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

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Appendix IV. Synthesis of archaeobotanical sources of the Hazendonk

IV.1 Introduction

The vegetation around the Hazendonk has been investigated intensively by various authors. The aim of this appendix is to compare the results from appendix III with the results of other pollen diagrams. Focus points are the reconstruction of the natural vegetation, human impact and the influence of distance on the evidence of human impact. At the Hazendonk, it is possible to distinguish at least six occupation phases (see table III.1) labelled as Hazendonk phases (Haz) and Vlaardingen phases (VL), related to the Swifterbant culture, Hazendonk group, and Vlaardingen group, and an activity phase related to the Bell Beaker culture. There are indications of Mesolithic occupation and a phase Haz 0 as well (Van Dijk *et* al. 1976; Van der Woude 1983) but data on these phases are scarce. See the introduction of appendix III and the original sources for more information on the Hazendonk, and chapter 2 for more information on the palaeogeography in the central river area.

IV.2 Sources

The analysed sources are publications and reports of Steenbeek (1980), Voorrips (Louwe Kooijmans 1974, 136-143), Van der Wiel (1982), Van der Woude (1983), and new data on pollen and macroremains from the slopes of the dune (appendix III).[39] The location of the cores of Steenbeek (1980) and Van der Woude (1983) is shown below, while the location of the other cores in shown in appendix III (fig. III.2). For each source, some details will be given on the pollen sum, the distance between the sample point and the dune, the occupation phases that can be recognised and the anthropogenic influence that is described in the original publications. The information on the pollen sum (included taxa and number of included pollen) indicates the quality of the diagram, the possibility of comparison between the different cores and the degree of suitability to answer questions about changes in dryland vegetation due to human activity.

The new on-site pollen, non-pollen palynomorph and macroremains diagrams (appendix III) are the result of several cores and pollen boxes sampled in units B and C of the excavation. The diagrams give clear anthropogenic signals. The pollen analyses are based on an upland pollen sum varying between 266 and 492 pollen grains. The occupation phases that can be recognised are Haz 0, Haz 1, Haz 2a, Haz 2b, Haz 3, VL 1a and VL 1b. Occupation levels are distinguished on the basis of correlation with archaeological refuse layers, changes in the curves of trees, shrubs and herbs, changes in the diversity of taxa and the total number of macroremains and (partial) recovery of the vegetation after occupation phases.

The core of Van der Wiel (1982) is sampled in unit B and concerns the analysis of pollen, non-pollen palynomorphs, macroremains and wood remains. The core is sampled at the same distance from the dune as some of the material presented in appendix III. The pollen analysis resulted in two diagrams: one diagram is based on an arboreal pollen sum (300 pollen) while the other diagram is based on an upland arboreal pollen sum (300 minus the wetland tree pollen). The diagram based on the upland sum is comparable with the recalculated diagram of Voorrips (presented below) and those in appendix III, and is therefore used in the following analysis. In the diagram of Van der Wiel, the occupation phases Haz 1, Haz 2, Haz 3 and VL 1b are distinguished by changes of mainly dryland trees, shrubs and herbs, and the presence of charcoal.

39 There is an additional study of Van Dijk (1979) that is not presented here since the preservation of the pollen was poor and since the results suggested reworking or contamination with secondary material.

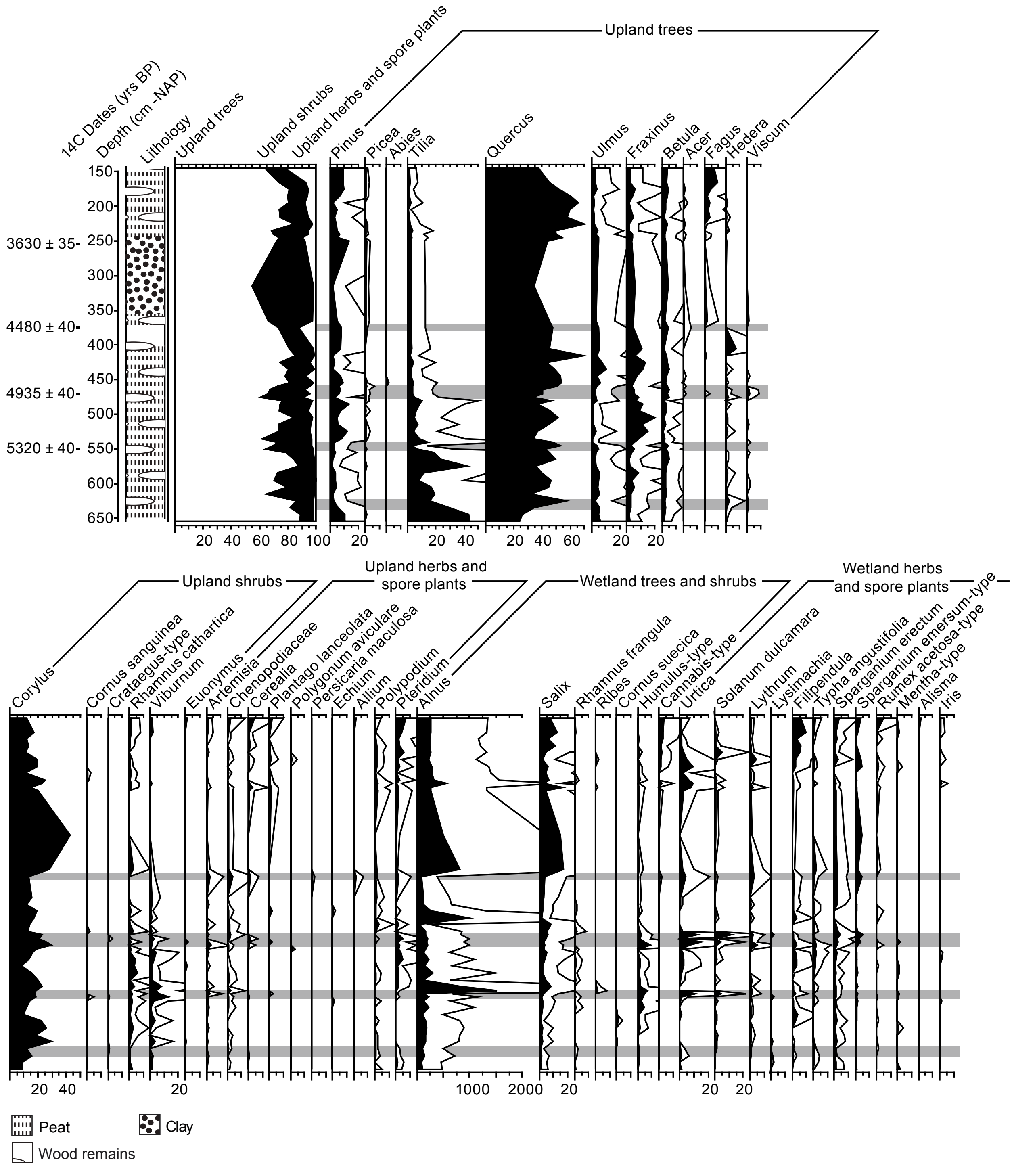

Figure IV.1 part 1.

