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.

Appendix I. Archaeobotany of Hardinxveld-Giessendam Polderweg and De Bruin, the Netherlands

I.1 Geology of Hardinxveld-Giessendam Polderweg

The site of Hardinxveld-Giessendam Polderweg is located on a Late Glacial inland dune in the central river area (coordinates 116.104/427.636; see fig. I.1). The top of the dune is at about 4.5 m -NAP. Its surface measured *c.* 80 x 50 metres (4000 m^2) at the start of occupation and became smaller through time. The relative height of the dune decreased from 3 to 2.5 metres during occupation phase 1, and to 1.2 m during phase 2 (the occupation phases are discussed below). The former landscape around the site was reconstructed by means of hand corings in an area of 1700 x 600 metres (see fig. I.2). During phase 1, marshes and open water surrounded the dune, while marshes and carr became increasingly important during the later phases. An open crevasse channel, active between *c.* 5500 and 5100 BC, was present approximately 500 metres to the south. Its presence resulted in the sedimentation of peaty clay with some local thin sand layers. At the start of occupation, Polderweg was one of four dunes protruding in the vicinity, located in the middle of a large marsh area without channels or large patches of open water. At the end of occupation, most of the other dunes had become submerged, while Polderweg would follow soon (Mol 2001a, 2003).

I.2 Archaeology of Hardinxveld-Giessendam Polderweg

The discussion of Hardinxveld-Giessendam Polderweg and De Bruin is primarily based on Louwe Kooijmans (2001a, b and 2003). Excavation of a part of the southern slope of the dune at Polderweg took place in 1997-1998. The excavation trench (28 x 16 metres) revealed a sequence of refuse layers formed during several occupation phases, large oval pits interpreted as huts (phases 0 and 1), round pits interpreted as fire pits, and postholes (see fig. I.3). The Holocene deposits (clay, colluvia and refuse layers: fossil anthropogenic horizons) comprised artefacts made of flint, stone, pottery as well as organic remains including human remains.

Four occupation phases have been distinguished: phase 0 before 5500 BC, phase 1 around 5500-5300 BC, phase 1/2 around 5100 BC and phase 2 around 5000 BC.[1] Phase 0 may only be the initial stage of phase 1. Phase 1 is the major phase and is represented by much more material than the other phases. Figure I.4 shows the extent of the refuse layers of the main phases. Archaeological finds in the corings indicated that the occupation during phases 0 and 1 extended over an area of 110 x 25 metres, while occupation during phases 1/2 and 2 together extended over an area of 80 x 20 metres.

The site can be characterised as Late or even Final Mesolithic in view of the absence of domesticates, and moreover represents the initial stage of the neolithisation process in the region in view of the first occurrence of pottery in phase 2. Phase 1 is contemporaneous with the *älteste* LBK, and the material of this phase contained three arrowheads in LBK style, which indicates some contact with these Neolithic communities and illustrates the start of the availability phase as defined by Zvelebil (1986; see chapter 1). The nearest known LBK settlements at this time were located in Hessen, Germany. Other stone and flint artefacts point to contact with communities within Southern Limburg and the Ardennes. Phase 2 is contemporaneous with the *jüngere* LBK and ended before the start of the Rössen culture (see fig.1.1). In phase 2, the scarce presence of characteristic pottery indicates that Polderweg was part of the initial phase of the Swifterbant culture.

The subsistence of the site Polderweg can be characterised as a broad-spectrum economy, with a special focus on the hunting of furred animals and on fishing (especially for pike). The consistent character of the faunal assemblages from all phases suggests a stable use of resources through time.

1 Recalculation of the ^{14}C dates of Polderweg resulted in the new conclusion that phase 1 dates between 5430±90 and 5350±100 cal BC and phase 2 between 5200±140 and 5069±140 cal BC (Mol and Van Zijverden 2007). See also fig. 2.5.

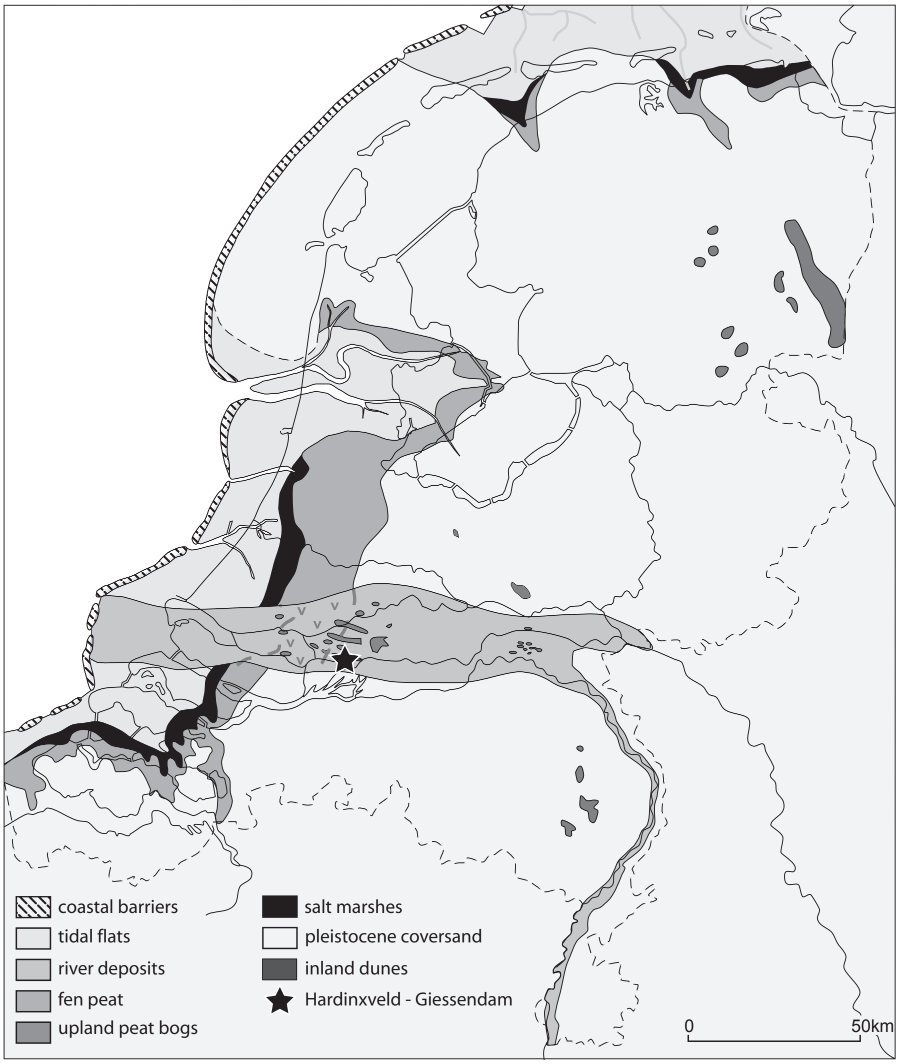


Figure I.1 Hardinxveld-Giessendam, the Netherlands, location plotted on a palaeogeographical map (*c.* 5700 BC; NITG).

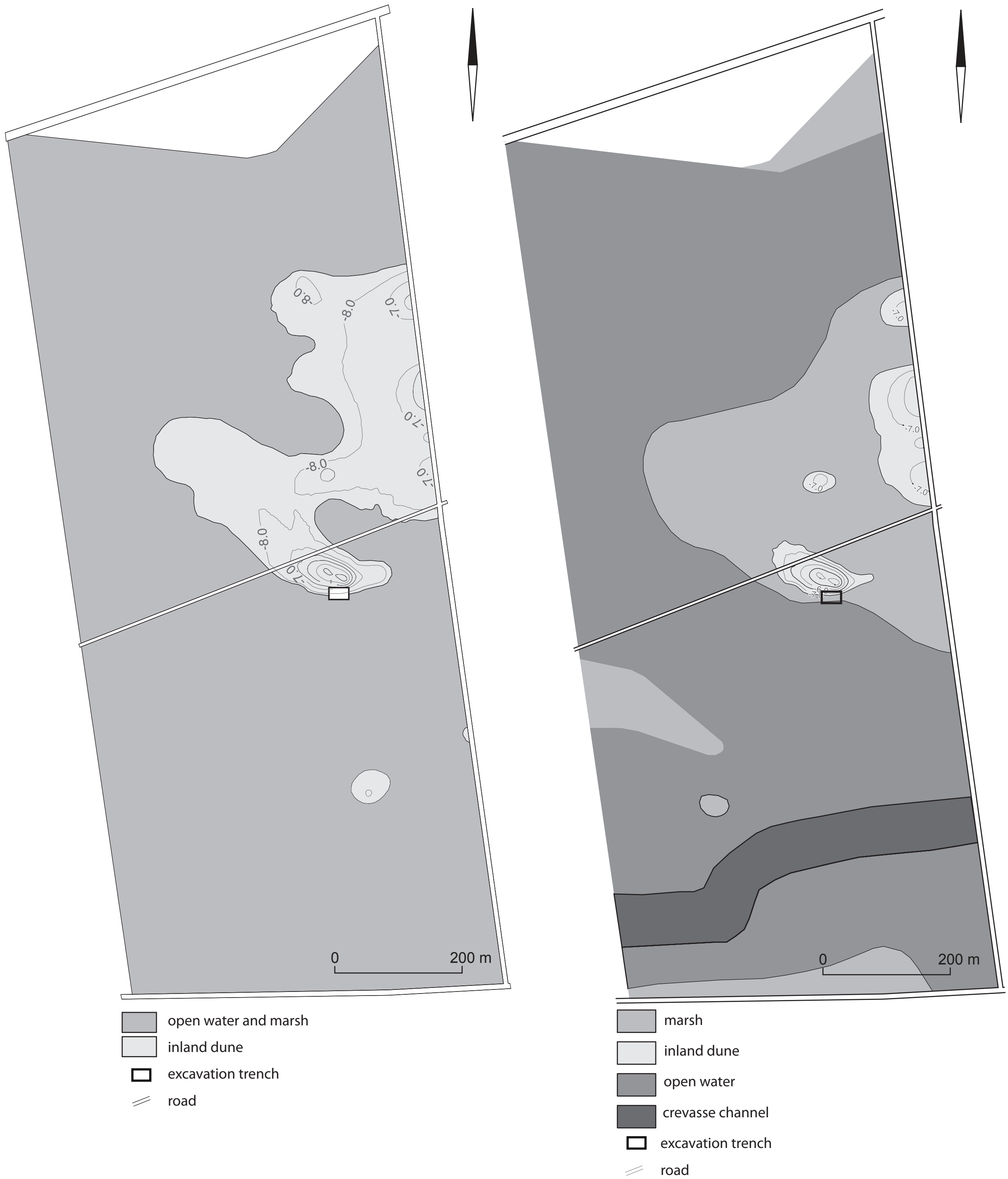


Figure I.2a Hardinxveld-Giessendam Polderweg, the Pleistocene subsurface (m –NAP) and palaeogeographical reconstructions for phases 0 (left) and 1 (right) (after Mol 2001a).

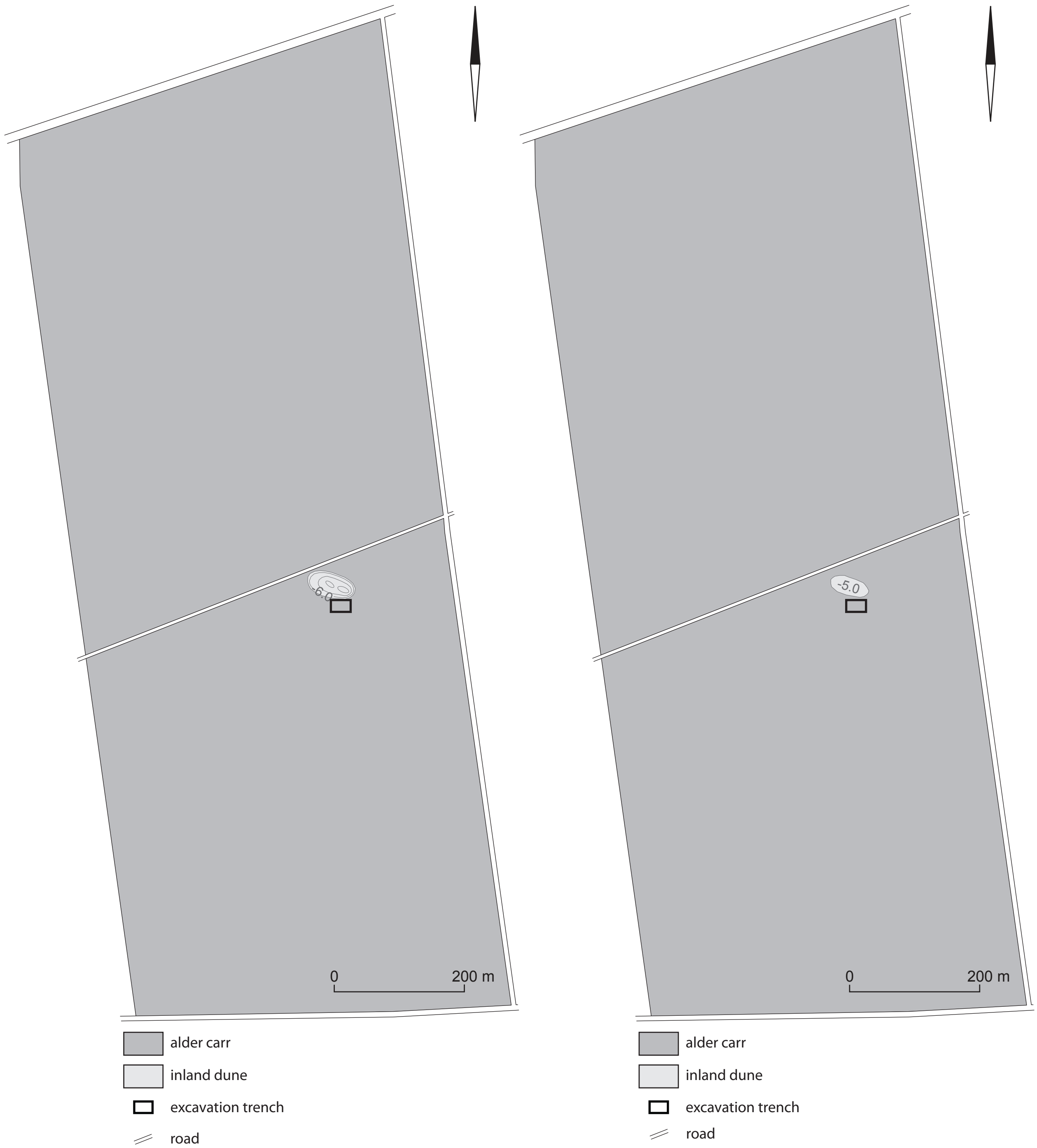


Figure I.2b Hardinxveld-Giessendam Polderweg, the Pleistocene subsurface (m –NAP) and palaeogeographical reconstructions for phases 1/2 (left) and 2 (right) (after Mol 2001a).

Crop plants and domestic animals other than dog are absent during all phases. For phase 1, the site is interpreted as a winter base camp. It could concern a main occupation in late winter and additional occupation in early autumn or occupation from September to March. There is not enough evidence for both other phases to make any conclusions about seasonality, but continuity in function seems most plausible. The interpretation of the site as a winter base camp implies that it represents only a part of a residential mobile settlement system. The indications of southern contacts make the southern coversand region the best candidate for occupation during other periods of the year, especially the summer. Unfortunately this is hard to prove due to bad preservation of sites on the southern sand grounds (Louwe Kooijmans 2001a, b, 2003).

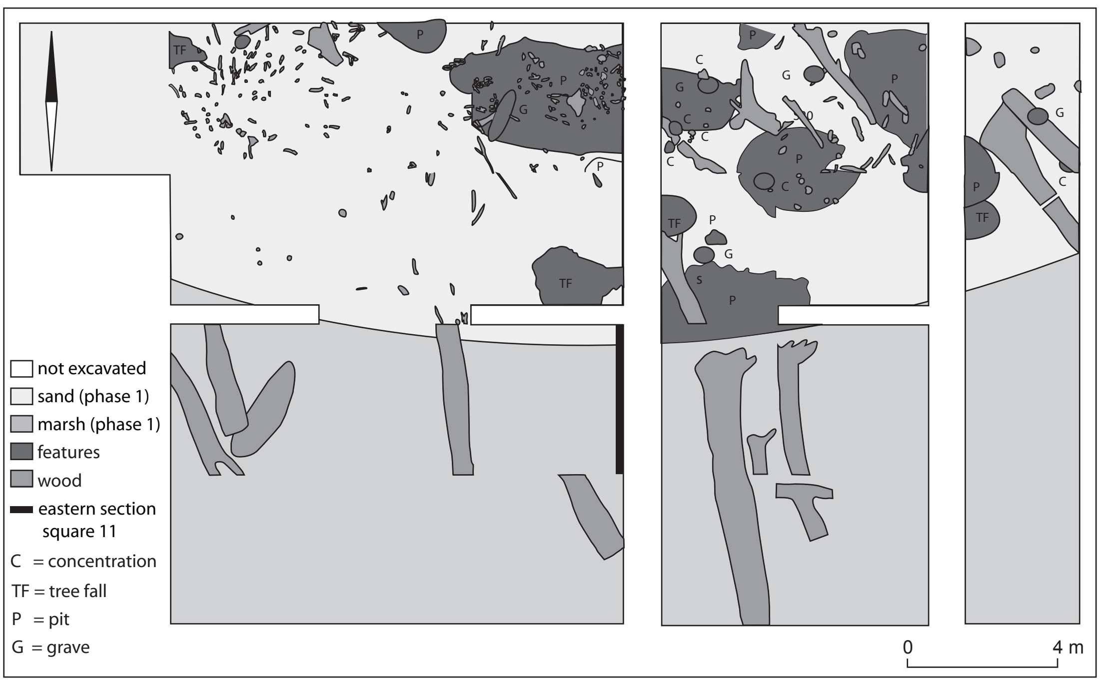


Figure I.3 Hardinxveld-Giessendam Polderweg, features of all phases (after Hamburg and Louwe Kooijmans 2001, adapted by L. Amkreutz).

