Sowing the seed ? : human impact and plant subsistence in Dutch wetlands during the Late Mesolithic and Early and Middle Neolithic (5500-3400 cal BC)

Out, W.A.

5. Eem region

The site Hoge Vaart has been included in this study despite the absence of a cluster of high-quality sites as the site offers a considerable amount of data. There are other relevant sites in the region (Gotjé 1997; Makaske *et al.* 2003; Van Smeerdijk 2003), but those subjected to palaeoecological analyses have provided less detailed information on human impact on the vegetation. The data of Hoge Vaart cover the Early Holocene from the Pre-Boreal onwards. The discussion below only includes periods before, during and after occupation (Middle Holocene). The discussion is based on the publication of Hogestijn and Peeters (2001) and related literature.

5.1 Geology and palaeogeography of the Eem region

The height of the Pleistocene subsurface of Southern Flevoland is shown in figure 4.1. The youngest Pleistocene strata below Southern Flevoland comprise Pleniglacial Rhine deposits (Kreftenheije Formation; Busschers *et al.* 2007), last interglacial coastal deposits (Eem Formation) and Pleniglacial and Late Glacial deposits of local provenance (Boxtel Formation). It is difficult to map the exact boundaries between these formations. At most locations, aeolian coversands (Wierden Member, Boxtel Formation) top the Pleistocene subsurface. Deposition of Rhine deposits in this area ceased early in the last glacial, before *c.* 40.000 BP. In the northern part of Southern Flevoland, the Kreftenheije Formation dissected and reworked the Eem Formation (Busschers *et al.* 2007). In the south, the Eem Formation directly underlies deposits of the Boxtel Formation and occurs up to depths as shallow as 10 m -NAP (Menke *et al.* 1998). Locally, aeolian coversands are present as elongated ridges that stood out some 1-2 metres above the surrounding surface, and had relative steep slopes. Some inland dunes flank a former course of the river Eem (Delwijnen Member, Boxtel Formation) and are considered to be of Late Glacial (Younger Dryas) age, but these dunes are relatively rare. In the Late Glacial and first part of the Holocene, soil formation took place in the Pleistocene subsurface (Makaske *et al*. 2003; Menke *et al.* 1998). Thereafter, the inundation due to the rising groundwater and sea level resulted in the burial of the landscape by peat and lagoonal deposits. These deposits form the Holocene sequence.

The Holocene deposits in Southern Flevoland consist of the Nieuwkoop Formation (peat) and the Naaldwijk Formation (marine clay). A basal peat layer (Nieuwkoop Formation) buries the Pleistocene subsurface. Locally, peat growth began in the Pre-Boreal, and on a regional scale in the Early Atlantic (*c.* 7000 BC) (Menke *et al.* 1998; Peeters and Hogestijn 2001; Spek *et al.* 2001a). These oldest peats are covered by the Wormer Member (Naaldwijk Formation) that consists of clay containing many peat clasts and reed fragments (Makaske *et al.* 2002). These clay deposits, which in 'older literature' are defined as the Calais deposits and Older Unio Clays (see paragraph 4.1), mark the existence of a relatively open tidal lagoon in the Atlantic. Tidal channel activity during the deposition of the Wormer Member has occasionally caused erosion of the underlying peat and Pleistocene subsurface (Makaske *et al.* 2002; Menke *et al.* 1998). The tidal deposits are covered by a second peat (Hollandveen Member, Nieuwkoop Formation), rich in reed fragments. It presumably dates to the Late Atlantic and Early Sub-Boreal. In Flevoland, this peat strongly suffered from Late Holocene lagoonal erosion (Flevomeer, Almere and Zuiderzee phases). Preserved patches of the Hollandveen Member are unevenly distributed through the region. On top of the Wormer Member and the Hollandveen Member, the Flevomeer deposits can be found (Lelystad Member, Naaldwijk Formation), formed during the Sub-Boreal. The sediment of the Flevomeer deposits consists of gyttja, detritus and reworked peat, deposited in freshwater lakes (Makaske *et al.* 2002; Menke *et al.* 1998).

Hoge Vaart is situated on a north-south oriented Pleistocene coversand ridge. The sand ridge is a foothill of the higher positioned sand grounds, connected with the Gooi and the Veluwe area. This coversand landscape was incised by several channels of the river Eem and streams that drained the northern part of the Veluwe. North and east of the sand ridge on top of which Hoge Vaart is located, a large depression was present in the landscape, three to four metres lower than the sand ridge. The depression at the eastern side was incised due to channel activity in the Early Holocene. In the Early Holocene, the landscape can be considered a dryland landscape. In the Middle Holocene it transformed into a gradually submerging freshwater tidal landscape. Due to the presence of the channel however, the site was located at the border of a dryland and wetland landscape from the first peat growth onwards until the site submerged in the Sub-Boreal.

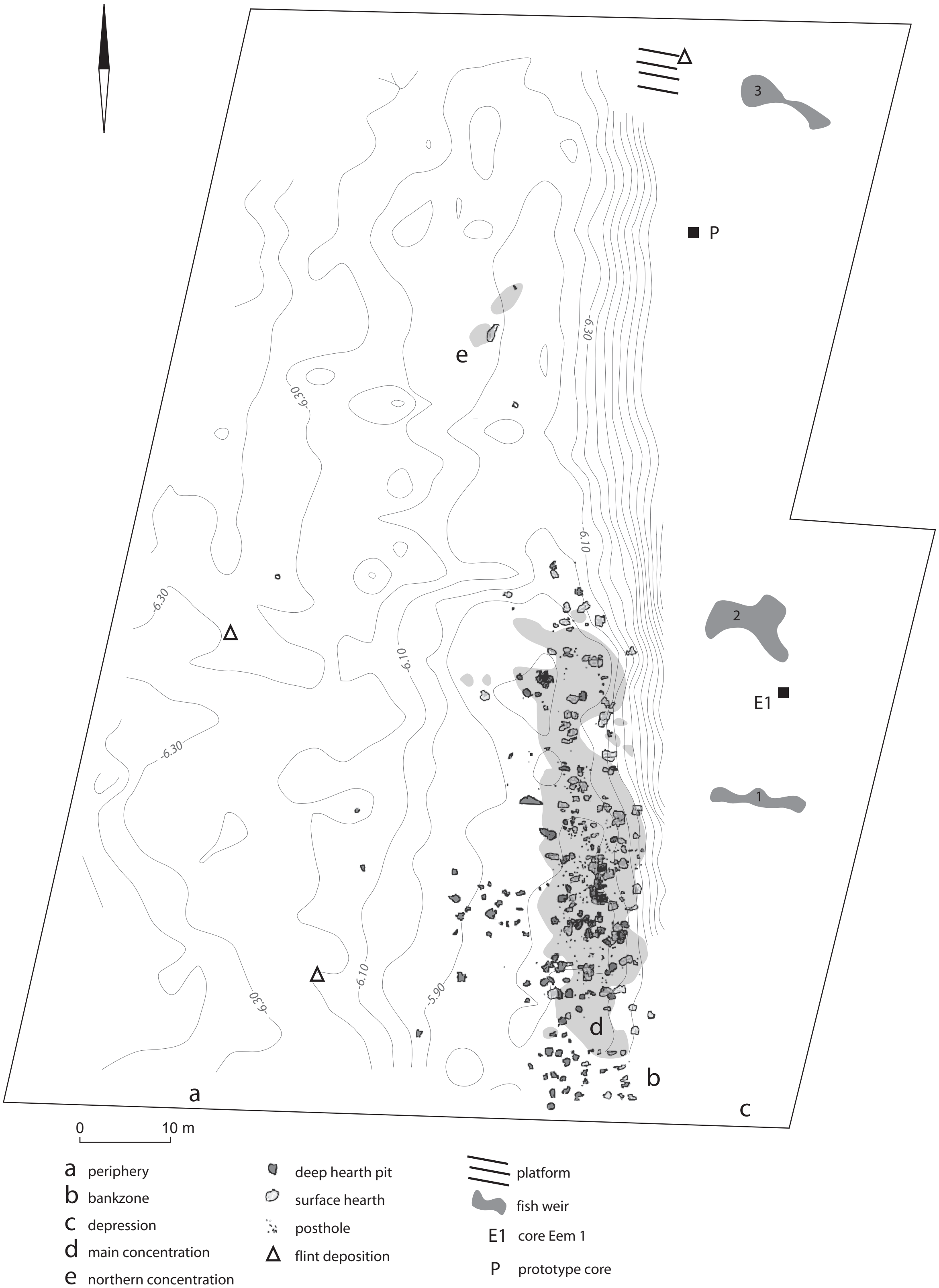
5.2 Archaeology of Hoge Vaart

The site of Hoge Vaart is located in the southern part of Southern Flevoland (coordinates 101.000/510.00, see fig. 4.1). Related to the construction of a new motorway (A27), excavation took place in 1994-1996 by RAAP, the Dutch National Service for Archaeological Investigations and the Directie IJsselmeergebied van Rijkswaterstaat. The initial prospection in the surrounding area indicated the presence of five other sites dating to the Mesolithic and/or Neolithic, which were not excavated since they were not threatened.

The site of Hoge Vaart lies on a coversand ridge at *c.* 6 m -NAP with an extent of 110 x 20 metres and includes a part of the sand ridge (periphery of the settlement area), a slightly higher part of the ridge at the central eastern side rich in finds and features (*c.* 5.80 m -NAP) and a transitional river bank zone between the ridge and a depression next to it (*c.* 10 m -NAP), which was incised by a channel (see fig. 5.1). The southern part of the bank zone has been eroded. The investigated area measures 4800 m^2. The sand ridge was investigated by coring, using a 2 x 2 metres coring grid. The bank zone was investigated by means of six test pits, each measuring 10 x 0.5 metres. The depression received only minor attention during excavation. At the site, two concentrations of archaeological remains were recognised: a main concentration (775 m^2) located on the higher part of the sand ridge that contained the majority of finds, and a minor concentration (100 m^2) located in the northern peripheral area (northern concentration). Only these two concentrations were completely excavated in squares of 50 x 50 cm, while *c.* 20% of the peripheral area was systematically excavated by squares of 2 x 2 metres (Hamburg *et al.* 2001; Peeters and Hogestijn 2001).

The site was occupied repetitively during a period of several thousand years. Restricted distinction of occupation periods was possible on the basis of ^{14}C dates and stratigraphy. The first phase is dated to *c.* 6800-6500 BC (based on a single ^{14}C date of a deep hearth). The second phase is dated between *c.* 5500 and 4900 BC, associated with deep hearth pits. The third phase is dated between 5000 and 4500 BC, associated with surface hearths. The number of features from this phase suggests that it reflects the most intensive occupation period. The fourth phase is dated between 4350 and 4050 BC, associated with three fish weirs and a single sherd. Occupation before and after phase 1 and before phase 2 cannot be excluded since the number of relevant dates was relatively small. Although the calibrated dates of phases 2 and 3 suggest overlap, it was possible to make a distinction between phases 2 and 3 on the basis of stratigraphy and archaeology (deep hearths *versus* surface hearths). The distinction of phase 4 is based on the stratigraphy of a layer of clay and detritus, and on the dates of three fish weirs in this detritus. The first two phases are considered to be Mesolithic, based on the dates, typology of part of the flint and absence of pottery and domesticates. The last two phases are considered to be Neolithic. The third phase is considered to be part of the early phase of the Swifterbant culture, based on the dates, presence of pottery, and the typology of the pottery and part of the flint. The fourth phase is considered to be part of the middle phase of the Swifterbant culture, based on the presence of a sherd, the age of the sherd and the age of the fish weirs (Hogestijn and Peeters 2001, 143).

Figure 5.1 Hoge Vaart, the relief of the Pleistocene subsurface (m -NAP), the zones and concentrations, the main features and the location of the pollen cores of Gotjé (after Hamburg *et al.* 2001).



-6.30
-6.10
-5.90
e
d
a
b
c
1
2
3
E1
P
0
10 m
a periphery
b bankzone
c depression
d main concentration
e northern concentration
deep hearth pit
surface hearth
posthole
flint deposition
platform
fish weir
E1 core Eem 1
P prototype core

The excavation revealed amongst others *c.* 100 deep hearth pits that date to the first and second phase, *c.* 150 surface hearths that date to the third phase, postholes, pits including a clay-mixing pit, pottery, flint, stone, organic remains including human remains, remains of three fish weirs with fish traps, three flint depositions and a possible wooden platform (see fig. 5.1 for the location of the main features). House structures could not be recognised despite the large number of postholes (Hogestijn and Peeters 2001). There are indications that people produced pottery at the site (Haanen and Hogestijn 2001, 16; Jansen and Peeters 2001, 46; Peeters 2001, 13). The flint assemblage is considered as Mesolithic and Neolithic, while Neolithic material is dominant. Use-wear analysis of the flint indicated amongst others the working of reed, the light working of wood, the working of plants containing silica, and plant working activities such as the debarking of branches.