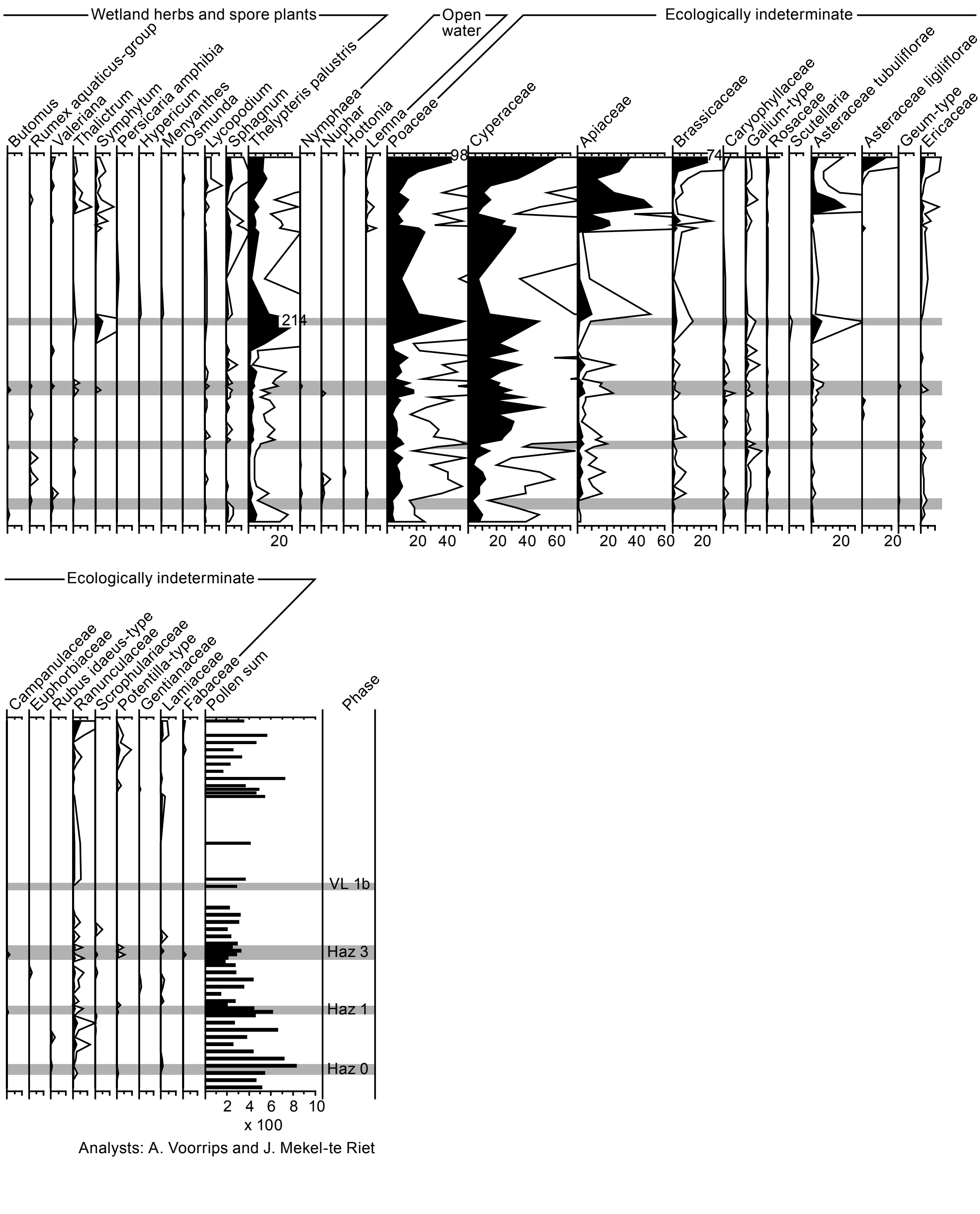

Figure IV.1 The Hazendonk, pollen diagram based on an upland pollen sum, exaggeration 5 x (after Louwe Kooijmans 1974), part 2.

The pollen diagram of Voorrips (Louwe Kooijmans 1974) is sampled at *c.* 10 metres distance from unit B of the excavation. The pollen sum exists of an unspecified upland pollen sum varying between *c.* 200 and 500 pollen grains. The published diagram shows a selection of taxa. The occupation phases that can be recognised by changes of several dryland and wetland taxa are Haz 0, Haz 1, Haz 3 and VL 1b. The analysis of the VL 1b level is based on two samples. Anthropogenic influence on the vegetation is described as a decrease in *Quercus* sp. and *Fraxinus* sp. and an increase in *Corylus avellana* (during some phases), and the presence and peaks of a variety of dryland and wetland herbs including pollen of Cerealia-type (recognised during all phases). As part of this study, the pollen diagram of Voorrips was recalculated based on an upland pollen sum (including dryland trees, shrubs, herbs and spore plants, again between *c.* 200 and 500 grains). This calculation resulted in a new diagram (fig. IV.1). This diagram is not discussed in detail (see Louwe Kooijmans 1974 for the interpretation) and has been used for further discussions in this appendix. The grey zones indicate the recognised occupation periods.