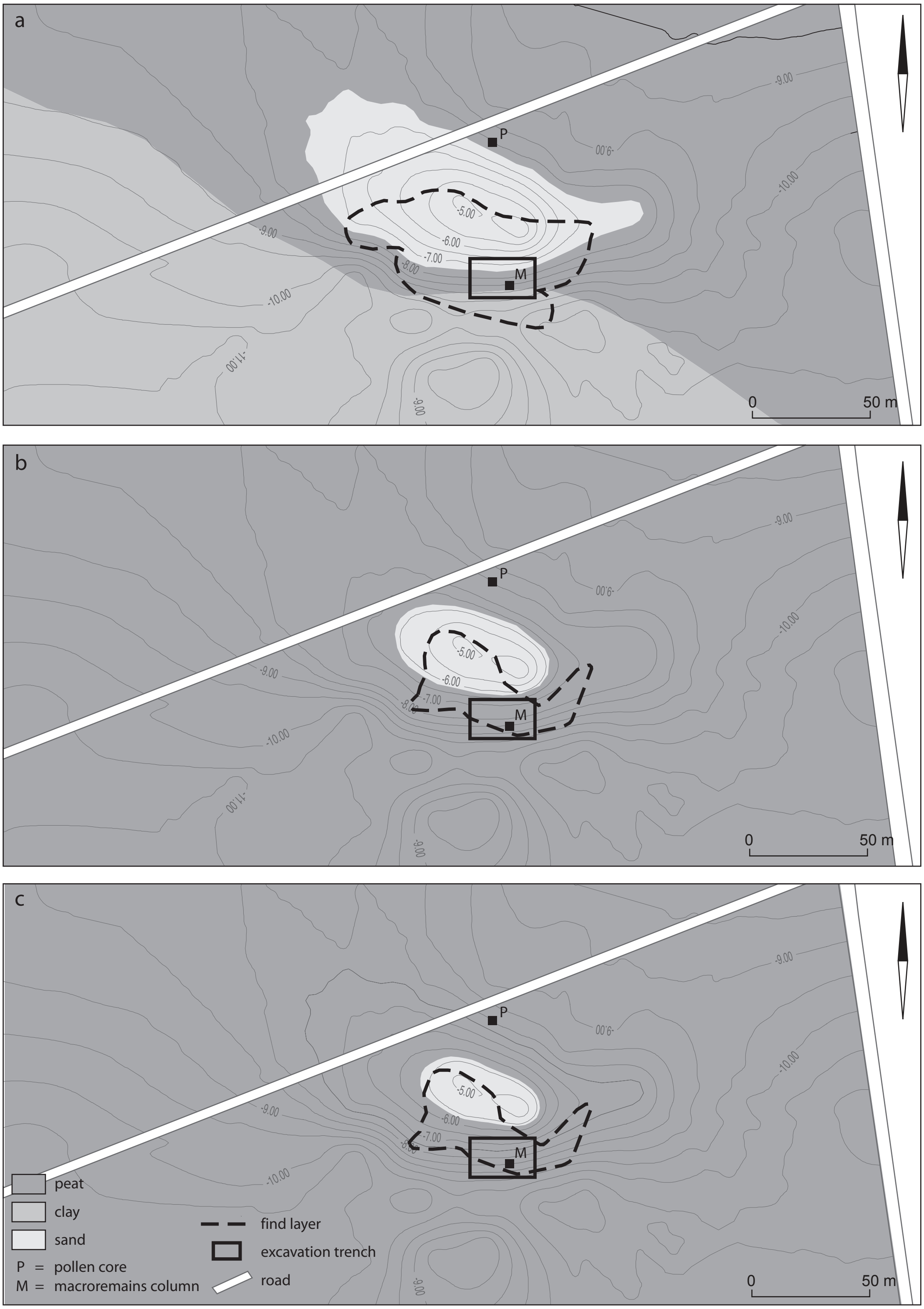


Figure I.4 Hardinxveld-Giessendam Polderweg, the Pleistocene subsurface (m –NAP), the extent of the surface of the dune and the refuse layers for phases a) 1, b) 1/2 and c) 2 (after Mol 2001a).

I.3 Archaeobotany of Hardinxveld-Giessendam Polderweg

The archaeobotanical data of Polderweg consist of a dated pollen diagram and information on macroremains, worked and unworked wood, charcoal and fungi published by Bakels and Van Beurden (2001), and an unpublished macroremains diagram (De Kort 1998). All source material was collected in the excavation trench, with the exception of the pollen core.

I.3.1 Pollen analysis

The location of the pollen core was chosen at the northern side of the dune where the influence of the crevasse channel was small (see fig. I.2 and I.4). The core was located at 4 metres from the attachment point[2] of phase 1, at 26 metres from the attachment point of phase 2, and at *c.* 40 metres from the refuse layer (*i.e.* the settlement area, at the other, southern site of the dune) during all phases. The sediment of the core consists of sandy peat with a layer of gyttja at 7.55 to 7.66 m -NAP. The pollen analysis is based on an upland pollen sum of at least 300 pollen grains. The pollen diagram (see fig. I.5) provides the development of the vegetation during phases 1, 1/2 and 2 (between 5584 to 5230 BC and 4916 to 4540 BC, see the publication for ^{14}C dates). Periods before and after these occupation phases are not represented in the pollen diagram because such a long sequence of peat was not available. The pollen diagram indicates that the natural vegetation on the dune consisted of mixed deciduous woodland and woodland edge vegetation, with some open patches of herb vegetation. The dry dune was surrounded by alder carr, marsh and open water. For the wetlands surrounding the dune, the lower part of the diagram shows relatively open riparian vegetation, which changed into alder carr approximately around phase 2.

It is not possible to discern clear signals of human impact in the diagram (Bakels and Van Beurden 2001). The diagram shows a decreasing percentage of dryland trees and an increasing percentage of dryland shrubs that could be related to human impact, but this may also be caused by the submergence of the dune. There are some other changes in the diagram that may be related to human activity as well[3], but a strong causal relationship cannot be demonstrated. In addition sudden decreases in dryland trees or peaks in dryland herbs are absent, and the different occupation phases are not separately recognisable. One would expect signals of occupation phase 1 in particular since the distance between the dune and the sample point is very small during this phase (4 metres) and since phase 1 is the longest and most intensive occupation period, although the phase is possibly not reflected completely in the diagram. However, even signals of this phase cannot be discerned accurately. This indicates that any human impact was probably of restricted scale.

The weak human impact is rather unexpected in view of the length of occupation at the dune and the evidence of use of the vegetation as demonstrated by the analysis of macroremains, wood and charcoal. A possible explanation is that the evidence of human impact at Polderweg is weak due to the absence of agriculture. There are however several other explanations for the weakness of the anthropogenic signal. Firstly, possible evidence of human impact may be blurred by the changes in the vegetation that were caused by the rising water table, which led to the continuous submerging of trees, and resulted in the development of open patches in the vegetation and growth of secondary vegetation. Secondly, the distance to the dune and the distance to the refuse layer may play a role. The distance between the sample location and the dune (phase 1: 4 m; phase 2: 26 m) is, however, not exceptionally large and is not suspected to explain the weakness

2 Attachment point: location where the peat is attached to the dune, indicative of the height of the ground water level and representing the transition from the dune to the surrounding wetlands.

3 In the first spectrum of the diagram (8.00 m -NAP, phase 1), *Urtica*-type and Poaceae as well as monoletae psilatae fern spores show small peaks, while *Filipendula* sp. shows a peak in the top of the diagram. Other possible anthropogenic signals are a decrease in *Quercus* sp. (7.50 m -NAP, phase 1/2) and *Tilia* sp. (7.30 m -NAP, phase 1/2), a gradual increase in dryland shrubs and herbs in the middle and upper part of the diagram indicating increased openness of the vegetation (phases 1/2 and 2, indicated by pollen of *Corylus* sp., *Rhamnus cathartica*, *Viburnum opulus*, *Cornus sanguinea*-type, *Sambucus nigra*-type and Chenopodiaceae, *Artemisia* sp., *Plantago lanceolata* and *Pteridium* sp.).

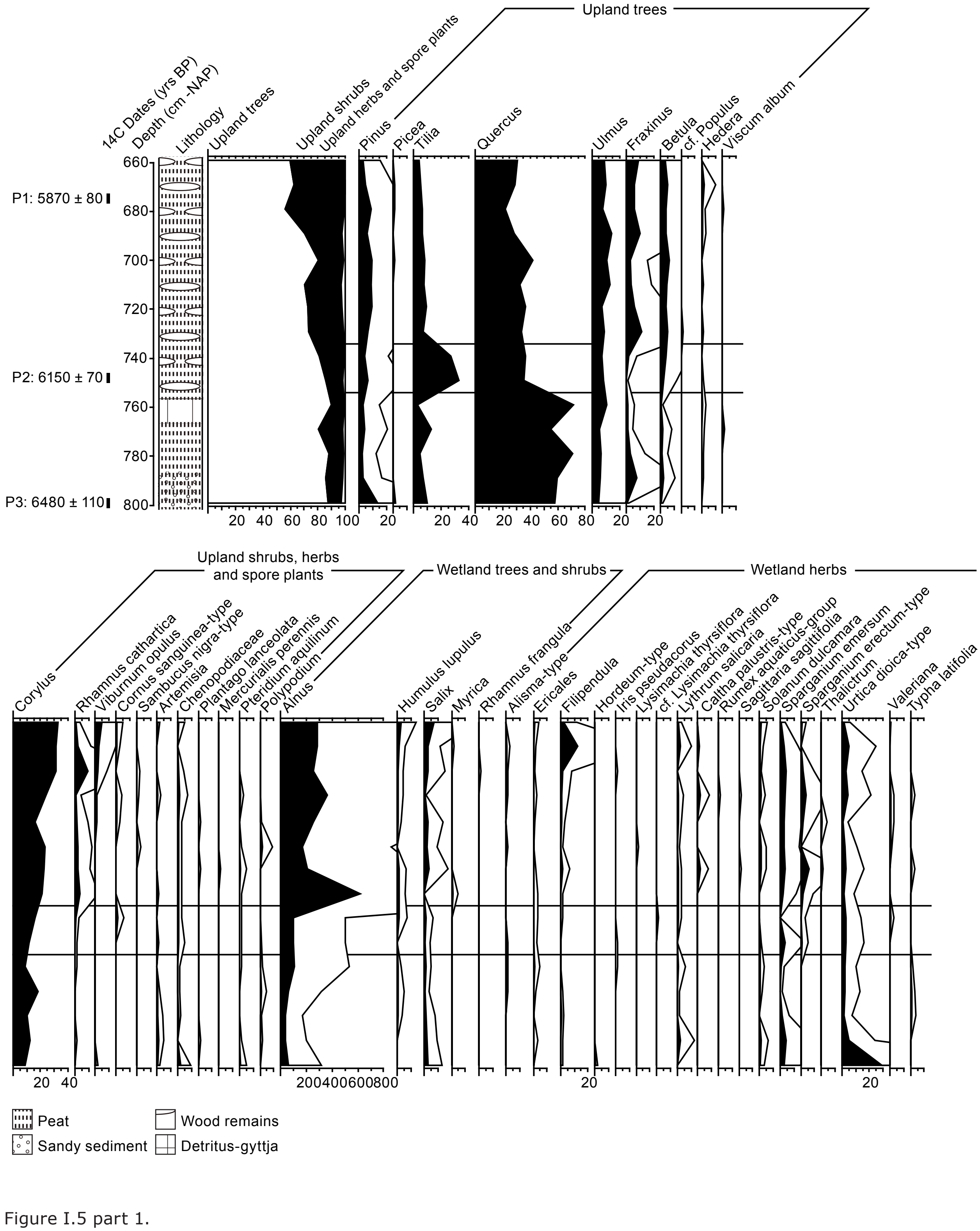


Figure I.5 part 1.

of the signal (compare with appendix II and III). In contrast, the distance to the refuse layer is relatively large (*c.* 40 metres). It is very probable that this hampers the distinction of evidence of human impact, since dispersal of the pollen signal related to human occupation at the settlement may have been restricted by the presence of high and dense vegetation between the settlement and the sample point.

I.3.2 Macroremains analysis

I.3.2.1 Reconstruction of the vegetation

The main analysis of macroremains concerns 65 samples, of which 51 were sieved on a mesh width of 0.25 mm and 14 on a mesh width of 2 mm. The samples were collected in pits and refuse layers dating to phases 1 and 2 from sediments consisting of sand, peat and clay, and were collected from different parts of the slope of the dune in the excavation trench. During all phases, several deposition processes may have played a role in the formation of the macroremains assemblages, resulting in assemblages indicative of diverse ecological conditions (*e.g. in situ* deposition, colluviation resulting in transport down the slope, flooding of the slopes of the dune resulting in transport in upwards direction, and transport by people and/or animals).

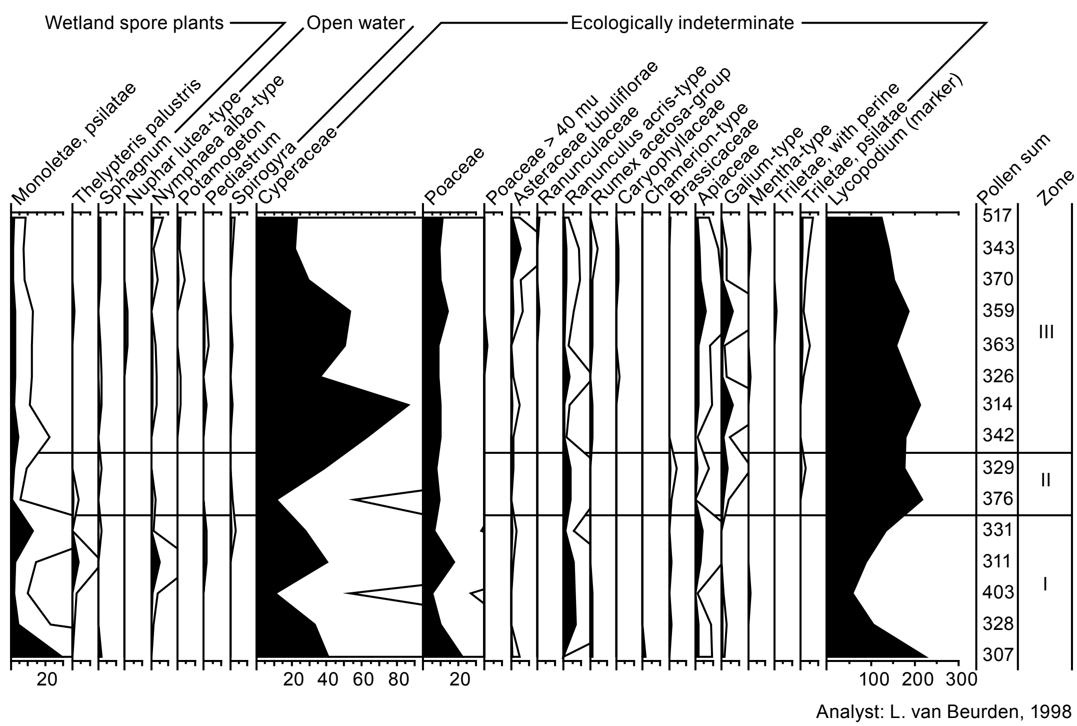


Figure I.5 Hardinxveld-Giessendam Polderweg, pollen diagram based on an upland pollen sum, exaggeration 5 x (after Bakels and Van Beurden 2001), part 2.

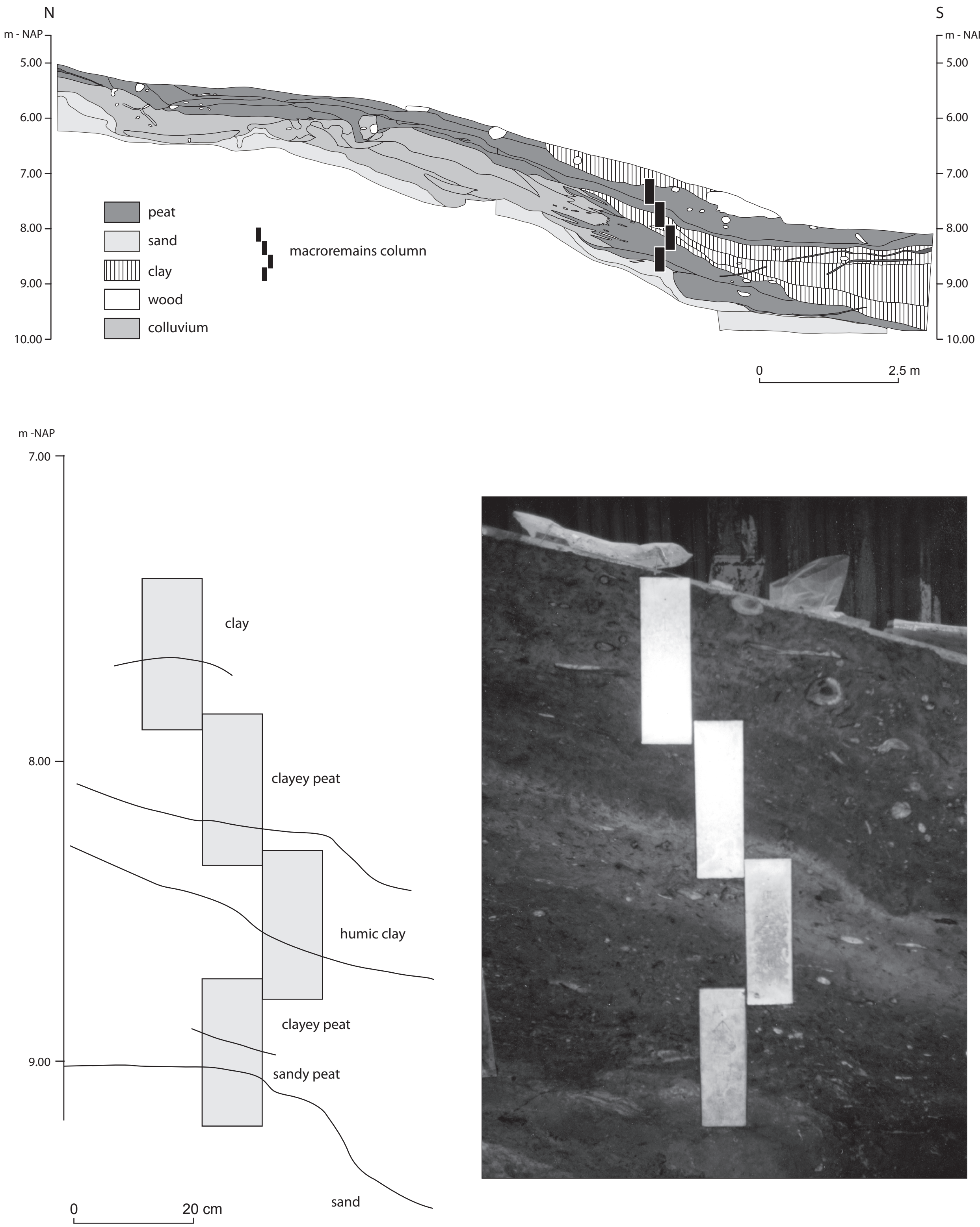


Figure I.6 Hardinxveld-Giessendam Polderweg, eastern section of square 11, position of the sample boxes (after Louwe Kooijmans and Mol 2001, fig. 3.2, and De Kort 1998, photograph: W.J. Kuijper).

The assemblage of macroremains mainly consisted of waterlogged remains.[4] The macroremains assemblage of phase 1 indicates the presence of eutrophic open marsh and bank vegetation at the location of the excavation trench, combined with open water. During phase 2, the slope of the dune was covered with alder carr, marsh and bank vegetation with some open patches. These results correspond with the reconstruction of the wetland vegetation based on the pollen diagram. The vegetation on the slope was less varied than during phase 1. The increasing water levels resulted in a decrease in dryland vegetation at the lower parts of the dune and in the spread of *Alnus* vegetation upward over the slopes of the dune.