The animals that formed an important part of the animal bone assemblage are deer and wild boar. Remains of domestic animals and plants have not been found except for the remains of dog and their presence is rejected, although the presence of domestic cattle and pigs could not be excluded due to the degree of burning of the bone (Laarman 2001; Visser *et al.* 2001). The absence of domestic animals in phase 3 apparently differs from the presence of domestic animals in the central river area at this time (see chapter 2). Comparative data from the Vecht region are not known (see paragraph 4.7).

The site is interpreted as a special activity camp for hunting, fishing, fowling and gathering that was repeatedly visited, sometimes for a few days, sometimes longer (as suggested by the production of pottery at the site). This interpretation is however mainly based on the analysis of the northern concentration, and extrapolation of its interpretation to the main concentration, and in addition on the last occupation phase. Information on the length and seasonality of single phases is mostly unknown. There are zoological indications of autumn and winter occupation (Laarman 2001, 20; Peeters and Hogestijn 2001, 34). The botanical finds indicate summer and autumn occupation (especially for phase 3), and give minor indications of spring occupation (Van Rijn and Kooistra 2001; Visser *et al.* 2001).

The investigators suggest that it is rather unlikely that people exchanged their materials via long exchange networks since most of the flint and stone types can be collected in a relatively limited area including outcrops of glacial till in the Vecht region, ice-pushed ridges in the northern part of the Netherlands and/or the ice-pushed ridges of the Gooi area and the Utrechtsche Heuvelrug (Peeters and Hogestijn 2001, 155).

5.3 Sand ridge

5.3.1 Reconstruction of the natural vegetation and abiotic factors at the sand ridge

For the reconstruction of the natural vegetation at Hoge Vaart, there are two sources available that are amongst others based on pollen analysis. The first source is primarily based on the analysis of section samples of the sand ridge (Spek *et al.* 2001a, b) while the second source is based on cores from the bank zone (Gotjé 2001). The reconstruction of the natural vegetation and human impact of each source will be discussed separately. The paragraph below is based on the first source and discusses general information on the landscape, vegetation, soil processes and the ground water table, based on the analysis of geology, the analysis of soil sections, pollen analysis and micromorphology. The pollen was sampled on the northern, southern and middle part of the sand ridge on the highest part of the sand ridge (four sections), and at the eastern side of the sand ridge near the bank of the channel (two sections). The volume of the pollen samples is 1 to 50 cm^3; the pollen sum includes trees and shrubs (191-769 pollen grains). The diagrams include percentage diagrams and concentration diagrams (not included here) that were analysed and interpreted by D.G. van Smeerdijk. The pollen samples were collected from a palaeosoil and therefore, precise reconstruction of the vegetation through time was not possible.

The combination of the reconstruction of the soil development, the results of 14 ^{14}C dates from four of the investigated sections and the interpretation of the pollen diagrams have nevertheless resulted in a general reconstruction of vegetation for each occupation phase.[1] The development of the soil is extensively described in Spek *et al.* (2001a, see also the appendix of that publication).

5.3.1.1 Early and Middle Atlantic (phase 1)

During the Early Atlantic, the rise of the sea level indirectly influenced the environment of Hoge Vaart by a gradual rise of the ground water level and a gradual approach of the coast towards the area. There was however no direct marine influence. See Peeters (2007) for information and discussion on the reconstruction of the ground water level rise. During the Atlantic, the site was positioned at the border of coversands and peat marshes that developed into open water (Spek *et al.* 2001b). During a long period of the Atlantic, the level of the ground water fluctuated between 1.5 and 0.9 metres (spring and autumn, respectively) below the surface of the sand ridge. Changes in the ground water level were mainly influenced by the supply of surface water from the hinterland.

During the Early and Middle Atlantic, the vegetation on the coversand ridge consisted of a relatively dense deciduous woodland of dry terrain dominated by *Tilia cordata* and *Quercus* sp., accompanied by *Tilia platyphyllos*, *Corylus avellana*, *Betula* sp., *Fraxinus* sp. (probably *F. excelsior*), *Ulmus* sp., *Hedera helix*, *Viscum album*, *Lonicera periclymenum* and probably ferns in the understory. In the lower zones of the landscape, including the depression next to Hoge Vaart, *Alnus* sp. (probably *A. glutinosa*), *Ulmus* sp. and *Salix* sp. occurred. The presence of *Succisa pratensis*, *Polypodium vulgare*, *Lycopodium* sp. and *Dryopteris* sp. is discussed and questioned for this phase by Spek *et al.* (2001a, b). Except for *Succisa pratensis* these taxa could have been part of the vegetation as they were also present in the woodland at the dunes in the central river area.

The relative high percentage of *Tilia* sp. indicates that the soil on the sand ridge was quite rich in nutrients and still rather calcareous. This last characteristic of the soil is also indicated by the presence of *Viscum album*, a halfparasite that prefers hosts growing on calcareous soils. The woodland soil consisted of probably not too compact, well mixed soil containing rootlets and including an organic layer, with a high decomposition rate resulting in the preservation of nutrients in the relatively closed nutrient cycle. When time passed by, decalcification of the soil must have taken place gradually. Following after decalcification, the weathering of minerals occurred, resulting the development of a brown woodland soil.

5.3.1.2 Middle and Late Atlantic (phases 2 and 3)

Figures 4.3a and 4.3b show a palaeogeographical reconstruction of the province of Flevoland at the time of phases 2 and 3 at Hoge Vaart. At *c.* 5000 BC, the rising ground water table became a major factor influencing the vegetation and soil formation at the sand ridge. The ground water level fluctuated between 1.00 to 0.8 metres below the top of the sand ridge, depending on the season and tide. Between *c.* 4900 to 4500 BC (phase 2), the rise of the ground water level was 20 cm/century. Overall, the increasing water level and the activity of the channel resulted in a decrease in the extent of the coversand ridge and the deposition of sand in the channel (Peeters and Hogestijn 2001). Nevertheless, occupation on the sand ridge was still possible after *c.* 4900 BC, at least during some parts of the year (Spek *et al.* 2001b).

In the Late Atlantic, a freshwater tidal channel developed in the depression at the eastern side of the sand ridge as part of a freshwater tidal system. The channel was first active between *c.* 5000-4900 BC (first activity phase), resulting in the deposition of sand and clay. Afterwards, the dynamics decreased and the channel filled up with detritus. Due to activity of the channel, the sand ridge became washed over several times

1 The dated material consists of peat, detritus, roots, charcoal and organic components from humic sand (Spek *et al.* 2001a, b).

from *c.* 5000 BC onwards by floods of limited strength, resulting in the erosion of organic material from the topsoil. This erosion made it possible to distinguish phase 2 from phase 3. Additionally, erosion of the lower parts of the eastern slopes the sand ridge took place.

During the Middle and/or Late Atlantic, the woodland at the sand ridge became dominated by *Quercus* sp. (from at least *c.* 5200 BC onwards). In the low parts of the area, *Alnus* carr was present combined with some trees of *Betula* sp. and *Salix* sp., as well as peat, marshes and open water. The pollen diagrams show a variety of taxa that were present contemporaneously during the late phase of the *Quercus* vegetation: *Quercus* sp., *Betula* sp., *Corylus avellana*, small numbers of *Tilia* sp., *Fraxinus* sp. and *Ulmus* sp., *Rhamnus cathartica*, *Sorbus aucuparia*, *Ligustrum vulgare*, *Ilex* sp. (probably *I. aquifolium*), *Viburnum opulus*, *Acer* sp. (probably *A. campestre*), *Hedera helix*, *Viscum album*, *Sambucus nigra*, *Lonicera periclymenum*, *Humulus lupulus*, *Anemone nemorosa*, *Silene* sp., *Stellaria* sp., *Osmunda* sp., *Polypodium vulgare*, *Dryopteris* sp., *Melampyrum* sp. (probably *M. pratense*), *Pteridium aquilinum*, Chenopodiaceae, *Plantago major*, *Urtica dioica*, *Rumex acetosella*, *Rumex acetosa*-group, *Jasione montana*, *Cerastium fontanum*-type, Brassicaceae, Caryophyllaceae, Asteraceae tubuliflorae and Asteraceae liguliflorae.

Spek *et al.* (2001a, 28) make a comparison with modern Lysimachio-Quercetum woodland, based on the specific environmental conditions and soil characteristics that occur during the Late Atlantic at Hoge Vaart (Dirkse 1993; Van der Werf 1991). This vegetation forms a transition between true alder carr, dry and mesotrophic *Betula*/*Quercus* woodland and dry and eutrophic *Quercus*/*Fagus* woodland. The Neolithic *Quercus/Fagus* vegetation in this region did not however include *Fagus* sp. but *Tilia* sp. instead. Important factors related to the presence of this vegetation are the strong fluctuations and lateral movement of the ground water. It can be added that the flooding implies that the woodland developed into hardwood alluvial woodland. If flooding occurred during the winter season and not on a yearly basis, *Quercus* sp. and even *Tilia* sp. tolerate these conditions. The combination of herbs indicate the presence of a vegetation class that is characteristic of the partly shaded transition between closed woodland and more open terrain on sandy soils (Melampyro-Holcetea mollis; Schaminée *et al.* 1996).

During the Atlantic, the characteristics of the soil gradually changed. The nutrient cycle of the soil became more open, the vegetation became more mesotrophic and the soil became more acidic. This resulted in decreased decomposition of organic remains and decreased activity of the soil fauna. Only minor podsolisation may have occurred. In the near vicinity of the site, several abiotic factors probably varied noticeably through time: the water table, the pH and the presence of oxygen in the soil. Human impact on the vegetation may have influenced the development of the soil and vegetation as well.

5.3.1.3 Initial submerging of the sand ridge (end phase 3)

At *c.* 4550 BC, the ground water level reached the top of the sand ridge. Most parts of the sand ridge were inundated during large parts of the year. A very shallow pool developed, of which the depth and presence depended on changes in the water level, influenced by tide, season and channel activity. The rate of decomposition of organic material and activity of soil fauna further decreased. The top of the sand ridge became influenced directly by the freshwater tidal system. The pollen diagrams that represent the development of this phase are hard to interpret since secondary deposition of pollen, related to flooding of the site, cannot be excluded.

The combined data of Spek *et al.* (2001a, b) indicate that the *Quercus* dryland woodland submerged almost completely at *c.* 4550 BC as a result of the rising ground water level, confirmed by the dendrochronological dates from the submerged trees (4535 BC; Peeters *et al.* 2001). Despite the submerging of the *Quercus* woodland, there are no strong indications of the development of a dense alder carr on the sand ridge. Potential explanations for the absence of alder carr vegetation are the quick rise of the ground water table and/or regular flooding of the sand ridge. Instead of alder carr, marshy patches developed, especially in tree falls. The marsh vegetation was alternated with minor patches of woodland. Important taxa present in the zones of the pollen diagrams that probably correspond with this period are *Alnus* sp., *Fraxinus* sp., *Ulmus* sp., *Rhamnus frangula*, *Hedera helix*, *Viscum album*, *Lonicera periclymenum*, *Pteridium aquilinum*, Cyperaceae, Poaceae, *Rumex* sp., *Rumex acetosella*, *Typha angustifolia/latifolia*, *Sparganium* sp. and other marsh taxa. The presence of Cymatiospaera sp. (type 116) may indicate brackish conditions.

5.3.1.4 Complete submerging of the sand ridge (phase 4)

Figure 4.3c shows a palaeogeographical reconstruction for the period corresponding with the last occupation phase. Renewed activity of the channel occurred during *c.* 4450-4250 BC (second activity phase). The channel filled up afterwards with clay under slightly brackish conditions, followed by deposition of detritus (Gotjé 2001; Spek *et al.* 2001a, b). As a result of the changing dynamics, the higher parts of the sand ridge of Hoge Vaart quickly submerged and disappeared beneath the peat between *c.* 4450 and 4350 BC. The coversand ridge became covered by eutrophic *Phragmites* peat combined with many marsh taxa, followed by more mesotrophic *Carex* peat. The pollen diagrams furthermore indicate the presence of *Rhamnus cathartica* and *Sorbus aucuparia*, and a large diversity of marsh herbs (*Trifolium*-type, *Hydrocotyle vulgaris*, *Valeriana* sp., *Ophioglossum* sp., *Vicia*-type, *Lysimachia* sp., *Lythrum salicaria*, *Lotus* sp., *Lychnis flos-cuculi* and *Lathyrus palustris*).

5.3.2 Evidence of human impact on the vegetation from the sand ridge pollen diagrams

One can only very roughly reconstruct and compare the vegetation before, during and after single phases since the pollen analysis of the sand ridge is based on the analysis of a palaeosoil and since the precise periods of occupation are not reconstructed. For the Early Atlantic corresponding with phase 1, when the vegetation is characterised by relative high values of *Tilia* sp., there are only very weak signals of disturbance of the vegetation. These signals comprise the presence of pollen of *Hedera helix*, Asteraceae tubuliflorae, *Ranunculus acris*-type, *Rumex* sp., Chenopodiaceae and *Polygonum persicaria*-type (*Persicaria maculosa*), all found in quantities smaller than 5%, and relative high values and a high diversity of ferns.[2] The identified taxa may be indicative of the presence of open patches and/or disturbance. It may concern human impact on the vegetation or natural disturbance such as the activity of wild animals.

