight (Stockmarr 1971).

Pollen analysis

A total of 27 samples have been analysed regarding pollen. In each sample 300–500 pollen grains have been counted. At routine counting a magnification of 400× has been used. Identification of pollen and spores has been made using mainly Faegri & Iversen (1989), Moore et al. (1991). A reference slide collection, made at the Palynological Laboratory, Swedish Museum of Natural History, Stockholm, has also been used for comparative studies. In the basic sum (pollen sum) for percentages calculations are included: terrestrial pollen of trees, shrubs, dwarf shrubs and herbs. Pollen of aquatics, fen plants and spores of ferns, mosses and algae were excluded from the pollen sum in the relative percentage diagram.

Microscopic charcoal particles >20 micron have been counted in parallel with the pollen analysis. The charcoal particles can provide information about fires close to the sampling point, (cf. Zackrisson 1977, Singh et al. 1981, Tolonen 1986, Patterson et al. 1987, Bradshaw & Hannon 1992, Renberg et al. 1993, Almquist-Jacobson 1994).

Diagram construction

In the pollen diagram from the Hovgårdsberg fen the percentage curves (black) are enlarged tenfold (dotted) so that the low values can be seen more clearly (Appendix 2). Trees, shrubs and dwarf shrubs are presented in separate groups. Taxa regarded as indicators of human impact have been divided in ecological groups, represented by cultivated land, ruderal communities, fresh meadows, dry pastures and grazed forest.

The composition of the groups are mainly after Behre (1981), Berglund & Ralska-Jasiewiczova (1986) and Gaillard and Berglund (1988). The pollen diagram is divided into pollen assemblage zones (marked as HOV-1, HOV-2 etc.), mainly based on changes in the pollen composition. The diagram has been compiled using the Tilia computer programs, Tilia and Tilia graph (version 2.0. b.4), devised by Eric Grimm (1991a, 1991b).

In Appendix 3 the pollen diagram from Lake Vendel is presented (Atkinson 1998). The diagram is redrawn in a similar way to that from the Hovgårdsberg fen (Appendix 2) for easier comparison.

Vegetation maps

An attempt has been made to reconstruct the vegetational composition in the Vendel area by means of vegetation maps representing four time slices; 4000 BP, 1600–1200 BP, 200 BP and recent time (1979). Cartographical material used included an economical map, scale 1:10,000, an earth deposit map, scale 1:50,000, surveying maps from the end of 1700:th century and the beginning of the 1800:th century together with pollen diagrams and ^{14}C dates. Symbols for different kinds of trees on the vegetation maps mainly follow Ryberg & Drakenberg (1979a, b).

^{14}C datings

In total five ^{14}C datings have been carried out, all with accelerator mass spectrometry (AMS) at the Ångström laboratory, Uppsala University. Four bulk samples (each 1 cm thick) and one macrofossil (acorn) have been dated. The insoluble fraction (INS), which consists of primary organic matter was dated by direct ion counting (Possnert 1990). Calibrations have been done by using the calibration programme CALIB 3.0.3 (Stuvier & Pearson 1993, Pearson & Stuvier 1993). Half-life T1/2=5568±30 years has been used and is given in years BP (Before Present=1950). A correction for $\sigma^{13}C$=-25 per mill against PDB was made, the correction being given by the deviaton in the ^{13}C content of the sample compared with a standard (Possnert 1990, 1995, Olsson 1991, 1997). The results are presented in Table 2.

Table 2. Results of ^{14}C datings from the Hovgårdsberg fen.

Depth (cm)	Material dated	^{14}C dates years BP	Calibrated age BC/AD 1 sigma	Lab. Nr.	Event
24.5–25.5	fen peat	220±55	AD 1649	Ua-13440	increase of cereals
29.5–30.5	fen peat	775±55	AD 1220–1290	Ua-13805	increase of apophytes
34.5–35.5	fen peat	1390±55	AD 610–690	Ua-13806	increase of apophytes
40.5–41.5	fen peat	2290±65	398 BC	Ua-13441	immigration of spruce (Pc°)
89.5–90.5	acorn	3965±70	2465 BC	Ua-13442	earliest peat formation

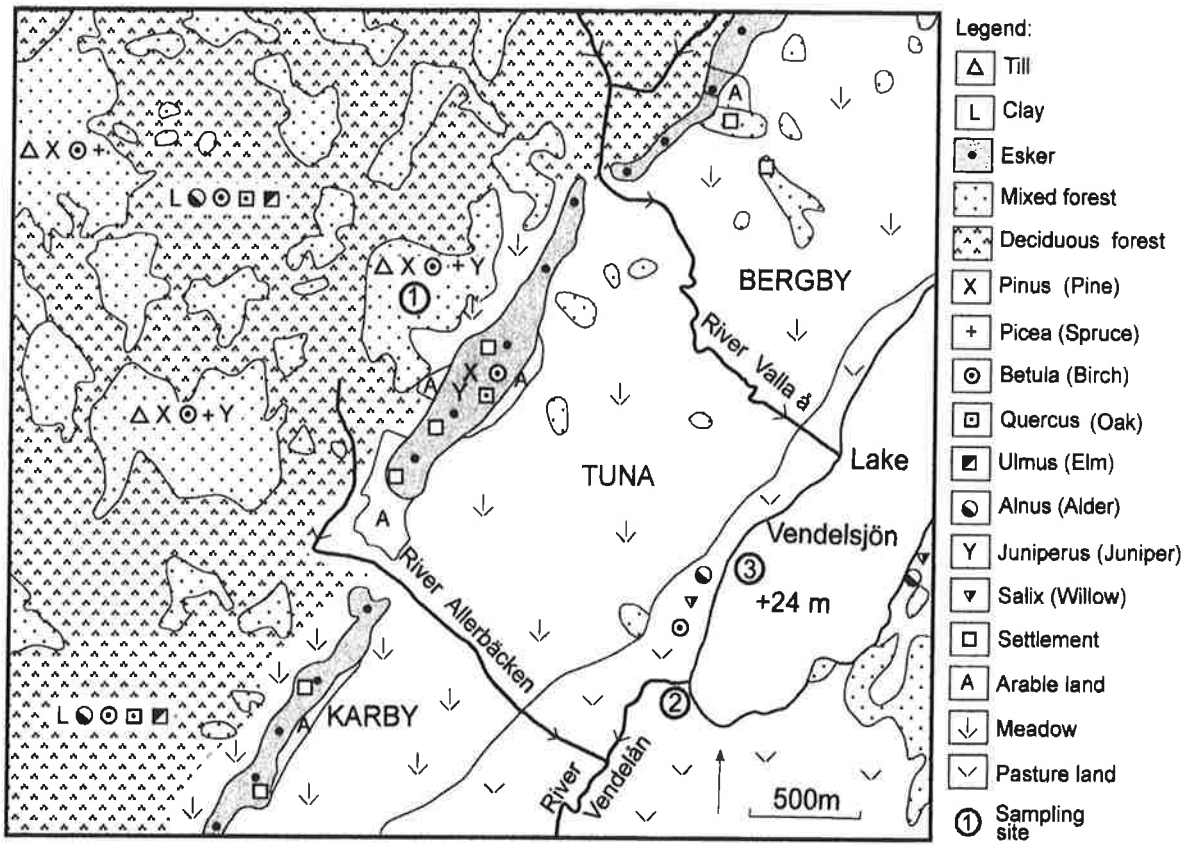


Figure 5. (1600–1200 BP). Due to the regressive shore displacement (land uplift), the sea has dissappeared from the Vendel area. Left is Lake Vendel. The areas west of the esker were probably forested, including mixed coniferous and deciduous trees on till areas and deciduous forest on clay. Settlements were mainly located on the esker itself. Three large manors existed: Bergby, Tuna and Karby. Cultivation was probably located at sandy areas on and close to the esker. The slopes facing Lake Vendel were used as meadows. The forested areas west of the esker and the shores of Lake Vendel were probably used for pasture.

Results and interpretation

The pollen diagram from the Hovgårdsberg fen is supposed to show the local vegetation history, within a radius of up to 1 km from the sampling site; because of the small size of the fen, the pollen flora mainly represents the local vegetation (cf. Tauber 1965, Moore et al. 1991). The pollen diagram is divided into three local pollen assemblage zones (HOV 13), mainly based on changes in the composition of the pollen spectra.

Zone HOV-1

100–81 cm, c. 4200–3700 BP. The first peat formation at a depth of c. 100 cm was formed in a bedrock depression around 4000 BP. The shore line is supposed to have been about 30 to 35 m higher than today according to compilation data compiled for northern Uppland (Robertsson & Persson 1989, Mikko 1995, Risberg in manuscript, Hemström 1999). A survey of the supposed vegetation composition at c. 4000 BP in the area can be seen in fig. 4. The shore line is placed at the 35 m contour line. The Vendel area is assumed to have been located at the western shore of a wide strait in the former Litorina Sea (Markus 1996, p. 19, fig. 12).