The unpublished macroremains diagram of De Kort (1998) consists of nine samples collected with four sample boxes in the eastern section of square 11, just outside the local colluvium but still relatively close to the dune and the location of human activity (see fig. I.4 and I.6). The analysed section is *c.* 150 cm long, the sample size of the samples was 200 cm^3 (0.2 litres), and the mesh width of the sieves was 0.25 mm. The ^{14}C dates (see table I.1) as well as the stratigraphy indicate that the diagram corresponds with phases 1 and 2.

sample	depth (m -NAP)	lab code	age (yrs BP)	age (yrs cal BC, 2σ)	phase	dated material
HG-PW 11-783	7.83	GrA-9802	6050 ± 50	5210-4790	2	Alnus sp., cones
HG-PW 11-818	8.18	GrA-9798	6320 ± 50	5470-5210	t.a.q. 1	Cornus sanguinea, fruit stones
HG-PW 11-864	8.64	GrA-9803	6380 ± 50	5480-5220	1 late	Iris pseudacorus, seeds, Schoenoplectus lacustris, fruits
HG-PW 11-919	9.19	GrA-9799	6540 ± 50	5620-5370	1 early	Quercus sp., fruits

t.a.q. = *terminus ante quem*

Table I.1 Hardinxveld-Giessendam Polderweg, ^{14}C dates of the macroremains diagram of square 11 (Louwe Kooijmans and Mol 2001, 68).

4 Identifications that are supplementary to the results published in Bakels and Van Beurden (2001) are *Torilis* sp. (probably representing *Torilis japonica*), *Glechoma hederacea*, *Persicaria cf. hydropiper* (Jongste and Verbruggen 1998), *Betula* sp. and *Stellaria neglecta* (unpublished data Faculty of Archaeology, Leiden University).

The results of the macroremains analysis by De Kort are shown in figure I.7. Table I.2 provides the relevant stratigraphy. The lowest two spectra show the presence of disturbed dryland vegetation (*Tilia* sp., *Quercus* sp., *Chenopodium album*, *Solanum nigrum* and *Galeopsis bifida*-type) as well as marsh vegetation (*Phragmites* sp., *Typha* sp., *Alisma plantago-aquatica* and *Urtica dioica*). Subsequently, slowly running water reached the sample location, as indicated by clayey sediments, followed by the development of marsh vegetation dominated by *Schoenoplectus lacustris*, *Typha* sp. and *Alisma plantago-aquatica*. The presence of the disturbance indicators *Persicaria lapathifolia*, *Solanum nigrum* and *Chenopodium album* at 8.45 m -NAP is probably related to the activity of the nearby crevasse channel. At 8.18 m -NAP, the diagram shows a major change in the vegetation: alder carr gradually developed, initially combined with *Carex* species and *Lythrum salicaria*. Dryland trees and shrubs reappear in the diagram while the values of water plants are low. These changes can all be explained by a diminished influence of the channel and partial recovery of the dryland vegetation in the extra-local vegetation. *Urtica dioica* shows maximal values just before and after the activity of the crevasse.

The first three spectra are rich in charcoal, implying human activity. The diagram does not, however, show clear indications of anthropogenic influence on the vegetation, with the exception of a carbonised seed of *Iris pseudacorus* at 8.64 m -NAP (late part of phase 1). Although *in situ* deposition can be questioned, this carbonised seed indicates the horizon of anthropogenic influence and it is therefore not excluded that the taxa at 8.45 m -NAP indicative of disturbance (*Persicaria lapathifolia*, *Solanum nigrum* and *Chenopodium album*), interpreted as the result of disturbance by the crevasse, result instead from human activity. The absence of other signals of anthropogenic influence on the vegetation is remarkable in view of the sample location in the excavation trench. The absence of more carbonised macroremains corresponds, however, with the small number of taxa found in a carbonised state at the excavation.

depth (m -NAP)	sediment	sample (m -NAP)
7.64-7.43	peaty clay poor in wood remains	7.57
7.75-7.64	clayey peat poor in wood remains	
8.15-7.75	peat containing wood remains	8.02, 7.83, 7.78
8.21-8.15	clayey peat	8.18
8.40-8.21	peaty clay poor in wood remains	
8.51-8.40	clay rich in wood remains	8.45
8.62-8.51	humic clay poor in wood remains	
8.87-8.62	sandy peat rich in wood remains	8.64
8.92-8.87	sandy peat poor in wood remains	
9.02-8.92	peat rich in wood remains	8.95
9.12-9.02	peaty sand poor in archaeological remains	9.11
9.26-9.12	humic sand poor in wood remains	

Table I.2 Hardinxveld-Giessendam Polderweg, stratigraphy of the macroremains diagram of square 11 (De Kort 1998).

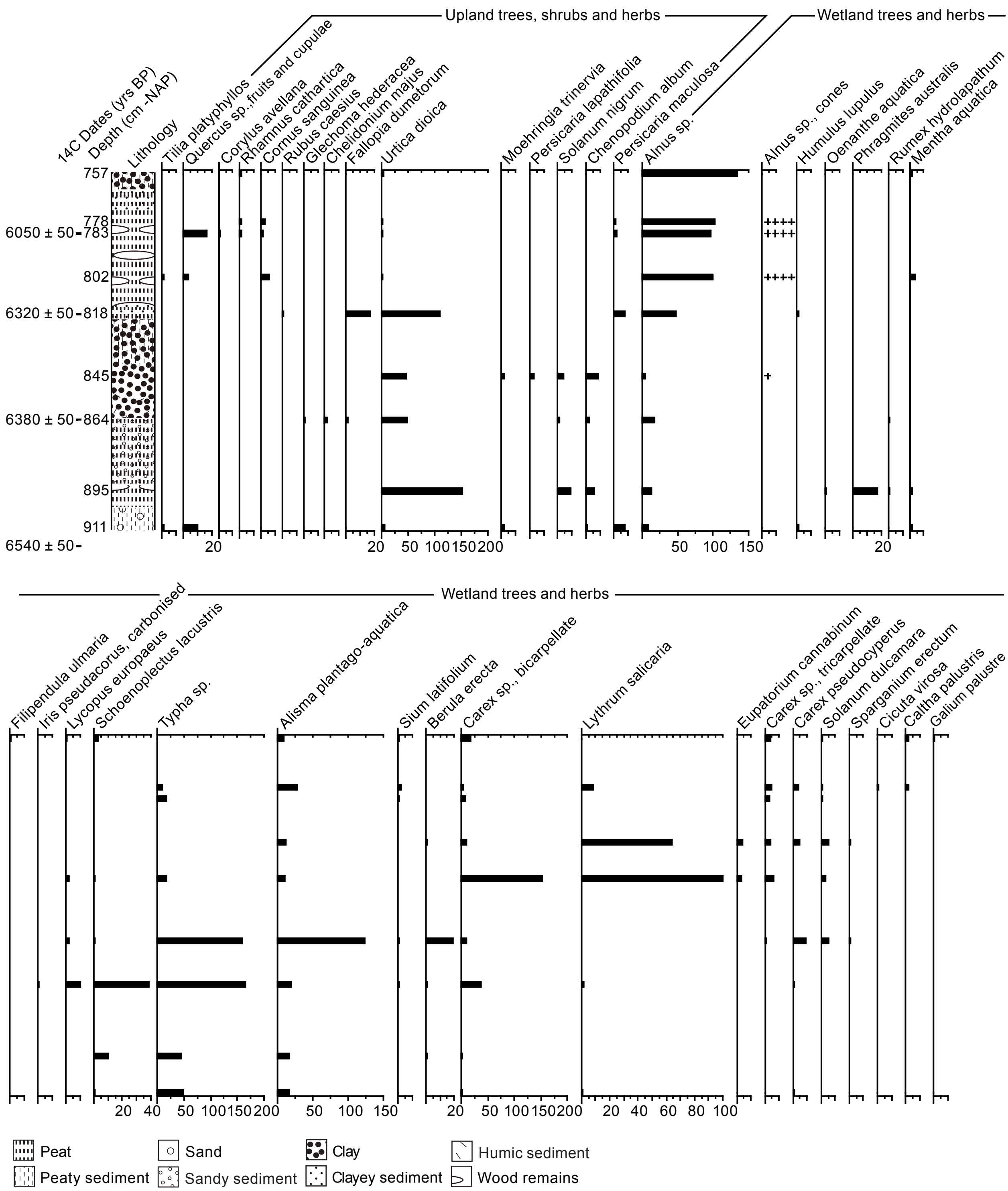


Figure I.7 part 1.

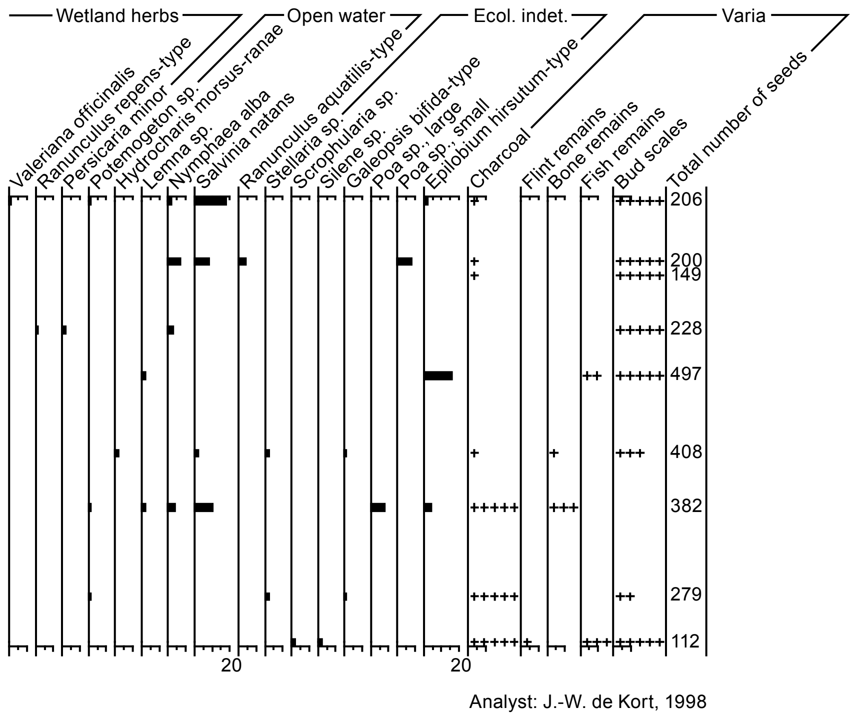


Figure I.7 Hardinxveld-Giessendam Polderweg, macroremains diagram of the eastern section of square 11, + = few (1-10), ++ = some tens (10-49), +++ = many tens (50-99), ++++ = some hundreds (100-499), +++++ = many hundreds (500-999) (after De Kort 1998), part 2.

Since both the pollen diagram (Bakels and Van Beurden 2001) and the macroremains diagram (De Kort 1998) are dated, the diagrams can be linked to each other. The diagrams are contemporaneous, while the sequence of De Kort ends earlier. The clay in the middle of the macroremains diagram probably corresponds with the gyttja in the pollen diagram, and the increase in *Alnus* sp. after phase 1 can be found in both diagrams. The difference between the sediments can be explained by the presence of the crevasse channel at the southern side of the dune where the macroremains sequence was collected. Neither diagram shows strong indications of human impact.

I.3.2.2 Crop plants and disturbance indicators

Cultivated plants were absent in the samples of all phases despite the analysis of 74 macroremains samples and an active search for crop plants. On one hand, the absence of crop plants at Polderweg corresponds with the absence of crop plants at De Bruin (Bakels *et al.* 2001) and the early phases of Brandwijk-Kerkhof (see appendix II), and corresponds with the absence of pottery in phase 1 at Polderweg and the absence of domestic animals other than dog. On the other hand, the absence of crop plants can be considered as unexpected since the people at Polderweg had contact with people of the agricultural LBK (see paragraph I.2).

Despite the absence of crop plants, there are various finds of waterlogged macroremains and pollen identifications of taxa of which the ecology is similar to that of arable weeds, *i.e.* taxa that show a preference for open, disturbed, eutrophic soils (see table I.3[5]). How can we explain the presence of these taxa?

5 The selection of taxa in table I.3 is explained in chapter 10.

taxon / category	W	P
Arctium sp.	+	-
Artemisia sp.	-	+
Atriplex patula/prostrata	+	-
Capsella bursa-pastoris	+	-
Chenopodiaceae	-	+
Chenopodium album	+	-
Chenopodium ficifolium	+	-
Chenopodium murale	+	-
Cirsium sp.	+	-
Galeopsis-type	+	-
Galium spurium	+	-
Lychnis sp./Silene sp.	+	-
Moehringia trinervia	+	-
Persicaria lapathifolia	+	-
Persicaria maculosa	+	-
Plantago lanceolata	-	+
Ranunculus acris-type	-	+
Rumex acetosa-group	-	+
Solanum nigrum	+	-
Sonchus sp.	+	-
Stellaria media	+	-
Stellaria neglecta	+	-
Urtica dioica	+	-
Urtica dioica-type	-	+
Urtica urens	+	-

W = waterlogged macroremains

P = pollen

+ = present

- = not present

Table I.3 Hardinxveld-Giessendam Polderweg, taxa of which the ecology is comparable to that of arable weeds (after Bakels and Van Beurden 2001; De Kort 1998).

Firstly, zones at the border of open water and rivers where drift litter is deposited form the natural habitat of certain taxa that developed into arable weeds after the introduction of agriculture. Secondly, the occupation of the dune resulted in disturbance of the vegetation. As a result, the dune formed an excellent habitat for taxa that prefer disturbance, the presence of nutrients (nitrate and ammonia) and light. The taxa indicative of disturbance were probably native, representing the natural vegetation of the river area, although there is a theoretical possibility that they were imported (unintentionally) from locations elsewhere where agriculture was practised.

I.3.2.3 Carbonised macroremains of non-cultivated plants

Non-cultivated taxa that are known as plant food sources of which remains were found in a carbonised state in the material of phase 1 are *Malus sylvestris*, *Corylus avellana*, *Trapa natans* and *Ranunculus ficaria* (tubers). The material of phase 2 comprises only carbonised remains of *Trapa natans*. The carbonised state suggests that people used these taxa in some way and their edibility suggests that they were consumed. The excavation at Polderweg did not reveal strong contextual evidence of consumption of the taxa mentioned above except for *T. natans*. The distribution of remains of this species of phase 1 shows concentrations on the higher part of the slope where the plant will not have grown since it is a water plant. On the basis of this distribution pattern, it has been concluded that *T. natans* was collected and consumed by people during phases 1 and 2 (Bakels and Van Beurden 2001). Taxa that have edible parts and that were present at Polderweg in a waterlogged state only are *Quercus* sp., *Prunus spinosa*, *Rosa* sp., *Crataegus monogyna*, *Cornus sanguinea*, *Sambucus nigra (/racemosa)*, *Rubus caesius*, *Viburnum opulus*, *Nuphar lutea*, *Nymphaea alba*. Furthermore some taxa with edible tubers were attested and a large variety of herbs and grasses of which the seeds, fruits and leaves are edible (see chapter 9).

The presence of people at the dune during the early autumn can be deduced from the presence of carbonised seeds, fruits or tubers of *Ranunculus ficaria*, *Corylus avellana*, *Iris pseudacorus* and *Trapa natans*.

The first three species can be collected in the autumn while tubers of *R. ficaria* can be collected from autumn to early spring (discussed in Bakels and Van Beurden 2001). In addition, the carbonised fruits of *Hedera helix* may indicate the presence of people at the dune in March and/or April. These periods all correspond with the assumed period of occupation of Polderweg, as mainly based on archaeozoological evidence. The presence of *Malus sylvestris* is not informative of the season of occupation since it is concluded that this species is not part of the local vegetation (see paragraph I.7.1). This implies that wild apples could have brought to the site from elsewhere, possibly in a dried state.

I.3.3 Wood and charcoal analysis

The discussion of unworked wood, charcoal and wooden artefacts is based on Bakels and Van Beurden (2001), Hänninen *et al.* (1999) and Louwe Kooijmans, Vermeeren and Van Waveren (2001). Material from phase 1 has the better representation in the analysis. A selection of 225 samples of unworked and presumably unworked wood trunks, branches and twigs has been identified (see table I.4). *Alnus* sp. and *Quercus* sp. were the most common trees in the vegetation, followed by *Salix* sp. and *Fraxinus excelsior*. Other identified taxa are *Tilia* sp., *Ulmus* sp., *Acer* sp., *Corylus avellana*, *Viburnum* sp., *Cornus* sp., *Prunus padus*[6] and Pomoideae. Comparison of the unworked wood assemblages of the different phases generally shows continuity through time (Bakels and Van Beurden 2001). Only *Salix* sp. forms an exception, being especially important during phase 1, when the distance to the crevasse channel was smallest. *Salix* sp. might therefore have been present in the local vegetation at the southern slope of the dune during phase 1.

	N					%				
phase / taxon	0	1	1/2	2	total	0	1	1/2	2	total
Acer sp.	-	-	1	1	2	-	-	3	1	1
Alnus sp.	-	40	11	35	86	-	38	30	43	38
Cornus sp.	-	3	1	1	5	-	3	3	1	2
Corylus avellana	-	6	-	1	7	-	6	-	1	3
Fraxinus excelsior	-	7	-	6	13	-	7	-	7	6
Pomoideae	-	-	3	-	3	-	-	8	-	-
Prunus padus	-	1	-	-	1	-	1	-	-	-
Quercus sp.	2	17	6	20	45	x	16	16	25	20
Salix sp.	-	16	3	3	22	-	15	8	4	10
Tilia sp.	-	1	1	-	2	-	1	3	-	-
Ulmus sp.	1	5	-	3	9	x	5	-	4	4
Viburnum sp.	-	-	1	2	3	-	-	3	2	1
Indet.	-	8	10	9	27	-	8	27	11	12
total	3	104	37	81	225					

- = not present x = no meaningful percentages

Table I.4 Hardinxveld-Giessendam Polderweg, unworked and presumably unworked wood for each phase, twigs included (after Bakels and Van Beurden 2001).

6 But see the remarks on the possibility to identify wood of *Prunus* species other than *Prunus spinosa* in chapter 7.

The charcoal analysis is based on the investigation of 577 fragments. The selection of samples included a single concentration of each phase as well as a few additional samples from the different refuse layers, which were considered to represent scattered charcoal material without a specific context. The results are shown in table I.5. The dominant taxa are *Alnus* sp., *Quercus* sp., *Fraxinus* sp. and *Corylus* sp. Several taxa are present in limited numbers (*Salix* sp. and *Ulmus* sp.), while many others are scarce (*Cornus* sp., *Rhamnus cathartica*, *Rhamnus frangula*, *Viscum album*, Pomoideae and *Viburnum* sp.). The number of taxa in the charcoal assemblage is slightly higher than that in the unworked wood assemblage, probably as a result of the larger number of investigated charcoal fragments. The charcoal assemblage does not allow an analysis of changes through time since the samples of phase 0 were all collected from one concentration and since the number of identifications of phase 1/2 and phase 2 is rather small (*contra* Bakels and Van Beurden 2001, 352). Characteristics of the charcoal indicate the use of old wood (*Alnus* sp., *Corylus* sp., *Salix* sp. and *Alnus* sp./*Betula* sp.) and moist wood (*Alnus* sp., *Quercus* sp., *Fraxinus* sp., *Rhamnus frangula* and *Viburnum* sp.). In general, the charcoal assemblage does not indicate the selective use of taxa as fuel, but there are two possible exceptions.