In the Middle/Late Atlantic corresponding with phases 2 and 3 when the dryland woodland was strongly dominated by *Quercus* sp., there are many taxa that may indicate human impact on the vegetation. The diagrams indicate a strong increase in the diversity of shrubs, herbs and anthropogenic indicators (*cf.* Behre 1981), all indicating relatively open vegetation, that may be related to human impact on the vegetation (*Rhamnus cathartica*, *Sorbus aucuparia*, *Ligustrum vulgare*, *Ilex aquifolium*, *Viburnum opulus*, *Acer* sp., *Hedera helix*, *Viscum album*, *Sambucus nigra*, *Lonicera periclymenum*, *Pteridium aquilinium*, *Plantago major*, *Urtica dioica*, *Rumex acetosella*, *Rumex acetosa*-group, *Melampyrum* sp., *Jasione montana*, *Cerastium fontanum*-type, Brassicaceae, Caryophyllaceae, Asteraceae tubuliflorae and Asteraceae liguliflorae). The strong increase in the variety of taxa and the increase in the percentages of these taxa suggest that human impact increased, which corresponds with the number of features known from phase 3. It can not be excluded however that pollen from the earliest occupation period suffered more from corrosion and decay than the pollen from the later occupation period and that human impact of older phases is underrepresented.

It is not possible to reconstruct anthropogenic influence on the vegetation during phase 4 when marsh vegetation occurred, because the number of spectra is too limited for the analysis of subtle changes and because the vegetation was already very open naturally. Contemporaneous with the ongoing submergence of the site, the percentage of Chenopodiaceae increased, which is often indicative of anthropogenic influence on the vegetation, but which may also represent the natural vegetation of moist disturbed terrain along the channel, and possibly taxa that tolerate brackish conditions.

2 See horizon 3B of the sections of squares 51 and 10, Spek *et al.* 2001b.

5.4 Bank zone

5.4.1 Reconstruction of the natural vegetation of the bank zone based on pollen and macroremains

The reconstruction of the natural vegetation of the bank zone is based on Gotjé (2001). The bank zone was investigated by analysis of pollen, diatoms and macroremains of three cores: the prototype core, core Eem 1 (a series of sample boxes) and core Eem 2 (Gotjé 2001). Core Eem 2 is not discussed here since it does not add relevant information related to occupation. The analysis of the macroremains was based on samples of 15 grams (diameter of the core: 5 cm). These macroremains samples were sieved on a mesh width of 0.25 mm. The calculation of the pollen percentages by Gotjé was based on an arboreal pollen sum that includes all dryland trees, all wetland trees, unidentified arboreal pollen (?) and pollen of Ericales (up to 350 pollen grains). For optimal comparison of the pollen diagrams of the bank zone at Hoge Vaart with pollen diagrams from other regions, the diagrams of the bank zone were recalculated based on an upland pollen sum (including dryland trees, shrubs, herbs and spore plants). However, *Betula* sp. is excluded from the pollen sum since the diagram of core Eem 1 clearly shows that it is part of the local wetland vegetation. A small part of the *Betula* pollen may nevertheless originate from dry terrain, especially in the prototype core.

The locations of the two cores are shown in figure 5.1. The prototype core is sampled in the bank near the sand ridge, relatively far away from the main concentration of archaeological remains but *c.* 10 metres away from the northern concentration. Core Eem 1 is sampled at 15 metres distance from the main concentration, in the depression. The distance between the two cores is *c.* 50 metres.

The pollen- and macroremains diagrams of the two sample locations form the main source of information on the vegetation at the bank zone. While the pollen analysis of sand ridge (Spek *et al.* 2001a, b) focuses on phases until the assumed submerging of the sand ridge, the diagrams from the bank zone (Gotjé 2001) reflect the late occupation phases and theoretically also the period after occupation. The ^{14}C dates of Gotjé are shown in tables 5.1 and 5.2. The diagrams are dated between *c.* 5200 BC and later (possibly to *c.* 1500 BC), and thus should correspond with the last three phases of the site. The results of the upper two dates of the prototype core suggest that the results are not correct in all details.

The resulting pollen diagrams of the prototype core and core Eem 1 are shown in figures 5.2 and 5.3 respectively. The lithology is shown in tables 5.3 and 5.4. As a result of the recalculation of the diagrams, the new pollen sums do not reach 300 pollen grains and cannot be considered as sufficiently representative. In zone I of the prototype core, the diagram represents mainly dryland vegetation on a sandy soil, indicating that the sample point was located above the mean ground water level at that time. The zone is characterised by relatively high values of *Tilia* sp. (10-15%, in contrast to 5% in later zones) and the presence of *Pteridium* sp. and *Polypodium* sp. In my opinion, the relative high percentages of *Tilia* sp. represent the importance of the taxon in the Early and/or Middle Atlantic deciduous woodland as proposed by Spek *et al.* (2001a). Alder carr was present in the lower parts of the landscape (along the channel). The diatoms indicate freshwater conditions (Gotjé 2001, 16).

depth (m -NAP)	age (yrs BP)	age (yrs cal BC, 2σ)	phase	dated material
5.74-5.72	5749 ± 35	4690-4500		wood
6.08-6.05	3305 ± 41	1690-1490		seeds and two roots of Phragmites australis
6.40-6.38	5413 ± 45	4360-4070	4	Phragmites australis
6.78-6.76	5838 ± 40	4800-4580	3	bud scales and wood
6.95-6.92	6080 ± 43	5210-4840	2	wood

Table 5.1 Hoge Vaart, the prototype core, ^{14}C dates (Gotjé 2001).

depth (m -NAP)	age (yrs BP)	age (yrs cal BC, 2σ)	phase	dated material
6.19-6.18	4701 ± 47	3640-3360		moss
6.41-6.40	5062 ± 48	3970-3710		seeds
6.71-6.70	5210 ± 50	4230-3940	(4)	seeds and insect remains
6.85-6.84	5300 ± 50	4260-3980	4	seeds and insect remains
7.05-7.03	5467 ± 44	4450-4230	4	roots and detritus

Table 5.2 Hoge Vaart, core Eem 1, ^{14}C dates (Gotjé 2001).

depth (m -NAP)	sediment
5.90-5.75	peat with wood remains
6.10-5.90	clayey peat
6.30-6.10	clay, peat and sand
6.40-6.30	peat with remains of Carex sp.
6.60-6.40	detritus with rootlets
6.80-6.60	detritus
6.93-6.80	sandy detritus
7.00-6.93	sand

Table 5.3 Hoge Vaart, the prototype core, lithology (Gotjé 2001).

depth (m -NAP)	sediment
6.70-6.15	peat
7.10-6.70	detritus
7.55-7.10	clay and peat

Table 5.4 Hoge Vaart, core Eem 1, lithology (Gotjé 2001).

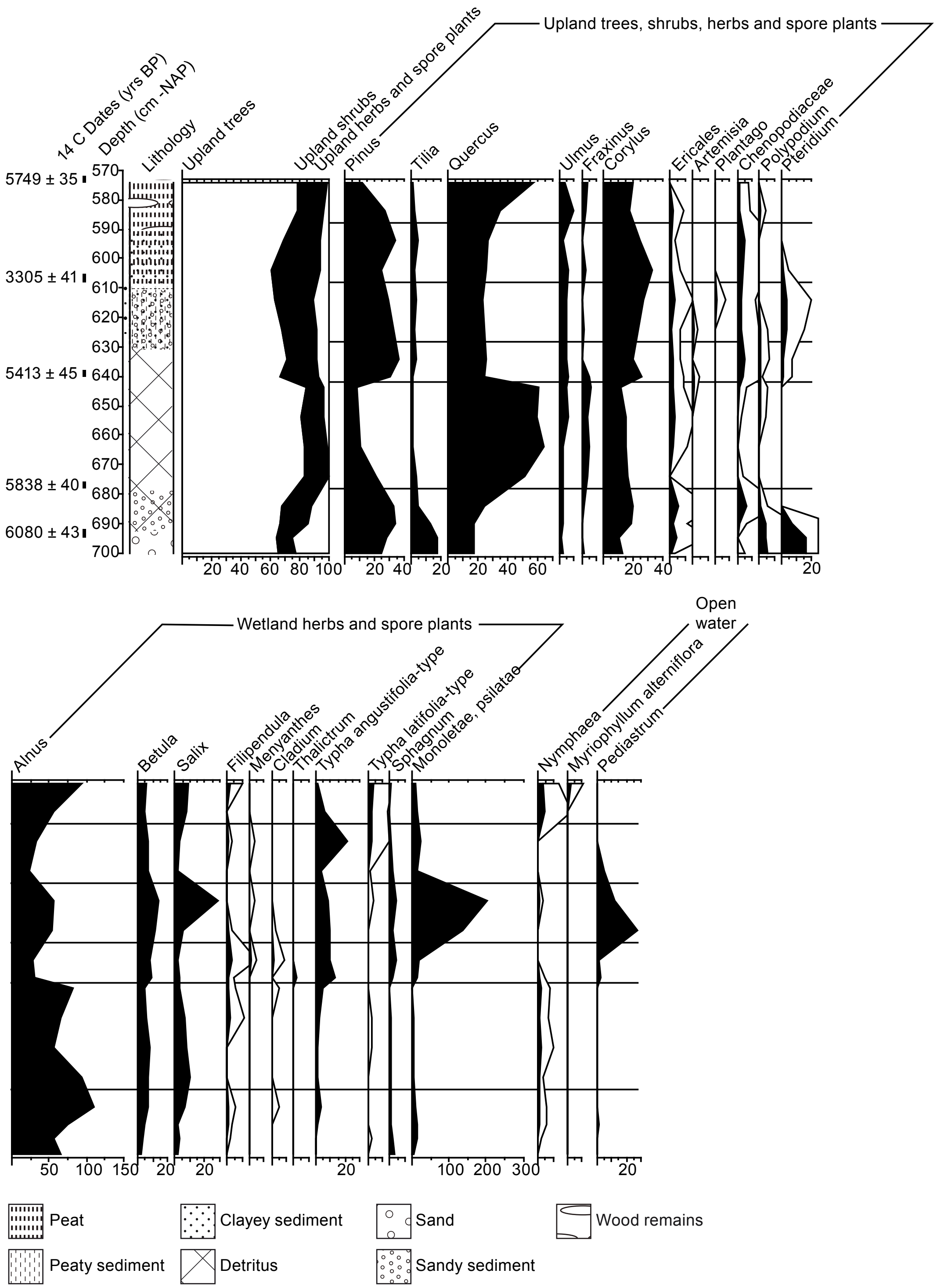


Figure 5.2 part 1.

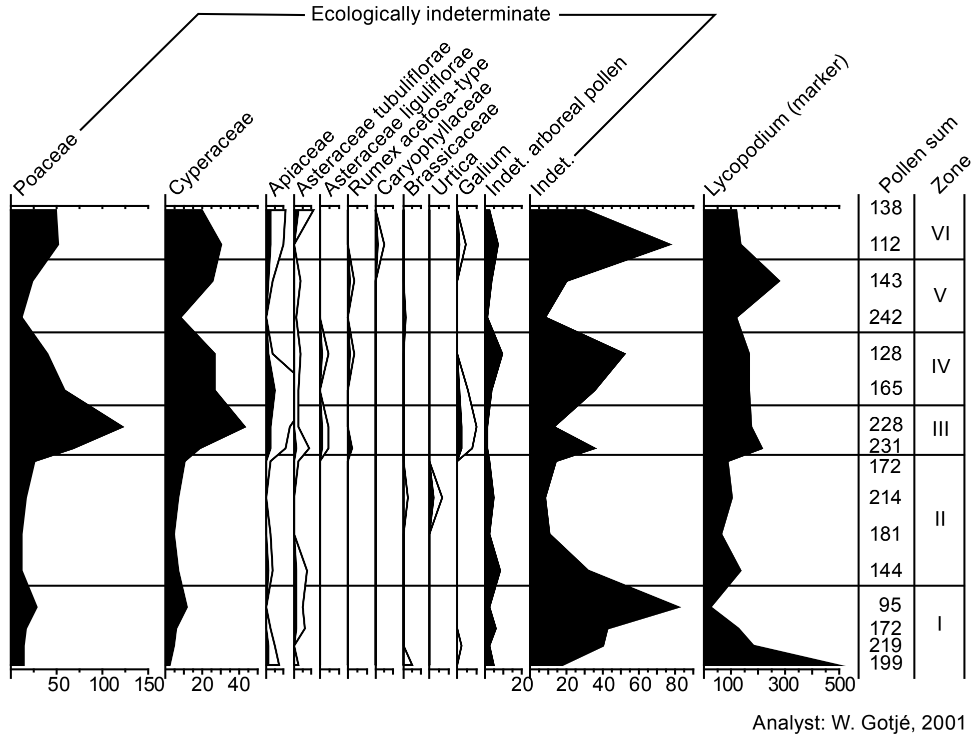


Figure 5.2 Hoge Vaart, prototype core, pollen diagram based on an upland pollen sum, exaggeration 5 x (after Gotjé 2001), part 2.

