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PRESENTED TO LEENDERT LOUWE KOOIJMANS

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14 The scale of human impact at the Hazendonk, the Netherlands, during the Late Neolithic

Welmoed Out

14.1 Introduction

This paper is concerned with the archaeobotany of the Hazendonk, a site that has played an important role in Leendert Louwe Kooijmans' research on neolithisation. The site is located on one of many river dunes in the Dutch Rhine/Meuse river area (fig. 14.1). The top of the dune was located at 0.10 m +NAP (Dutch Ordnance Datum), emerging *c*. 10 metres from the surrounding Pleistocene subsurface during the Early Holocene. The rise of the Mean Sea Level and of the ground water level resulted in the continuous formation of peat and sedimentation of clay under calm conditions in the river area from *c*. 6000 cal BC onwards (Van der Woude 1983), and in a decrease in the dune's dry surface over time from 1.2 to 0.4 hectare during occupation. Preservation of organic material was good due to continuous waterlogging around the dune.

The Hazendonk was occupied repeatedly between 4020 and 2470 cal BC and at *c*. 2000 cal BC (Verbruggen 1992). The excavations, under direction of Louwe Kooijmans between 1974 and 1976, revealed features such as postholes, pits, hearths, and a palisade. Refuse layers (fossil anthropogenic horizons) along the slopes of the river dune moreover revealed flint, stone, pottery, human remains, bone remains of wild and domestic animals and other organic material. The precise function of the site for each of the phases of occupation is not clear; it could have been a supportive special activity site, but occasional permanent occupation cannot be excluded either (Louwe Kooijmans 1993, 131; 2007a, 170; Raemaekers 1999, 117). The similarity of the finds assemblages suggest however that site function remained stable over time (Louwe Kooijmans 2007a, 170). The economy of the site was semi-agrarian during all phases, and subsistence was based on a combination of hunting, gathering and agriculture. Hunting, fowling, fishing and gathering played an important role in the economy, and predominantly beaver and otter were hunted during all phases in combination with wild boar, red deer and roe deer. The importance of domestic animals decreased over time (Zeiler 1997, 108), and throughout the practise of local arable farming on a large scale is unlikely (Bakels 1986). For more information, see the various publications of Louwe Kooijmans (*e.g*. 1974; 1987), Raemaekers (1999) and Amkreutz *et al*. (this volume).

The Hazendonk is a good location to study neolithisation since the site is characterised by a long sequence of occupation in the Neolithic, with the Swifterbant Culture followed by the Hazendonk Group and then the Vlaardingen Group, corresponding to the period of neolithisation in the southern central Netherlands. The semi-agrarian Swifterbant Culture and the Hazendonk Group have their roots in the Late Mesolithic and represent the substitution phase of the neolithisation process (cf. Zvelebil 1986). The Vlaardingen Group, rooted in the earlier Swifterbant Culture and Hazendonk Group, is considered as a Late Neolithic group in the European context, and it is contemporaneous with the fully Neolithic Funnel Beaker Culture that was present in the northern part of the Netherlands from *c*. 3400 cal BC onwards. At the regional scale, the subsistence mode and apparent degree of neolithisation of the Vlaardingen Group vary strongly between ecological zones (Louwe Kooijmans 1993, 133; Raemaekers 1999; Van Gijn/Bakker 2005). At some sites hunting and gathering remained important subsistence strategies even in the Late Neolithic, while more agrarian sites could be considered as representing the consolidation phase of the neolithisation process (Louwe Kooijmans 1993, 1998, 420; Raemaekers 2003; cf. Zvelebil 1986). The continuous site function of the Hazendonk and the stable, restricted role of agriculture at the site, which are in contrast to more developed neolithisation in other parts of the Netherlands, can probably be explained by the environmental conditions at the site on the one hand, and choices of local populations on the other hand.

In this paper the neolithisation process at the Hazendonk will be studied by analysis of human impact on the vegetation, focussing on the occupation phase Vlaardingen 1b. This phase has been selected in the expectation that the presence of people of this Late Neolithic group would have resulted in clear evidence of human impact, a hypothesis based on the generally observed pattern that human impact gradually increased after introduction of agriculture. Phase Vlaardingen 1b, which dates to 3260-2960 cal BC (Verbruggen 1992), was one of the major occupation phases at the Hazendonk, although it is not precisely known whether occupation was continuous or intermittent. The Vlaardingen 1b refuse layer has a surface spread of 760 m^2 (fig. 14.2). It is