	N					%				
phase taxon	0	1	1/2	2	total	0	1	1/2	2	total
Alnus sp.	1	114	25	94	234	2	32	50	78	41
Alnus sp./Betula sp.	-	-	1	-	1	-	-	2	-	0
Betula sp.	1	-	-	-	1	2	-	-	-	0
Cornus sp.	-	2	-	1	3	-	1	-	1	1
Corylus avellana	31	18	17	-	66	62	5	34	-	11
Euonymus europaeus	-	42	2	1	45	-	12	4	1	8
Fraxinus excelsior	13	53	-	-	66	26	15	-	-	11
Pomoideae	-	1	1	-	2	-	0	2	-	0
Quercus sp.	4	95	3	13	115	8	27	6	11	20
Rhamnus cathartica	-	3	-	-	3	-	1	-	-	1
Rhamnus frangula	-	2	-	-	2	-	1	-	-	0
Salix sp.	-	8	-	7	15	-	2	-	6	3
Ulmus sp.	-	9	-	2	11	-	3	-	2	2
Viburnum sp.	-	7	-	2	9	-	2	-	2	2
Viscum album	-	1	-	-	1	-	0	-	-	0
Indet.	-	2	1	-	3	-	1	2	-	1
total	50	357	50	120	577					

- = not present

Table I.5 Hardinxveld-Giessendam Polderweg, charcoal for each phase (Bakels and Van Beurden 2001).

Firstly, one pit contained a relatively abundance of *Corylus avellana* charcoal (up to 62% of the contents of the pit). Secondly, one sample from phase 1 contained a large quantity of charcoal of *Euonymus* sp. (26% of the contents of the pit), which may indicate selective use in view of the absence of the taxon in the assemblages of macroremains, pollen and wood at Polderweg except for a single fragment of worked wood. It could concern selective use of the wood for fuel or for a skewer (Bakels and Van Beurden 2001, 352).

The assemblage of worked wood and artefacts yielded 57 identifications (see tables I.6 and I.7). The assemblage comprises a variety of objects interpreted as posts, fragments of a bow, hafts, paddles, pointed roundwood including possible points of spears, planks including possible fragments of canoes, skewers and digging sticks. Selective use of wood for artefacts based on the quality of the wood and the function of artefacts is indicated by the limited use of *Alnus* sp. and *Quercus* sp., which were dominant elements in the vegetation, and by the high correlation between artefact type and the wood species (see tables I.6 and I.7). In addition to the wood and charcoal, the finds comprised several knots and a fragment of a net made of the bark of *Acer* sp. and/or *Ulmus* sp., *Tilia* sp. and an unknown (probably herbaceous) plant.

	N				%				interpretation
phase taxon	1	1/2	2	total	1	1/2	2	total	
Acer sp.	-	1	1	2	-	13	10	4	roundwood
Alnus sp.	8	5	5	18	30	63	50	40	planks, post, other
Cornus sp.	-	-	1	1	-	-	10	2	roundwood
Corylus avellana	3	1	-	4	11	13	-	9	post, pointed roundwood, skewer, other
Euonymus europaeus	-	-	1	1	-	-	10	2	skewer
Fraxinus excelsior	3	1	1	5	11	13	10	11	skewer, roundwood, other
Quercus sp.	6	-	-	6	22	-	-	13	anvil, beams, plank, roundwood
Salix sp.	3	-	-	3	11	-	-	7	digging stick, plank, other
Tilia sp.	2	-	-	2	7	-	-	4	planks
Ulmus sp.	1	-	1	2	4	-	10	4	other
Viburnum sp.	1	-	-	1	4	-	-	2	digging stick
total	27	8	10	45					

- = not present

other = other interpretation of the function

Table I.6 Hardinxveld-Giessendam Polderweg, identifications and interpretation of presumably worked wood for each phase (Louwe Kooijmans, Vermeeren and Van Waveren 2001).

	N				%	interpretation
phase taxon	1	1/2	2	total	total	
Acer sp.	1	-	-	1	8	haft
Fraxinus excelsior	7	-	1	8	67	paddles, haft, points
Salix sp.	1	-	-	1	8	haft?
Ulmus sp.	2	-	-	2	17	bow
total	11	-	1	12		

- = not present

Table I.7 Hardinxveld-Giessendam Polderweg, identifications and interpretation of wooden artefacts for each phase (Louwe Kooijmans, Vermeeren and Van Waveren 2001).

I.3.4 Other sources

The botanical analysis included six species of fungi that indicate the local presence of trees including old or weak trees (Bakels and Van Beurden 2001, see table 2.7). The analysis of arthropod remains indicated the presence of *Caltha palustris*, *Phragmites australis*, *Solanum dulcamara*, *Equisetum* sp., *Alnus* sp., and the presence of dying or recently cleared trees, dead wood, dead branches that are still attached to trees, dead trees with loose bark, trees that are strongly decayed, fungi, wood floating in water, and running water (Hakbijl 2001). This information all corresponds with the archaeobotanical results.

I.4 Geology of Hardinxveld-Giessendam De Bruin

Hardinxveld-Giessendam De Bruin is located on an inland dune in the central river area (coordinates 115.200/427.170). The top of the dune is at about 4.0 m -NAP and is slightly higher than Polderweg, which is located at 1 km distance to the northeast. During phase 1 the surface of the dune was 44.200 m^2 and the dune protruded 4 metres above the landscape. During phase 2, the surface of the dune was 4200 m^2 and the relative height 1.5 metres. During phase 3, the dune was divided into two tops with a total surface of 940 m^2 and a relative height of 0.8 metres. The former landschape around the site was reconstructed by means of hand corings in an area of 1500 x 1000 metres around the dune, directly west of the Polderweg study area (see fig. I.8). During occupation, most of the area around the site of De Bruin was submerged and consisted of open water and marsh with a maximal depth of 1 metre. Carr vegetation was only present on the slightly higher patches in the surroundings. A few other dunes protruded above the floodbasin in the vicinity. The Holocene sediments at De Bruin largely resemble those of Polderweg. Here, however, occupation lasted longer and peat formation was interrupted twice by clay deposition resulting from fluvial activity. The first fluvial phase dates to *c.* 5500-5100 BC. The second fluvial phase started at *c.* 4700-4450 BC (Mol 2001b, 46). The influence of crevasse channels was slightly stronger at De Bruin than at Polderweg. Three crevasse channels were situated at a distance of 250-500 metres from the dune, one of them directly east of the dune. It is, however, not certain whether all crevasse channels were active simultaneously during the second phase of clay deposition. There are no channel belts situated in the investigated area around Polderweg and De Bruin (Mol 2001b, 2003).

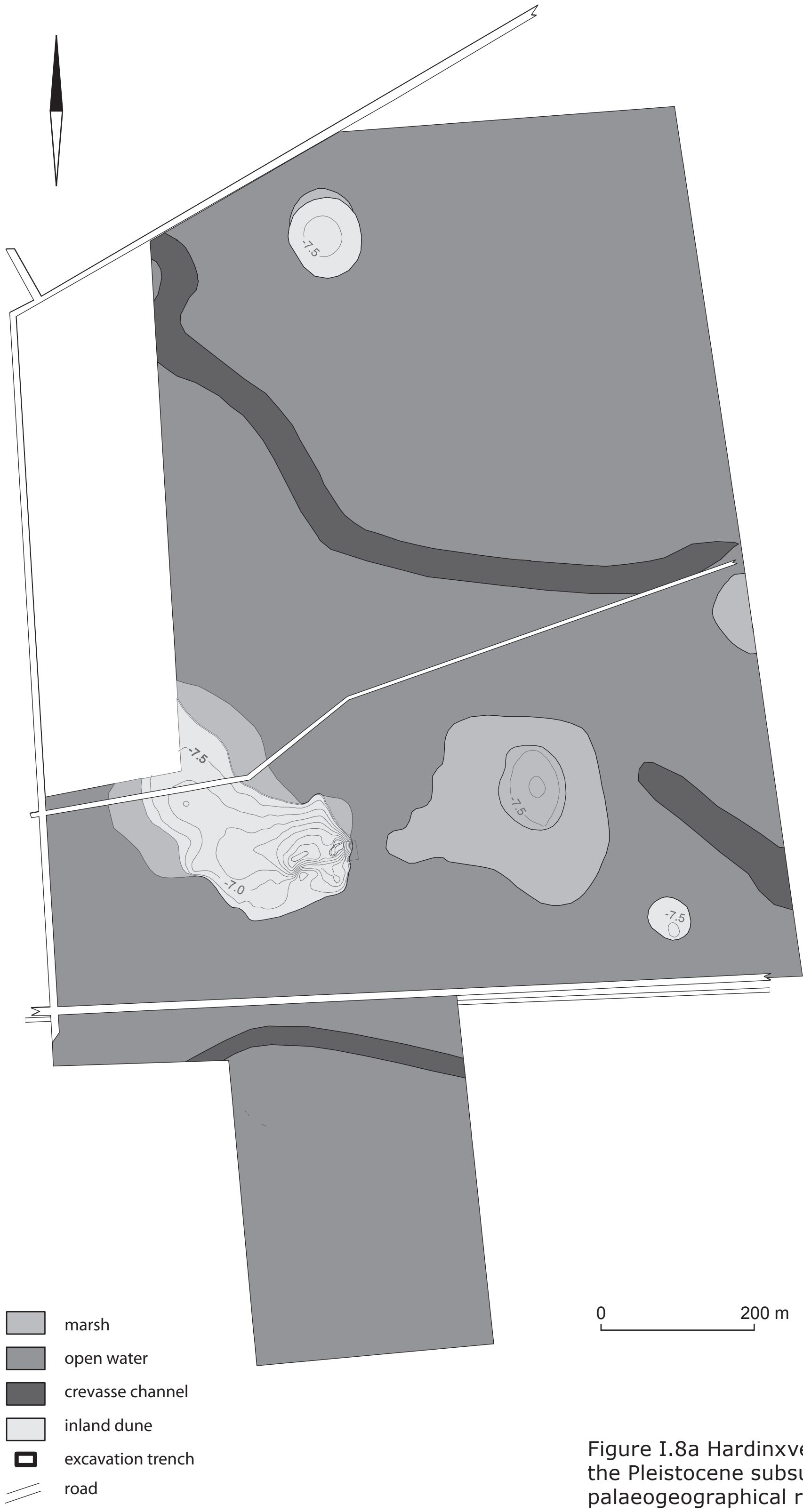


Figure I.8a Hardinxveld-Giessendam De Bruin, the Pleistocene subsurface (m –NAP) and palaeogeographical reconstructions for phase 1 (after Mol 2001b).

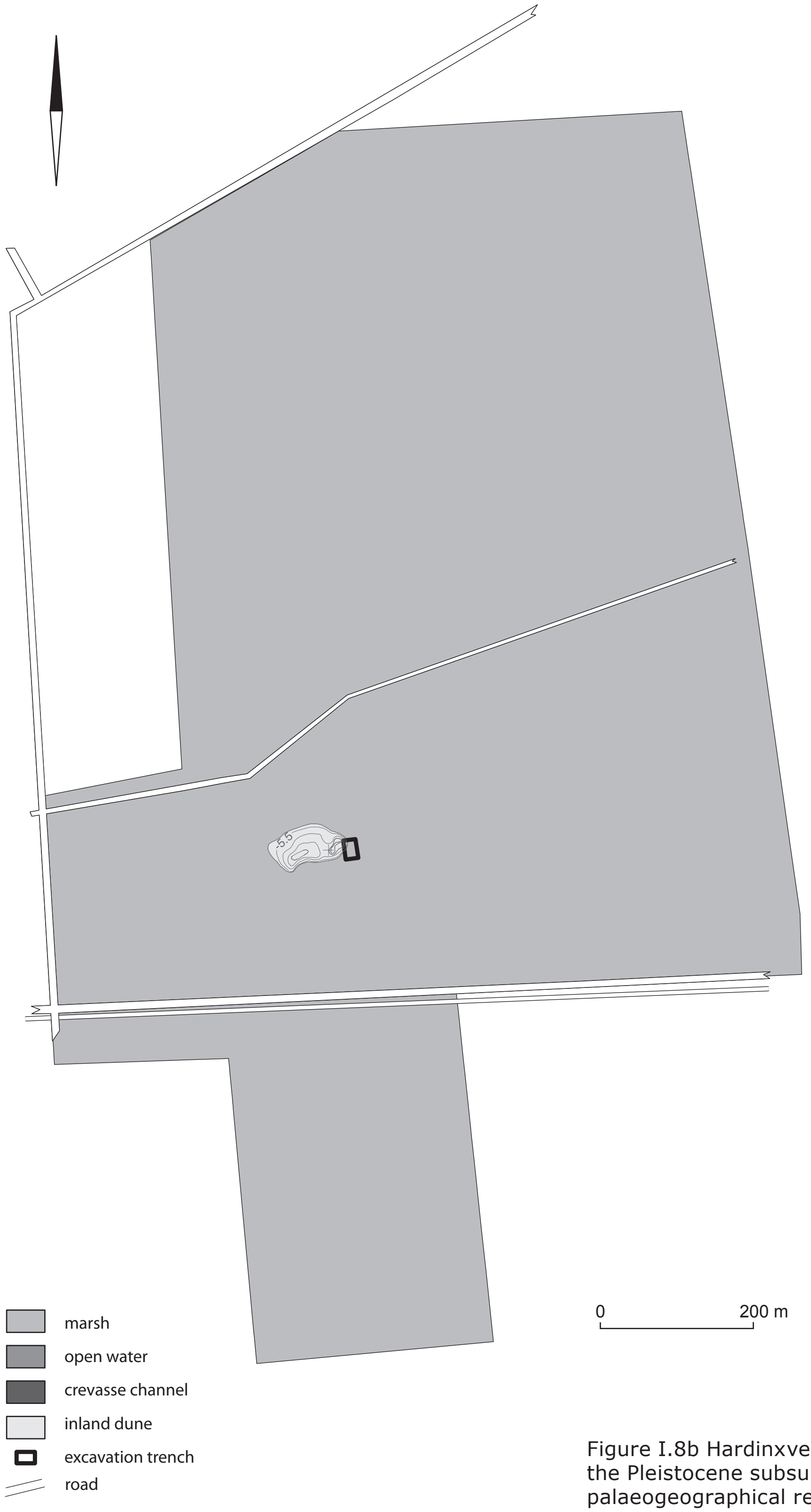


Figure I.8b Hardinxveld-Giessendam De Bruin, the Pleistocene subsurface (m –NAP) and palaeogeographical reconstructions for phase 2 (after Mol 2001b).

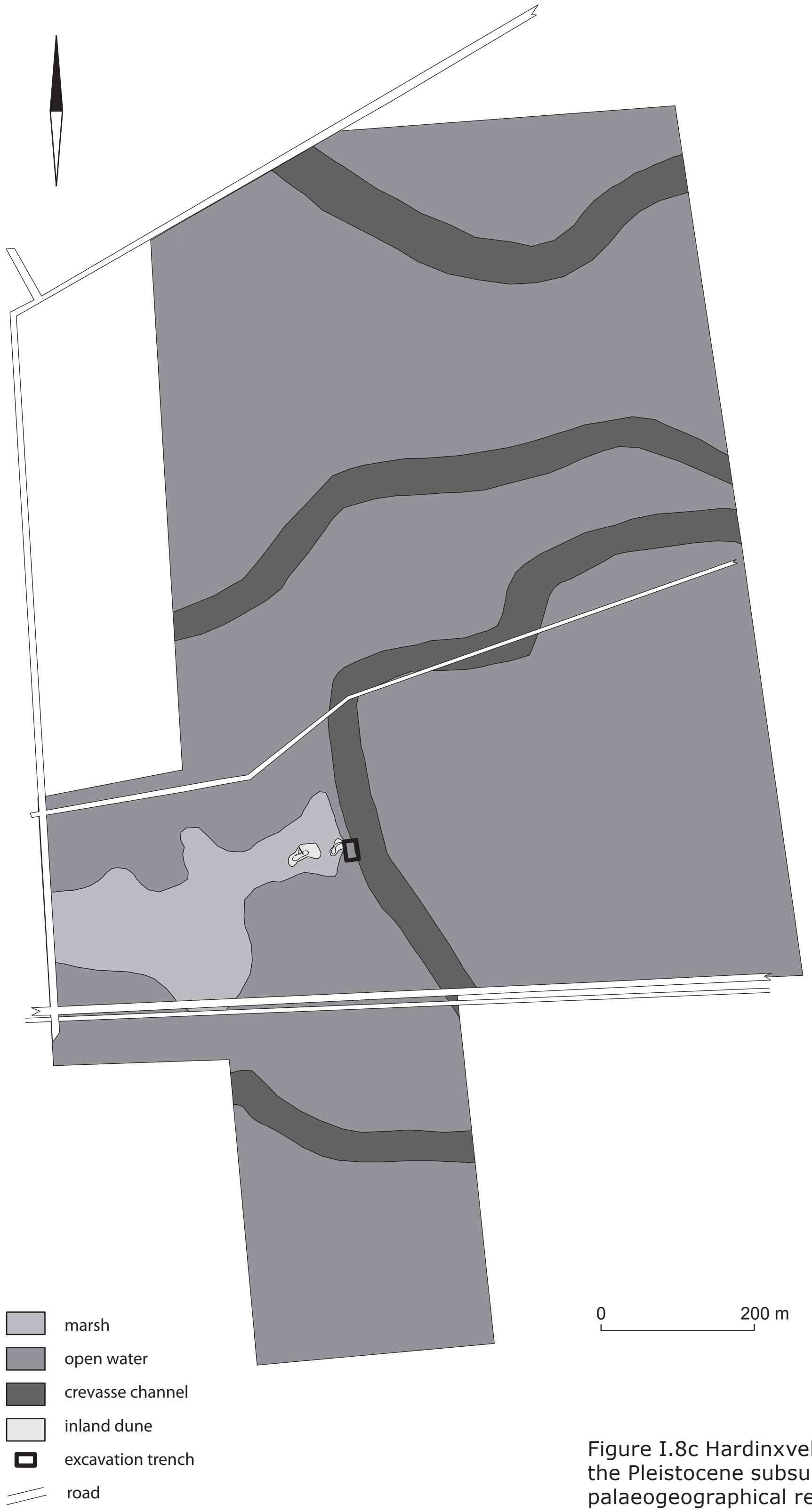


Figure I.8c Hardinxveld-Giessendam De Bruin, the Pleistocene subsurface (m –NAP) and palaeogeographical reconstructions for phase 3 (after Mol 2001b).

I.5 Archaeology of Hardinxveld-Giessendam De Bruin

Excavation of a part of the eastern slope of the dune of De Bruin took place in 1998. The excavation trench (15 x 23 metres) revealed refuse layers formed during several phases, large pits with an unknown function though comparable with the pits at Polderweg that were interpreted as huts, round pits interpreted as fire pits, postholes, a feature interpreted as a small landing place for canoes and some intentional depositions, all covered by layers of clay and peat (see fig. I.9). The Holocene deposits contained flint, stone, pottery and organic remains including scarce bones of domestic animals (phase 3) and human remains.