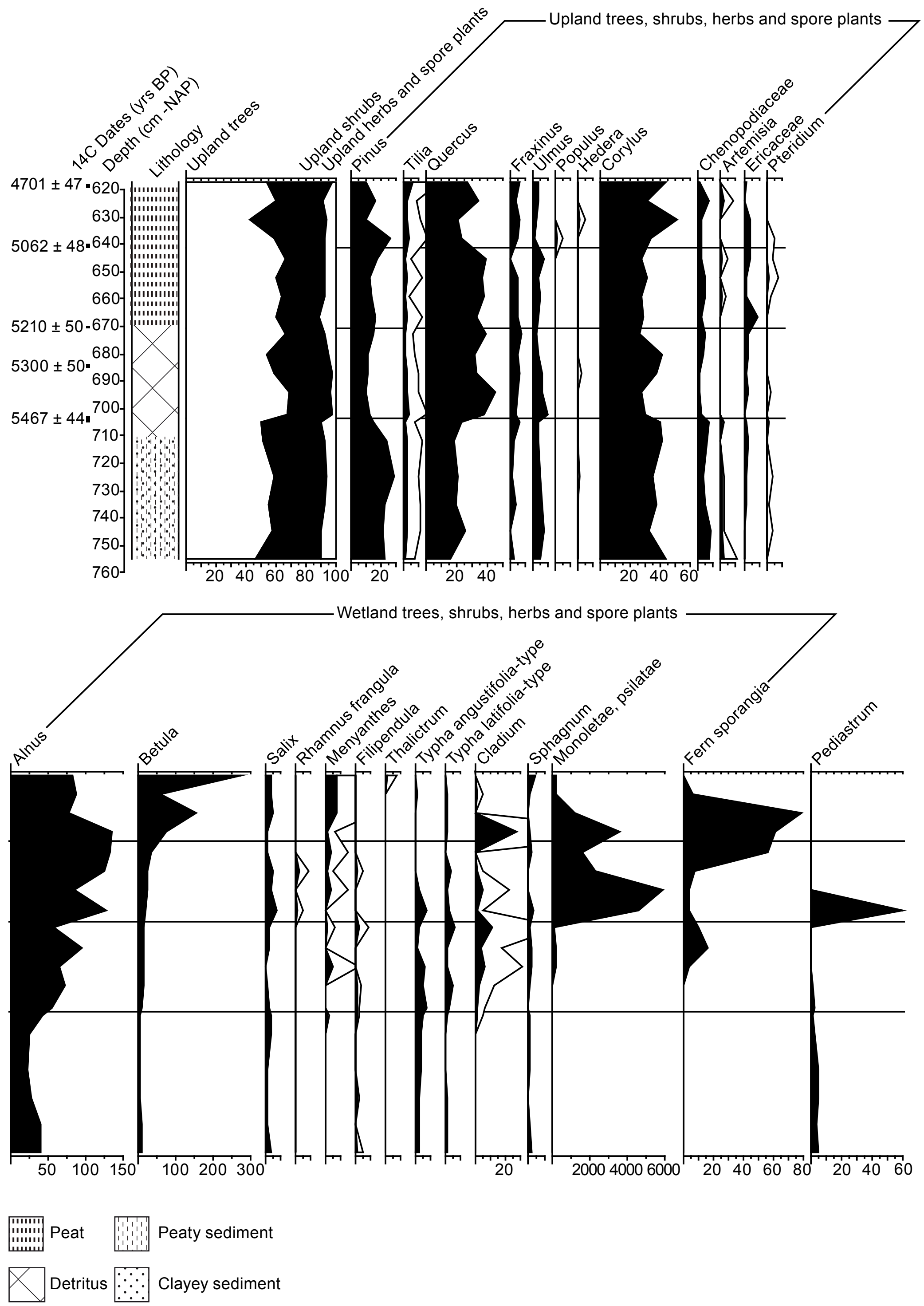


Figure 5.3 part 1.

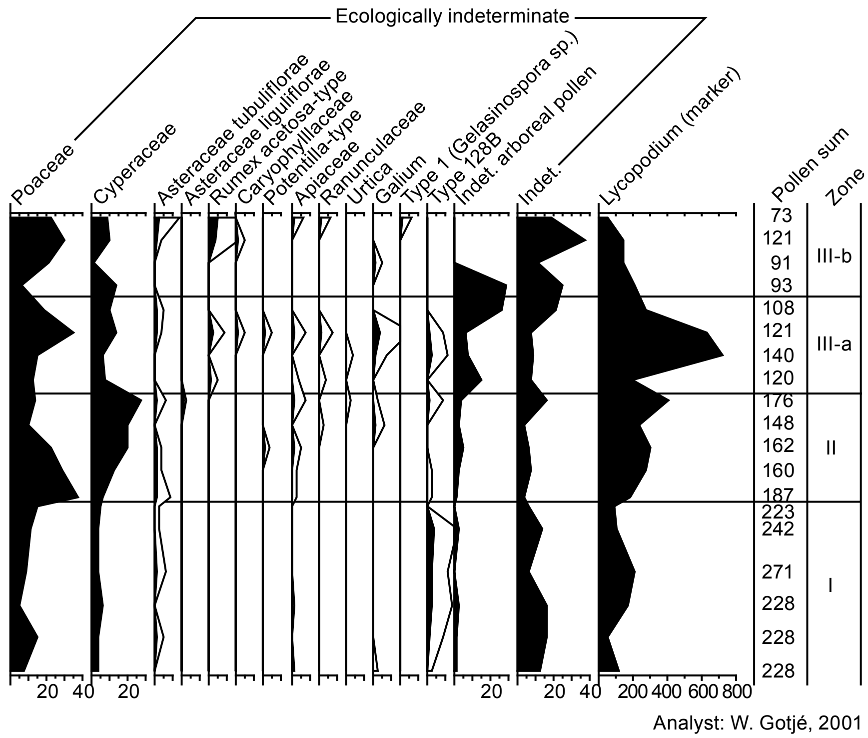


Figure 5.3 Hoge Vaart, core Eem 1, pollen diagram based on an upland pollen sum, exaggeration 5 x (after Gotjé 2001), part 2.

In zone II of the prototype core, the character of the sediment (detritus) and the increase in wetland taxa indicate an increase in the water level. *Tilia* sp. decreased and instead *Quercus* sp. and *Fraxinus* sp. increased. The local presence of *Quercus* sp. is demonstrated by macroremains and wood remains of *Quercus* sp., found at the depth of zone II in the very near surroundings of the core (Gotjé 2001, 17). The macroremains of this zone indicate the presence of a variety of biotopes in the local environment, including *Quercus* vegetation, *Alnus* carr mixed with *Betula* sp., as well as shallow water with a depth of 0.5 to 2 metres. The variety can be explained by the steep slope of the bank, covered with various narrow vegetation zones. The diatoms indicate slightly brackish conditions (Gotjé 2001, 17).

In zone III of the prototype core, *Quercus* sp. disappeared from the bank zone. *Corylus* sp. was probably transported by the river water and was not an important element of the extra-local vegetation, although a minor presence cannot be concluded. Absence of *Corylus* sp. is supported by the reconstruction of Spek *et al.* (2001a, b) and explains the scarcity of *Corylus* sp. in the wood and charcoal remains (see below). In the local vegetation, alder carr disappeared from the local vegetation and the curves of Poaceae and Cyperaceae show high values, indicating the development of a retrogressive hydrosere resulting in open wetland vegetation (*contra* Gotjé 2001, 18). Submerging of the local vegetation is also confirmed by the increase in *Typha angustifolia*, and the start of a curve of *Menyanthes trifoliata* that indicates more mesotrophic conditions. The reed and sedge vegetation is combined with ferns in the next zone. The peak of *Salix* sp. in zone IV in combination with the mixed sediment comprising peat, clay and sand, indicates dynamic and variable conditions. These conditions are confirmed by the diatoms, indicative of a combination of freshwater and marine conditions. The diatoms indicative of marine conditions must have been transported together with the clay since true marine conditions were not present at Hoge Vaart (Gotjé 2001, 18).

At the beginning of zone V, the presence of Foraminiferae (not shown in the pollen diagrams) indicates slightly brackish conditions, which are confirmed by the diatoms, although the indicators may have been deposited after secondary transport. The brackish conditions probably caused of some changes in the diagram (a decrease in Poaceae, Cyperaceae and absence of *Nymphaea alba*). Already in the same zone the channel developed into a freshwater environment and brackish conditions decreased. The macroremains indicate continuous presence of reed vegetation. The diatoms indicate that the local area developed into a freshwater environment again. In zone VI, alder carr developed. The interpretation of the upper part of the prototype core is however problematic since the pollen sum is very low and as the ^{14}C dates indicate that the material may be reworked.

The ^{14}C dates show that the prototype core and core Eem 1 partly overlap and that core Eem 1 can be used to reconstruct the development of the vegetation that follows on from the reconstruction of the prototype core. Despite the overlap, some differences in the local vegetation may have existed due to differences in the local vegetation at the sample locations. In zone I of core Eem 1 the sediment consists of peaty clay, indicative of slowly running water, which is confirmed by the smooth pollen curves and the absence of macroremains. The deposition of this clay represents the second activity phase of the channel (*c.* 4450-4250 BC, see paragraph 5.3.1.4) and probably corresponds with the presence of clay in the upper part of the prototype core. The running water probably transported most pollen of dryland tree taxa as well as of Chenopodiaceae. The diatoms indicate freshwater and slightly brackish conditions. Zone II shows the deposition of detritus, indicating the development of open water into marsh that was dominated by vegetation of *Stratiotes aloides* (macroremains), followed by the development of alder carr in the upper part of zone II.[3] In correspondence with the change of sediment, the diatoms indicate a major decrease in brackish conditions and the development into freshwater conditions.

3 The importance of *Stratiotes aloides* in zone II of core Eem 1 corresponds with the presence of high numbers of macroremains of this species in the macroremains samples that were sampled in the direct vicinity of the fish weirs (number 1 and 3). Elements of the fish weirs are dated to *c.* 4300-4000 BC and *c.* 4300-4050 BC (weir number 1 and 2), while the presence of *S. aloides* in core Eem 1 is dated between *c.* 4450-4250 BC and *c.* 4300-3950 BC (based on dating of detritus).

The increase in *Quercus* sp. appears to suggest local presence, but the pollen sum is very low and the reconstruction of Spek *et al.* (2001a, b) demonstrated that the *Quercus* vegetation had already submerged at the time of zone II (see paragraph 5.3.1). In zone IIIa, the local vegetation consisted of alder carr with an undergrowth of ferns and grasses. The diatoms indicate the presence of eutrophic shallow water (Gotjé 2001, 22).

In zone IIIb the alder carr is replaced by birch carr, as shown by the pollen and macroremains that indicate relative oligotrophic and acid conditions. This development took place at *c.* 4000 BC onwards, *i.e.* during or after phase 4. The scale of the distribution of the *Betula* carr is however unclear and the pollen diagrams of the sand ridge again do not show a similar development. The macroremains indicate that it concerns *Betula pendula* (while presence of other species is not excluded). The dominance of *Betula* sp. in the upper part of the core corresponds with the presence of wood remains of roots of *Betula* sp. in between and above fish weir 1.[4]

5.4.2 Evidence of human impact on the vegetation from the bank zone diagrams

The prototype core corresponds with the second, the third and the fourth occupation phase at Hoge Vaart. It should however be realised that the distance between the prototype core and the main concentration is *c.* 50 metres. In zone I of the prototype core, which corresponds with phase 2, the high percentage of *Pteridium* sp. is probably indicative of human impact in the *Tilia* woodland. The high values of *Pteridium* sp. may be related to woodland grazing (Behre 1981), which can be related to wild animals only at this site, or may be related to the frequent growth of *Pteridium* sp. at old hearths representing mineral-rich soils, and with more general human impact on the vegetation. *Pteridium* sp. especially reaches high values due to eutrophication and disturbance of the Melampyro-Holcetea mollis class discussed above (Schaminée *et al.* 1996). The increase in *Pteridium* sp. is thus likely to be related to human impact. Moreover, further disturbance and eutrophication of *Pteridium* vegetation can result in the development shrubs of *Rubus* sp. (Schaminée *et al.* 1996), of which both carbonised and waterlogged remains have indeed been found in surface hearths. *Rubus* shrubs may additionally be represented by pollen of Rosaceae in the pollen diagrams of Spek *et al.* (2001b).

In zone II, which corresponds with phase 3, there are no indications of human impact on the vegetation. There are no indications of anthropogenic influence in zone V and VI either. The changes that occur in the lower part of zone V are related to the activity of the channel that resulted in brackish conditions.

In zone III, of which the lower boundary corresponds with phase 4, and in zone IV, there are some changes that potentially indicate human activity at the site. There is an increase in the diversity of herbs and certain taxa show very minor increases in percentages: *Artemisia* sp., Chenopodiaceae, *Plantago* sp., *Pteridium* sp., *Persicaria lapathifolia*, *Rumex acetosa*-type, *Galium* sp., *Filipendula* sp., Apiaceae, *Mentha aquatica*, *Thalictrum flavum*, *Typha angustifolia*, and Asteraceae tubuliflorae (pollen and/or macroremains). In addition, the core contained charcoal remains in various samples[5], although this could concern secondary deposition. There are no clear indications of recovery of the vegetation. The presence of thin layers of sand in the peat of zone III may be related to anthropogenic influence as well.