The tree vegetation on the till areas surrounding Hovgårdsberg fen was probably dominated by pine-birch forest with elements of oak, hazel and lime (*Pinus, Betula, Quercus, Corylus, Tilia*) (cf. Balsberg-Påhlsson (eds) 1984, p. 165). The occurrence of oak is verified by finds of a acorn dated to 3965±70 BP (Ua-13442). Hazel is supposed to have grown on slopes with thicker Quaternary deposits and good water supply, maybe as undergrowth to oak. North of the fen there is a relatively boulder rich area facing in a south position, suitable for a mixed deciduous forest. This area supported lime, elm and oak (*Tilia, Ulmus, Quercus*). The wet/moisty parts, directly connected to the fen contained alder (*Alnus*) together with stands of meadowsweet and sedge (*Filipendula ulmaria,* Cyperaceae). The wet clayey areas, along the fen's shores and within it were dominated by alder, while the somewhat drier parts

with clayey soils were covered in a mixed deciduous forest (QM): elm, oak and an abundance of hazel. Pine dominated the esker with elements of birch along the slopes together with deciduous forest. No traces of human activity can be seen in the pollen composition. If people occupied in the surroundings at this time they did not leave any obvious impact on the landscape.

A comparison with the uppermost parts of zone Ve-I and Ve-II in the pollen diagram from Lake Vendel (Appendix 3, Atkinson 1998) shows a dominance of pollen from pine and birch together with abundant hazel, alder and oak for corresponding periods, which means about the same composition as in the Hovgårdsberg fen.

Zone HOV-2a

81–67.5 cm, c. 3700–3200 BP. The pollen content shows an obvious change in the vegetation composition. Oak and pine markedly decrease while of birch, hazel, alder and willow increase (*Quercus, Pinus, Betula, Corylus, Alnus, Salix*). Lime (*Tilia*) has unchanged values around 5%. According to Huntley & Birks (1983) this low value reflect locally common occurrence, given that lime is pollinated by insects, has a low pollen production and a low capacity to spread. A few pollen grains have been found of ash (*Fraxinus*) and hornbeam (*Carpinus*). Dwarf shrubs are represented by heather pollen (*Calluna*) which increases in parallel with an increase in the level of charcoal particles found in the peat around 3700 BP. The increase in both values probably results from the same cause: forest fires in the surrounding areas, which provided favourable conditions for heather to develop. Whether such fires were natural or the result of a phase of forest clearing, is uncertain. No obvious signs in the herb pollen composition indicate anthropogenic activity. Pollen of plants associated with fen environments e.g. meadowsweet, bur-reed and horsetail (*Filipendula ulmaria, Sparganium, Equisetum*) increases in the 3700–3200 period.

The increase of alder, birch and willow (*Alnus, Betula, Salix*) pollen can probably be connected to wetter parts of the fen and indicate an overgrowth of the fen.

Zone HOV-2b

67.5–44 cm, c. 3200–2500 BP. The lower zone boundary has been placed where the first obvious signs of anthropogenic activity are reflected in the pollen diagram. The tree vegetation is more or less unchanged. Herbs associated with the cultural landscape occasionally appear in the form of cereals, ruderals, meadow- and pasture-land plants e.g. barley, crucifers, meadow buttercup, clover and cow-wheat (*Hordeum*-type, Brassicaceae, *Ranunculus acris*-type, *Trifolium, Melampyrum*). Cultivation can have occurred on the sandy slopes on the west side of the esker. The distance from the esker to the fen is a few hundred metres. The high values of birch and low value of pine pollen indicate a sparsely covered forest surrounding of the sampling site. There is also an increase of the charcoal particles in the peat. It is possible that the forest had a pasture-like composition with birch, oak, lime and rowan and occasional pine (*Betula, Quercus, Tilia, Sorbus aucuparia, Pinus*) suitable for grazing.

The fen was quite overgrown during this period, with typical fen plants such as buckbean, bur-reed, buckler ferns together with meadowssweet, sedges and common reed (*Menyanthes, Sparganium, Equisetum, Filipendula,* Cyperaceae (probably *Carex*) and *Phragmites*). From the fen margin peat-moss (*Sphagnum*) growth was increasing.

Zone HOV-3

44–0 cm, c. 2500–0 BP. The lower zone boundary has been placed at the level in the peat where spruce pollen (*Picea*) has a distinct increase to several percent, which shows that spruce is established in the area. A few cm upwards (41 cm) a charcoal layer has been found in the peat. The charcoal layer could indicate a fire in connection with clearance of the area but it could also have been caused by a natural forest fire. The peat at 41 cm is radiocarbon dated to 2290±65 BP (Ua-13441). Oak, hazel, lime and elm seems appears to become more scarce with the spread of the spruce. Exactly the same vegetation change can be seen in the diagram from Lake Vendel (Appendix 3) at the zone border Ve-III and Ve-IV at the 73 cm level. Whether this alteration is due to a general climate change or anthropogenic activity is uncertain. Fries (1962, p. 90) noted the same phenomena in Lake Ösby, in southern Uppland, and suggested that the spruce had invaded areas deforested of oak and hazel. In connection to the charcoal layer in the peat at 41 cm, there is a short increase of birch pollen to 60%, after which it more or less continuously decreases to c. 20% in the upper part of the zone.

An opposite trend is shown in the content of pine pollen, which increases towards the upper part of the peat layer. If in this case the carbon layer suggests anthropogenic deforestation in order to exploit the land, the later increase in pine could result from overgrowth of those areas which proved unproductive to cultivate. Alternatively, the increase of pine may also indicate that the landscape in general became more open, allowing wind-blown pine pollen to spread further and more effectively across it. The increase in juniper (*Juniperus*) pollen at a depth of 35 cm can also be taken as evidence that such a change occured, juniper being a tree that thrives in less overgrown conditions. At the same depth in the peat layer there is a marked increase in the number of taxa associated with anthropogenic activity.

The peat is dated to 1390±55 BP (Ua-13806) which corresponds to the Vendel Period (c. 1400–1200 BP). A similar increase in taxa indicating human impact can be seen in the pollen diagram from Lake Vendel, where

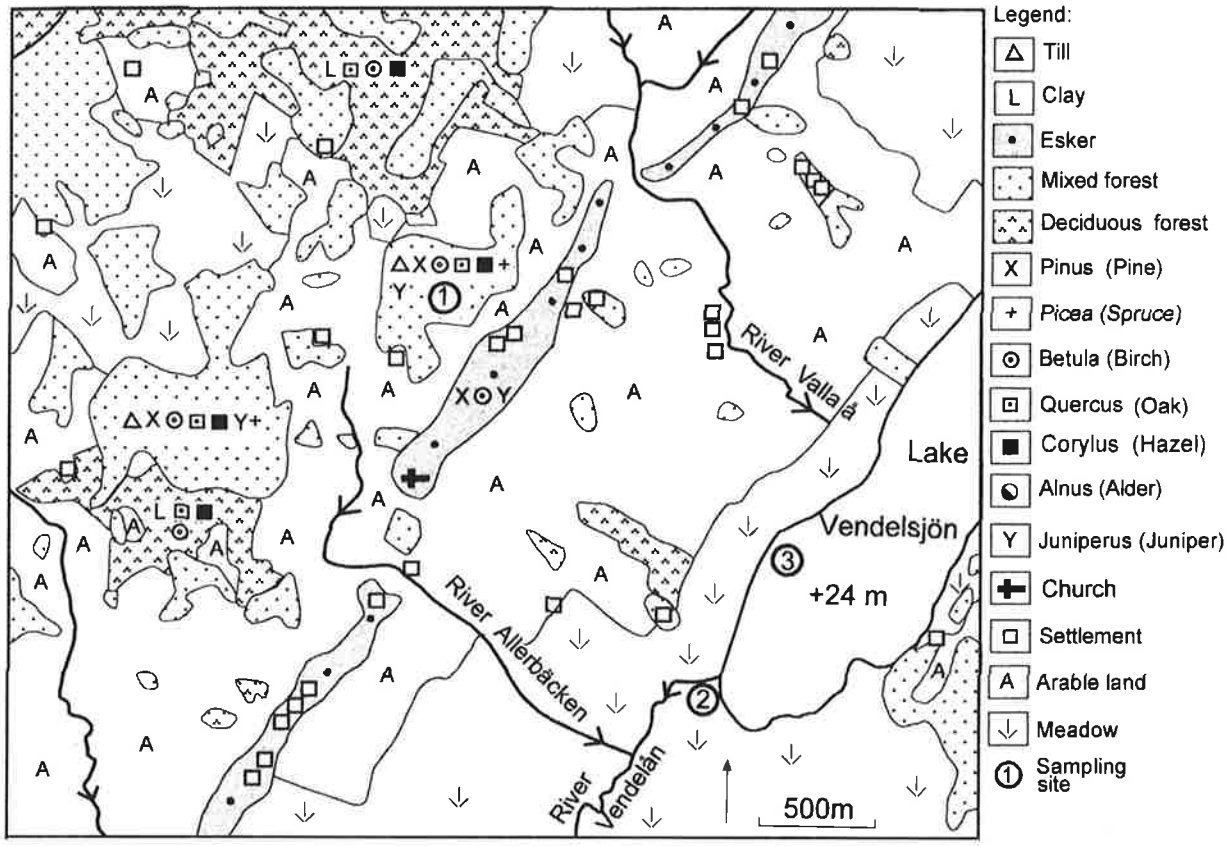


Figure 6. (200 BP). Areas both west and east of the esker were put under the plough. Cultivation of cereals was extended from the sandy areas on the esker to the clay areas. Meadows were mainly located along Lake Vendel. Parts of the till areas were transformed to pasture land and were covered with scattered deciduous trees and shrubs, e.g. birch, oak, hazel and juniper (Betula, Quercus, Corylus, and Juniperus).

three ^{14}C datings have given ages between 1500 and 1300 BP (Appendix 3, Atkinson 1998).