The pollen analysis of Van der Woude (1983) is based on several off-site cores sampled in the extra-local area of the Hazendonk, at a distance of *c.* 1-3 km from the dune (see fig. IV.2 for the location of the cores). The pollen diagrams are based on an arboreal pollen sum of 300 pollen grains including both dryland and wetland trees, which makes the diagrams less comparable with the above mentioned diagrams. Together, the cores of Van der Woude could reflect all occupation phases of the Hazendonk. Anthropogenic influence related to *Quercus* sp. is suggested during some phases (Van der Woude 1983, details presented below). Cores H1110, H2114, H2115, H2118 and H2178 are located near the Hazendonk and may give information on human impact. Cores H2114, H2115 and H2118 are also located near another dune, the Kweldamsdonk, and will probably reflect the vegetation development at this dune.

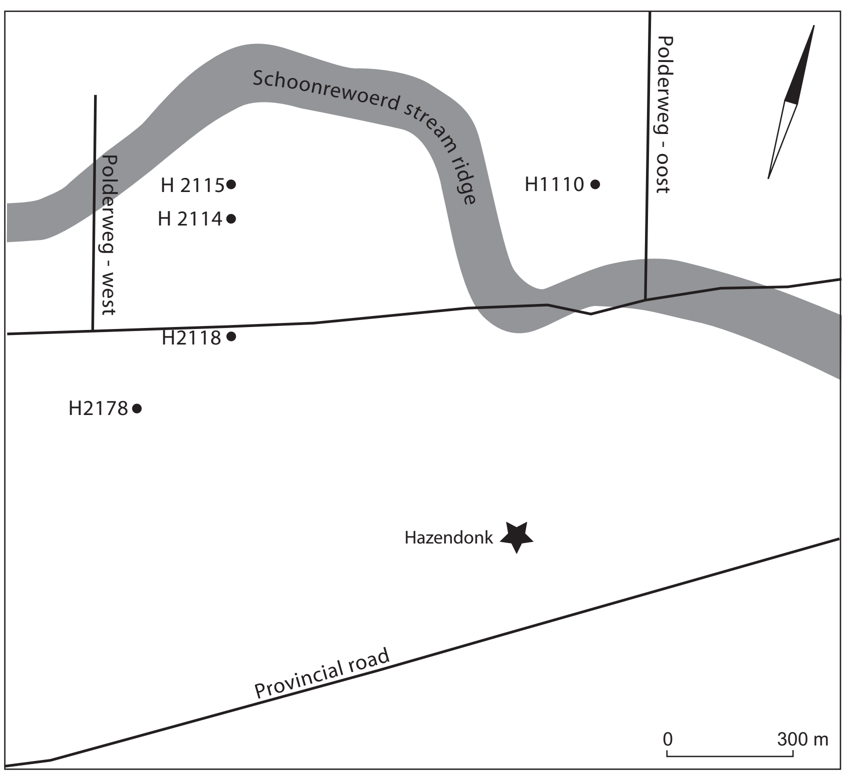

Figure IV.2 The Hazendonk, the location of the pollen cores presented by Steenbeek and Van der Woude (Van der Woude 1983).

The study of Steenbeek (1980), concerning core H2114 and H2115 (see fig. IV.2), was performed in close cooperation with Van der Woude. The analysis of core 2114 resulted in three diagrams: one based on an arboreal pollen sum of 300 pollen grains (H2114), one on the same pollen sum without *Alnus* sp., characterised by a very low pollen sum (H2114a), and one with an arboreal pollen sum without *Alnus* sp. of 200 pollen grains (H2114b). The pollen sum of H2115 consisted of 300 arboreal pollen grains.

IV.3 Reconstruction of the natural vegetation

Despite the differences in methodology, pollen sum and distance to the dune, the reconstructions of the natural local and extra-local vegetation at the Hazendonk are roughly similar amongst the various sources. In the discussion below, the dryland vegetation is emphasised since the dryland vegetation is primarily expected to be influenced by human activity.

The large-scale developments of the landscape and the wetland vegetation are extensively described by Van der Woude (1983) with emphasis on the dynamics of lakes and rivers. From *c.* 5000 BC onwards, the environment is dominated by *Alnus* carr vegetation combined with *Phragmites* vegetation, marsh ferns, Cyperaceae and calm lakes. After phase Haz 1, the lakes expanded at the expense of swamp forest (alder carr), and clastic deposition increased, presumably resulting in better accessibility of the Hazendonk (Van der Woude 1983, 89). The water depth decreased from *c.* 3360 BC onwards (around phase VL 1a). The alder carr remained present but was more alternated with open patches. Initial fluvial activity might have been present in the area after *c.* 3360 BC, while fluvial deposition strongly increased from *c.* 2600 BC onwards.

The local environment of the Hazendonk can be characterised as a mainly eutrophic environment. There were some taxa present at the dune that indicate patches of mesotrophic conditions due to peat growth in stagnant water that were not influenced by river water, though these patches were a minor element in the vegetation. Prehistoric soils were not found during the excavation of the dune (pers. comm. Louwe Kooijmans 2004). The subsurface of the dune consisted of sand that was locally calcareous on the lower parts of the dune, although soil formation had probably taken place already since the development of the dune in the Younger Dryas, which presumably had affected the higher parts of the dune in particular. Traces of calcium may additionally have been supplied by seepage water and river water. In the wetlands around the dune, many humic clayey patches were present, as well as sandier patches.

The Hazendonk dune was a small patch of dryland terrain in the middle of wetlands, covered with woodland vegetation of dry terrain. Before the first known period of anthropogenic influence, a patch of rather dense Atlantic woodland vegetation was presumably present on the top and slopes of the dune. The presence of the indicator species *Tilia* sp. and *Pteridium aquilinum* confirm the presence of old woodlands (Weeda *et al.* 1985, 1987), while taxa such as *Galium odoratum*, *Carex remota* and *Neckera crispa* (found in the macroremains assemblage of the excavation) indicate shaded conditions. Dryland vegetation remained present on the dune at least until the period after phase VL 1b and probably also during phase VL 2. Unfortunately, there are no pollen diagrams available that reflect the vegetation at the time of occupation phase VL 2.

Around the dune, a variety of marshes, lakes and small channels were present. These wetlands were covered by vegetation consisting of alder carr, riparian vegetation and open water vegetation. The increasing water table caused a shift of vegetation belts along the slope of the dune in an upwards direction. This can for example be demonstrated by the presence of *Alnus* sp.; *Alnus* carr developed at the slope of the dune between the phases Haz 1 and 2 and gradually became the dominant element of the vegetation in unit C. Shortly after phase VL 1b the influence of water activity increased strongly, resulting in the presence of *Salix* sp., the increased presence of water plants and a decrease in *Alnus* sp. at the southern and eastern side of the dune (appendix III; Louwe Kooijmans 1974; Van der Wiel 1982).