It must be doubted whether the changes in zone III and IV that correspond with phase 4 can be related to human impact with certainty as the site was probably accessible during summer only, and since the amount of refuse related to phase 4 is small. The disturbance indicators can also be related to natural processes, especially to the submerging of the site. This submergence probably resulted in a considerable increased availability of light in the vegetation, for example due to tree falls. Human impact during this phase was furthermore probably

4 The *Betula* wood was somewhat younger than the wood of the fish remains but this can be explained by the fact that it concerned wood of roots.

5 The charcoal was present in the samples 6.95, 6.54, 6.40, 6.24, 6.04 and 5.94 m -NAP. The size of the charcoal particles is unknown.

of a small scale compared with the natural changes in the vegetation. Therefore, the changes in zones III and IV can only tentatively be related to human impact on the vegetation.

Core Eem 1 only corresponds with occupation phase 4; this concerns the lower half of the core. It is not possible to detect evidence of human impact in the relevant part of the diagram (zone I and II). At the end of zone II and in zone IIIa however, there are subtle changes in the vegetation that may represent the development of the natural vegetation or that may have resulted from very restricted human impact. It is not possible to distinguish between these two possible explanations as the changes are very weak.[6] Zone IIIb does not show indications of anthropogenic influence on the vegetation. Overall, there are no strong indications of anthropogenic influence on the vegetation in core Eem 1.

In conclusion, the prototype core shows indications of human impact on the natural vegetation during phase 2 and possibly during phase 4. The absence of indications of human impact during phase 3, which is in contrast to the interpretation of the diagrams by Spek *et al.* (2001a, b) is not understood, since it is during this phase that most impact is expected in view of the amount of refuse dating to this phase. A possible explanation may be the distance between the core and the activity zone. In contrast to the prototype core, core Eem 1 does not show clear evidence of human impact. This may be related to the distance to the sand ridge (core Eem 1 is *c.* 7 metres further away from the sand ridge than the prototype core) that influences the strength of the signal of human impact in the investigated cores. More importantly, core Eem 1 corresponds with phase 4. The amount of refuse that could be related to phase 4 is small, while the site mainly functioned as a fishing location, which may explain the little evidence of human impact on the vegetation.

5.5 Macroremains analysis

5.5.1 Materials and methods

The information on the botanical macroremains is based on the publications of Brinkkemper *et al.* (1999) and Visser *et al.* (2001). Four types of samples of botanical macroremains can be distinguished, comprising standardised samples collected on the ridge (N = 70), samples from hearths, mainly representing surface hearths (N = 110), samples from the bank zone (N = 4) and samples from the direct surroundings of the fish weirs (N = 3). Botanical remains were also collected during general sieving for archaeological remains on a 2 mm sieve. Figure 5.4 shows the locations of the samples. The standardised samples were systematically collected in a limited number of squares inside and just outside the area with the concentration of archaeological remains on the higher part of the sand ridge. The samples, with a volume of 5 or 10 litres, represent 1% of the excavated soil from a single excavation square (2 x 2 metres). The investigation methods and assumptions for the samples of the hearths were similar to the methods used for the standardised samples. The investigation of hearths included only the macroremains of those hearths for which strong disturbance (bioturbation/erosion) had been excluded. It was demonstrated that there was no significant difference between the macroremains assemblages of different layers of surface hearths. The samples from the bank zone have a volume of 1 to 2 litres. The samples collected near the fish weirs have a volume of *c.* 2 litres. All samples have partially or totally been sieved on a 0.25 mm sieve after flotation. The analysis included only fractions of the samples that were collected.

6 In the upper part of zone II for example, there is a slight decrease in *Alnus* sp. while the macroremains of *Alnus* sp. also decrease to recover afterwards. From the end of zone II onwards, some ruderals and wetland herbs appear that may indicate disturbance of the natural vegetation: *Artemisia* sp., *Pteridium* sp., a peak value of *Galium* sp., presence of *Rumex acetosa*-type and presence of burned plant remains. These species can however simply be part of the natural vegetation. The burned plant remains may have been preserved *in situ* but could also have been redeposited.

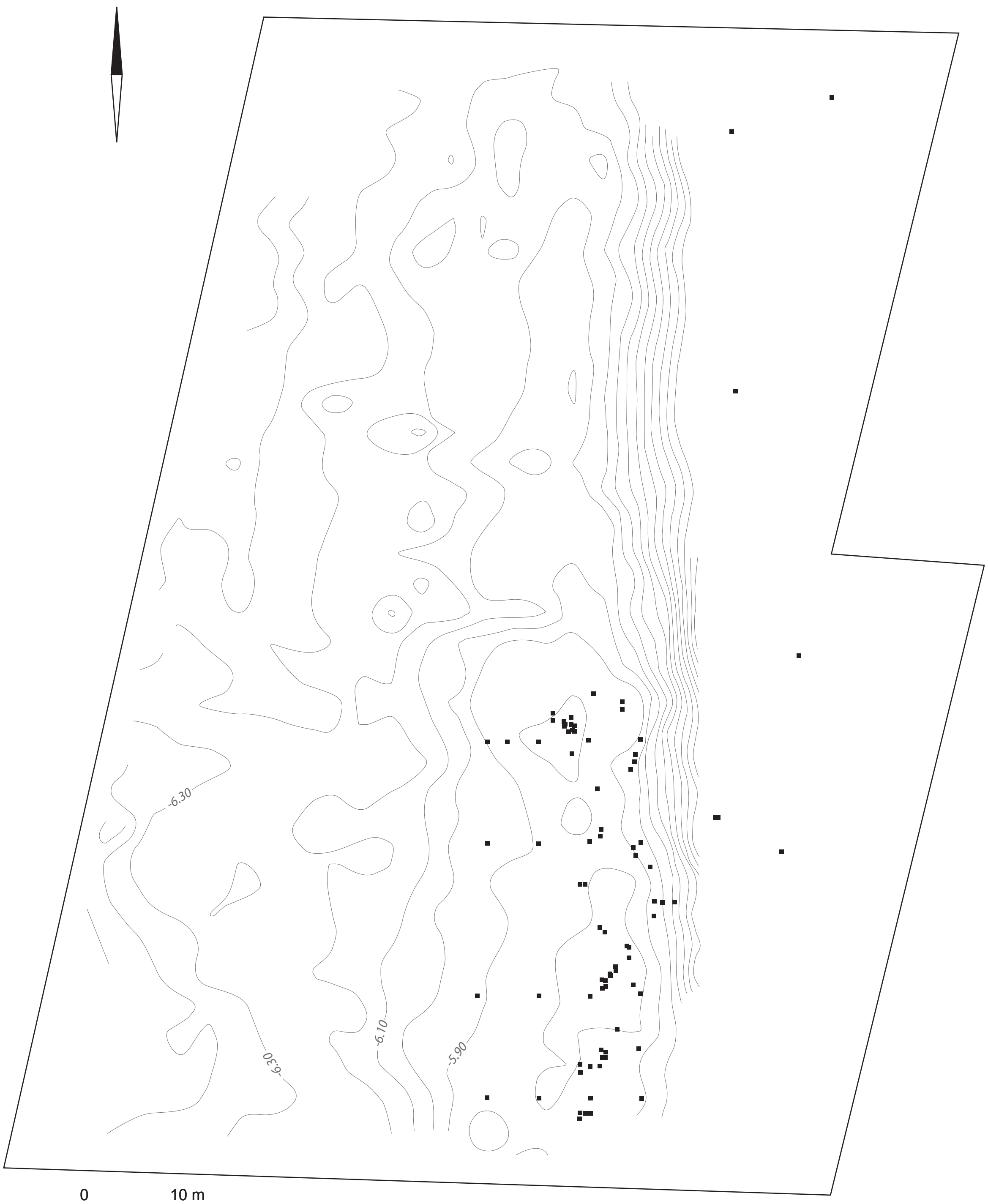


Figure 5.4 Hoge Vaart, map of the excavation of showing the Pleistocene subsurface (m −NAP) and the locations of the macroremains samples (after Visser *et al.* 2001). Some sample locations represent more than one sample.

The investigations concentrated on the main concentration zone on the slightly elevated part of the sand ridge. The northern concentration and postholes were not sampled for botanical remains but only investigated by analysis of the residue from the 2 mm sieve. Furthermore, the number of samples from deep hearths, the river bank zone and fish weirs is small. The analysis of samples of the sand ridge (standardised samples and hearth samples) concerned only carbonised remains, since waterlogged (uncarbonised) remains were assumed to date to the period of peat formation after occupation. Waterlogged macroremains were collected in the bank zone and around the fish weirs. Dating of individual samples by analysis of stratigraphy was often not possible because of the palimpsest conditions at the site. Some contexts of the excavation are nevertheless attributed to a phase (deep hearths, surface hearths and fish weirs) and in this way, there is some information on changes in the macroremains assemblage through time.

5.5.2. Results

The botanical macroremains indicate the presence of open woodland and woodland edge vegetation of dry terrain, disturbed vegetation characterised by pioneer species, a river bank or lake bank, open, stagnant or slowly running water, nutrient-rich and nitrogen-rich conditions, and brackish conditions. The investigators do not mention changes in the vegetation through time that do not correspond with the development of the landscape as reconstructed above.

The macroremains assemblage of some of the standardised samples, samples from surface hearths and deep hearths contained relatively large quantities of *Erica tetralix*, *Agrostis* sp. */Poa* sp., *Stellaria neglecta* and *Moehringia trinervia* (all present in high densities in one or more samples). Taxa that were present in a high frequency (in many samples) are *Corylus avellana*, *Galium aparine*, *Mentha aquatica/arvensis*, *Moehringia trinervia*, *Nuphar lutea*, *Nymphaea alba*, *Scirpus lacustris* ssp. *lacustris* and *Stellaria neglecta*. Many deep hearths were poor in identifiable macroremains; the only taxa that were found in these hearths are *Hippuris vulgaris*, *Moehringia trinervia* and *Nymphaea alba*. The limited number of deep hearths and the limited number of macroremains found in them unfortunately do not allow comparison of deep hearths *versus* surface hearths. The macroremains of one of the samples collected in the river bank zone reflects eutrophic alder carr and river bank vegetation that is highly comparable with elements of the vegetation present at the dunes in the central river area. The assemblage is characterised by macroremains of *Alnus glutinosa*, *Urtica dioica*, *Carex* species including *Carex acuta*, *Epilobium hirsutum*, *Lythrum salicaria*, *Mentha aquatica/arvensis*, *Phragmites* sp., *Rumex hydrolapathum* and *Typha* sp. The fish weir samples (phase 4) contain relatively large numbers of macroremains of *Carex acutiformis*, *Typha* sp., *Stratiotes aloides*, *Potamogeton* sp. and *Nymphaea alba*. All these taxa may represent species that tolerate minor brackish conditions.

The assemblage of macroremains comprised *Aster tripolium*, *Ruppia maritima* and *Najas marina* (Gotjé 2001; Visser *et al.* 2001) dating to the third and fourth phase. The presence of these taxa, and especially the relatively numerous fruits of *Ruppia maritima*, indicates the influence of the tidal system resulting in slightly brackish conditions in the (extra-) local environment.

5.5.3 Carbonised macroremains

Table 5.5 shows the taxa that were found in a carbonised state at Hoge Vaart. The carbonised macroremains found at the excavation are interpreted to originate primarily from the hearths, since the density of carbonised remains and the diversity of species was maximal in the hearths. Indeed, the samples from the river bank contained very few carbonised remains.[7] The hearths contained not only carbonised remains of dryland taxa and probable food plants but also carbonised macroremains of a large variety of wetland taxa.

7 One sample from the river bank contained carbonised remains of *Ruppia maritima*, *Carex* sp. and *Agrostis* sp./*cf. Poa* sp.). One sample from the fish weirs contained carbonised fruits of *Potamogeton* sp. and another sample contained carbonised seeds and fruits of *Potamogeton* sp. and *Lotus pedunculatus* (Visser *et al.* 2001, 27).