For the time slices 1600–1200 BP, approximately corresponding to the Migration-Vendel Period, it is assumed that the area west of the esker was mainly covered by mixed coniferous forest on till areas and deciduous forest on clay (fig. 5). Settlements were located on the Vendel esker (cf. Seiler 1997, fig. 2, p. 63). These were connected to three manors, Bergby in the north, Tuna south of Bergby bordered by the Valla river, and in the south Karby, where the Allerbäcken river formed the border to Tuna (fig. 5). Karby was probably not established before the Vendel Period (Arrhenius pers. com.). Primitive farming implements limited the kind of soil that could be used for cultivation, and arable land was located on the sandy slopes of the esker. Not until the 13–14th centuries with the introduction of the iron-edged spade, would it be possible to ditch and cultivate heavy clay soils on a large scale basis (Myrdal 1985).

With the pollen diagrams from both the Hovgårdsberg fen and Lake Vendel it has been assumed that the slopes towards Lake Vendel east of the esker, as well as small parts west of the esker, were occupied by meadows. Pasture land was probably located adjacent to Lake Vendel, particularly in the areas west and south of the lake. It is also likely that cattle were grazed in the forests west of the esker.

An increase in pollen from cereals occurs around 25 cm depth, where pollen from barley (*Hordeum*) as well as wheat and rye (*Triticum, Secale*) are found. A ^{14}C date of the peat at 25 cm gave an age of c. 200 BP. This date fits well with the evidence provided by cartographical material recording the farming history of the Vendel area during the 17th and 18th centuries. Such maps show that this time large areas both east and west of the esker were put under the plough; the nutrient rich clay soils, rather than the sandy soils on the esker, were now used for arable land, a change which is logical given the developing technical possibilities for drainage and ploughing (fig. 6).

Meadows were located on the shores of Lake Vendel, and in a few larger areas south of the lake and west of Hovgårdsberg fen. Pasture land for grazing is also marked on the older cartographical material, especially in

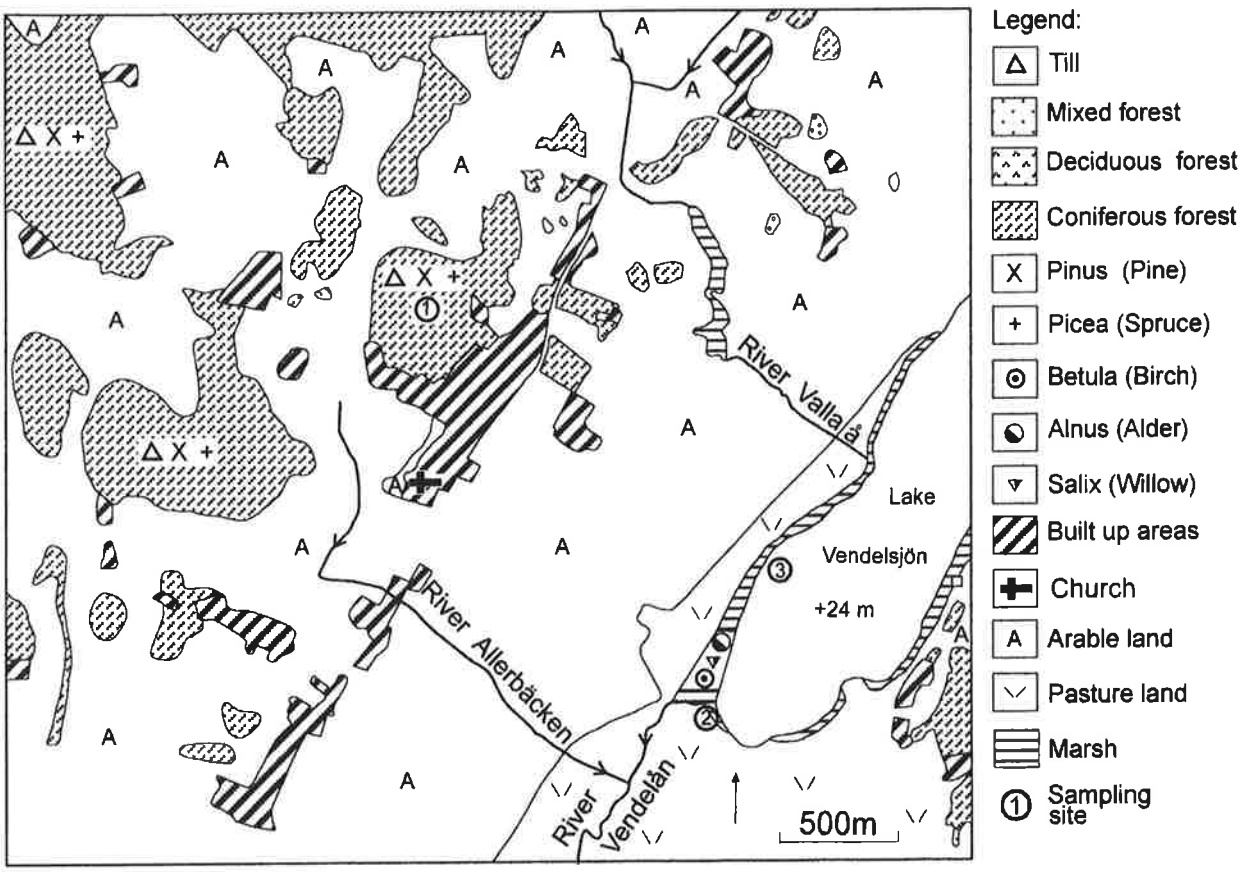


Figure 7. (recent; 1979). Today the Vendel area is characterized by large cultivated fields on the clayey areas. The fields are alternatively used for cultivation of cereals, haymaking or grazing, although the water meadows along Lake Vendel are still used for grazing. Natural meadows do not exist in the area today. On the areas covered by till, pasture land has been replaced by coniferous forest.

connection to till areas, and was commonly contained with occasional deciduous trees and shrubs; juniper (*Juniperus*) was common (Gustawsson 1970). This change is also clearly reflected in the pollen diagram from the Hovgårdsberg fen. On the maps from the 18th century the till area surrounding the fen is marked as pasture land. In the cartographical material a cattle path is also shown, leading from the esker to grazing areas west of the esker. Occasional coniferous trees could have grown in the pasture land. Increasing values for pine and cowberry/bilberry (*Pinus, Vaccinium myrtillus/V. vitis-idaea*) in the pollen diagram from the Hovgårdsberg fen indicate that the pasture land started to take on the appearance it has today – a closed pine-spruce dominated coniferous forest with a field layer dominated by cowberry vegetation (*Vaccinium myrtillus*).

Current land use in the Vendel area has changed this landscape. The meadowlands, formerly cut to provide winter food for cattle, are used for forest cultivation, arable fields or pasture land (fig. 7). Overall, arable land forms a large part of the recent Vendel area. The arable fields are alternatively used for cereal production, haymaking and grazing. At till areas the former pasture vegetation has been replaced by coniferous forest – pine on the driest and poorest parts, and spruce in depressions where the soil is thicker.

Discussion

The oldest traces of cultivation and grazing are reflected in the pollen diagram from the Hovgårdsberg fen at 65 cm, corresponding to c. 3000 BP by interpolation between existing radiocarbon dates. Above 65 cm, traces of human impact are pronounced in the diagram at c. 45 cm (c. 2500 BP) and continuously from 35 cm, dated to c. 1400 BP corresponding to the Vendel Period. On these levels there is an obvious increase in plants from cultivated land, ruderal communities and fresh meadows, correspondingly. Consequently the human impact on the surroundings of Hovgårdsberg fen is interpreted to have been sporadic during the Bronze Age and the Early Iron Age and continuous from the Late Iron Age on (cf. pollen diagram Appendix 2–3). The dominating cereal seems to have been barley (*Hordeum*),

which from its first appearence in the pollen composition during the Bronze Age has been the most continuously cultivated cereal. Pollen grains of wheat (*Triticum*) have been found in the peat dated to the early Medieval Period and later, but must have been in use earlier in the Vendel area as wheat occurs as macrofossil in layers from the Vendel Period. In the pollen diagram from Lake Vendel cereals are evident at least from the Bronze Age. Their species has not been determined but they were probably in large part barley (*Hordeum*). The dominance of barley is suggested by the results from macrofossil analyses of samples from the area (Hjelmqvist 1955, 1990, Hansson 1997). Barley has been found in graves, from settlements and as imprinted in pottery dated to the Migration Period, Vendel Period, Viking Age and the Medieval Period (c. 1600–500 BP).