A short summary of Van der Woude (1983, 101) illustrates his reconstruction of the natural vegetation in the area of the Hazendonk: "The arboreal vegetation of these dry sites consisted mainly of *Quercus*, *Ulmus* and *Corylus*, and some *Tilia* on the higher parts of the dunes. … Marsh herbs occurring along the margins and at shallow places of the wet basins, and at open sites in swamps forests [mainly *Alnus* swamp], were among others *Phragmites* (and other hygrophilous grasses), *Typha angustifolia*, ferns, *Scirpus* (and other Cyperaceae), *Alisma* and Umbelliferae [Apiaceae]."

Van der Wiel (1982) discusses the development of vegetation between approximately 4300 and 2600 BC at the southern side of the dune. She describes the presence of a mixed *Tilia*/*Quercus* woodland on the higher parts of the dune, which she compares with a *Quercus*/*Fraxinus* vegetation rich in *Ulmus* sp. (Ulmion carpinifoliae), sometimes partly replaced by *Fraxinus* sp. and in the long term replaced by *Ulmus* sp. due to increasing water levels. As a result of the rise of the water table, peat formation increased and mixed *Alnus*-*Fraxinus* carr (comparable with the Circaeo-Alnion), present on the lower parts of the slope, changed into backswamp vegetation. Vegetation comparable with the Nymphaeion was replaced by reed vegetation (Phragmitetalia), and afterwards by *Salix* carr (Salicion albae).

Voorrips (Louwe Kooijmans 1974) describes woodland dominated by *Quercus* sp. with an undergrowth of *Corylus avellana* on top of the dune, a transitional zone with *Ulmus* sp. and *Fraxinus* sp. lower along the slope, followed by *Alnus* vegetation combined with wetland herbs, ferns and *Carex* species.

Principally, these sources reflect well the vegetation present at the Hazendonk, and it should be realised that the descriptions above are only summaries of detailed studies. However, all three summaries only partially recognise the large variety of the natural vegetation that is especially shown by the new data (see also paragraph III.4.1). In addition to the underestimation of the variety, the importance of *Tilia* sp. is strongly neglected by most authors except for Van der Wiel. The differences seem to be caused by the fact that the studies of Voorrips (Louwe Kooijmans 1974) and Van der Wiel (1982) are only based on a single core. The cores of Van der Woude (1983) are moreover taken at some distance from the dunes and therefore focus on the wetland vegetation.

The natural vegetation at the Hazendonk can be summarised as deciduous woodland vegetation. The vegetation on the top and higher parts of the dune was presumably more or less comparable with the modern-day Stellario-Carpinetum (major elements *Tilia* sp. and *Quercus* sp. but in the case of the Hazendonk no *Fagus* sp. or *Carpinus* sp.). The vegetation at the lower parts of the slope that were temporarily flooded during the year was comparable with the Alno-Padion (major elements *Fraxinus* sp. and *Ulmus* sp.), and the vegetation at the lowest parts of the dune that were inundated during large parts of the year with the Alnetea glutinosae (major element *Alnus* sp.) (Stortelder *et al.* 1999). The vegetation of the various communities was probably present in mosaic-like structures consisting of a variety of patches. It should be realised that the reconstructed vegetation communities that were present at the Hazendonk (especially the Stellario-Carpinetum) differed considerably from the modern-day vegetation since the composition of the flora and plant communities has changed due to various factors including human impact.

Detailed reconstruction of the development of the vegetation (including the reconstruction of human impact) at the Hazendonk is only possible for the southeastern side of the dune, despite additional indications of occupation at the northwestern side of the dune. The only pollen cores sampled at the northern side are the cores of Van der Woude (1983) of which the value for the reconstruction of human impact is discussed below.

IV.4 Human impact

The paragraphs below compare the signals of human activity as recognised by investigators for each occupation phase separately. The signal of specific vegetation as reflected by pollen diagrams generally decreases when the distance between the sample point and the vegetation increases, depending on the size of the catchment basin and the strength of the signal of the vegetation. Similarly, only pollen diagrams sampled close enough to human activity on the vegetation reflect the anthropogenic influence on the vegetation (Behre and Kučan 1986; Fægri and Iversen 1989). It is therefore expected that cores that are sampled close to the Hazendonk will reflect more strongly the anthropogenic influence on the vegetation at the dune than cores sampled at some distance from the dune.

IV.4.1 Mesolithic occupation

The pollen diagrams of Van der Woude (1983) are sampled at 1 to 3 km from the dune, in parts of the landscape where the Pleistocene subsurface is generally lower than at the dune. One the one hand, these pollen diagrams are suited to study the signals of Mesolithic occupation since peat growth (and registration of the development of the vegetation) started relatively early in the lower parts of the landscape. On the other hand, the relatively large distance between the sample points and the dune restricts the possibilities to recognise human influence on the vegetation.

It is suggested that an anthropogenic signal related to Mesolithic occupation is present in the diagram of core H2118 (see figure. IV.1 for the location). The signal is characterised by a fall of the *Quercus* curve, dated to *c.* 6000-5600 BC in another core (Van der Woude 1983, 45-47). Although the possibility of an anthropogenic signal in core H2118 is supported by changes that correspond with later anthropogenic signals that are more strongly confirmed by archaeological indicators (see below), other curves indicate that it might concern a change in the water table instead of an anthropogenic signal. It is therefore not possible to distinguish the cause of the changes in the vegetation unless further archaeological investigations are performed.[40]

Van der Woude (1983, 46) also suggested that the signal in core H2118 possibly corresponds with indications of occupation in the diagram of core H2178 (again a fall of the *Quercus* curve). The diagram is however not completely published, a statistical cause for the decrease in *Quercus* sp. is not excluded, and the association with Mesolithic occupation is tentative (Van der Woude 1983, 45). Therefore, this diagram does not provide sufficient evidence of human activity.

IV.4.2 Hazendonk 0

In the diagram of Voorrips (Louwe Kooijmans 1974), phase Haz 0 can be recognised by a fall and recovery of *Tilia* sp., a peak of *Quercus* sp., low values of *Ulmus* sp., a small peak of *Hedera* sp., an initial rise of *Corylus* sp., the presence of *Crataegus*-type, *Artemisia* sp., Cerealia-type (a single pollen grain), *Urtica* sp. and Brassicaceae, and a decline of Cyperaceae.