Woodland vegetation	*Carr, marsh vegetation*	*Open water vegetation*
of dry terrain	Alnus sp.	Hippuris vulgaris
Corylus avellana	Alnus glutinosa	Najas marina
Malus sylvestris	Alisma sp.	Nuphar lutea
Quercus petraea/robur	Carex acuta	Nymphaea alba
Rhamnus cathartica	Carex paniculata	Potamogeton acutifolius
Rosaceae	Carex pseudocyperus	Potamogeton sp.
Rubus idaeus	Carex riparia	Ruppia maritima
Ajuga reptans	Cladium mariscus	
Chelidonium majus	Eupatorium cannabinum	*Ecologically indeterminate*
Fallopia dumetorum	Lotus pedunculatus	Agrostis sp./Poa sp.
Galium aparine	Lychnis flos-cuculi	Anagallis sp./Glaux sp.
Moehringia trinervia	Lycopus europaeus	Apiaceae
Ranunculus ficaria, tubers	Lysimachia vulgaris	Asteraceae
Silene dioica	Lythrum salicaria	Atriplex littoralis/prostrata
Stellaria neglecta	Oenanthe aquatica	Carex sp.
Urtica dioica	Potentilla reptans	Carex acutiformis/rostrata
Vicia sepium	Rumex obtusifolius	Caryophyllaceae
	Schoenoplectus lacustris	Caryophyllaceae/Chenopodiaceae
Ruderals and pioneers	Schoenoplectus sp./	Cerastium sp.
of dry terrain	Scirpus sp. s.l.	Chenopodiaceae
Arenaria serpyllifolia ssp.	Sparganium erectum	Chenopodium sp.
serpyllifolia	Stellaria palustris	Fabaceae
Atriplex patula/prostrata	Typha sp.	Mentha aquatica/arvensis
Lapsana communis	Menyanthes trifoliata	Mentha sp.
	Carex flacca/panicea	Myosotis sp.
	Erica tetralix	Poaceae
	Veronica officinalis	Polygonaceae
		Polygonum sp.
	Wetland pioneer	Potentilla sp.
	vegetation	Rumex sp.
	Chenopodium glaucum/	Scrophularia sp.
	rubrum	Trifolium arvense/campestre/
	Persicaria minor	dubium
		Trifolium sp.
		Veronica sp.
		Vicia sp.

Table 5.5 Hoge Vaart, taxa of which macroremains have been found in a carbonised state (Visser *et al.* 2001 and RADAR 2005).

In general, Visser *et al*. (2001, 30) assume the non-intentional deposition of the wetland taxa in the hearths for most taxa (by flooding *etc*.) followed by non-intentional charring since all the wetland taxa were also found in a waterlogged state in the samples from the river bank. Intentional deposition and carbonisation is assumed only for a selection of the wetland taxa that are overrepresented, that in addition have edible parts and/or that could have been used in some way (discussed below). An alternative explanation for the high number of taxa that was found in a carbonised state is that people collected drift litter to bank their fires (building small walls around the fire or covering the fire in order to protect it and keep it glowing until the next moment of use). This could explain why the macroremains have remained preserved in a carbonised state instead of being completely burned. A second alternative explanation is that the macroremains were present in the water or wet organic material that was used to extinguish the fire in the hearths (see also appendix V). A third option is that people burned the drift litter to get rid of the decomposing material (Cappers 1993, 179).

Carbonised remains of the following potential food plants were found in anthropogenic contexts at Hoge Vaart: *Quercus* sp., *Corylus avellana*, *Malus sylvestris, Rubus idaeus*, *Nuphar lutea*, *Nymphaea alba* and tubers of *Ranunculus ficaria*. The 2 mm sieve residues contained many remains of *Quercus* sp. and *Corylus avellana*. The distribution of the remains of *Corylus avellana* was strongly related to the distribution of hearths and the remains of flint, burned bone, pottery and charcoal within the main concentration on top of the sand ridge, which strongly indicates an anthropogenic context of the nuts. The remains of *Quercus* sp. were mainly located within the main concentration as well. Carbonised pips and half a carbonised fruit of *Malus sylvestris* have been found in surface hearths, and waterlogged apple pips were also found in samples of the bank zone and fish weir 1. Carbonised tubers of *Ranunculus ficaria* have been found in the surface hearths dating to phase 3 and in a standardised sample (possibly older than phase 3). The tubers are edible (especially in spring when toxicity is minimal) and the context suggests that they were collected for consumption. It could however be possible that the tubers were carbonised accidentally since they may have been present in the soil where surface hearths were created naturally (see chapter 9). In addition to the taxa mentioned in this paragraph, carbonised remains of many other potential food plants were found (see also chapter 9).

In contrast to the central river area, the excavation at Hoge Vaart did not indicate the presence of *Trapa natans*, of which the fruits are edible. This is probably a valid result since a representative number of samples were sieved on a fine mesh width and since the fruits of *T. natans* are large enough to be found relatively easily. The absence of *T. natans* is probably not related to seasonality since there are indications of autumn occupation, while autumn is the harvest season of water chestnuts. An alternative explanation is that the ecological conditions where not suitable for growth of *T. natans*, such as microclimate, water current, water temperature and the salinity during the later phases.

Crop plants were not found at the site, despite (partial) analysis of 176 botanical samples on a 0.25 mm sieve and sieving for archaeological finds of samples spread over the whole excavated terrain on a 2 mm sieve.

5.6 Disturbance indicators

The presence of true field weeds at Hoge Vaart is improbable since crop plants were not found. The botanical assemblage nevertheless shows the presence of disturbance indicators at the site. The taxa that indicate disturbance and of which the ecology corresponds with the ecology of arable weeds (see chapter 10) are shown in table 5.6 (based on macroremains and pollen identifications). The presence of all taxa shown in this table may have resulted from human impact and/or natural sources of disturbance such as activity of wild animals and water activity.

category taxon	C	W	P
Agrostis sp./Poa sp.	+	+	-
Ajuga reptans	+	-	-
Anagallis sp./Glaux sp.	+	-	-
Arenaria serpyllifolia ssp. serpyllifolia	+	-	-
Artemisia sp.	-	-	+
Atriplex littoralis/prostrata	+	+	-
Atriplex patula/prostrata	+	-	-
Cerastium sp.	+	-	-
Chelidonium majus	+	-	-
Chenopodiaceae	+	-	+
Chenopodium glaucum/rubrum	+	-	-
Chenopodium sp.	+	+	-
Cirsium-type	-	-	+
Clematis vitalba	-	+	-
Daucus carota	-	+	-
Fallopia dumetorum	+	-	-
Galium aparine	+	-	-
Lapsana communis	+	-	-
Lotus pedunculatus	+	+	-
Lychnis flos-cuculi	+	+	-
Malva sylvestris-type	-	-	+
Mentha aquatica	-	+	-
Mentha aquatica/arvensis	+	+	-
Mentha sp.	+	-	-
Mentha-type	-	-	+
Moehringia trinervia	+	+	-
Persicaria lapathifolia	-	+	+
Persicaria minor	+	+	-

category taxon	C	W	P
Plantago sp.	-	-	+
Plantago major	-	-	+
Poaceae	+	-	-
Polygonaceae	+	-	-
Polygonum persicaria-type	-	-	+
Polygonum sp.	+	+	-
Ranunculus acris-type	-	-	+
Ranunculus ficaria, tubers	+	-	-
Rumex acetosa-type	-	-	+
Rumex acetosella	-	-	+
Rumex obtusifolius	+	-	-
Rumex sp.	+	+	+
Scrophularia	+	-	-
Silene dioica	+	-	-
Spergularia-type	-	-	+
Stellaria neglecta	+	-	-
Trifolium arvense/ campestre/dubium	+	-	-
Trifolium sp.	+	-	-
Trifolium-type	-	-	+
Urtica dioica	+	+	+
Urtica urens	-	+	-
Valeriana officinalis	-	+	-
Verbena officinalis	-	-	+
Veronica officinalis	+	-	-
Veronica sp.	+	-	-
Vicia cracca-type	-	-	+
Vicia sepium	+	-	-
Vicia sp.	+	-	-
Vicia-type	-	-	+

C = carbonised macroremains
W = waterlogged macroremains   + = present
P = pollen   - = not present

Table 5.6 Hoge Vaart, identifications of taxa that are comparable to arable weeds (Visser *et al.* 2001 and RADAR 2005).

5.7 Wood analysis

The analysis of the wood and charcoal remains is based on Van Rijn and Kooistra (2001). The wood analysis is based on *c.* 600 identifications. The wood remains consist of three categories: unworked wood remains, presumably worked wood remains and artefacts. There is no information on the sampling strategy applied in the field. The material that was not part of the fish weirs could not be assigned to a single phase. A group of 37 unworked trunks of oak were used for dendrochronology and were therefore not included in the analysis (see Peeters *et al.* 2001).

5.7.1. Unworked wood remains

The major part of the assemblage of unworked wood (N = 202; see table 5.7) was collected in the main concentration at the slightly higher part of the ridge. The dominant taxa are *Betula* sp., *Quercus* sp. and *Alnus* sp. *Corylus* sp. is remarkably absent in this group. The variety of taxa found (N = 8) is small compared with the variety of the taxa of trees and shrubs as indicated by the pollen and charcoal data. The low number of taxa may be caused by poor preservation on the higher part of the sand ridge during the first occupation phases, while a larger number of identifications would probably also have resulted in a longer taxa list.

On the coversand ridge, trunks and root systems were present, indicating the former presence of trees. The number of trunks of *Quercus* sp. (of ages up to 200 years) is interpreted as being indicative of the presence of woodland dominated by *Quercus* sp. during occupation, although *Quercus* wood may be overrepresented because of its high chance of preservation. The good status of preservation furthermore indicates rather rapid growth of peat at the moment that the lower parts of the ridge submerged (at 4535 BC as indicated by dendrochronology; Peeters *et al.* 2001). There were a few finds of *Tilia* sp. at a lower depth than the *Quercus* trunks, suggesting that *Tilia* trees died earlier than *Quercus* trees. This corresponds with the ecological preferences of *Quercus* sp. that tolerates moist conditions better than *Tilia* sp., and with the information from the pollen diagrams (see paragraph 5.3.1). The unworked wood assemblage also contained wood remains of *Pinus* sp. (probably *Pinus sylvestris*). The morphology and context of these finds suggest that they date to the Pre-Boreal (Van Rijn and Kooistra 2001; see also chapter 7).

The presence of wood remains of roots of *Betula* sp. in/around a fish trap is interpreted as being indicative of the presence of *Betula* carr at the site after the submerging of the sand ridge. This supposed presence of *Betula* carr corresponds with the high values of *Betula* sp. in the pollen diagrams of Gotjé (2001) as discussed above (paragraph 5.4.1).

5.7.2 Presumably worked wood remains

The context of several of the wood remains indicated that it concerned unnaturally deposited finds and even artefacts, although there were no clear traces of working and the finds were not recognised as part of a structure. The assemblage of presumably worked wood remains (N = 23) is based on information in Hamburg *et al.* (2001) and Van Rijn and Kooistra (2001). The combined results are shown in table 5.8. According to Hamburg *et al.* (2001), the anthropogenic features comprised two posts of *Quercus* sp., some remains of posts of *Alnus* sp., *Fraxinus* sp. and *Quercus* sp. (quantities unknown), and four trunks of *Quercus* sp. The data set of wood remains by Van Rijn and Kooistra (2001) indicates that there were posts of the taxa mentioned by Hamburg *et al.* (2001), and also posts of *Rhamnus cathartica* (N = 2) and *Tilia* sp. (N = 1). Several of these presumably worked wood remains were located near one of the fish weirs, and may represent a part of this structure.

taxon	N	%
Alnus glutinosa/incana	46	23
Betula sp.	73	36
Fraxinus excelsior	4	2
Pinus sp.	15	7
Quercus sp.	56	28
Rhamnus cathartica	3	1
Salix sp.	3	1
Tilia sp.	2	1
total	202	

Table 5.7 Hoge Vaart, unworked wood (Van Rijn and Kooistra 2001).

taxon	function	N
Alnus sp.	post	2
	post?	2
	branch/post?	1
	branch/post	2
Fraxinus sp.	post?	1
	branch/post?	1
	branch/post	1
Quercus sp.	post?	1
	trunk/post	3
	beam?	2
	beam	1
	post	1
	post	2
Rhamnus cathartica	post/stake	1
	post	1
Tilia sp.	post/trunk	1
total		23

Table 5.8 Hoge Vaart, presumably worked wood (Hamburg *et al.* 2001; Van Rijn and Kooistra 2001).

A few finds of presumably worked wood are discussed in detail (Hamburg *et al.* 2001). One post of *Quercus* sp. was present next to a deposition of flint. Two posts of *Quercus* sp. were found in the near surroundings of two skulls of aurochs. Four trunks of *Quercus* sp. were present close to fish weir 3, possibly representing a platform (see fig. 5.1). These four trunks did not show any traces of working but were free of branches, and were situated parallel and *c.* 1.2 metres from each other at the edge of the depression, and were located on top of a deposition of flint, which all suggest an anthropogenic context. Two of the trunks were dated to phase 3.

5.7.3 Wooden artefacts

The assemblage of worked wood remains consists of three fish weirs[8] (see fig. 5.1 and 5.5) and a fragment of a paddle, all dating to phase 4. Table 5.9 shows the identification of the wood remains of the fish weirs. The weirs all consisted of series of posts of various taxa of wood, preserved *in situ*, and remains of a fish trap that had been fixed at the end of the fish weir.