The size of arable fields, meadows and pasture land for the Vendel area is discussed by Seiler (1997, p. 66). He state that at least 200 hectares wet meadows have been available for the manors of Tuna, Karby and Husby situated south of Karby. The area of these meadows should be enough to give winter fodder to at least 120 cattle (Broberg 1990, Borgegård 1996). The "Seiler hypothesis" is that large scale farming was practised in the Vendel area already in the Vendel Period. According to the pollen diagram from Lake Vendel this seems to be possible. Therefore the main part of the area east of the Vendel esker has been marked as meadow (cf. fig. 5).

If the ^{14}C dates for the 41 and 25 cm levels are correct, the large difference between them suggests that, at least in this area, the peat is highly compressed. The accuracy of the datings for the strata of peat through this thickness can be confirmed by comparison with other data, particularly by looking for characteristic signatures of pollen content dated to various periods in other examples. Thus, for example, the dating at 41 cm, 2290±65 BP (Ua-13441), which corresponds to a dramatic increase in the level of spruce pollen, is corroborated by a similarly dated upswing in spruce pollen content in the investigation att Lake Vendel. Similarly, the 35 cm level, dated to 1390±55 BP (Ua-13806) and corresponding to the Vendel Period, shows an upswing in the content of pollen associated with human activity that is again reflected in the samples taken at Lake Vendel.

The 30 cm level, dated to 775±55 BP (Ua-13805) and corresponding to the Early Medieval Period, also contains a pollen signature: ribwort plantain and juniper (*Plantago lanceolata, Juniperus communis*) have a higher content which appears logical given the expansion in pasture land that is known to have occured at that time. Only the date at 25 cm, 220±55 BP (Ua-13440) appears to fall outside this pattern, and seems to be much too young, a result which could arise through its contamination with younger rootlets (cf. Appendix 2 and 3).

Summary

In connection with archaeological investigations in Vendel, northern Uppland, a pollen analytical investigation has been carried out on a peat sequence from the Hovgårdsberg fen (figs. 1–2). When the peat accumulation started at c. 4000 BP, the fen basin was situated together with the Vendel esker on a large island along the western part of a broad strait in the former Litorina Sea (fig. 4). The shore line was situated c. 35 m above present sea level. The vegetation on till areas was dominated by pine and birch with elements mainly of oak and lime (*Pinus, Betula, Quercus, Tilia*). On clay areas mixed deciduous forest occured (QM = Quercetum mixtum) with hazel (*Corylus*) as a common element. Wet parts of the clayey areas were dominated by alder and willow (*Alnus, Salix*).

About 3000 BP Lake Vendel was isolated from the Litorina Sea. The immigration of spruce to the area occurred c. 2500 BP or slightly earlier. In the pollen material from the Hovgårdsberg fen there are traces of occasional clearance in the area, suggesting land was used for grazing and possible for cultivation from approximately 3000 BP – 2500 BP. From 1400 BP, corresponding to the Vendel Period and onwards, an increase of the number of plant taxa associated with human impact occur, indicating a continuous opening up of the landscape. Mixed deciduous forest, as well as alder, show a marked decrease, which indicates an obvious change in land use (fig. 5).

Settlements belonging to the manors of Bergby, Tuna and Karby were mainly located on the Vendel esker during Migration/Vendel Period (c. 1600–1200 BP). Although Karby was established first during the Vendel Period. Cultivation occured on the sandy slopes of the esker. East of the esker there were probably large meadows along the slopes of Lake Vendel. Grazing probably occured in the forest west of the esker and on the wetlands around the lake. From the Medieval Period onwards the landscape was extensively modified transforming the clayey areas to arable fields and till areas to pasture land (fig. 6). Today the pasture land is covered to a large extent with coniferous forest. Meadows have disappeared and instead the arable fields have been extended and are used alternatively for cereal cultivation, as well as haymaking and grazing (fig. 7).

Acknowledgements

The author is indebted to following persons from the Archaeological Research Laboratory and the Department of Quaternary Research, Stockholm University, who have contributed to the investigation in different ways: Birgit Arrhenius who initiated the investigation, Kjell Persson for participating in the field work, Anton Seiler for providing old cartographical maps. Ivan Romero carried out the laboratory work, Ann-Marie Robertsson and Urve Miller commented on the

manuscript. Tim Anstey revised the English. The Bank of Sweden Tercentenary Foundation provided financial support.

References

Almquist-Jacobson, H., 1994. *Interaction of the Holocene climate, water balance, vegetation, fire, and the cultural land-use in Swedish Borderland.* LUNDQUA Thesis 30, Lund University, Department of Quaternary Geology.

Arrhenius, B. 1998a. Arkeologernas forskning i Vendel just nu (hösten 1997). *Vendelkråkan. Vendels Hembygdsförenings Årsskrift* 1998, 16–20.

Arrhenius, B. 1998b. Bebyggelsestrukturen i det förhistoriska Vendel och järnålderns mångmannagårdar. *Centrala Platser – Centrala frågor. En vänbok till Berta Stjernqvist.* Uppåkrastudier 1. Lund. 179–187.

Arrhenius, B., Atkinson, H. & Miller, U., 1990. Vegetational development in Vendel and Sutton Hoo. *Norwegian Archaeological Review* 23:1–2, 60–64.

Arrhenius, B. & Eriksson, G., 1997: *SIV – Svealand i Vendel och Vikingatid. Studier från delprojekten vid Stockholms universitet.* Arkeologiska forskningslaboratoriet, Stockholms universitet.

Atkinson, H., 1990. The boat grave studies of Sutton Hoo and Vendel – a palaeoenvironmental study. *Norwegian Archaeological Review* 23:1–2, 65–78.

Atkinson, H., 1998. Land use and the natural environment during the late Iron age in Vendel, eastern Svealand, Sweden. In: C. A. Livadie and F. Ortolani (eds): *Il sistema uomo-ambiente tra passato e presente.* Centro Universitario Europeo per i beni culturali, Ravello. Bari 1998. 147–158.

Balsberg-Påhlsson, A.-M. & Påhlsson, L., (eds.)., 1984. *Vegetationstyper i Norden.* Nordiska Ministerrådet.

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

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

Borgegård, S.O., 1996. Söderboda på Gräsö i Uppland – ett idag unikt fodermarkslandskap. I: H. Slotte & H. Göransson (ed.). *Lövtäkt och stubbskottsbruk. Människans förändring av landskapet – boskapsskötsel och åkerbruk med hjälp av skog.* Del 1. Kungliga skogs- och Lantbrukakademien. Stockholm. 39–51.

Bradshaw, R. H. W. & Hannon, G., 1992. Climatic change, human influence and disturbance regime in the control of vegetation dynamics within Fiby Forest, Sweden. *Journal of Ecology* 80. 625–632.

Broberg, A., 1990. Bönder och samhälle i statsbildningstid. En bebyggelsearkeologisk studie av agrarsamhället i Norra Roden 700–1350. *Upplands Fornminnesföreningens Tidskrift* 52. Uppsala.

Brunberg, A.-K. and Blomqvist, P., 1998. *Vatten i Uppsala län* 1997. Beskrivning, utvärdering, åtgärdsförslag. Rapport 8/1998. Upplandsstiftelsen, Uppsala.

Faegri, K. & Iversen, J., 1989. *Textbook of pollen analysis*, 4th edition. (Revised by K. Faegri, P.E. Kaland & K. Krzywinski). Chichester.

Fitter, R. S. R., 1971: *Finding wild flowers. A practical handbook to plant-hunting in Britain and a county-by-county guide.* London.

Fries, M., 1962: Studies of the sediments and the vegetational history in the Ösbysjö basin north of Stockholm. *OIKOS* 13:1, 76–96.

Gaillard, M.-J. & Berglund, B.E., 1988. Land-use history during the last 2700 years in the area of Bjäresjö, southern Sweden. In: H.H., Birks, H.J.B., Birks, P.E., Kaland & D. Moe (eds.) 1988: *The cultural landscape. Past, present and future.* Cambridge.

Godwin, H., 1984. *History of British flora. A factual basis for phytogeography.* Second edition. Cambridge.

Grimm, E.C., 1991a: *TILIA 2.00.* Illinois State Museum, Research & Collections centre, 1920 South 10½ St., Springfield, IL 62703, USA.