In the pollen diagrams of square 57 and core 3 (appendix III), comparable changes take place during this phase, but *Ulmus* sp. does not decrease, pollen of Cerealia-type and *Crataegus*-type are not present, pollen of *Plantago major* is present, *Viburnum* sp. shows a small peak (core 3) and the Cyperaceae show a small peak. Differences between the pollen diagrams of square 57 and core 3 are explained by local vegetation differences.

40 The possibility of an anthropogenic signal in core H2118 is supported by the following changes in the pollen diagram: a decrease in the AP curve, an increase in *Corylus* sp., *Viburnum* sp. and monoletae psilatae fern spores, and the increased precipitation of (regional) *Pinus* pollen that indicates the presence of open patches in the vegetation. These changes correspond with later anthropogenic signals that are confirmed by archaeological indicators. The indications that these changes are related to a change in the water table are the absence of an increase in the dryland herbs, and an increase in *Ulmus* sp., *Salix* sp., Cyperaceae and *Typha angustifolia*. In the case of a change in the water table, the increase in *Corylus* sp. and *Viburnum* sp. would be caused by the increased presence/flowering of these shrubs in gaps in the vegetation where dryland trees disappeared due to submergence.

The macroremains diagram of core 3 shows very limited signals of occupation on the vegetation in the near surroundings during phase Haz 0 (an increase in macroremains and species diversity), while the macroremains diagram from square 57 shows two fruits of *Urtica dioica*.

Van der Woude (1983, 31) suggests the possibility of anthropogenic influence corresponding with phase 0 in core H1110[41] (see figure IV.1), consisting of a decrease in *Alnus* sp. and *Corylus* sp., although a temporarily fall of the water level is suggested as well. The signal in the pollen diagram is not strongly characteristic of anthropogenic influence at the Hazendonk. The imprecise dating of core H1110 and phase Haz 0 hampers further interpretation.

IV.4.3 Hazendonk 1

In the diagrams of Voorrips (Louwe Kooijmans 1974), Van der Wiel (1982) and those presented in appendix III, phase Haz 1 is characterised by a decrease in *Tilia* sp. which is followed by decreased values of Cyperaceae, increased values of *Quercus* sp., an increase in *Corylus* sp., *Alnus* sp. and Poaceae and the presence of Cerealia-type, *Artemisia* sp., Chenopodiaceae, *Plantago lanceolata*, *Allium* sp., *Polygonum persicaria*-type (*Persicaria maculosa*), *Polypodium* sp., *Pteridium* sp., *Humulus* sp., *Urtica* sp., *Filipendula* sp., *Lythrum* sp. and Apiaceae. These changes are probably directly linked to human activity, although the increases in *Quercus* sp. and *Corylus* could be partly a statistical result of the decrease in *Tilia* sp. The curve of Poaceae increases during occupation at the southeast side of the dune (appendix III) but this signal is already diminished in the diagrams of Van der Wiel (1982) and Voorrips (Louwe Kooijmans 1974). The same is true for the fall of the Cyperaceae (that show a pattern opposite to the grasses). This shift in the strength of the anthropogenic signal directly corresponds with the distance between cores and the location of most of the archaeological finds (unit C). The increased values of *Alnus* sp. during phase Haz 1 probably reflect increased flowering or the increased presence of alder trees at some distance from the dune since the macroremains do not support the increase in alder in the local vegetation (appendix III, Van der Wiel 1982).

Concerning the diagram of Voorrips (Louwe Kooijmans 1974), some additional remarks can be made. The curves of *Betula* sp., *Cornus sanguinea*, *Crataegus*-type and *Ribes*-type show small peaks. The small increase in these taxa indicates the increased presence of light due to the clearance of trees (particularly *Tilia* sp.), which corresponds with more open vegetation. Comparably, *Viburnum* sp. shows a high peak, which must represent local vegetation since this peak does not correspond with other diagrams. In the macroremains diagrams in appendix III, phase Haz 1 is reflected by an increase in *Urtica dioica*, *Persicaria maculosa*, *Veronica beccabunga*-type, *Lythrum* sp., *Chenopodium album*, *Valeriana officinalis* and others, which correspond very well with the information from the above-mentioned pollen diagrams.

In core H2118 (Van der Woude 1983; sampled at *c.* 40 metres distance from the Kweldamsdonk, see paragraph IV.2) there are some minor fluctuations, and a pollen grain of Poaceae > 40 µm is present in the zones that presumably correspond with phase Haz 1 (zones 2a and 2b), though there are no changes in the diagram that can certainly be related to anthropogenic influence. This absence of a clear anthropogenic signal indicates that the occupation pressure on the Kweldamsdonk during the period that presumably corresponds with phase Haz 1 (organic layer 2-3) was probably limited. For core H2114(b) (Steenbeek 1980), it is suggested that the influence of occupation phase Haz 1 is expressed by the presence of *Rumex* sp. and *Artemisia* sp. in the upper part of the diagram. This is tentatively confirmed by an increase in *Corylus* sp. and a fall of Cyperaceae.

41 Zone 10, upper part of organic layer 2-3 dated roughly between 5200 and 4300 BC; 6060±80 and 5590±70 BP.

IV.4.4 Hazendonk 2

The indications of anthropogenic influence on the natural vegetation during phase Haz 2 are limited. Van der Woude (1983) and Voorrips (Louwe Kooijmans 1974) do not mention this occupation phase explicitly, and indeed the phase is not easily recognised in their diagrams.