The posts that were part of the wattle work of the fish weirs were mainly constructed of *Alnus* sp., though also from other taxa including *Salix* sp. The wood was not affected by fungi and therefore it can be concluded that people mainly used fresh wood. The growth rings of some of the remains of weir 1 indicate bad growth conditions, while the growth rings of remains of *Acer* sp. of weir 3 indicate stressed growth as well. It is argued that the wood remains of the weirs were randomly selected from the vegetation in the near surroundings as the construction of the weirs is simple, the weirs are made of a variety of taxa, the assemblage comprises many taxa that prefer or tolerate a relatively high ground water table, and as the wood remains show indications of growth under stressed conditions (Van Rijn and Kooistra 2001). Fish weir 3 may have been repaired, as the wood shows indications of the collection of the wood during both spring and autumn (in contrast to the other two fish weirs). Fish weir 2 shows a low variety of taxa that may indicate the selection of *Alnus* sp., possibly related to the preference for trees that had already been used earlier for the collection of branches (see paragraph 8.7.3 for further discussion). A small number of *Alnus* branches of the other fish weirs may have been collected from such trees as well.

	N			%		
fish weir / taxon	1	2	3	1	2	3
Acer campestre-type	-	-	4	-	-	4
Alnus glutinosa/incana	107	60	65	66	97	73
Betula sp.	-	-	4	-	-	4
Corylus avellana	7	-	5	4	-	6
Pomoideae (type Crataegus sp./Malus sp.)	-	1	-	-	2	-
Populus sp.	-	-	3	-	-	3
Prunus padus-type	1	-	-	1	-	-
Quercus sp.	3	-	-	2	-	-
Salix sp.	43	1	8	27	2	9
Indet.	-	-	+	-	-	-
total	161	62	89			

+ = present - = not present

Table 5.9 Hoge Vaart, wood of the fish weirs including the fish traps (Van Rijn and Kooistra 2001).

8 The word fish weir in this study indicates fences used to guide fish into a fish trap and does not indicate weirs stretching over the whole width of a channel.

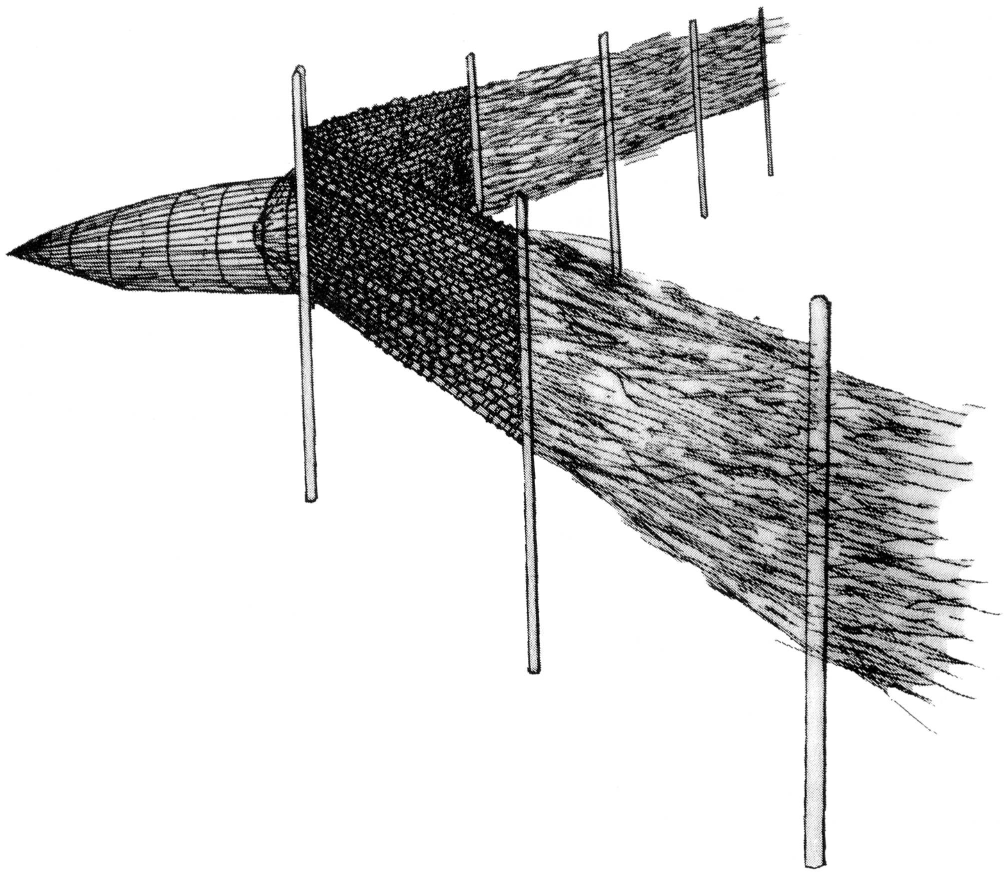


Figure 5.5 Hoge Vaart, reconstruction of a fish weir (Hamburg *et al.* 1997).

The fish traps were disturbed and only partly preserved, which made it difficult to recognise which wood fragments were part of the traps (see figures and photographs in the original publication). Therefore, the wood of the traps was distinguished from the remains of the fish weirs on the basis of their position, their deviating diameters, the deviating season during which growth ended, and the number of growth rings (Van Rijn and Kooistra 2001, 12-13). All fish traps were made of *Salix* sp. (N = 35, N = 1, N = 8), while a few withies from trap 1 of *Alnus* sp. and *Quercus* sp. may also have been elements of the fish trap (pers. comm. Van Rijn 2006). All withies from the fish traps were 1, 2, or 3 years old, though mainly 2 years. In addition the range of the diameters is limited. Together this indicates that the wood was probably collected selectively from trees that were regularly used for collection of branches, and that were possibly coppiced (see paragraph 8.7.3).[9] *Salix* sp. is regularly used for fish traps in prehistory in Northwestern Europe as well as in the northern part of the Netherlands during the Neolithic (Out 2008b), and indeed the flexibility of willow is very suitable for the production of fish traps.

9 There is a risk of circular argument here since the withies of the fish trap were distinguished by certain characteristics of the wood that are later used to support that the withies were collected from possibly managed trees. However, the fish traps were partly complete, which facilitated distinction of the relevant wood independent of other factors.

Fish traps 2 and 3 (best preserved) were tied together with rope made of bark. According to Van Rijn and Kooistra (2001), the most likely species used for the rope is *Sorbus aucuparia*, though exact identification was not possible. Pollen of *Sorbus aucuparia*-type has been attested in the pollen assemblages sampled in the soil from the coversand ridge (Spek *et al.* 2001a, b).

A fragment of a paddle has been found in the detritus corresponding with phase 4 (see fig. 5.6). The paddle was made of the wood of *Acer campestre* (*A. campestre*-type; identification L. Koehler and J. Nientker, pers. comm. Koehler 2005). The choice for *Acer* sp. instead of *Fraxinus excelsior* to make a paddle is unexpected since they are generally thought to be made of *F. excelsior* (see paragraph 8.4.2.3). *F. excelsior* was not used for the fish weirs either, which suggests that this species may have been absent at the site during phase 4.

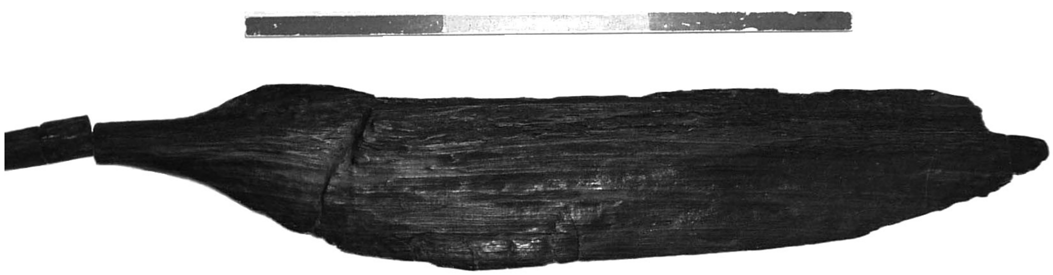


Figure 5.6 Hoge Vaart, fragment of a paddle (photograph: D. Velthuizen, Nieuw Land Erfgoedcentrum, Lelystad).

5.8 Charcoal analysis

The charcoal analysis comprised 7807 fragments of charcoal larger than 2 mm, which was a selection of rich samples from the excavated material. There were three categories of samples: surface hearths (N = 11), one deep hearth, and one pit that possibly represents a refuse pit. Table 5.10 shows the results of the identifications for each type of feature. All taxa that were part of the wood assemblage were also found in the charcoal assemblage. Most charcoal remains of the deep hearth[10] and the pit were identified as *Quercus* sp. (mainly dry dead wood), and it is argued that the selective use of *Quercus* sp. for fuel based on the qualities of the wood occurred. Admixture of other wood taxa may be related to the use of taxa for the initial lightning of a fire (Van Rijn and Kooistra 2001).

The surface hearths contained 16 taxa in total. Single surface hearths contained up to 11 taxa. The dominant taxa, present in almost all surface hearths, were *Quercus* sp., *Alnus* sp. and additionally Pomoideae (*Crataegus* sp./*Malus* sp.). The dominance of *Quercus* and *Alnus* charcoal remains corresponds with their dominant role in the natural vegetation (*Quercus* sp. on the sand ridge and *Alnus* sp. in the bank zone), suggesting that the selection of fuel was primarily based on availability of taxa. Some selection of wood for fuel based on the qualities of the wood nevertheless occurred since *Quercus* sp. and Pomoideae are very suited for fuel, enabling a fire to burn for a relatively long time. The scarcity of *Tilia* sp. moreover supports selective use of fuel as well, although preservation may also play a role.

The charcoal did not show indications of the use of wet or fresh wood. Instead, part of the charcoal assemblage of the surface hearths indicates regular use of dead wood remains affected by fungi for all taxa and especially the rare taxa.

10 This deep hearth dates to 5220-4930 BC (phase 2 or 3).

feature	N surface hearths	N deep hearth	N pit	N total	% surface hearths	% deep hearth	% pit	% total
number of features	11	1	1					
taxon								
Acer campestre-type	1	-	-	1	0	-	-	0
Alnus glutinosa/incana	331	6	3	340	20	0	2	4
Betula sp.	6	-	-	6	0	-	-	0
Corylus avellana	7	-	-	7	0	-	-	0
Euonymus europaeus	1	-	-	1	0	-	-	0
Fraxinus excelsior	18	-	-	18	1	-	-	0
Pinus sp.	3	1	2	6	0	0	1	0
Pomoideae	90	-	2	92	5	-	1	1
Populus sp.	24	-	-	24	1	-	-	0
Quercus sp.	902	5931	171	7004	54	99	93	90
Rhamnus cathartica	48	-	-	48	3	-	-	1
Salix sp.	1	-	-	1	0	-	-	0
Tilia sp.	44	18	-	62	3	0	-	1
Ulmus sp.	1	-	-	1	0	-	-	0
Viburnum opulus	11	-	-	11	1	-	-	0
Viscum album	1	-	-	1	0	-	-	0
Indet.	172	7	5	184	10	0	3	2
total	1661	5963	183	7807				

- = not present

Table 5.10 Hoge Vaart, identifications of the charcoal from several features (Van Rijn and Kooistra 2001).

5.9 Other sources

In a single pit in the main concentration, impressions of several circular mats with a diameter of at least 1-1.2 metres were found at several levels in the pit. The context finds resulted in the interpretation that the mats were used during the production of pottery. The main component of the mats could well be grasses or sedges. In the impression of a mat fragment, carbonised remains could be identified as a grass (Poaceae) and corresponded strongly with *Phragmites australis*. The impressions of a certain mat fragment contained few carbonised fragments of branches or bark of *Betula* sp. (Hamburg *et al.* 2001).

In the bank zone, carbonised remains of the fungus *Ganoderma cf. lucidum* have been found. This species grows on old/weak deciduous trees, preferably *Quercus* sp. (and *Fagus* sp.), thus supporting the presence of deciduous woodland on the sand ridge. The fungus was probably carbonised together with wood used for fuel since it has no known function (Visser *et al.* 2001).

In addition to the botanical remains, the analysed remains of animals, fish and arthropods give information on the landscape, environmental conditions and vegetation. In general, the faunal remains indicate ecological conditions that correspond with a wooded sand ridge located next to a river or marsh. Laarman (2001, 19) argues that the presence of wild horse remains form an exception since they indicate a very open landscape. This open landscape may have been present at the sandy soils south of Hoge Vaart.

The arthropods are indicative of a variety of ecological conditions/biotopes: mosses, lichens, organic matter, solid substrate (trees, stone or flint) present in woodland soils, sandy soils, dryland woodland, carr, eutrophic peat, grassland, and brackish grassland and/or aquatic habitats under dry, moist and/or wet conditions. The biotopes include all gradients between dry and wet, both brackish water and fresh water, and both dense woodland and open meadow vegetation. In addition, there were only a few arthropods indicating decomposition of organic material. Although the activities of people must have resulted in the accumulation of organic waste, the absence of arthropods indicative of such waste suggest that the amount of waste was restricted or that the waste was burned or deposited in the low part next to the ridge where the channel may have flooded the waste away (Schelvis 2001).