Grimm, E.C., 1991b. *TILIA GRAPH 1.25.* Illinois State Museum, Research & Collections centre, 1920 South 10½ St., Springfield, IL 62703, USA.

Gustawsson, K.A., 1970: *Fornminnesvård.* 2:a upplagan.

Hansson, A.-M., 1997. Arkeobotaniska undersökningar i Vendel och Valsgärde. *SIV – Svealand i Vendel- och Vikingatid. Studier från delprojekten vid Stockholms universitet.* (eds.): B. Arrhenius & G. Eriksson. Arkeologiska forskningslaboratoriet. Stockholms universitet, 5–14.

Hemström, S., 1999. Fördelningen land-hav i östra Mellansverige 7000 BP med hänsyn tagen till olikformig isostasi. B.A thesis. QUATERNARIA B 15. Kvartärgeologiska institutionen, Stockholms universitet.

Hjelmqvist, H., 1955. *Die älteste Geschichte der Kulturpflanzen in Schweden.* Opera Botanica 1:3. Stockholm.

Hjelmqvist, H., 1990. Über die Zusammensetzung einiger prähistorischer Brote. *Fornvännen* 85, 9–21.

Huntley, B. & Birks, H.J.B., 1983. *An atlas of past and present pollen maps for Europe: 0–13000 years ago.* Cambridge.

Hyenstrand, Å., 1996: *Lejonet, draken och korset. Sverige 500–1000.* Lund.

Isaksson, S. & Seiler, A., 1998: Landscape, settlement and visibility. Some thoughts on the location of an Iron-Age manor. *Laborativ arkeologi* 10–11. Archaeological Research Laboratory 1998, Stockholm University, 27–33.

Jowsey, P.C., 1966. An improved peat sampler. New Phytologist 65, 245–248.

Launert, E., 1984. *The country life guide to edible and medicinal plants of Britain and northern Europe.* Middlesex.

Markus, F., 1996. Neolitikum i Vendel. *CD-uppsats i laborativ arkeologi 95/96, del 1.* Arkeologiska forskningslaboratoriet, Stockholms universitet.

Mikko, H., 1995. Fish and seal remains in Skattmansöådalen – A chronological and palaeoenvironmental evaluation of the finds. Uppsala University. Department of Quaternary Geology. Unpublished licentiate thesis.

Moore, P. D, Webb, J. A & Collinson, M. E., 1991. Pollen analysis. Second edition. Blackwell Scientific Publications, Oxford.

Myrdal, J., 1985. *Medeltidens åkerbruk. Agrarteknik i Sverige ca 1000 till 1520.* Nordiska Museets Handlingar 105. Borås. Dissertation. Stockholm university.

Olsson, I.U., 1991. Accuracy and precision in sediment chronology. *Hydrobiologia* 214, 25–34.

Olsson, I.U., 1997. *Kol-14 datering. Metoden och diskussion av speciella problem med isländska prov och redovisning av två serier dateringar av arkeologiskt material.* The Åsa G. Wright Memorial Lectures IX. National Museum of Iceland.

Patterson III, W. A., Edwards, K. J. & Maguire, D. J., 1987. Microscopic charcoal as a fossil indicator of fire. *Quaternary Science Reviews* 6, 3–23.

Pearson, G.W and Stuvier, M., 1993. High-precision bidecadal calibration of the radiocarbon time scale, 500–2500 BC. *Radiocarbon* 35, 25–33.

Persson, Ch., 1982. Beskrivning till jordartskartan 12 I Östhammar SV. *Geological Survey of Sweden*, Ae 53.

Persson, Ch., 1984. Beskrivning till jordartskartan 12 I Östhammar NV. *Geological Survey of Sweden,* Ae 61.

Possnert, G., 1990. Radiocarbon dating by the accelerator

technique. *Norwegian Archaeological Review* 23, 30–37.
Possnert, G., 1995. Datering med acceleratorer. *KOSMOS 1995*. Svenska Fysikersamfundet, 163–179.
Renberg, I., Korsman, T. & Birks, H. J. B., 1993. Prehistoric increases in the pH of acid-sensitive Swedish lakes caused by land-use changes. *Nature* 362, 824–826.
Risberg, J. Manuscript. Strandförskjutningen i NV Uppland under Subboreal. Kvartärgeologiska institutionen, Stockholms universitet.
Robertsson, A.-M., & Persson, Ch., 1989. Biostratigraphical studies of three mires in northern Uppland, Sweden. *Geological Survey of Sweden*, C 821.
Ryberg, M. & Drakenberg, B., 1979a. *Anvisningar för kartering av terrester vegetation.* Del I. Bergianska Stiftelsen. Kungliga Vetenskapsakademien.
Ryberg, M. & Drakenberg, B., 1979b. *Anvisningar för kartering av terrester vegetation.* Del II. Bergianska Stiftelsen. Kungliga Vetenskapsakademien.
Seiler, A., 1997. Bebyggelsearkeologiska studier kring Vendels sockens förhistoria. En första redogörelse. *SIV – Svealand i Vendel- och Vikingatid. Studier från delprojekten vid Stockholms universitet.* (eds.): B. Arrhenius & G. Eriksson. Archaeological Research Laboratory, Stockholm University, 61–68.
Singh, G., Kershaw, A. P. & Clark, R., 1981. Quaternary vegetation and fire history in Australia. In: A. M. Gill, R. H. Groves, & I. R. Noble (eds): *Fire and the Australian biota.* Australian Academy of Science, Canberra, 23–54.
Stockmarr, J., 1971. Tablets with spores used in absolute pollen analysis. *Pollen et Spores*, XIII, 4. 615–621.
Stuvier, M and Pearson, G.W., 1993. High-precision bidecadal calibration of the radiocarbon time scale, AD 1950–500 BC and 2500–6000 BC. *Radiocarbon* 35, 1–23.
Tauber, H., 1965. Differential pollen dispersion and the interpretation of the pollen diagrams. *Danmarks Geologiske Undersøgelse* II 89.
Tolonen, K., 1986. Charred particle analysis. In: B. E. Berglund (ed.): *Handbook of Holocene Palaeoecology and Palaehydrology.* Chichester, 485–496.
Zackrisson, O., 1977. Influence of forest fire on the north Swedish boreal forest. *Oikos* 29, 22–32.

Cartographical material

Apelskog, J., 1720: Arealafmätning, Torsmyra, skala 1:4000. Conceptkarta, Lantmäteriet, Uppsala.
Apelskog, J., 1721: Arealafmätning, Norrby och Åkerby, skala 1:4000. B75:55–1, Lantmäteriverket, Gävle.
Apelskog, J., 1721: Skogsmätning, Ål, skala 1:4000. Conceptkarta, Lantmäteriet, Uppsala.
Berg, d.ä K.F & Psilander, D.K., 1775–76: Storskifteskarta, Valla, skala 1:8000. Conceptkarta, Lantmäteriet, Uppsala.
Braun, J., 1702: Ägoafmätning, Stora Enen, skala 1:4000. Conceptkarta, Lantmäteriet, Uppsala.
Braun, J., 1705: Geometrisk afmätning, Lamyra, skala 1:4000. Conceptkarta, Lantmäteriet, Uppsala.
Braun, J., 1712: Ägoafmätning, Prästgården, skala 1:4000. B75:76–1, Lantmäteriverket, Gävle.
Braun, J., 1729: Geometrisk afmätning, Kättslinge, skala 1:4000. Conceptkarta, Lantmäteriet, Uppsala.
Elvius, P., 1695: Geometrisk afmätning, Allerbäcke, skala 1:4000. Conceptkarta, Lantmäteriet, Uppsala.
Enberg, C., 1698: Arealafmätning, Bergby, skala 1:4000. Conceptkarta, Lantmäteriet, Uppsala.
Grånäs, K., 1990: Jordartsgeologiska kartbladet 12H Söderfors SO, Sveriges Geologiska Undersökning, serie Ae 104, skala 1:50 000. Uppsala.
Hesselgren, 1696: Arealafmätning, Kläringe, skala 1:4000. Conceptkarta, Lantmäteriet, Uppsala.
Lantmäteriet., 1979: Ekonomisk karta över Sverige. Uppsala län. 12 H 4 j Vendel. Skala 1: 10 000. Statens Lantmäteriverk, Gävle.
Lantmäteriet., 1979: Ekonomisk karta över Sverige. Uppsala län. 12 I 4 a Kättslinge. Skala 1: 10 000. Statens Lantmäteriverk, Gävle.
Persson, Ch., 1982: Jordartskartan 12 I Östhammar SV. Sveriges Geologiska Undersökning, Ae 53, skala 1:50 000. Uppsala.
Persson, Ch., 1984: Jordartskartan 12 I Östhammar NV. Sveriges Geologiska undersökning, Ae 61, skala 1:50 000. Uppsala.
Pettersson, A.L.TH., 1871: Bladet "Salsta", Sveriges Geologiska Undersökning, serie Aa 43, skala 1:50 000. Stockholm.
Prosperius, E., 1702: Arealafmätning, Karby, skala 1:4000. Conceptkarta, Lantmäteriet, Uppsala.
Psilander, D.K., 1776–77: Storskifteskarta, Fånby, skala 1:8000. Conceptkarta, Lantmäteriet, Uppsala.
Svebel, G., 1702: Arealafmätning, Hamra, skala 1:4000. Conceptkarta, Lantmäteriet, Uppsala.
Svebel, G., 1702: Geometrisk afmätning, Hovgårdsberg, skala 1:4000. B75:42–1, Lantmäteriverket, Gävle.
Svebel, G., 1702: Geometrisk afmätning, Kullbol, skala 1:4000. Conceptkarta, Lantmäteriet, Uppsala.
Svebel, G., 1703: Geometrisk afmätning, Gärdsmyra, skala 1:4000. Conceptkarta, Lantmäteriet, Uppsala.
Svebel, G., 1703: Arealafmätning af alla ägor, Brundby, skala 1:4000. Conceptkarta, Lantmäteriet, Uppsala.
Svebel, G., 1703: Arealafmätning, Lilla Enen, skala 1:4000. Conceptkarta, Lantmäteriet, Uppsala.