Van der Wiel (1982) suggests that phase Haz 2 is characterised by a fall in the curve of *Quercus* sp. at the end of the phase and by increased values of *Artemisia* sp., Chenopodiaceae, *Galium*-type and occurrence of fruits of *Rumex acetosella* (between samples 50 and 60). In addition, the phase is characterised by the presence of pollen grains of *Plantago lanceolata*, both pollen and fruits of *Persicaria maculosa* and an increase in Poaceae, Apiaceae and *Urtica* sp. Van der Wiel's interpretation implies that human impact during phase Haz 2b would be stronger and would have lasted longer than during phase Haz 1. This is however unlikely since such changes are not confirmed by the results of appendix III and since this does not correspond with the restricted distribution of refuse of phase Haz 2. It is more likely that the signal of phase Haz 2 recognised by Van der Wiel probably represents phase 2a, which would be characterised by clearance of *Quercus sp.* and restricted presence of indicators of disturbance and open patches. In addition, the changes higher in the diagram (at spectrum 67) may represent phase 2b. This signal of phase Haz 2b consists of increased values of Chenopodiaceae, *Artemisia* sp., *Galium*-type, *Plantago lanceolata*, *Urtica* sp., Poaceae and Apiaceae. The diagram does not show a strong contrast between the supposed phases 2a and 2b, except for the increase of *Tilia* sp. after the presumed phase Haz 2a. In contrast to the signal of previous occupation phases in this diagram, the Cyperaceae seem to increase here in reaction to occupation, indicating open vegetation.

In the pollen diagram of square 57 (appendix III), the phases Haz 2a and 2b are both recognisable with considerable accuracy due to the close distance between the dune, the location of occupation and the sample location. The signal corresponds with other anthropogenic signals in the diagram and is characterised by low values of *Quercus* sp. (during phase Haz 2a), *Fraxinus* sp. and Cyperaceae, and increased values of *Corylus* sp., *Artemisia* sp., *Plantago lanceolata* (phase 2b), *Polypodium* sp., *Pteridium* sp., *Humulus* sp., *Filipendula* sp., *Lythrum* sp. and *Urtica* sp.

In the macroremains diagrams of square 41 and core 57 (appendix III), it is possible to recognise phase Haz 2, which is characterised by the presence of *Urtica dioica* and to a lesser degree by *P. maculosa*, *Chenopodium album*, *Solanum dulcamara*, *Lythrum salicaria*, *Typha* sp. and *Juncus effusus*. The presence of these taxa corresponds moderately with the pollen diagrams (*Juncus* pollen was rarely found during analysis).

In conclusion, only the material sampled at a very close distance (appendix III and Van der Wiel 1982) reflects the anthropogenic signal of phase Haz 2, suggesting clearance of *Quercus* sp. The limited expression of this occupation phase corresponds with the limited presence and spread of the occupation horizons and archaeological finds. Cerealia-type pollen grains were absent in all pollen diagrams during the phase, but macroremains finds from one sample indicate that cereals were present (see paragraph III.3.8.1).

IV.4.5 Hazendonk 3

Van der Woude (1983) does not mention phase Haz 3. In the diagram of Voorrips (Louwe Kooijmans 1974), phase 3 is characterised by a fall of *Quercus* sp. at the start of the phase followed by recovery, a decrease in *Tilia* sp., *Fraxinus* sp. and Cyperaceae, a rise of *Betula* sp. and *Corylus* sp., and increased values of Cerealia-type, *Artemisia* sp., Chenopodiaceae, *Rumex acetosa*-type, Poaceae, *Humulus* sp., *Urtica* sp., *Solanum dulcamara*, *Lythrum* sp., *Sparganium erectum*, *Sparganium emersum*-type, Apiaceae and Asteraceae tubuliflorae. Voorrips (Louwe Kooijmans 1974) argued that the vegetation on the dune was cleared in favour of arable land while "bush vegetation" on the lower slopes of the dune was saved, resulting in "marshy underwood". The practice of crop cultivation on the dune, the working hypothesis used during the late seventies, is however not proven (see paragraph III.4.5). The anthropogenic signal of the diagram of Voorrips corresponds well with the diagram of square 57 (appendix III). In the latter diagram, phase Haz 3 is characterised by the same taxa as in the diagram of Voorrips, as well as by a high peak of *Viburnum opulus*. Interestingly, *Viburnum* sp. characterised phase Haz 1 in the diagram of Voorrips (Louwe Kooijmans 1974). Apparently, this species is indicative of anthropogenic disturbance, but is only locally present and spreads only small quantities of pollen, which results in the presence of peak values in single diagrams only. In the macroremains diagram of square 41 (appendix III), phase Haz 3 is characterised by *Lythrum* sp., *Chenopodium ficifolium* and *Typha* sp., which corresponds well with the pollen diagrams.

Van der Wiel suggests that phase Haz 3 is reflected in 36 cm of sediment. She mentions a fall of *Tilia* sp. and the presence of sand at sample 85, and a peak of fruits of *Urtica dioica* at sample 115, which corresponds with presence of charcoal and sand in the sediment. Van der Wiel (1982, 70) explains the limited strength of the signal by a tentative hypothesis that "..occupation started at the northside of the 'donk' [dune] and gradually shifted, via the eastside, to the southside of the 'donk'..". If the weakness of the signal must be explained, not shifting occupation but simply the distance to occupation can be put forward. However, it can be argued that the signal is not weak since there are various other changes characteristic of anthropogenic influence at the Haz 3 level. At spectrum 85, Chenopodiaceae, *Artemisia* sp. and Cerealia-type are present or increase. Spectrum 115 is characterised by the presence of much sand and charcoal, a decrease in *Tilia* sp., *Quercus* sp. and *Alnus* sp., an increase in *Corylus* sp., a peak of *Urtica* fruits, and the presence of *Solanum nigrum* seeds. The curve of *Plantago lanceolata* starts only after phase Haz 3 and is not related to occupation (see also III.3.1).

The number of spectra that is suggested to reflect phase Haz 3 in the diagram of Van der Wiel (1982) represents a very long period compared with the other occupation phases of the same diagram and the same phase in other diagrams. Two explanations are possible for the thick horizon in the core of Van der Wiel: 1) Sedimentation took place rather fast, possibly because of the erosion of material at the top of the dune and colluviation, and the anthropogenic signals at spectrum 85 and 115 both correspond with phase Haz 3. This could have occurred locally but is not confirmed by the other pollen diagrams sampled around the Hazendonk. 2) The signal at spectrum 115 corresponds with phase VL 1a (all occupation between phases Haz 3 and VL 1b). This hypothesis is however not likely since finds of this occupation phase were rarely found at this side of the dune and since the anthropogenic signal of this phase is weaker than that of Haz 3 in the other pollen diagrams sampled at a close distance to the dune (appendix III). It must therefore be concluded that the signal of phase Haz 3 in the undated diagram of Van der Wiel (1982) is difficult to correlate with archaeological finds and other pollen diagrams.