The non-botanical remains confirm the occurrence of slightly brackish conditions. The assemblage of fish consists of eight freshwater taxa and five taxa that tolerate brackish or saline conditions. An anthropogenic context is assumed for three non-freshwater taxa. Remains of those three species were found in a carbonised state in the main concentration on top of the sand ridge. The scarcity of fish that tolerate brackish conditions indicates that marine resources were consumed but never formed a main food source for the people that visited Hoge Vaart. In addition, the scarcity of fish taxa indicative of brackish conditions supports that the environment of Hoge Vaart was predominantly a freshwater environment during occupation (Laarman 2001).

5.10 Synthesis Eem region

5. 10.1 Reconstruction of the natural vegetation

5.10.1.1 Reconstruction of the natural vegetation of dry terrain

There is not much information on the natural vegetation during the first occupation phase at Hoge Vaart during the Early Atlantic. The woodland of dry terrain was dominated by *Quercus* sp. and *Tilia* sp., and was probably relatively dense compared with later phases, with relatively little herb vegetation in the understory. Spek *et al.* (2001b) suggest that the Early Atlantic vegetation comprised *Tilia* sp., *Quercus* sp., *Fraxinus* (*excelsior*), *Ulmus* sp., *Betula* sp., *Corylus* (*avellana*), *Ericales*, *Polypodium vulgare* and *Dryopteris* sp.

For phases 2 and 3 (Middle and Late Atlantic), more details are known. During the Middle Atlantic (second phase), mixed deciduous woodland developed on top of the sand ridge. Initially, *Tilia* sp. dominated the eutrophic and calcareous dryland woodland, in combination with *Quercus* sp., *Betula* sp. and *Corylus* (*avellana*).

Later on (phase 3), *Quercus* sp. dominated the dryland vegetation, together with taxa that were already present during earlier phases and with a variety of secondary trees, shrubs and climbers, *i.e. Acer campestre*, *Rhamnus cathartica*, *Viburnum opulus*, *Humulus lupulus* and *Lonicera periclymenum*. *Malus sylvestris* may have been present as well since fruits and macroremains were found, since charcoal of Pomoideae (including *Malus* sp.) was present in all surface hearths and since *Malus* sp. was also represented in the wood of the fish weirs.

At the end of phase 3 (*c.* 4500 BC), many oaks submerged, indicating the submerging of the dryland vegetation. The higher parts of the sand ridge of Hoge Vaart quickly submerged and disappeared beneath the peat between *c.* 4450 and 4350 BC. During phase 4, there was hardly any woodland of dry terrain left. After final submerging, a marshy area developed at the sand ridge which was dominated by eutrophic marsh vegetation, resulting in *Phragmites* peat with some patches of wetland trees.

5.10.1.2 Reconstruction of the wetland vegetation

During the Atlantic, the area next to the sand ridge developed from dry terrain into an area with lakes and marshes. The slope of the sand ridge formed a special biotope where a strong change in gradients occurred due to the steepness of the slope. In the Early Atlantic, dryland vegetation was probably present, mixed with some extra *Fraxinus excelsior*. Alder carr with *Alnus* sp., *Salix* sp. and *Rhamnus frangula* was present from *c.* 4700 BC onwards, contemporaneous with phase 3. The wood assemblage indicates that *Alnus* sp. formed an important element of the landscape during phase 4. After occupation, birch carr with *Betula* sp., *Salix* sp. and possibly some *Alnus* sp. developed at some patches in the depression. In the Middle and Late Atlantic, a channel, part of a freshwater tidal system, was active at the border of the sand ridge between *c.* 5000-4900 BC and during *c.* 4450-4300 BC. After the second activity period, the channel filled up with clay under slightly brackish conditions, followed by deposition of detritus.

The water plants of Hoge Vaart will be discussed here since the information on these taxa is spread over the volumes of the publication. The water plants found at Hoge Vaart are *Nymphaea alba*, *Nuphar lutea*, *Myriophyllum spicatum*, *Myriophyllum alterniflora*, *Potamogeton* sp. *Potamogeton cf. acutifolius*, *Potamogeton cf. acutifolius/densus*, *Potamogeton cf. pusillus*, *Ceratophyllum demersum*, *Stratiotes aloides*, *Hippuris vulgaris*, *Ruppia maritima* and *Najas marina* (Spek *et al.* 2001b; Visser *et al.* 2001). In addition, the analysis of arthropods has demonstrated the presence of *Lemna gibba* (Schelvis 2001). Although local occurrence can never be assured for water plants due to the possibility of transport by water, the ecological conditions of the taxa highly correspond with each other, thus supporting the local presence of the taxa. Most taxa are indicative of moderate to very eutrophic conditions and stagnant to slowly running water, although some species tolerate some stronger currents. Most plants are rooted in the soil, while the leaves are either submerged or floating on the water (except for *Hippuris vulgaris* and *Stratiotes aloides*). The species generally prefer a water depth of maximally *c.* 2 metres, except for *M. verticillatum*. Most taxa tolerate at least slightly brackish conditions, except for *Myriophyllum alterniflora* and *Potamogeton cf. acutifolius*.

The assemblage of macroremains indicates the influence of the tidal system connected to the lagoon north of Hoge Vaart, resulting in slightly brackish conditions in the (extra-) local environment. This influence is also indicated by the composition of the assemblage of pollen, diatoms, fish and mammals, although some of the taxa do not necessarily represent the local environment. The period of brackish conditions is not precisely known though can be expected to have taken place during the second activity phase of the channel (*c.* 4400-4300 BC). In addition, the occasional flooding events from phase 3 onwards may have resulted in a very minor brackish influence or the transport of indicators of brackish conditions, as supported by the diatom analysis (Gotjé 2001).

5.10.2 Human impact on the vegetation

It is generally not possible to reconstruct human impact on the vegetation at Hoge Vaart in detail since there are no pollen diagrams that precisely reflect the development of the vegetation before, during and after each phase. Despite repetitive occupation at the site, the indications of human impact on the vegetation at the site appear to be restricted. The diagrams of Spek *et al.* (2001a, b) indicate that the disturbance of the vegetation is maximal during phase 3, which may be related to human impact, while other disturbance factors cannot be excluded. The diagrams of Gotjé (2001) indicate human impact during phase 2 and possibly during phase 4. These conclusions can be supported by several arguments:

- The soil analysis (Spek *et al.* 2001a, b) does not demonstrate changes that were certainly caused by anthropogenic influence on the vegetation other than erosion of the eastern slope of the sand ridge during phase 1.
- The pollen diagrams of the sand ridge do not enable precise analysis of human impact on the vegetation but do provide considerable indications of it. The strongest disturbance indications consist of the variety of taxa that were part of the *Quercus* vegetation and the somewhat increased number and presence of taxa that prefer open patches (phases 2 and/or 3). It is not possible however to distinguish the disturbance that was caused by human impact from the disturbance that resulted from the submergence of the site. The only exception to this is the massive submerging of *Quercus* trees that is certainly related to the rise of the ground water level.
- The cores of Gotjé (2001) show only weak evidence of potential human impact. Temporary changes followed by the recovery of the vegetation cannot be observed (in contrast to the central river area).
- There are no indications of large-scale deforestation or local crop cultivation.
- The number of herb taxa that indicate disturbance present in the macroremains assemblage is limited.
- The wood and charcoal assemblages (especially the unworked wood remains) contain only a minority of remains from taxa that form elements of the secondary vegetation and that prefer open conditions.
- The wood assemblage does not support extensive use of wood for the production of artefacts during the first three phases, although this may be related to preservation and the sampling strategy. Only for phase 4 is there considerable evidence of the exploitation of the vegetation for the manufacture of wooden artefacts.
- The charcoal assemblage indicates that people hardly cleared trees for fuel but instead used dead wood, and thus exerted limited direct influence on the living vegetation.[11]

A first hypothesis to explain the limited strength of human impact on the vegetation is related to site function. The site is interpreted as an extraction camp used for hunting, gathering, fishing and fowling, though the indications of the local production of pottery and the presence of human bone remains suggest that the site was used more intensive during some periods. However, it is possible to distinguish human impact at some sites in the central river area that apparently had a similar site function. Moreover, the site function of Hoge Vaart is poorly understood for some (parts) of the of occupation phases. In general, the hypothesis that weak human impact is related to site function must therefore be rejected. Only for phase 4 the site function may explain the absence of evidence of human impact, since the site functioned as a fishing spot during this phase.

A factor that is related to site function and that may explain the limited evidence of human impact at Hoge Vaart is the (apparent) absence of domestic animals. The influence of domestic animals on the vegetation at the Dutch wetland sites is poorly understood. This subject is also discussed in paragraph 8.2.8.

11 The collection of dead wood also influences the ecosystem at the site and therefore implies indirect influence on the vegetation. Dead wood supplies a habitat for many insects, arthropods and micro-organisms (Van Rijn and Kooistra 2001).

A second hypothesis to explain limited human impact on the vegetation is occupation intensity (frequency, length of separate occupation periods and number of people). This explanation may partly explain the indications of anthropogenic influence on the vegetation during phase 3 since the number of features of phase 3 is relatively large compared with other phases. This explanation could furthermore explain the limited evidence of human impact during phases other than phase 3. It is however difficult to compare the occupation intensity and the strength of anthropogenic influence on the vegetation in detail, since the occupation phases are not stratigraphically separated and since they are based on the analysis of a limited number of ^{14}C dates.

Another aspect related to occupation intensity that may explain the restricted evidence of human impact is the size of the dryland terrain where the site was located. Hoge Vaart consists of a relatively large patch of dry terrain. As a result, anthropogenic influence on the vegetation at Hoge Vaart was not necessary concentrated in a small area, resulting in low human impact per surface unit.

A third hypothesis to explain the limited strength of human impact on the vegetation concerns the characteristics of the Pleistocene subsurface. It concerns a coversand ridge and this type of subsurface is not present at any of the other sites that are included in this study. The vegetation can best be compared with the vegetation on the dunes in the central river area that also represents deciduous woodland, although there were some differences between the vegetation of the two regions as well (see chapter 7).

5.10.3 Crop cultivation

5.10.3.1 Suitability of the landscape for cultivation

Two relevant factors influencing the suitability of the site of Hoge Vaart for arable farming are the presence of nutrients and the hydrology. The analysis of the soil indicated that the sand ridge was sufficiently nutrient-rich during the Middle Atlantic, just like the sandy soils south of the site. In the Late Atlantic however, the soil became less eutrophic and increasingly acid. The ground water level may have been too low for the successful practice of arable farming in the Early Atlantic, although the presence of capillary water may have reduced this problem. At this period however, the Neolithic subsistence had not spread into Northwestern Europe (see paragraphs 1.2 and 5.10.3.2). In the Middle Atlantic (until *c.* 5200/5000 BC), the conditions may have been favourable for the practice of arable farming. In the Late Atlantic, the ground water level was presumably too high and too variable, and probably prevented successful arable farming (Spek *et al.* 2001a, b).

5.10.3.2 Absence of indications of agriculture at Hoge Vaart

At Hoge Vaart, there are no indications of the presence of domestic plants in the assemblage of pollen and macroremains despite the analysis of a large number of samples. There are furthermore no indications of deforestation on such a scale that it can possibly be related to the presence of fields, no finds of traces of sickle gloss on the flint (Peeters, Schreurs and Verneau 2001) and no finds of querns (Peeters 2001, 13). As a result, it is concluded that crop plants were not present and that crop cultivation was not practised at the site. There are no indications of the practice of animal husbandry either (see paragraph 5.2).

The absence of cultivation practices appears to be in contrast to the introduction of cultivation in the loess regions in Germany, Belgium and the very southern part of the Netherlands at *c.* 5300 (see chapter 1). The data from the central river area indicate that domestic animals may have been expected at Hoge Vaart during phase 3, while crop plants could have been present during phase 4. More precisely, this study indicates that crop plants were introduced at the Dutch wetland sites between 4400 and 4100 BC (see chapter 11), although the evidence from the Eem and Vecht regions could be improved.

Brinkkemper *et al.* (1999) suggested that the absence of crop plants at Hoge Vaart may be related to the spread of agriculture after 5300 BC, the site function and the sampling locations. Site function may indeed have played a role, particularly during phase 4. However, although some of the sites in the central river area may have had a similar site function, cereals were still present at these sites. The location of the samples does not necessarily explain the absence of crop plants either. If cereals had been present, they would have been expected in the main concentration as part of the settlement refuse, as is the case at the other agricultural wetland sites studied (see paragraph 11.4). The number of samples and the sampling strategy can additionally be considered as being extensive enough to support the absence of crop plants at Hoge Vaart (see paragraph 5.5.3).

The data of the wetland sites of the Swifterbant culture indicate that agriculture was not introduced at the wetland sites when the environmental conditions at Hoge Vaart were suitable for agriculture (phases 1 and 2). When agriculture could have become available, the environment was not suitable anymore (phases 3 and 4; *cf.* Peeters *et al.* 2000, 108). In addition, the visitors of Hoge Vaart had probably many possibilities to practise agriculture elsewhere. Furthermore, it cannot be excluded that occupation during phase 4 took place relatively early, *i.e.* around 4350 BC, while the introduction of crop plants occurred later. If so, it would not be the environmental conditions but the availability of cereals that explain the absence of crop plants at Hoge Vaart.