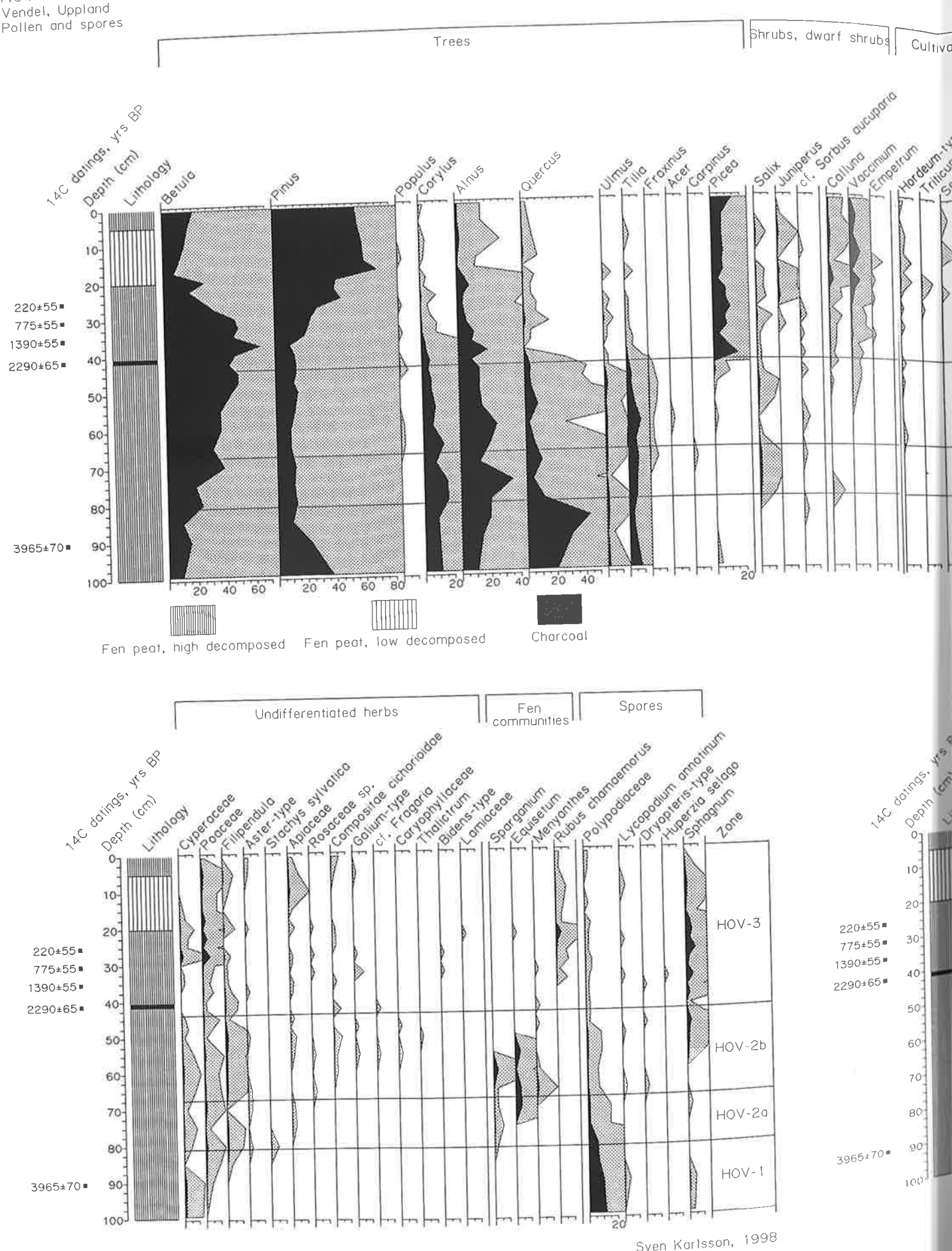
Appendix 1

List of identified pollen, spores and algae from Hovgårdsberg fen (this investigation) and Lake Vendelsjön (Atkinson 1994). The latin and swedish names mainly follows Mossberg, Stenberg & Ericsson (1992), the english names have been found in Godwin (1975), Fitter (1980), Launert (1984). (Cf. pollendiagrams in appendix 2 and 3.)

Latin	Swedish	English
	TRÄD	TREES
Acer	lönn	Maple
Alnus	al	Alder
Betula	björk	Birch
Carpinus	avenbok	Hornbeam
Corylus	hassel	Hazel
Fagus	bok	Beech
Fraxinus	ask	Ash
Picea	gran	Spruce
Pinus	tall	Pine
Populus	asp	Aspen
QM=Quercetum mixtum	ekblandskog	Mixed deciduous forest
Quercus	ek	Oak
Tilia	lind	Lime
Ulmus	alm	Elm
	BUSKAR	SHRUBS
Juniperus	en	Juniper
Salix	sälg, vide	Willow
Sorbus cf. aucuparia	rönn	Rowan, Mountain ash
	DVÄRGBUSKAR	DWARF SHRUBS
Calluna vulgaris	ljung	Heather, Ling
Empetrum	kråkbär	Crowberry
Vaccinium	blåbär, lingon m.fl	e.g. Cowberry, Bilberry
	ODLAD MARK	CULTIVATED LAND
Avena-type	havre	Oat
Cannabaceae	hampa, humle	Hemp, Hop
Centaurea cyanus	blåklint	Cornflower
Cerealia sp.	sädesslag	Cereal
Hordeum-type	korn	Barley
Secale cereale	råg	Rye
Triticum-type	vete	Wheat
	RUDERATSAMHÄLLEN	RUDERAL COMMUNITIES
Artemisia	gråbo, malört	e.g Mugwort
Brassicaceae	korsblommiga	Crucifers
Chenopodiaceae	mållor	Goosefoot Family
Epilobium angustifolium	mjölkört	Rosebay Willow-herb
Plantago lanceolata	svartkämpar	Ribwort plantain
Plantago major/media	groblad, rödkämpar	Great/Hoary plantain
Rumex acetosa/acetosella	ängssyra, bergssyra	Sorrel/Sheep's sorrel
Urtica	nässlor	Nettle
	FRISKÄNG	FRESH MEADOW
Anthemis-type	kulla, röllika	e.g. Mayweed, Yarrow
Centaurea jacea	rödklint	Knapweed
Cirsium sp.	tistlar	Thistles
Fabaceae (Leguminosae)	ärtväxter	Legume Family
Potentilla-type	fingerörter	Cinqefoil, tormentil
Ranunculaceae	ranunkelväxter	e.g Buttercup