IV.4.6 Vlaardingen 1a

Anthropogenic signals in pollen diagrams related to phase VL 1a (all occupation between the phases Haz 3 and VL 1b) are not mentioned in Voorrips (Louwe Kooijmans 1974), Van der Wiel (1982) or Van der Woude (1983). The possibility of recognising a signal of this phase in the diagram of Van der Wiel is discussed above. Concerning the diagrams of Van der Woude (1983), it is indeed not expected that the signal of this phase can be distinguished when considering the visibility of anthropogenic influence on the vegetation during previous occupation phases and the restricted extent of the refuse layer of this phase. In the diagram of Voorrips, there are changes in between the horizons of phases Haz 3 and VL 1b horizon at several levels that may be related to anthropogenic influence but the evidence is not convincing. In the pollen diagram of core 2 (appendix III), the anthropogenic signal of phase VL 1a can be recognised by very weak changes: a small decrease in *Tilia* sp., a small rise of *Quercus* sp. and Chenopodiaceae, a slight decrease in Cyperaceae and the presence of *Urtica* sp. In the pollen diagram of square 57, minor anthropogenic signals visible between phases Haz 3 and VL 1b may represent phase VL 1a (see paragraphs III.3.1 and III.4.3.2). In the macroremains diagrams of core 2 and square 41 (appendix III), the VL 1a horizon is uniquely characterised by extreme values of *Cornus sanguinea* and *Sambucus nigra*, which probably reflects the development of the local vegetation. In conclusion, there is little evidence of human impact on the vegetation on the Hazendonk during phase VL 1a.

IV.4.7 Vlaardingen 1b

In contrast to phase VL 1a, the anthropological influence on the natural vegetation during phase VL 1b is comparable with phases Haz 1 and 3. In the diagram of Voorrips (Louwe Kooijmans 1974), the VL 1b level is characterised by a small decrease in *Corylus* sp., the presence and increase in *Betula* sp., *Rhamnus cathartica*, *Artemisia* sp., Chenopodiaceae, *Allium* sp., Cerealia-type, Poaceae, *Alnus* sp., *Urtica* sp., *S. dulcamara*, *Lythrum* sp., *Filipendula* sp., *Sparganium emersum*-type, *Symphytum* sp., *Thelypteris palustris*, Apiaceae, Brassicaceae and Asteraceae tubuliflorae and a decrease in Cyperaceae. It is not possible to recognise a fall of *Tilia* sp. or a strong rise in the curve of *Quercus* sp., although small-scale changes may be lost because of the limited number of analysed samples.

In the diagram of Van der Wiel (1982), phase VL 1b is characterised by a decrease in *Tilia* sp. and *Corylus* sp., low values of *Quercus* sp. and *Alnus* sp. in the early part of the phase, and an increase in *Fraxinus* sp., Chenopodiaceae, *Artemisia* sp., Cerealia-type, *Persicaria maculosa*, *Solanum nigrum*, Poaceae, Cyperaceae and *Urtica* sp. Afterwards, several marsh herbs (Apiaceae, *Alisma* sp., *Mentha aquatica*, *Lythrum salicaria*) confirm the presence of eutrophic open patches in the terrain. The increase in *Fraxinus* sp. (visible in the upland diagram in particular) is probably related to changes in the water table and flooding frequency.

In the pollen diagrams of core 2, M86 and M87 (appendix III), phase VL 1b is characterised by a slight decrease in *Tilia* sp. (not in M86), a decrease in *Quercus* sp. (in M87 only in the beginning of the phase, followed by recovery) and a decrease in *Alnus* sp., an increase in dryland shrubs, herbs and anthropogenic indicators including Cerealia-type, and an increase in Poaceae, Cyperaceae, *Urtica* sp. and *Solanum dulcamara*. Several taxa show increased values just after the occupation phase (*Lythrum* sp., *Solanum dulcamara*, *Sparganium erectum*, Apiaceae and Rubiaceae). This corresponds with the macroremains diagrams of square 41, M86 and M87 (appendix III), which also showed the presence of plants indicating disturbance and increased eutrophication of both the dryland and wetland terrain both during and after the occupation phase.

In core H1110, located 1 km north of the Hazendonk, Van der Woude (1983, 33, zone 15 and 20) recognises anthropogenic influence consisting of decreases in *Quercus* sp. that could be related to phase VL 1b. Repetitive occupation of such intensity that a signal is expected at 1 km distance is however not known from the excavation. The decrease in *Quercus* sp. in zone 15 could represent phase VL 1b since the diagram shows additional changes consisting of a peak of *Tilia* sp., a peak of Poaceae, high values of *Corylus* sp., a decrease of *Alnus* sp., the presence of small peaks of *Artemisia* sp. and Asteraceae, and the presence of Chenopodiaceae and *Rumex*-type. The increases in *Tilia* sp. and *Corylus* sp. may be a statistical effect of the decrease in *Quercus* sp. and *Alnus* sp.

Altogether, the various sources indicate that phase VL 1b is characterised by a slight decrease in *Tilia* sp. (only registered at some sample locations near the dune) and a decrease in *Quercus* sp. and *Alnus* sp., all pointing to clearance of the woodland vegetation. The decrease in *Quercus* sp. partly differs from earlier increases in the curves of this taxon, which may be related to the reduced surface of the dune and the resulting changes in the vegetation. A major characteristic of this phase is a strong signal in the macroremains diagrams, which may be related to increased or changed anthropogenic influence (possibly related to the palisade, see paragraph III.1) and the increased water level (resulting in good preservation). Further, most diagrams from the nearby sample locations show an increase in Cyperaceae. The difference in the curve of Cyperaceae between the various studies and the contrast with the earlier phases that mainly showed a decrease may be explained by differences and changes in the local vegetation, the increased presence of this taxon and increased openness of the vegetation near the sample locations during occuation, while statistical effects and variation in plant use through space cannot be excluded.