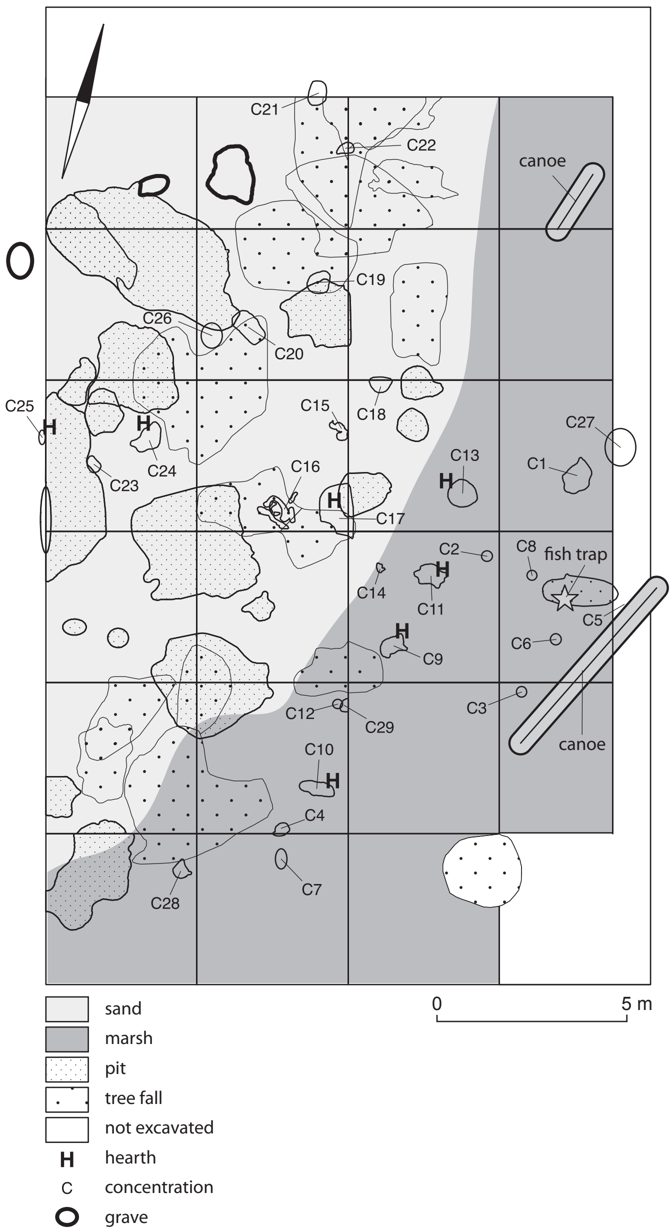


Figure I.9 Hardinxveld-Giessendam De Bruin, features of all phases (after Louwe Kooijmans and Nokkert 2001, adapted by L. Amkreutz).

The Holocene stratigraphy enabled to distinguish three occupation phases: phase 1 between 5475 and 5100 BC, phase 2 between 5100 and 4800 BC, and phase 3 between 4700 and 4450 BC.[7] Phase 1 yielded relatively few finds and is possibly separated from phase 2 in view of a level with a low find density, despite the overlap of *c.* 250 calibrated years in ^{14}C dates (Mol and Louwe Kooijmans 2001b, 69). Phase 2 yielded an extensive find assemblage and is separated from phase 3 by a more distinct archaeological hiatus. Fig. I.10 shows the extent of the corresponding refuse layers.

The site can be characterised as Late Mesolithic to Early Neolithic and covers the availability phase as defined by Zvelebil (1986) in view of the presence of pottery from phase 2 onwards and the small percentage of domestic animals during phase 3. Phase 1 is contemporaneous with the *ältere* and *jüngere* LBK, while phase 2 is contemporaneous with the *jüngere* LBK and the Großgartach culture. Phase 3 is contemporaneous with the Rössen culture (Louwe Kooijmans 2001b, 527). The pottery from phases 2 and 3 is characteristic of the Swifterbant culture, and shows some Blicquy elements in phase 2 (Raemaekers 2001). The bones of domestic animals in the assemblage of phase 3 (cattle, pig, goat and sheep) are the oldest in Northwestern Europe to the north of the loess zone. The number of bones, the distinct concentrations and the fact that they mainly consist of limb bones suggest that it probably concerns intentional depositions, interpreted as offerings, and that there were no living domestic animals present at De Bruin, with exception of dogs and possibly pigs. The introduction of pottery and domestic animals shows a gradual neolithisation process. The Blicquy pottery and characteristic flint and stone (phases 2 and 3) indicate contacts with southern regions. In addition, the flint indicates some contact to the north during phases 2 and 3. The nearest finds of similar material originate from the Utrechtse Heuvelrug area at *c.* 50 km distance.

The site is interpreted as a base camp, possibly with a shift in function from a winter base camp (similar to Polderweg during phase 1) to a year-round extraction site. For phase 2, there are indications of occupation during all seasons except for late autumn and early winter (November-January). For all phases, there are some minor indications of occupation during summer. During phase 3, the site was probably too small to function as a base camp (Louwe Kooijmans 2001b, 515-517).

I.6 Archaeobotany of Hardinxveld-Giessendam De Bruin

The archaeobotanical data of De Bruin consist of pollen columns collected inside and outside the excavation trench and macroremains, wood, charcoal, coprolites and fungi collected inside the excavation trench (Bakels *et al*. 2001; Verhoeven 2003).

I.6.1 Pollen analysis inside the excavation trench

For the pollen analysis inside the excavation trench, material of phase 1 was sampled in the western section of square 16, and material of phases 2 and 3 was sampled in the western section of square 24. The distance to the dune top is similar for both squares. The sample locations are situated within the refuse layers, and the distance between the sample locations and concentrations or considerably large quantities of refuse is less than 4 metres for all phases (see fig. I.10). Sampling was performed with the sampling boxes DB. The pollen diagrams are based on an upland pollen sum of at least 300 grains. The material from square 16 consisted of three spectra that reflect the vegetation but do not represent changes of the vegetation before, during and after occupation phase 1 (as a longer sequence of peat that reflects the relevant period was not available). The material of square 24 represents at least the period during and after phase 2 and the period during phase 3, and is directly dated between 5279-4959 BC and 4685-4367 BC (see fig. I.11 and the publication for ^{14}C dates). The top of the investigated sediment of square 24 may be 200 ^{14}C years younger, assuming a continuous sedimentation rate.

7 Recalculation of the ^{14}C dates of De Bruin resulted in the new conclusion that phase 1 dates between 5230±150 and 5110±90 cal BC, phase 2 dates between 5040±80 and 4850±170 cal BC and phase 3 between 4560±100 and 4480±160 cal BC (Mol and Van Zijverden 2007). See also fig. 2.5.

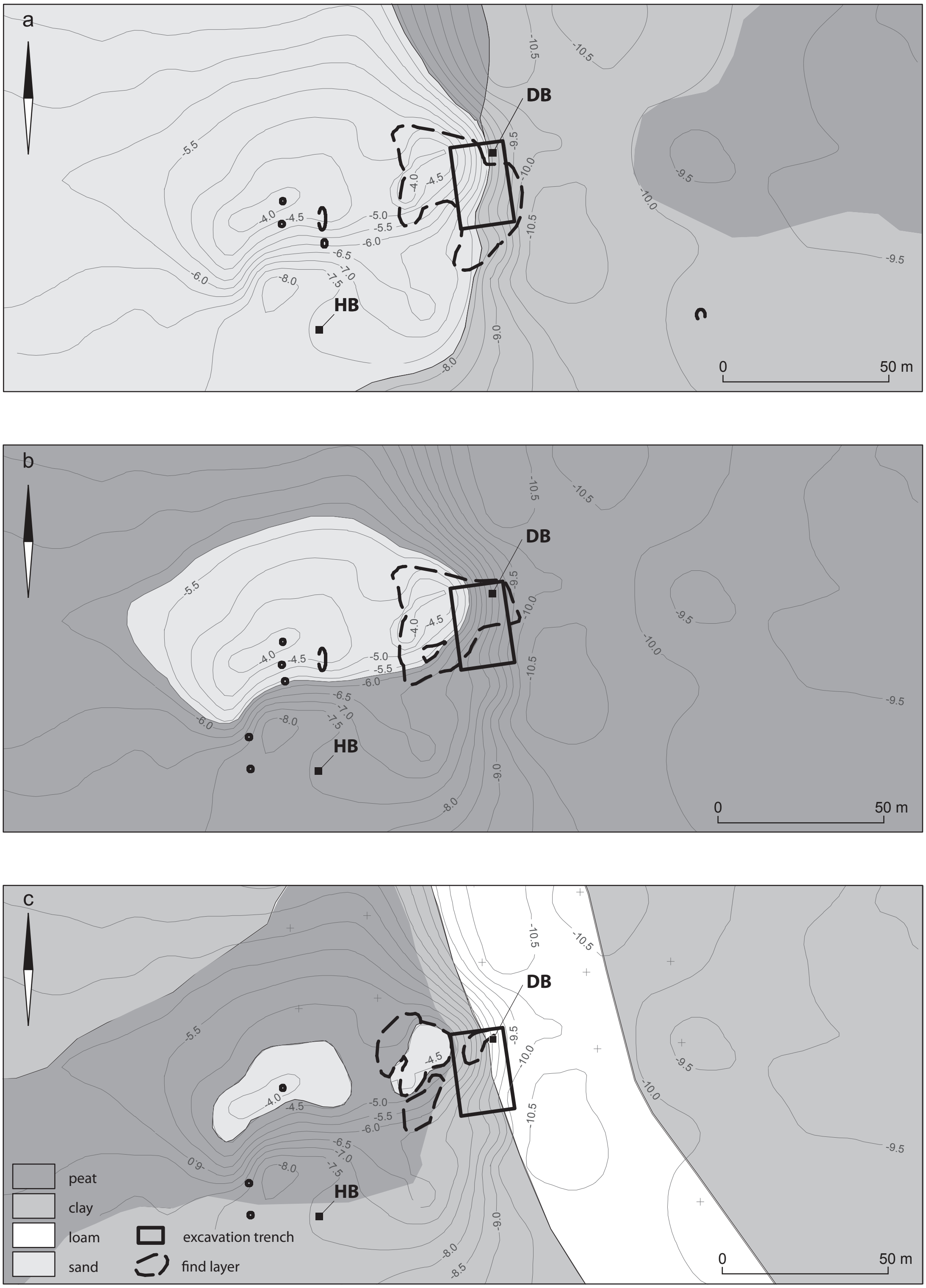


Figure I.10 Hardinxveld-Giessendam De Bruin, the Pleistocene subsurface (m –NAP), the extent of the surface of the dune and the refuse layers for phases a) 1, b) 2 and c) 3 (after Mol 2001b). The location of the pollen sample locations is indicated by DB and HB. dune at Hardinxveld-Giessendam De Bruin for phases 1 (a), 2 (b) and 3 (c) (after Mol 2001b). The location of the pollen sample locations is indicated by DB and HB.

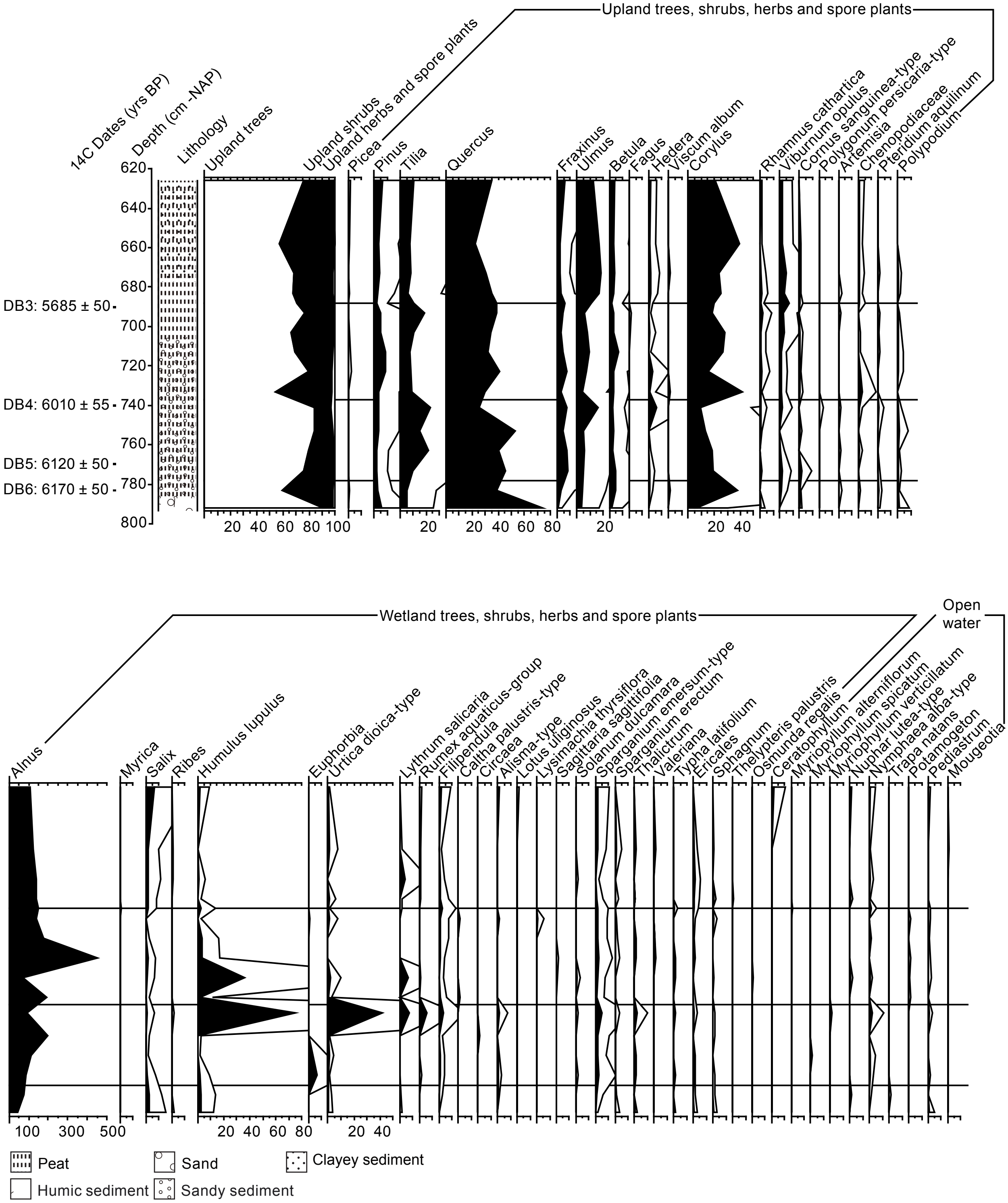


Figure I.11 part 1.

The pollen diagram of square 24 (see fig. I.11) indicates that the natural vegetation on the higher parts of the dune consisted of mixed deciduous woodland including *Tilia* sp., *Quercus* sp., *Fraxinus excelsior*, *Ulmus* sp., *Hedera helix*, *Viscum album*, *Corylus avellana*, *Rhamnus cathartica*, *Viburnum opulus*, *Cornus sanguinea*, dryland ferns, *Artemisia* sp. and Chenopodiaceae. The diagram further points to the presence of carr vegetation around the dune dominated by *Alnus glutinosa*, open patches with marsh and forb vegetation including *Phragmites australis* and *Carex* vegetation, open water with a minimum depth of 1.5 to 2 metres and shallow open water.

The material of square 16 (phase 1) does not give explicit information on human impact on the vegetation. Indications of human impact in the pollen diagram of square 24 are only present at 7.50-7.40 m -NAP, showing a decrease in *Quercus* sp. and *Tilia* sp. and an increase in *Pinus* sp., *Hedera helix*, *Corylus avellana*, *Rhamnus cathartica*, *Viburnum opulus*, Chenopodiaceae, Poaceae, *Humulus lupulus* and *Urtica dioica*-type, as discussed in Bakels *et al.* (2001, 378). It can be added that the curve of *Alnus* sp. decreased and the curve of Cyperaceae increased. The disturbance can be more easily recognised in the curves of wetland taxa than in the curves of the dryland taxa since the wetland taxa give higher peaks. The changes indicate the replacement of closed (dryland and wetland) woodland vegetation by more open shrub vegetation, but are not strong and are very temporal of character. It is difficult to distinguish whether the changes are caused by natural factors of disturbance, such as the submerging of the dune, or by human impact. The recovery of the wetland vegetation, as indicated by a peak of *Alnus* sp. and the return of other taxa to previous values, nevertheless indicates that it probably concerns human impact. For phase 3 there are no indications of human impact, despite the similar distance to the refuse layer and despite the small distance to the dry surface of the dune (max. 8 metres during phase 3, see Louwe Kooijmans and Nokkert 2001, fig. 4.1).

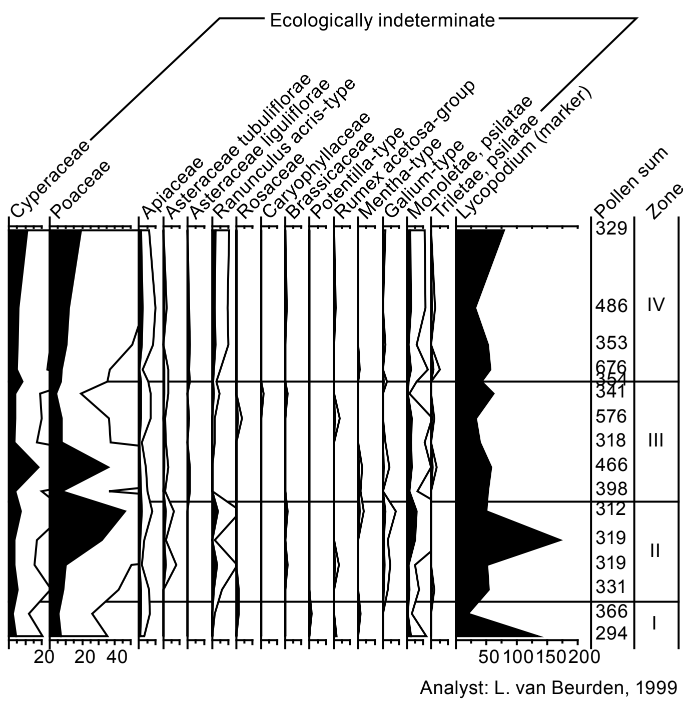


Figure I.11 Hardinxveld-Giessendam De Bruin, square 24, pollen diagram DB based on an upland pollen sum, exaggeration 5 x (after Bakels *et al.* 2001), part 2.

Summarising, possible human impact can only be distinguished during phase 2. Importantly, the sediments of phase 2 contain a considerable concentration of sturgeon remains (*Acipencer sturio*), located more or less at the same spot as the pollen sample location (Beerenhout 2001, 316). This concentration of fish remains can be interpreted as the waste from the local cleaning of fish. Furthermore, a structure interpreted as a landing place for canoes was present at only few metres away from the pollen sample location. It therefore appears that the relative strong signal of possible human activity in phase 2 indeed reflects human impact. The signal thus forms an exception to other changes in the pollen diagram, which is caused by sampling in the middle of a specific activity zone at the border of the dune.

I.6.2 Pollen analysis outside the excavation trench

I.6.2.1 Introduction

In addition to the boxes sampled inside the excavation trench, a pollen core was sampled south of the dune outside the excavation trench, beyond the area of human activity (coordinates 115.168/428.144, see fig. I.10). This new core HB was investigated by K. Verhoeven and W.J. Kuijper (Verhoeven 2003). The additional data enable the reconstruction of the natural vegetation and human impact, and additionaly allow a comparison of the two pollen diagrams. The core was located further away from the main find concentration than the on-site sample boxes DB, and is expected to show relatively weak evidence of human impact. However, the distance between the two sample points and the dry surface of the dunes is comparable, possibly reducing the difference. The environmental conditions at the two sample locations were probably different, since the location of the sample boxes DB was strongly influenced by the crevasse channel, while core HB was located further away from this channel.