Latin	Swedish	English
Ranunculus acris-type	smörblommor	Meadow buttercup
Succisa pratensis	ängsvädd	Devilsbit Scabious
Trifolium sp.	klöver	Clover
Vicia cracca-type	kråkvicker m fl	e.g. Tufted Vetch
	TORRÄNG	DRY PASTURE
Campanula-type	blåklockor	Bellflowers
Cerastium-type	hönsarv m fl	e.g. Mouse-ear Chickweed
Juniperus communis	en	Juniper
	SKOGSBETE	GRAZED FOREST
Anemone	sippor	e.g. Wood Anemone
Melampyrum	kovall	Cow-wheat
Pteridium aquilinum	örnbräken	Bracken
	ÖVRIGA ÖRTER	INDIFFERENT. HERBS
Apiaceae, Umbelliferae	flockblomstriga	Umbellifer Family
Aster-type	tussilago m fl	e.g. Coltsfoot
Bidens-type	skäror	Bur-marigold
Caryophyllaceae	nejlikväxter	Pink Family
Compositae cichorioideae	maskrosor m fl	e.g. Dandelion
Compositae tubuliflorae	korgblommiga	Composite Family
Cyperaceae	halvgräs	Sedges
cf. Fragaria vesca	smultron	Wild Strawberry
Filipendula	älgört, brudbröd	Meadowsweet, Dropwort
Galium-type	måror	Bedstraw
Lamiaceae, Labiatae	kransblommiga	Labiates Family
Poaceae, Gramineae	gräs exkl. sädesslag	Grass excl. Cereals
Rosaceae	rosväxter	Rose Family
Rumex cf. obtusifolius	tomtskräppa	Broad-leaved Dock
Sedum-type	fetknoppsväxter	Stonecrops
Stachys cf. sylvatica	stinksyska	Hedge Woundwort
Thalictrum	rutor	Meadow-rue
	VATTENVÄXTER	AQUATICS
Isoëtes	braxengräs	Quillworts
Myriophyllum	slinga	Water-milfoils
Nuphar lutea	gul näckros	Yellow Water-lily
Potamogeton	nate	Pondweed
Stratiotes	vattenaloe	Water Soldier
	KÄRRVÄXTER	FEN COMMUNITIES
Menyanthes	vattenklöver	Buckbean (Bogbean)
Rubus chamaemorus	hjortron	Cloudberry
Typha angustifolium	bredkaveldun	Lesser Reedmace
Sparganium	igelknopp	Bur-reed
	SPORER	SPORES
Dryopteris-type	bräken	Buckler Ferns
Equisetum	fräken	Horsetail
Huperzia (Lycopodium) selago	lopplummer	Fir Clubmoss
Lycopodium annotinum	revlummer	Interrupted Clubmoss
Polypodiaceae	ormbunksväxter	Firns
	MOSSOR	MOSSES
Sphagnum	vitmossa	Peat-moss
	ALGER	ALGAE
Pediastrum	grönalger	Green algae

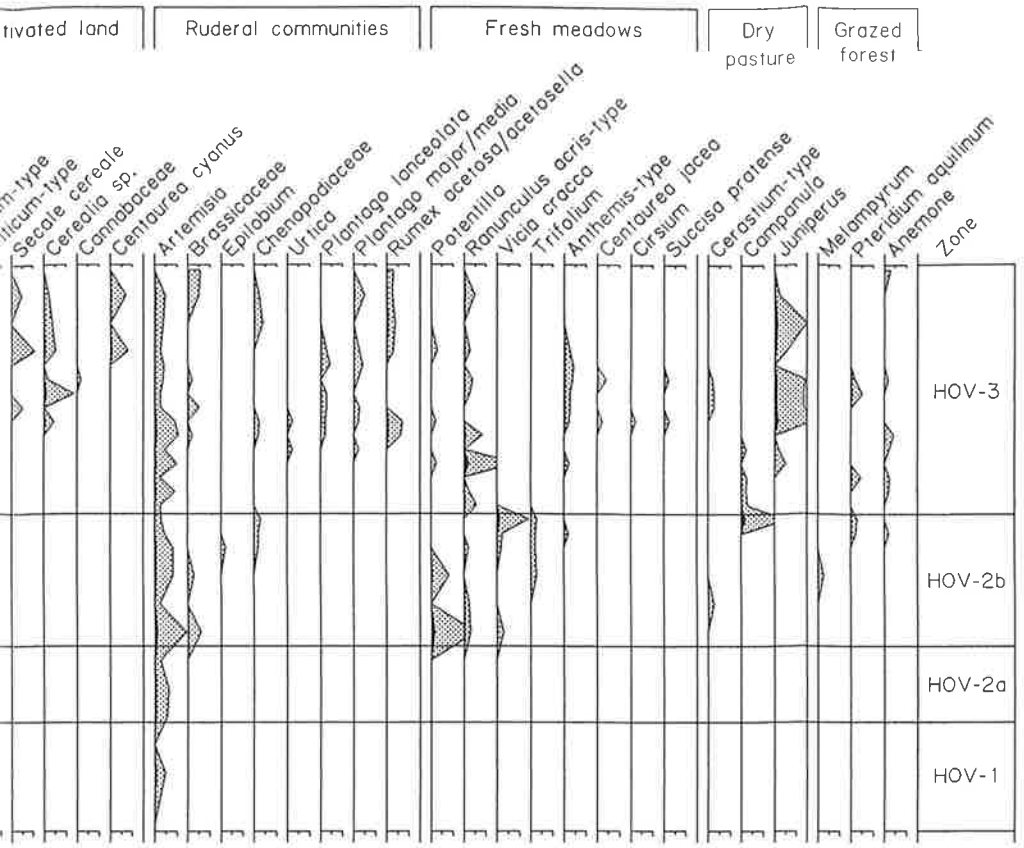
HOVGÅRDSBERG FEN +40-45 m
Vendel, Uppland
Pollen and spores