IV.4.8 Other occupation periods

The diagram of Van der Wiel (1982) does not show archaeological levels later than phase VL 1b. Some changes in the upper part of the diagram could be interpreted as signals of human influence (decrease in *Quercus* sp., rise of *Corylus* sp.), though peaks of herbs are absent and natural changes in the vegetation could also explain the changes. In the diagram of Voorrips (Louwe Kooijmans 1974), the next occupation period recognised is related to the Bell Beaker culture, characterised by considerable values of Cerealia-type and *Plantago lanceolata*. Van der Woude (1983, 33) suggests that low values of *Quercus* sp. and high values of *Corylus* sp. in core H1110 represent occupation related to phase VL 2b. It is not possible to confirm or reject this hypothesis since the sediment consists of peaty clay (leading to the possibility of reworked material in the clay) and since changes in other curves that could indicate anthropogenic influence are limited. There are pollen grains of Cerealia-type present in this zone but they do not correspond well with the changes in the curves of *Quercus* sp. and *Corylus* sp. Higher in the core, there are some other potential signals of occupation (the presence of Chenopodiaceae, Brassicaceae, *Plantago lanceolata* and Cerealia-type; Van der Woude 1983, 34), corresponding with the changes in the diagram of Voorrips (Louwe Kooijmans 1974). The peaks occur roughly around 1800-1400 BC (3340±80 BP) and may correspond to activity by people of the Bell Beaker culture.

IV.5 Summary of human impact

The combination of various studies sampled at different distances from the Hazendonk and at various distances from the zone of occupation (refuse) provides a relatively valid reconstruction of human impact. The pollen diagrams from appendix III, Voorrips (Louwe Kooijmans 1974) and Van der Wiel (1982) all reflect the main occupation phases and provide rather similar evidence of human impact. The data presented in appendix III provide the most precise information on human impact due to their location and the recognition of most of the refuse layers in the cores and sections. The diagram of Van der Wiel (1982) provides detailed information but the relation with the known occupation phases is not always clear. The diagram by Voorrips (Louwe Kooijmans 1974) provides information on the main occupation phases. In contrast, the diagrams of Steenbeek (1980) and Van der Woude (1983) hardly provide detailed information on human impact (further discussed in the next paragraph). Only core H2114 (Steenbeek 1980) shows indications of human impact that may correspond with phase Haz 1, although this may reflect activity at the Kweldamsdonk rather than at the Hazendonk.

The general pattern obtained from the diagrams sampled at the slope of the dune is that occupation during Neolithic occupation phases resulted in the clearance of particularly *Tilia* sp., *Quercus* sp. and *Alnus glutinosa*, the clearance of *Fraxinus excelsior* during phases Haz 2 and 3, an increase of *Corylus avellana*, the presence or increased presence of *Artemisia vulgaris*, Chenopodiaceae, *Plantago lanceolata*, Poaceae, *Humulus lupulus*, *Urtica dioica, Lythrum salicaria*, *Solanum dulcamara*, Apiaceae, while locally/during some phases *Viburnum opulus*, *Rhamnus cathartica*, *Allium* sp., Cerealia(-type), *Polygonum persicaria*-type, *Polypodium vulgare*, *Pteridium aquilinum*, *Filipendula ulmaria*, *Mentha* sp. and Brassicaceae increased. The Cyperaceae decreased during early phases and increased during phase VL 1b, which suggests disturbance at least during the early phases. The diagrams of Voorrips (Louwe Kooijamns 1974) and appendix III show that also shrubs other than *Corylus avellana*, *Viburnum opulus* and *Rhamnus cathartica* show increased values during occupation. The restricted presence of similar results in other studies can primarily be related to restricted production and dispersal of pollen of many shrubs.

Together, the changes of the vegetation indicate a small-scale disturbance of the dense woodland of dry terrain, as well as the disturbance of the wetland vegetation around the dune, as indicated by the increased values of wetland herbs that are not known as typical anthropogenic indicators (see also Van der Wiel 1982, 88). The disturbance resulted in a strong increase in light and was characterised by the presence of a variety of patches of shrubs, forb and herb vegetation and probably open terrain (in addition to patches of relatively undisturbed woodland). Many herbs and ferns indicative of human impact were part of the natural vegetation and did not depend on the presence of people. It is not the presence of these taxa that support the evidence of human activity but rather the changes in the curves and the contemporaneous presence of several taxa that supports their role as anthropogenic indicators.

The detailed analysis of human impact enables the assessment of some of the conclusions from earlier studies. Firstly, there are clear indications of the clearance of *Tilia* sp. at the Hazendonk (as demonstrated in appendix III), which was relatively unknown from earlier pollen diagrams from the site and only suggested by Van der Wiel (1982) for phases Haz 1 and 3. Furthermore, Van der Woude (1983, 30, 33, 87) suggested that anthropogenic influence at the Hazendonk mainly resulted in a decrease in *Quercus* sp. during the Late Mesolithic, phase VL 1b and a late Vlaardingen phase. The discussion above shows that the effect of human impact affected much more taxa and occurred during more occupation phases. Thirdly, the results of appendix III indicate that occupation affected *Alnus glutinosa*. This was not recognised in the studies by Voorrips (Louwe Kooijmans 1974) and Van der Wiel (1982). It is indeed difficult to distinguish a clear relationship between fluctuations of *Alnus* sp. and occupation phases in their diagrams.

IV.6 Distance between human activity and sampling point

In addition to the results presented in paragraph III.4.3.2, comparison of the various palynological data from the Hazendonk supports that cores that are sampled close to the dune reflect anthropogenic influence on the vegetation at the dune stronger than cores sampled at some distance from the dune. The distance to the dry surface and to the location of human activity plays a major role. At the Hazendonk, human activity is best represented in pollen cores that are sampled at the foot of the Hazendonk (appendix III; Van der Wiel 1982 and additionally Louwe Kooijmans 1974). The distance to the main zone of occupation (refuse) plays a role as well (see paragraph III.4.3.2). In contrast, the diagrams from cores sampled at a distance of 1 km or further from the dune do not give a signal that can be interpreted with certainty as anthropogenic (Steenbeek 1980; Van der Woude 1983). Absence of evidence of human impact in pollen diagrams located at a relatively large distance from the dune may be explained by disturbance and blurring of the signal of human impact on the dryland vegetation of the Hazendonk due to signals of other dryland patches, regional pollen rain (in the case of large catchment basins), and dominance of the pollen rain of the wetland vegetation (which is reinforced by a pollen sum that includes *Alnus* sp.). The absence of clear indications of human impact in the diagrams sampled at 1 km distance from the dune (Van der Woude 1983) indicates that anthropogenic influence on the wetland vegetation had a local character and was of restricted strength.