I.6.2.2 Materials and methods

The sediment of the core HB consisted of amorphous peat and detritus-gyttja, in the lower part of the core mixed with sand from the dune and in the upper part of the core mixed with clay deposited during the Middle Ages. The pollen samples with a volume of 1 cm^3 were prepared according to the standard methods, and pollen, non-pollen palynomorphs and macroremains from these samples were identified. To each sample, a *Lycopodium* tablet containing *c.* 12077 spores was added. The sample interval of the analysis is 20 cm in the lower and middle part of the core and 40 cm in the upper part of the core.[8] The pollen diagram is based on an upland pollen sum of at least 300 pollen grains (dryland trees, shrubs, herbs and spore plants including crop plants). The classification of plants in ecological groups is based on Van der Meijden (1996) and Weeda *et al.* (1985-1994). *Veronica beccabunga*-type represents *V. beccabunga*, *V. anagallis-aquatica* and *V. catenata*.

I.6.2.3 Dates

In order to correlate both pollen diagrams of De Bruin, four samples of the core were dated (see table I.8). The dates demonstrate that the core represents at least a part of the (Late) Atlantic and Sub-Boreal. In addition, pollen of *Juglans* sp., *Fagopyrum* sp., *Centaurea cyanus* and *Zea mais* in the very upper part of the diagram indicate that the Sub-Atlantic is represented in the diagram as well. This last period is not relevant for this study and will therefore not be discussed here. The reconstruction of the ground water level indicates that peat accumulation at the location of the core started at *c.* 5200 BC (Louwe Kooijmans and Nokkert 2001, 75),

8 The identification was based on literature (Fægri and Iversen 1989; Moore *et al.* 1991; Punt and Blackmore 1991; Punt and Clarke 1980, 1981, 1984; Punt *et al.* 1976, 1988, 1991; Reille 1992, 1995) and the reference collection of the Faculty of Archaeology, Leiden University.

sample	depth (m -NAP)	lab code	age (yrs BP)	age (yrs cal BC, 2σ)	dated material
HG De Bruin 4	3.29-3.30	GrA-30181	3975 ± 45	2620-2330	Alnus sp., three fruits, a bud and a bud scale
HG De Bruin 3	4.28-4.29	GrA-30180	4565 ± 45	3500-3090	Alnus sp., four fruits, Lythrum salicaria, three seeds
HG De Bruin 2	5.28-5.29	GrA-30178	5400 ± 60	4350-4050	Alnus sp., seven fruits
HG De Bruin 1	6.68-6.69	GrA-30177	5680 ± 60	4690-4360	Alnus sp., four fruits and a cone, Humulus lupulus, one fruit, Ranunculus repens-type, one fruit

Table I.8 Hardinxveld-Giessendam De Bruin, ^{14}C dates of core HB (Center for Isotope Research Groningen).

presumably corresponding with phase 1.[9] The large age difference of 500-800 years between the estimated age of the lowest level of the core and the first date at 6.68 m -NAP can be explained by compaction of the peat and possibly by absence of sedimentation and/or erosion since the presence of sand in the lower part of the core suggests that only restricted compaction could have occurred. Date HG De Bruin 1 corresponds with the period during or after occupation phase 3 and with the youngest date from the on-site samples boxes of De Bruin (date DB 3, GrA-14864), indicating that the lower part of diagram HB corresponds with the upper part of diagram DB.

I.6.2.4 Results and discussion

Figure I.12 shows the results of the pollen analysis and macroremains of core HB. The diagram is divided into four zones: zones I (7.27-5.97 m -NAP), II (5.97-4.12 m –NAP, divided into zone IIa and IIb at -5.37 m), III (4.12-2.67 m -NAP) and IV (2.67-1.87 m -NAP). The diagram presented here is highly similar to the unpublished diagram (Verhoeven 2003)[10] and I refer to this primary source for an extensive discussion of the diagram. In general the pollen diagram of core HB is similar to the diagrams of Polderweg and De Bruin and indicates similar vegetation for the Atlantic and Sub-Boreal. At the dune, dryland vegetation consisting of deciduous woodland was present, mixed with open patches with shrubs, herbs and spore plants. The wetland environment consisted of alder carr and open marshes. Alder carr was probably present in the earliest period, as indicated by a high percentage of *Alnus* sp., Cyperaceae, monoletae psilatae fern spores and scalariform perforation plates (type 114). In the remaining lower part of the diagram, representing the period of occupation of the dune, the importance of alder seems to be restricted. From 4.62 m -NAP onwards (the middle part of the diagram), the local presence of alder carr is indicated by the same curves as earlier.

9 Peat accumulation at the sample location could only start when the ground water level reached the surface. As a result, models of the rise of the ground water level can be used to date the lowest part of the core.

10 The presented diagram differs from the original diagram in the combined presentation of pollen and macroremains, and in the zonation.

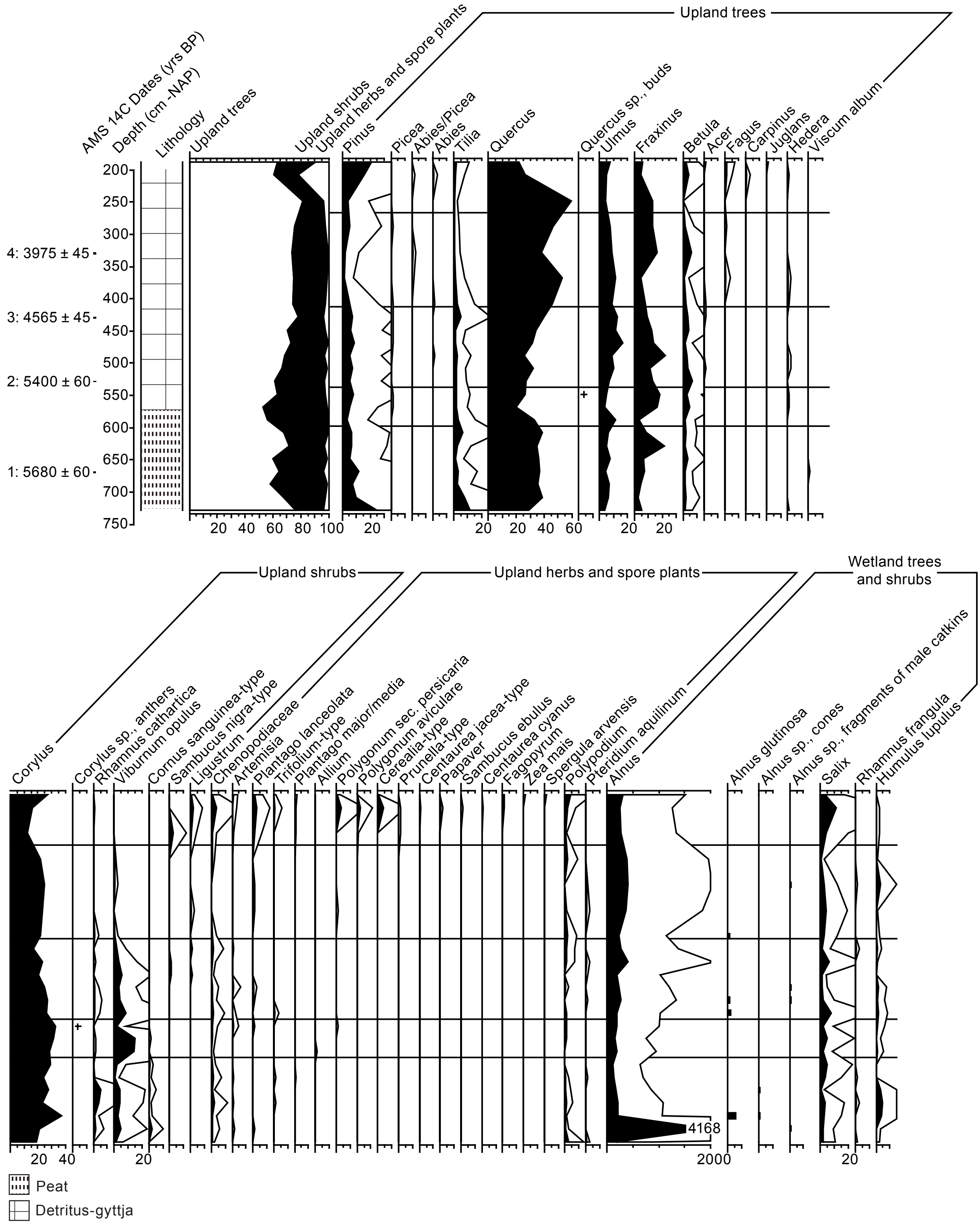


Figure I.12 part 1.

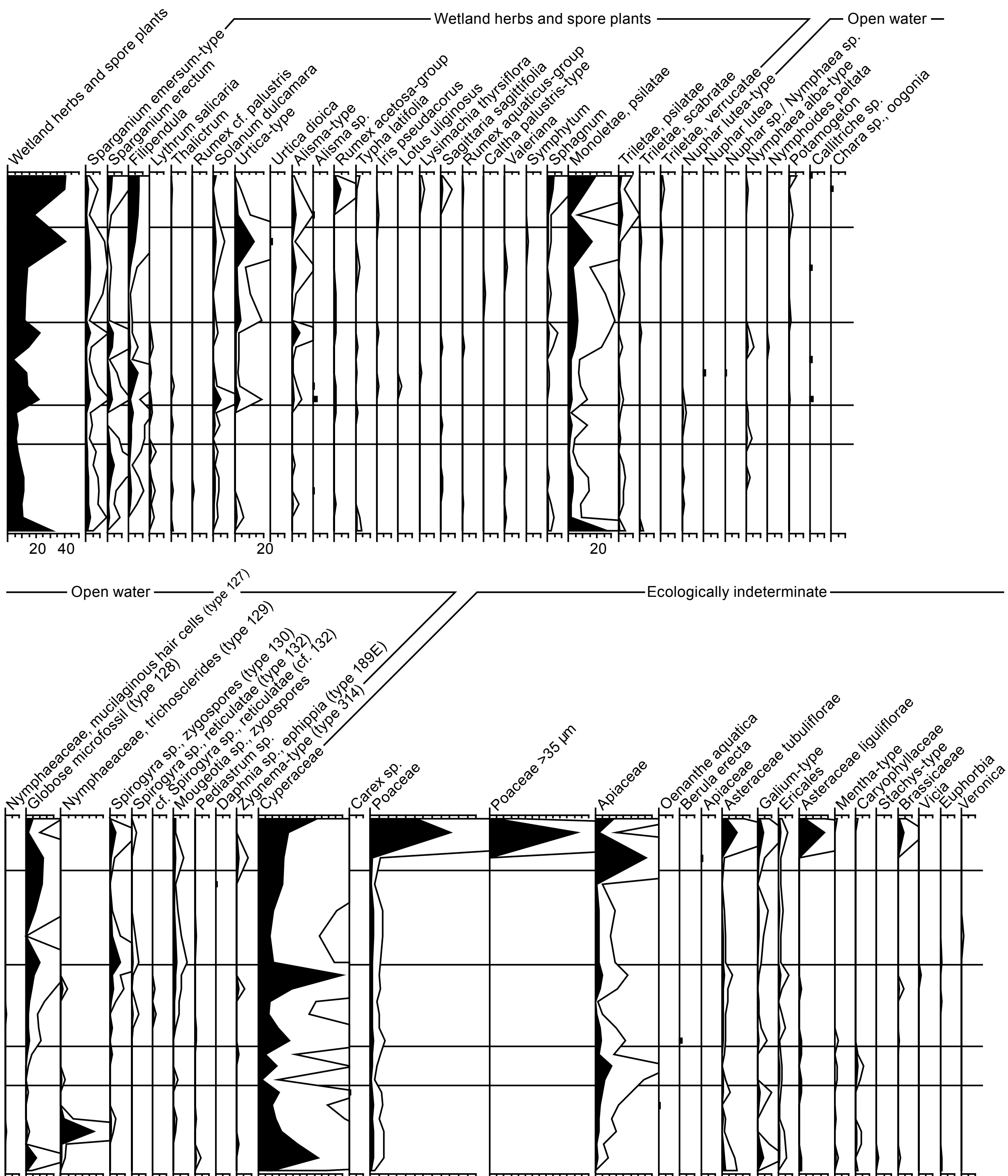
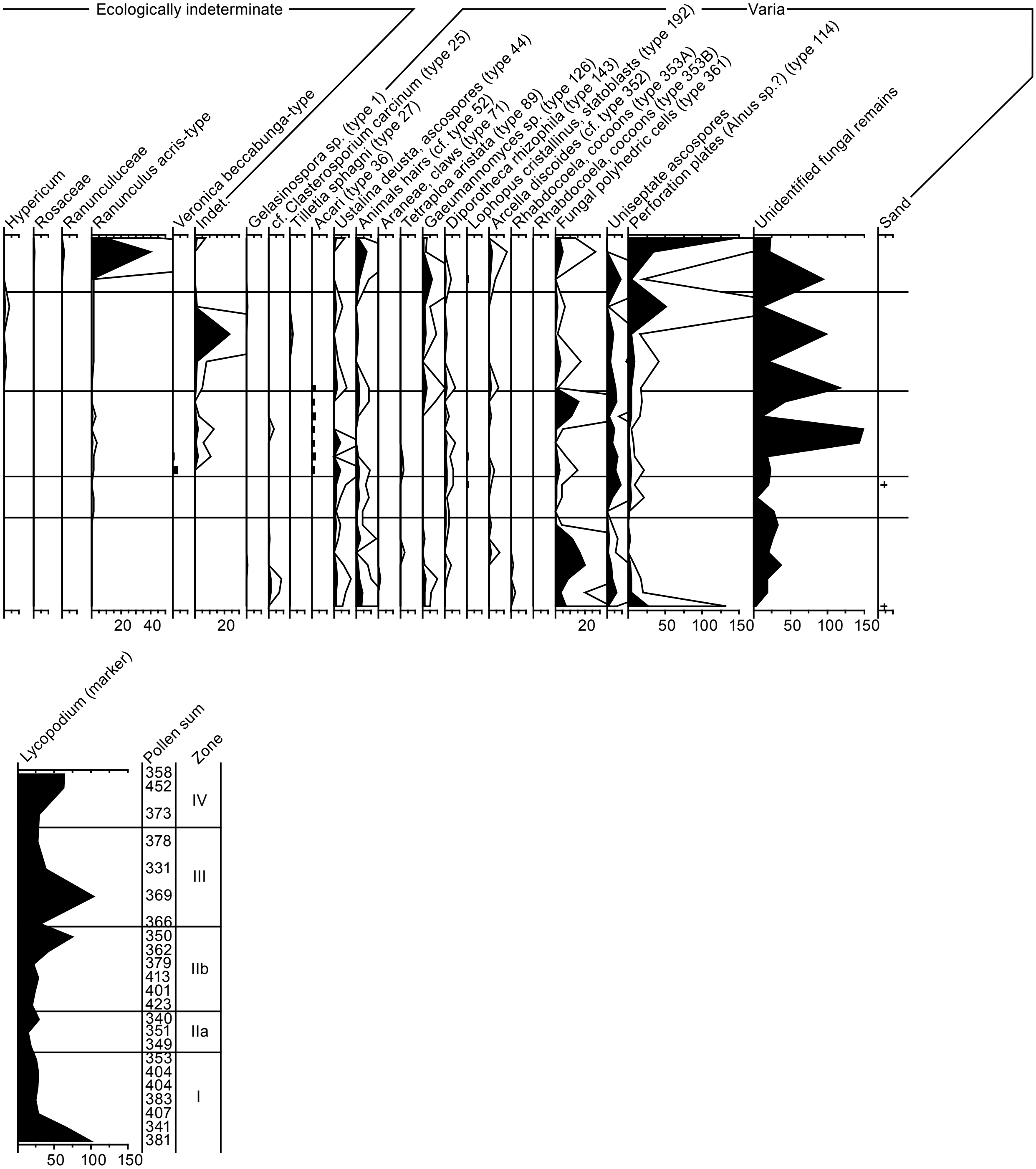


Figure I.12 part 2.



Analysts: K. Verhoeven and W.J. Kuijper, 2003

Figure I.12 Hardinxveld-Giessendam De Bruin, core HB, pollen, non-pollen palynomorphs (NPP) and macroremains diagram, pollen and non-pollen palynomorphs percentages based on an upland pollen sum, exaggeration 5 x, + = present (after Verhoeven 2003), part 3.

An important difference with other pollen diagrams of Hardinxveld-Giessendam is that this diagram represents the development of the dune vegetation relatively short before the submergence of the dune, and the subsequent developments. The point of submergence of the dune roughly corresponds with date HG De Bruin 2 (4350-4050 BC) at the start of zone IIB (5.29 m -NAP), since this date can be placed shortly after the end of occupation at De Bruin (presuming that occupation continued as long as possible). The submergence is supported by various changes in the relevant spectra of the pollen diagram. Firstly, the diagram shows the stabilisation of the curves of the total percentage of dryland trees and shrubs at the transition from zone IIa to zone IIb (after 5.37 m -NAP), while the percentage of dryland shrubs starts to decrease. Secondly, pollen grains of *Picea* sp. and *Abies* sp. are regularly present from the same level onwards, both indicating the influence of river water. Thirdly, the percentage of dryland shrubs is relatively high in zone IIa, and sand and macroremains of *Quercus* sp. and *Corylus* sp. are still present, indicating the local presence of dryland vegetation and erosion respectively. There are however no longer any indications of the local presence of dryland vegetation in zone IIb. The relatively high value of *Ulmus* sp. and the increase in *Quercus* sp. in zone IIb probably represent transport by river water since the peak values correspond with small peaks of *Abies* sp. and *Pinus* sp. In addition, the curve of the total percentage of wetland herbs shows an increase at 5.37 m -NAP (related to the increase in *S. dulcamara*, *Urtica*-type, *Alisma*-type, *Rumex acetosa*-group and others). Finally, changes in the curves of various non-pollen palynomorphs indicate the submergence of the sample location. From the start of zone IIb (slightly higher than 5.37 m -NAP), the percentage of non-pollen palynomorphs increases strongly and starts to fluctuate, while the curves of *Spirogyra* sp. and *Mougeotia* sp. appear, indicating the presence of stagnant shallow eutrophic water. Type 128 shows a continuous increasing curve as well, indicating shallow, mesotrophic or eutrophic, stagnant or slowly moving water. In addition, the curve of unidentified pollen grains starts at the same level, also indicating environmental change.

The macroremains support the occurrence of environmental change at the levels 5.28 m -NAP and in a minor degree at 5.08 m -NAP (both lower part zone IIB), characterised by a significant increase in the number of taxa and the number of macroremains, especially macroremains of wetland (riparian) taxa. The increased seed production is probably related to the final submergence of the (dryland) woodland of the dune, resulting in the drowning of the trees, which created major gaps and led to the absence of living woodland vegetation. This resulted in improved access of herbs and wetland taxa to light at the sample location, leading to increased seed production. Human impact as the cause of increased seed production is unlikely since level 5.29 m -NAP corresponds with date HG De Bruin 2, which clearly postdates the last occupation phase.