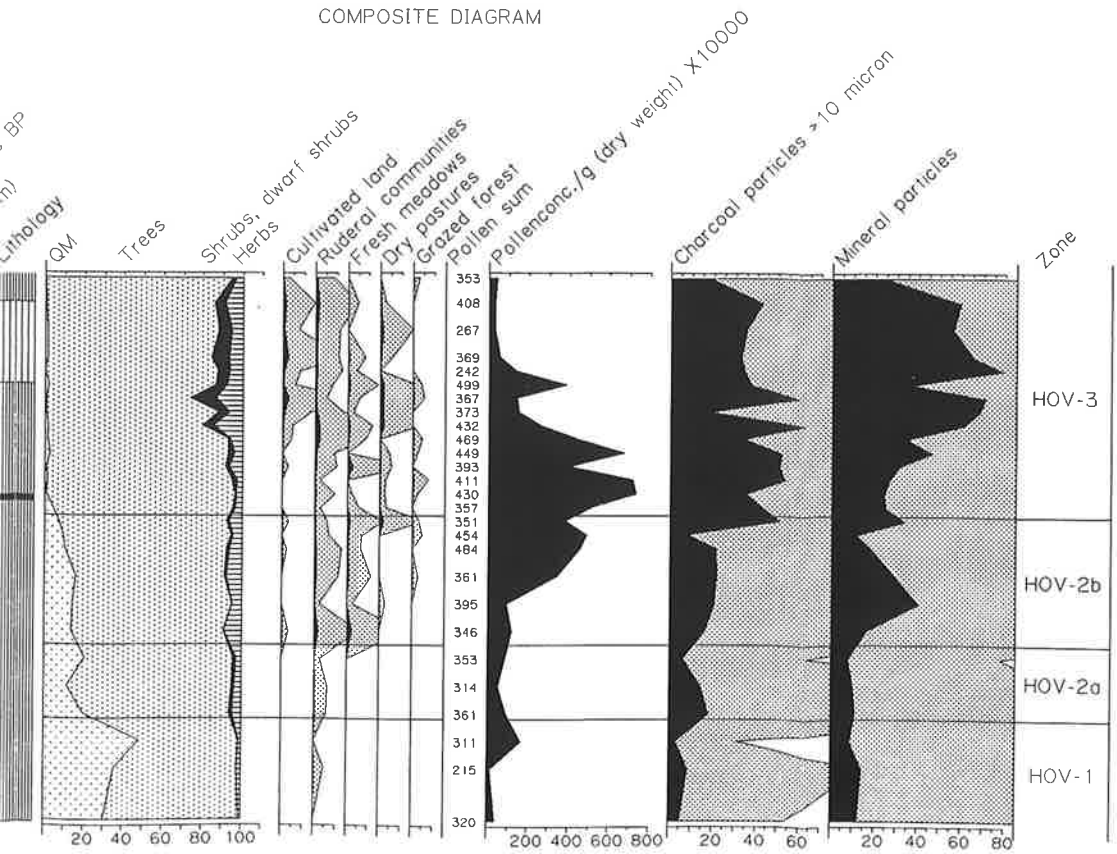


Sven Karlsson, 1998

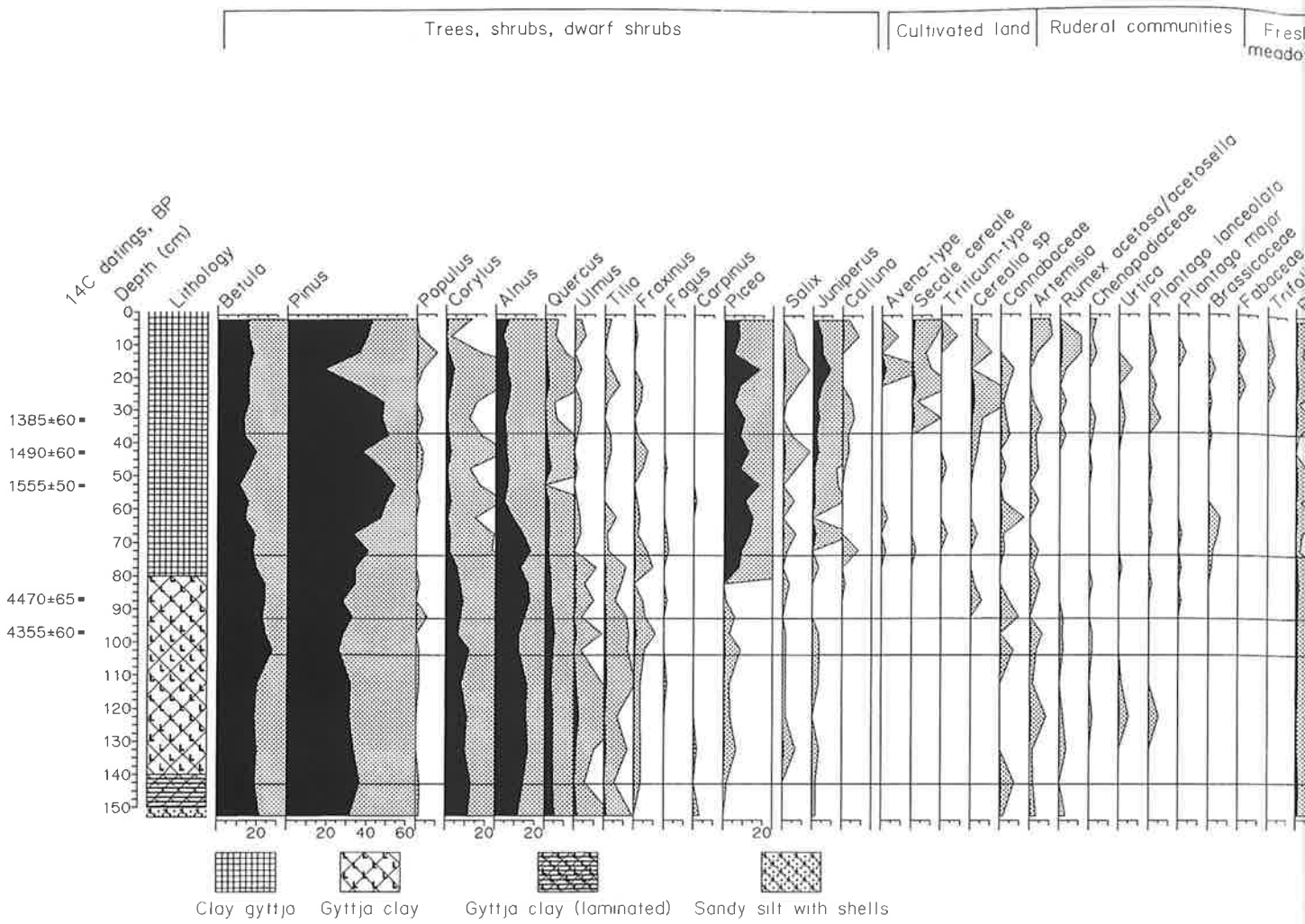
Appendix 2

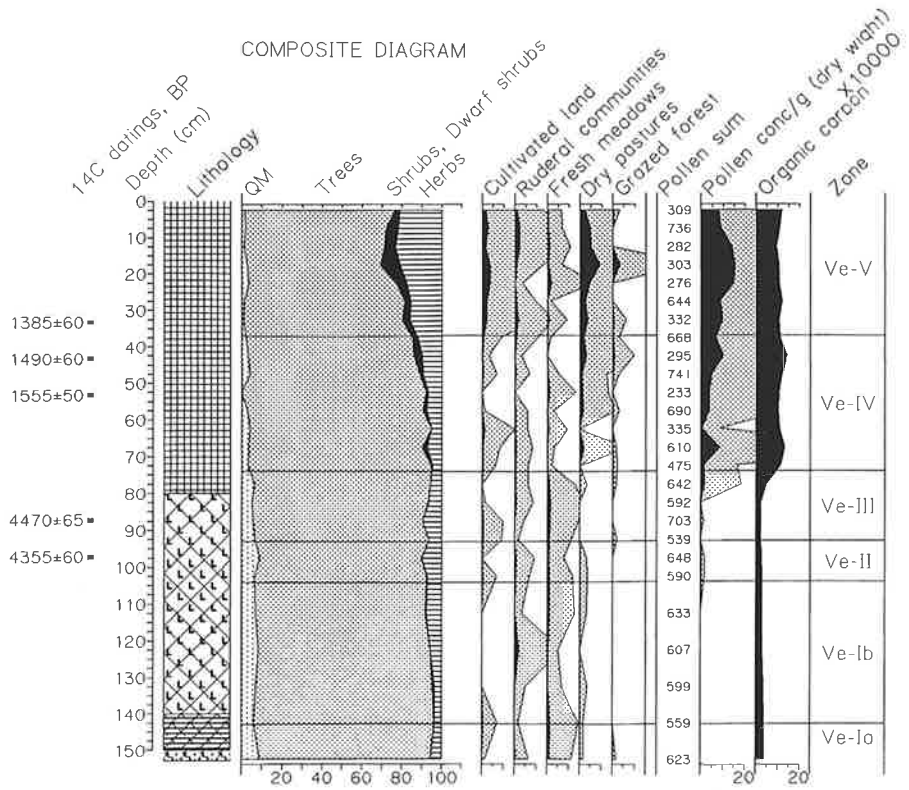
Pollen diagram from the Hovgårdsberg fen showing the vegetation changes in the Vendel area from c. 4000 BP up to recent times. Solid areas represent percentage and stippled areas per milles.



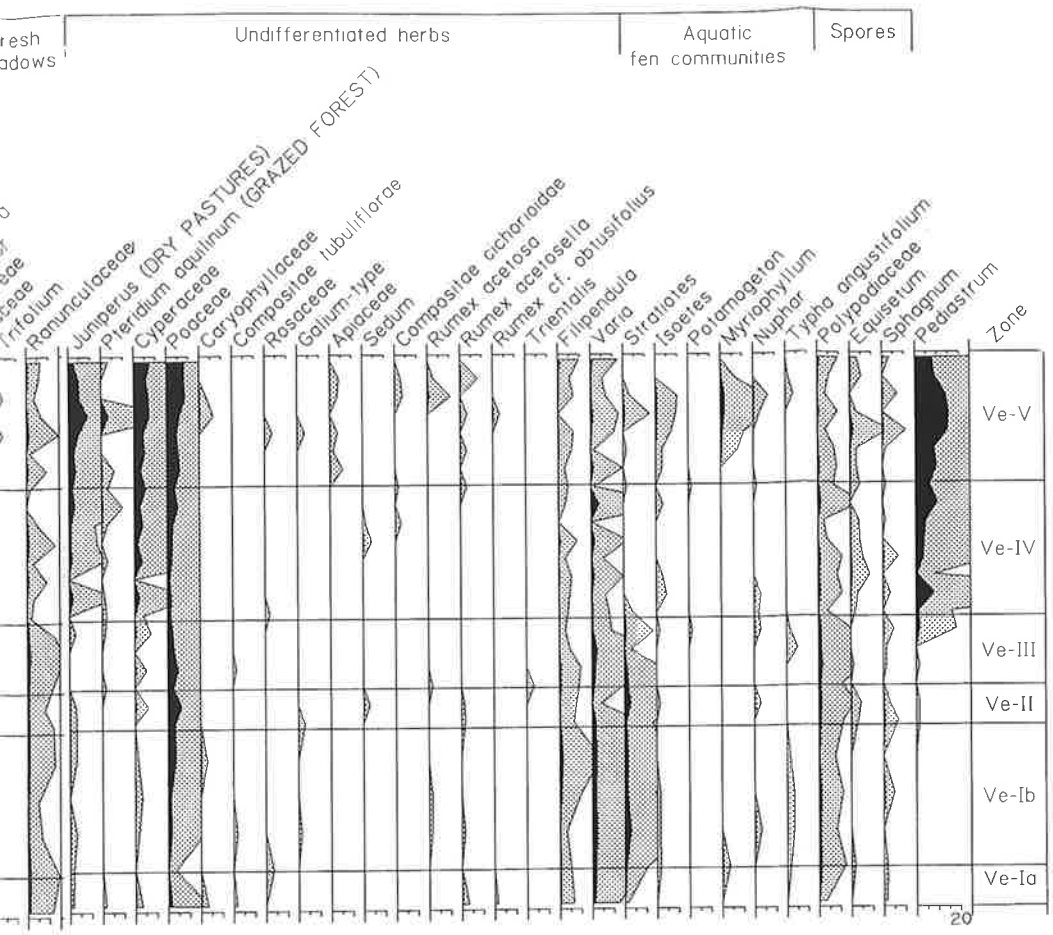


LAKE VENDELSJÖN, +24 m
Vendel, Uppland
Pollen and spores





Appendix 3



Helen Atkinson, 1993

Pollen diagram from Lake Vendelsjön showing the vegetation changes in the Vendel area from c. 5000 BP up to recent times. Solid areas represent percentage and stippled areas per milles.