If the changes at the beginning of zone IIb represent the submergence of the dune including the sample location, the fluctuations of dryland shrubs and herbs in zone II have to be explained, especially since there were no other dryland patches left in the direct surroundings of De Bruin during/after the last occupation phase and since the dispersion of pollen of dryland herbs is generally limited. Pollen grains of dryland taxa present in the middle of zone II may represent the last elements of dryland vegetation at the dune since the top of the dune is located higher than the mowing field at the location of core HB. The macroremains and the dates however strongly indicate that this argumentation cannot be used to explain presence of remains of dryland taxa in the upper part of the zone. The rise of *Quercus* sp. in zone IIb therefore definitely does not represent vegetation on the dune De Bruin, while similarly the pollen of dryland shrubs cannot represent (extra-) local vegetation. The small peaks of *Artemisia* sp. and *Plantago lanceolata* may simply represent pollen that was transported by the river water since these taxa are part of the natural vegetation along levees.

I.6.2.5 Human impact

Anthropogenic influence on the vegetation in the pollen diagram of core HB related to the investigated occupation periods can be expected in the samples before date HG De Bruin 2 (5.29 m -NAP: *c.* 4350-4050 BC), since this date likely represents a *terminus ante quem* of occupation. The pollen diagram shows that anthropogenic influence on the vegetation may be present in the lower part of zone I (first two samples), indicated by the relatively high value of *Pinus* sp. and the relatively low value of *Quercus* sp., the presence of small peaks of *Artemisia* sp., *Plantago lanceolata*, a small peak of *Cornus sanguinea*-type, and the presence of *Euphorbia* sp. The strength of this signal is however limited. In the next spectrum, *Corylus* sp. shows a peak volume, which may represent human impact, but this does not correspond with other changes.

Zone IIa may reflect anthropogenic influence on the natural vegetation as well, indicated by a decrease in *Fraxinus* sp., a peak of *Viburnum* sp., a slightly later decrease in *Quercus* sp., the presence of *Allium* sp. (*cf.* the Hazendonk, appendix III), a peak value of Apiaceae and a decrease in Cyperaceae. This potential signal is however not supported by the presence of any of the classical anthropogenic indicators. In addition, the curves of water plants show relatively high values as well, which may explain some of the observed changes.

Summarising, the changes that may be related to human impact at the dune are rather weak and are only moderately supported by changes in other curves, as was the case in the earlier published diagram DB (see paragraph I.6.1). This can be related to the character of the activities and the distance between the sample location and the activity zone. Due to the weak evidence of disturbance, it cannot be excluded that other disturbance processes, such as abiotic factors or the activity of wild animals, resulted in the observed changes in zones I and IIa. Important causes of natural disturbance may concern the rising water level and channel activity, as indicated by the almost continuous curve of Chenopodiaceae in both zones and the presence of pollen grains of *Abies* sp. and *Picea* sp. in zone IIa.

I.6.2.6 Correspondence with the pollen analysis inside the trench

This paragraph compares core HB with the earlier published pollen diagram DB. Zone B-IV of the earlier published diagram (Bakels *et al.* 2001) is contemporaneous with zone I and possibly with the lower part of zone II (below 5.29 m -NAP, date HG De Bruin 2) of core HB. The upper part of zone B-III of the published diagram may additionally be contemporaneous with the very lower part of zone I of core HB (below date HG De Bruin 1, 6.68 m -NAP). A difference between both sample locations during phase 3 is the deposition of clayey peat at the location of the published diagram, related to presence of a nearby crevasse channel. This results in relatively smooth curves in this diagram (zone B-IV). At the sample location of core HB, the deposition of clay started later and the influence of the crevasse channel was weaker.

The results of core HB show that the results on the development of the vegetation from both sample locations are highly similar on a general level. Analysis and comparison of the contemporaneous zones of the pollen diagrams shows that it is not possible to compare the development of the vegetation in detail. This is on the one hand due to the large distance between the sample points, and on the other hand due to the large sample interval and the smooth curves. The first factor, the distance between the sample points, reduces the possibility of comparing the presence of those taxa which produce little pollen. For the earlier published diagram DB it is furthermore difficult to reconstruct which taxa were present in the local environment and which taxa represent pollen transported by the channel. The second factor restricts the possibility to discern changes in the vegetation that occurred at both sample locations and which may link the diagrams to each other. Interestingly, there is one exception, since there is one example of a change in the vegetation that can be observed in both diagrams. The earlier published pollen DB diagram shows a peak of *Corylus* sp. in zone B-IV that is contemporaneous with occupation phase 3. The diagram of core HB also shows a peak value of *Corylus* sp. in the lower part of zone I. These peaks, probably indicative of more open vegetation, may indicate that the diagrams correspond at these levels.

I.6.3 Macroremains analysis

I.6.3.1 Reconstruction of the vegetation

The analysis of macroremains concerned grid samples (N = 12, sample size 0.5 litres, minimal mesh width 0.25 mm), samples from features (N = 15, sample size 0.5 litres, minimal mesh width 1 mm), samples analysed in order to investigate the presence of carbonised cereal remains (N = 50, sample size 0.5 litres, minimal mesh width 1 mm), and a high number of handpicked samples and remains collected from the residue of sieving (minimal mesh width 4 mm) from phases 1, 2 and 3. The grid samples were collected in the zone that was waterlogged during occupation. In addition, macroremains in the pollen samples from the sample boxes collected in square 24 were analysed (sample volume 1 cm^3, mesh width 0.25 mm), as well as larger samples collected from the same sample boxes (N = 10, mesh width 0.25 mm, sample volume 0.15 litres). The analysis of the last group of samples (volume 0.15 litres) unfortunately did not include those spectra where the pollen diagram shows the strongest indications of human impact. The representativity of the macroremains analysis of phase 2 is restricted due to the small number of samples and the applied mesh width.

The variety of ecological groups in the taxa is large, which can be explained by the presence of a water channel next to the dune and the rolling down of macroremains from dryland taxa downwards along the slope of the dune, while anthropogenic influence may have played a role as well. Comparison of the macroremains of the different phases indicates that the water level rose through time, resulting in a shift of the vegetation belts in an upslope direction. Macroremains of *Tilia* sp. are very common in the material of the first phase. During phases 2 and 3, the relative importance of the macroremains of of dry terrain woodlands and woodland edge vegetation, including *Tilia* sp., decreased, while the importance of marshland and riparian taxa increased. The marsh taxa indicate moderate to highly eutrophic conditions in an open or moderately shaded environment. The macroremains of phase 1 contained a theca of *Betula* sp. with pollen grains inside, strongly indicating the local presence of *Betula* sp.

The analysis of the 0.15 litre macroremains samples (fig I.13, next page) confirms the gradual submerging of the dune at the end of phase 2 as concluded above. Nevertheless, the remains of *Tilia* sp., *Quercus* sp. and various shrubs indicate that woodland vegetation of dry terrain still remained present in the extra-local vegetation. The macroremains analysis of the pollen samples (fig I.14, next page) shows the presence of charcoal and sand in large parts of the core, indicating colluviation and/or human activity. The results of both diagrams correspond with each other.

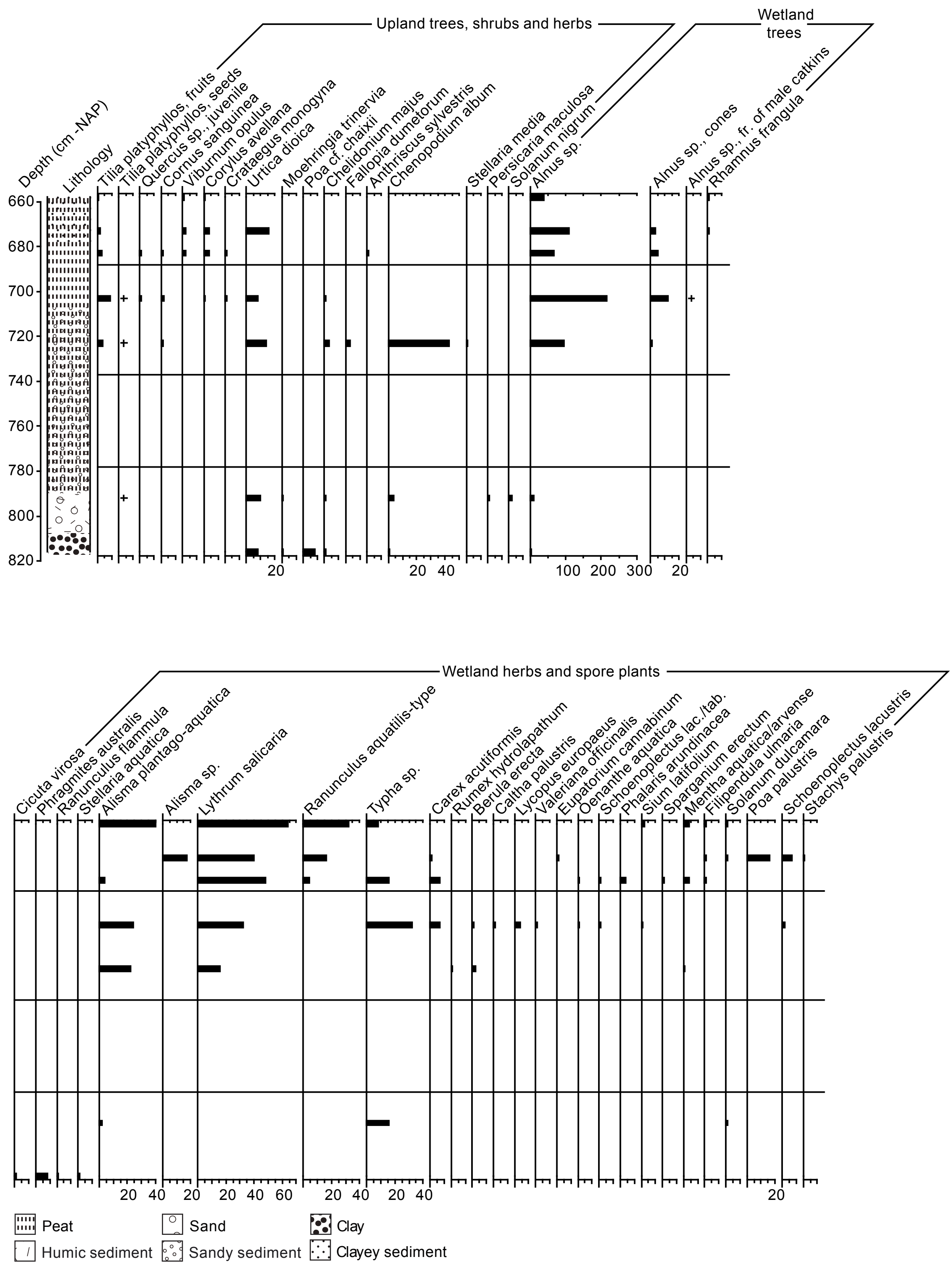


Figure I.13 part 1.

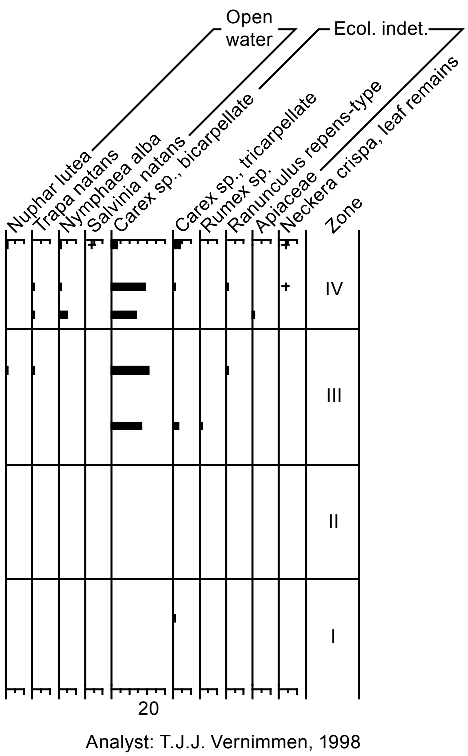


Figure I.13 part 2 Hardinxveld-Giessendam De Bruin DB, square 24, macroremains diagram from samples with a volume of 0.15 litres, + = few (after Bakels *et al.* 2001, 393). Part of the sample column was not analysed.

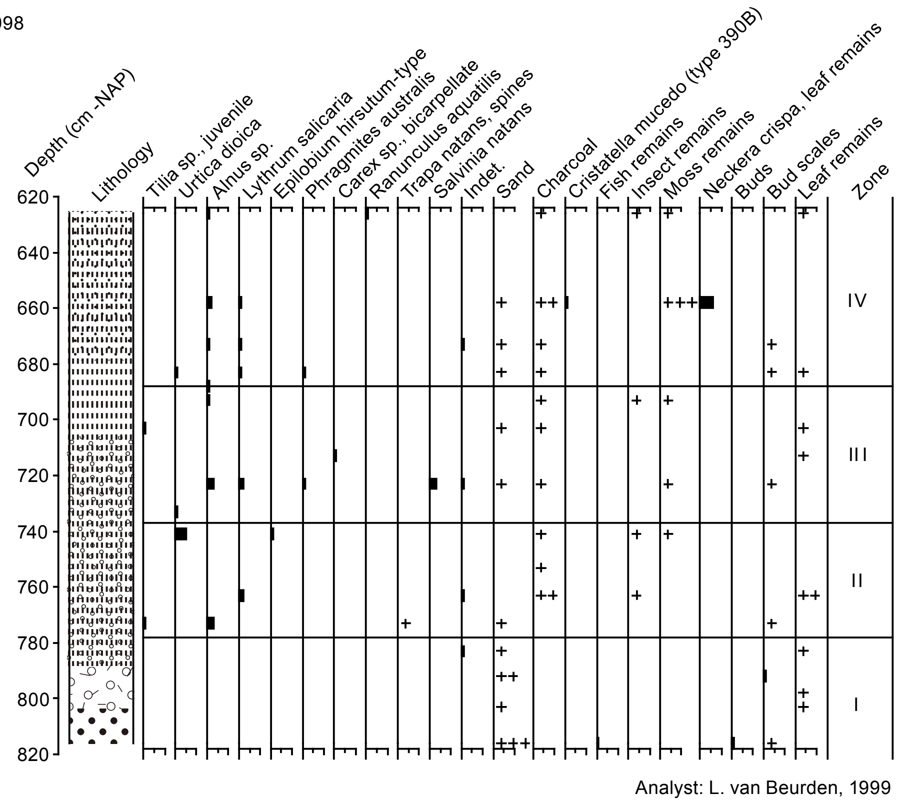


Figure I.14 Hardinxveld-Giessendam De Bruin DB, square 24, macroremains diagram from the pollen samples with a volume of 1 cm3, + = few (1-10), ++ = some tens (10-49), +++ = many tens (50-99) (after Bakels *et al.* 2001, 377). See figure I.13 for the lithology key.

category taxon	C	W	P
Artemisia sp.	-	-	+
Chenopodiaceae	-	-	+
Chenopodium album	-	+	-
Fallopia convolvulus	-	+	-
Galeopsis-type	-	+	-
Galium aparine	+	+	-
Moehringia trinervia	-	+	-
Persicaria lapathifolia	-	+	-
Persicaria maculosa	-	+	-
Poa annua	-	+	-
Ranunculus acris-type	-	-	+
Rumex acetosa-group	-	-	+
Silene sp.	-	+	-
Solanum nigrum	-	+	-
Stellaria media	-	+	-
Urtica dioica	-	+	-
Urtica dioica-type	-	-	+

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

Table I.9 Hardinxveld-Giessendam De Bruin, taxa of which the ecology is comparable to that of arable weeds (after Bakels *et al.* 2001).

I.6.3.2 Crop plants and disturbance indicators

Cultivated plants were absent in all phases despite the active search for crop plants by sieving 50 extra samples on a 1 mm sieve. On the one hand, the absence of crop plants at De Bruin corresponds with the absence of crop plants at contemporaneous Dutch wetland sites and the early phases of Brandwijk-Kerkhof. On the other hand it is remarkable that the introduction of pottery and domestic animals at Hardinxveld-Giessendam did not result in the introduction of crop plants. Table I.9 shows the taxa of which the ecology is comparable with that of arable weeds[11] (based on Bakels *et al*. 2001; Verbruggen and Verpoorte 1998). The interpretation of these taxa is the same as for similar taxa found at Polderweg (see discussion above). The single species found in a carbonised state is *Galium aparine*.

I.6.3.3 Carbonised macroremains of non-cultivated plants

Non-cultivated plants of which macroremains were present in a carbonised state are *Tilia platyphyllos*, *Quercus* sp., *Corylus avellana*, *Cornus sanguinea*, *Trapa natans* (all five all phases), *Crataegus* sp. (phases 2 and 3), *Malus* sp. (phase 2 or 3), Rosaceae (phase 2), *Acer campestre* (phase 2), *Galium aparine* (phase 2), *Ranunculus ficaria* (phase 3), *Schoenoplectus lacustris/tabernaemontani* (phase 2), *S. lacustris* (phase 2) and Poaceae (small seeds, phase 3) (Bakels *et al.* 2001). Macroremains of *Tilia* sp., *Corylus avellana*, *Galium aparine*, *Ranunculus ficaria*, *Schoenoplectus lacustris* and *Trapa natans* were found in anthropogenic contexts (pits, deposition pits or surface hearths) or in concentrations of charcoal. In addition, the analysis of a concentration of charcoal additionally resulted in a find of *cf. Quercus* sp. All taxa found in a carbonised state are known as food plants, except for *Acer* sp., *Tilia* sp., *Galium aparine* and *Schoenoplectus* sp. (though see chapter 9 for a discussion on the function of *Galium aparine*). Taxa that have edible parts and that were present at De Bruin but that were not found in a carbonised state are *Rubus caesius*, *Ribes* sp., *Nymphaea alba*, *Nuphar lutea* and a large variety of herbs and grasses of which the seeds and fruits, leaves and tubers may have been consumed as well (see chapter 9).

The carbonised state of many taxa indicates occupation during the autumn (September /October) for all phases. The carbonised remains of *Tilia* sp. indicate a somewhat earlier occupation for all phases (July and/or August), while *Galium aparine* indicates summer and/or autumn occupation (July to September) for phase 2. Winter occupation cannot be excluded on basis of botanical remains. The charcoal assemblage indicates occupation during spring for phase 2.

11 The selection of taxa is explained in chapter 10.

I.6.4 Wood and charcoal analysis

The discussion of wood and charcoal remains is based on Bakels *et al.* (2001), Hänninen and Vermeeren (1999) and Louwe Kooijmans, Hänninen and Vermeeren (2001). Wood remains were categorised as unworked and possibly worked wood remains[12] or as presumably worked remains and artefacts.[13]

The assemblage of unworked wood remains consists of trunks, branches and twigs (N = 188). The identifications are shown in table I.10. In this assemblage, *Alnus* sp. is the dominant taxon, followed by *Fraxinus* sp. and *Ulmus* sp. Other identified taxa are *Cornus* sp., *Quercus* sp., *Viburnum opulus*, *Salix* sp., *Corylus avellana*, *Betula* sp., *Euonymus europaeus*, *Tilia* sp., Pomoideae and *cf. Rhamnus frangula*. The assemblage is diverse and contains a diverse array of shrubs. *Tilia* sp. is absent in phase 3, in contrast to earlier phases.

	N				%			
phase / taxon	1	2	3	total	1	2	3	total
Alnus sp.	19	22	22	63	37	31	33	34
cf. Alnus sp.	-	1	-	1	-	1	-	1
Betula sp.	3	-	-	3	6	-	-	2
cf. Betula sp.	-	6	-	6	-	9	-	3
Cornus sp.	1	4	5	10	2	6	7	5
Corylus avellana	3	3	1	7	6	4	1	4
cf. Corylus avellana	-	1	-	1	-	1	-	1
Euonymus europaeus	-	1	1	2	-	1	1	1
Fraxinus excelsior	3	5	8	16	6	7	12	9
Pomoideae	-	1	-	1	-	1	-	1
Quercus sp.	1	7	2	10	2	10	3	5
cf. Quercus sp.	7	-	-	7	14	-	-	4
cf. Rhamnus frangula	-	1	-	1	-	1	-	1
Salix sp.	2	1	6	9	4	1	9	5
cf. Salix sp.	1	-	-	1	2	-	-	1
Tilia sp.	-	2	-	2	-	3	-	1
cf. Tilia sp.	2	-	-	2	4	-	-	1
Ulmus sp.	3	7	7	17	6	10	10	9
Viburnum sp.	-	-	10	10	-	-	15	5
Indet.	6	8	5	19	12	11	7	10
total	51	70	67	188				

- = not present

Table I.10 Hardinxveld-Giessendam De Bruin, unworked wood for each phase, twigs included (after Bakels *et al.* 2001).

12 The possibly worked wood remains comprised finds without indications of working, for which the original orientation of the wood in the trunk indicated that it may concern worked wood.

13 The presumably worked wood remains comprised finds that did not show traces of working but that were nevertheless distinguished due to non-natural characteristics. They were interpreted as semi-finished artefacts and refuse of artefact manufacture.

The absence of *Tilia* sp. at the dune can however be rejected since several macroremains of *Tilia* sp. have been found in the macroremains assemblage of phase 3 (*contra* Bakels *et al.* 2001, 411).

The charcoal from two charcoal concentrations of each phase was identified (N = 607; 47 to 95% of the charcoal of each concentration). Three of the six concentrations are interpreted as surface hearths, and the other concentrations may represent similar hearths (Louwe Kooijmans and Nokkert 2001, 82). The results of the charcoal analysis are shown in table I.11. *Alnus* sp., *Quercus* sp. and *Viburnum opulus* are present in all phases. *Alnus* sp. is dominant, and the percentage of this taxon increases in every phase. Other identified taxa are *Fraxinus* sp., *Ulmus* sp., *Corylus* sp., *Cornus* sp., Pomoideae, *Rhamnus cathartica*, *Viscum album*, *cf. Betula* sp., *Rhamnus frangula*, and *Salix* sp. The variety of taxa is greatest in phase 1, which may be explained by the large extent of the dune during phase 1. The variety may alternatively be related to the disturbed context of both concentrations of phase 1 (in contrast to the concentrations of the other two phases). The assemblage contains two taxa that were not identified in the pollen and macroremains assemblage of both De Bruin and Polderweg: *cf. Sorbus* sp. (though pollen grains of *Sorbus* sp. might have been identified up to family level as pollen of Rosaceae in the pollen analysis) and *Prunus avium*.[14] The broad spectrum of the charcoal assemblage as well as the importance in individual contexts of taxa that were dominant in the local vegetation

	N				%			
phase taxon	1	2	3	total	1	2	3	total
Alnus sp.	42	98	167	307	32	39	74	51
cf. Alnus sp.	1	2	-	3	1	1	-	0
cf. Betula sp.	1	-	-	1	1	-	-	0
Cornus sp.	-	7	9	16	-	3	4	3
Corylus avellana	15	8	-	23	11	3	-	4
cf. Corylus avellana	2	-	-	2	2	-	-	0
Fraxinus excelsior	-	107	14	121	-	43	6	20
Pomoideae	1	-	-	1	1	-	-	0
Prunus avium	2	-	-	2	2	-	-	0
Quercus sp.	3	5	4	12	2	2	2	2
Rhamnus cathartica	12	-	-	12	9	-	-	2
Rhamnus frangula	11	-	-	11	8	-	-	2
Salix sp.	4	1	-	5	3	0	-	1
cf. Sorbus sp.	-	-	6	6	-	-	3	1
Ulmus sp.	16	-	4	20	12	-	2	3
Viburnum sp.	8	8	3	19	6	3	1	3
Viscum album	-	1	1	2	-	0	0	0
Indet.	13	14	17	44	10	6	8	7
total	131	251	225	607				

- = not present

Table I.11 Hardinxveld-Giessendam De Bruin, charcoal for each phase (Bakels *et al.* 2001).

14 But see the remarks on *Prunus* sp. in chapter 7.

(*Fraxinus* sp. or *Alnus* sp., 62 up to 85%) indicates that there was no selection of wood for fuel. During phase 1, people often used fresh or moist wood as a source of fuel. During phase 2, people may have used old and mainly dry wood. During phase 3, people often used dry, dead wood as a source of fuel (Bakels *et al.* 2001).

The results of the analysis of possibly worked wood remains (N = 98) and wooden artefacts (N = 79) are shown in tables I.12 and I.13. The assemblage of wooden artefacts consisted of a variety of artefacts: fragments of a bow, hafts, paddles, pointed roundwood, skewers, posts, planks, planks interpreted as fragments of canoes and a fragment of a fish trap. Taxa that were present in the assemblage of artefacts are *Tilia* sp., *Quercus* sp.,

	N				%			
phase / taxon	1	2	3	total	1	2	3	total
Acer sp.	-	1	-	1	-	2	-	1
Alnus sp.	6	36	6	48	32	71	21	49
Cornus sp.	1	-	1	2	5	-	4	2
Corylus avellana	1	1	1	3	5	2	4	3
Fraxinus excelsior	2	5	12	19	11	10	43	19
Quercus sp.	6	6	7	19	32	12	25	19
Tilia sp.	1	1	-	2	5	2	-	2
Ulmus sp.	2	1	1	4	11	2	4	4
total	19	51	28	98				

- = not present

Table I.12 Hardinxveld-Giessendam De Bruin, possibly worked wood (after Louwe Kooijmans, Hänninen and Vermeeren 2001).

	N				%				interpretation
phase / taxon	1	2	3	total	1	2	3	total	
Acer campestre	-	-	1	1	-	-	5	1	haft
Alnus glutinosa	3	19	7	29	14	51	33	37	plank, point, skewer
Cornus sp.	2	2	3	7	10	5	14	9	fish trap, plank, post, point, skewer
Corylus avellana	1	1	1	3	5	3	5	4	point, skewer, wedge
Fraxinus excelsior	5	9	5	19	24	24	24	24	beam, haft, paddle, plank, point, post, trunk
Quercus sp.	3	6	4	13	14	16	19	16	haft, plank, post, point
Tilia sp.	6	-	-	6	29	-	-	8	canoes, plank, other
Ulmus sp.	1	-	-	1	5	-	-	1	bow
total	21	37	21	79					

- = not present

other = other interpretation of the function

Table I.13 Hardinxveld-Giessendam De Bruin, identification and interpretation of wooden artefacts for each phase (after Louwe Kooijmans, Hänninen and Vermeeren 2001).

Acer sp., *Fraxinus* sp., *Ulmus* sp., *Corylus* sp., *Cornus* sp. and *Alnus* sp. The dominant taxa are *Alnus* sp., *Fraxinus* sp. and *Quercus* sp., which corresponds with their dominance in the assemblage of unworked wood except for the importance of *Quercus* sp. instead of *Ulmus* sp., suggesting that people did not apply selective use based on the quality of the wood and the function of artefacts. The choice for certain taxa for specific artefacts nevertheless indicates such selective use (*Ulmus* sp. for a bow, *Tilia* sp. for canoes, *Alnus glutinosa* and *Quercus* sp. for planks, *Cornus sanguinea* for the fish trap and *Fraxinus excelsior* for paddles and spears).

Some of the pits that are considered as deposition pits also contained wood. One pit contained two branches of *Fraxinus excelsior* (length: 24 and 26 cm) and a root of *Euonymus europaeus* (length: 25 cm). Another pit contained a block of *Ulmus* wood of 20 x 20 cm and a branch of *Fraxinus excelsior* (length: 20 cm). The finds did not show indications of wood working. Intentional deposition is nevertheless assumed for the content of both pits due to the location and contexts of the remains, because of the equal length of the sticks in the first-mentioned pit, and since it was excluded that the block of wood found in the second pit represented a post.

I.6.5 Other sources

At De Bruin four species of fungi were found (see table 2.7). Two of the identified species prefer old or dead wood as a growing medium. The analysis of macroremains demonstrated the presence of the moss species *Neckera crispa*, indicative of moist and dense woodland.

I.7 Hardinxveld-Giessendam Polderweg and De Bruin: comparison of the archaeobotanical results

The distance between the sites Polderweg and De Bruin is only 1 km. Polderweg was occupied between 5500 and 5000 BC while De Bruin was occupied between 5500 and 4500 BC. At both sites, occupation started at approximately the same period and ended when sediments covered the dune. In view of this synchronicity and the close proximity both dunes are considered to have been used complementarily by one local community in the same territory in the early phases (Louwe Kooijmans 2003).

The occupation level was estimated for each occupation phase of each site based on the concentrations of archaeological finds. According to the resulting model, Polderweg was occupied the most intensively and De Bruin was used only complementary in phase 1. After 5300 BC, the main occupation shifted to De Bruin while Polderweg was used complementarily. After 5000 BC, occupation continued at De Bruin, while the Polderweg dune had become submerged as a result of the gradual water-level rise. There is however no explanation why people selected the dunes Polderweg and De Bruin and did not occupy the other, larger, dunes in the near surroundings. The reconstruction of the palaeogeography indicates that the presence/absence of crevasse channels and the distance to these channels alone cannot explain this pattern of settlement choice.

I.7.1 Reconstruction of the natural vegetation

The archaeobotanical information of Polderweg and De Bruin can be compared in detail since the distance between both sites is rather small and since the palaeogeography, the landscape and the natural vegetation of both sites are very similar. The pollen diagram of Polderweg partly reflects an earlier period than the pollen diagram of De Bruin, but there is an overlap in chronology between the pollen diagrams. Although the natural vegetation at both dunes is generally the same, there are indications of subtle differences.

At both sites, the dryland vegetation consisted of deciduous woodland vegetation consisting of *Tilia* sp., *Quercus* sp., *Ulmus* sp., *Fraxinus excelsior*, *Corylus avellana*, *Rhamnus cathartica*, *Viburnum opulus*, *Cornus sanguinea* and possibly *Humulus lupulus* (this last species might have grown in the alder vegetation as well). The characteristics of the wood and charcoal remains, the fungi and the mosses indicate that the woodland was generally moist, dense and of considerable age. At De Bruin, *Crataegus monogyna* was probably present, and *Betula* sp. and *Ribes* sp. possibly as well, while this is unlikely for Polderweg[15] (*Betula* sp.: *contra* Bakels and Van Beurden 2001, 355). The presence of the following taxa in the local and extra-local vegetation is uncertain: *Populus* sp. (Polderweg), *Ilex* sp. (De Bruin), *Sorbus aucuparia* (De Bruin: charcoal identifications), and *Acer campestre* (found at both sites). At both sites, there are indications that *Euonymus europaeus¸ Prunus avium*, *Prunus padus*, *Prunus spinosa*, and *Malus sylvestris* were not part of the local vegetation.[16] The natural vegetation at the dunes in the central river area nevertheless forms the natural habitat of these taxa so they may have been present before occupation, or at other dunes.

The wetland vegetation at both sites consisted of *Alnus* carr vegetation, forb vegetation, marsh vegetation and lake vegetation (both submerged and floating water plants). The wetland environment was very eutrophic with only minor mesotrophic patches. The alder carr was generally dense and old, though it might have been less stable than the dryland vegetation due to dynamic conditions in the wetland environment. The dune gradually submerged due to the gradual rise of the water level, resulting in a decrease in the dryland woodland vegetation and an increase in wetland vegetation though time.

I.7.2 Human impact based on pollen diagrams

It is not possible to accurately recognise signals of human activity on the vegetation in the pollen diagrams of Polderweg and De Bruin. The stable AP/NAP ratio indicates that the dryland vegetation does not show important changes that could have resulted from human impact. The percentage of dryland herbs remains very low and stable, and the number of anthropogenic indicators as defined by Behre (1981) is small. There are no indications of the recovery of the vegetation after most of the occupation phases. It is possible to observe an increase in the secondary shrub vegetation during occupation (*Viburnum opulus*, *Rhamnus cathartica*, *Cornus sanguinea*-type and *Sambucus nigra*-type), but the increase is mostly gradual and not supported by other anthropogenic indicators. It is furthermore not possible to distinguish whether the changes in vegetation are caused by human activity or by changes in natural conditions, such as tree falls, activity of wild animals or changes in the water table or water activity. Pollen grains of crop plants are absent at both sites. It must therefore be concluded that the strength of human impact was very restricted. Large-scale deforestation did not occur. The scarce evidence of human impact in the pollen diagrams appears to be in contrast to the indications of gathering of plant food and wood.

The only exception to the possibility of recognising anthropogenic influence on the vegetation in pollen diagrams is a major change in the vegetation 7.40 m -NAP in the diagram of De Bruin (Bakels *et al.* 2001) corresponding with phase 2. The change is characterised by peaks of especially wetland taxa that indicate the presence of light, nutrients and disturbance (Poaceae, *Humulus lupulus*, *Urtica dioica*-type, *Lythrum salicaria*). There are three arguments that support that it concerns evidence of human impact: 1) the strength of the signal, 2) the taxa that show peaks are taxa that are indicative of human impact at other sites as well (see for example appendix II and III) and 3) the vegetation recovered afterwards. The fact that it concerns mainly wetland taxa indicates that the anthropogenic influence affected mainly the local vegetation, and that it concerned small-scale disturbance.

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15 Finds of *Betula* sp. at Polderweg comprise a fruit and a single charcoal identification both dating to phase 0 only. The presence of *Crataegus monogyna* at De Bruin is indicated by the presence of pollen of Rosaceae and by the number of finds of macroremains that is relatively high compared with the number of finds at Polderweg (Polderweg N = 4; Bakels and Van Beurden 2001; Jongste and Verbruggen 1998). See also the remarks on *Prunus avium* in chapter 7.

16 At Polderweg, the number of macroremains of *Malus sylvestris* is *cf.* 1, and the number of wood and charcoal remains of Pomoideae is small as well (N = 4; Bakels and Van Beurden 2001). At De Bruin, only a single seed of *Malus sylvestris* was found. The presence of the attested finds can be explained by gathering of fruits for consumption and selective gathering of wood for fuel.

It can be questioned whether occupation pressure played a role in the evidence of human impact on the vegetation. The density of archaeological finds at Hardinxveld was highest at the site Polderweg during phase 1 (Louwe Kooijmans 2001b). The pollen diagram of Polderweg does however not show any clear signals of anthropogenic influence on the vegetation during this phase, despite the limited distance between the dry surface of the dune and the sample location. During later phases, occupation is concentrated at De Bruin. The pollen diagram of De Bruin DB shows a very local signal related to phase 2 but no signal related to phase 3. The absence of a signal related to phase 3 is unexpected since the extent of the refuse layer of phase 3 is only a little bit smaller than that of phase 2, while the sample location was still located in the refuse layer. It can therefore be tentatively concluded that it is not possible to reconstruct a relationship between occupation intensity and anthropogenic influence on the vegetation at Hardinxveld. The absence of accurate signals of human impact on the natural vegetation is further discussed in paragraph 2.8.3.

I.7.3 Crop plants and weeds

At both sites, crop plants are absent, despite an extensive sampling program and active search for cereal grains (discussed above). Archaeological finds that indicate cultivation of crop plants, such as sickle blades, sickle gloss or quern stones are absent as well. Although domestic plants are absent, it cannot be excluded that people did not know about crop plants as the result of contact with fully agricultural communities. Furthermore, the people who visited the Hardinxveld-Giessendam sites spent part of the year elsewhere, presumably the southern sand region. It is unknown when domestic plants where introduced there (see chapter 2.8.1).

Both sites show the presence of various taxa that would be identified as potential arable weeds if crop plants were present (see tables I.3 and I.9). Most macroremains were found in a waterlogged state only, except for fruits of *Galium aparine* and small fruits of Poaceae. The waterlogged state of most taxa does not provide evidence of a direct relationship with anthropogenic activities.

I.7.4 Carbonised macroremains

Most taxa found as macroremains in a carbonised state at Polderweg were present in a carbonised state at De Bruin as well: *Malus sylvestris*, *Corylus avellana*, *Ranunculus ficaria* and *Trapa natans*. These taxa may all represent food plants, and the similarity of the finds at the two sites therefore suggests similarity of plant food. At De Bruin, however, macroremains of seven more potential food sources were found in a carbonised state (5 taxa at Polderweg *versus* at least 13 food plant taxa at De Bruin). This difference can probably be partially explained by the higher number of samples of macroremains analysed at De Bruin (including the samples sieved on a coarse mesh width). Seasonality may have played a role as well, since there are scarce indications of summer occupation at De Bruin only. Other factors such as deposition processes and taphonomical processes may also have played a role. Overall, the evidence of plant consumption in the macroremains assemblages of Hardinxveld is small in view of the variety of potential food plants present at both sites (further discussed in paragraph 2.8.3).

I.7.5 Wood and charcoal

The assemblages of wood and charcoal indicate exploitation of both dryland and wetland vegetation in the near surroundings of the dunes. At both sites, the variety of taxa is high (N = 17, N = 18). Most wood could have been collected at the dunes themselves. *Alnus glutinosa*, *Quercus* sp. and *Fraxinus excelsior* are the dominant taxa in the assemblage of both unworked and charcoal remains. In addition to local resources, people also used non-local retrieved resources. Both at Polderweg and De Bruin, remains of *Acer campestre* and *Euonymus europaeus* were only present in the assemblages of worked wood, possibly worked wood or as whole trunks and branches, and not in the assemblages of unworked wood and charcoal, which suggests that they were brought in from elsewhere. However, three carbonised macroremains of *Acer* sp. were found at De Bruin. This suggests that local presence cannot be excluded, although the macroremains may also have been transported to the site on a branch.

Characteristics of the charcoal indicate the use of both old wood and moist, possibly fresh wood at both sites. The variety in the assemblage of wood and charcoal of both sites indicates that people usually did not select wood taxa for fuel. However, the analysis of concentrations of charcoal at Polderweg indicates some possible exceptions: one concentration of charcoal contained a high percentage of *Corylus avellana* and another concentration contained a high percentage of *Euonymus* sp. At De Bruin, the selection of *Euonymus europaeus* is also indicated by the find of worked wood remains of *Ulmus* sp., *Fraxinus excelsior* and *Euonymus europaeus* in pits interpreted as deposition pits. The types of artefacts found at the sites are very similar and the assemblages of both sites demonstrate that people selectively chose wood taxa because of their quality for the manufacture of specific artefacts continuously through all phases.