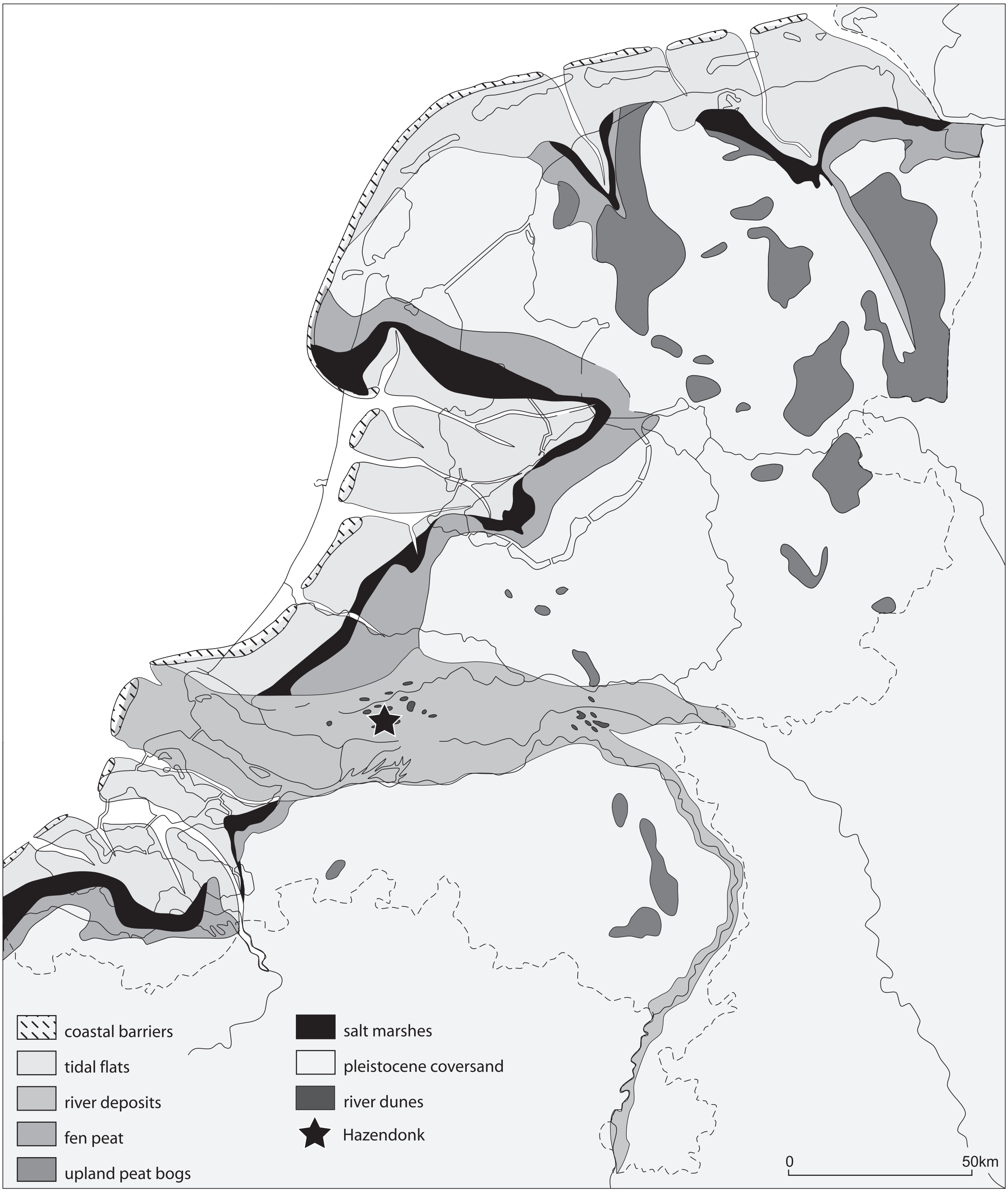


Figure 14.1 Location of the Hazendonk plotted on a palaeogeographical map of the Netherlands (*c.* 4200 BC).

assumed that the distribution of refuse corresponds to the zone of major anthropogenic activity, although refuse deposited on the top of the dune was not preserved. In addition to the refuse layer, a considerable trampling zone extended up to several metres from the dune edge into the peat. A palisade consisting of pointed posts of *Alnus glutinosa* was furthermore present at the southeastern top of the dune (fig. 14.2), presumably enclosing an area of *c*. 1000 square metres if representing a closed structure (Hamburg/Louwe Kooijmans 2006, 58). This palisade may have functioned as a border of the domestic space to exclude domestic animals, as a corral for domestic animals or as an enclosure around an arable field. The presence and distribution of refuse supports the first explanation, which is comparable with the interpretation of fences at the Middle Neolithic site of Schipluiden (Hamburg/Louwe Kooijmans 2006; Louwe Kooijmans 2007b). Wild animals dominate the bone assemblage of phase Vlaardingen 1b, especially red deer, and there are indicators of occupation during spring, summer, autumn and winter (Zeiler 1997).

The long occupation during phase Vlaardingen 1b, the potential year-round occupation, the size of the refuse layer, and the presence of a trampling zone and a palisade all indicate that people must have had a considerable impact on the natural vegetation during this phase. It is expected that such impact should be visible in the pollen and seed diagrams. Several archaeobotanical studies that discuss the Vlaardingen 1b occupation phase at the Hazendonk are already available (Bakels 1981; Louwe Kooijmans 1974; Van der Wiel 1982; Van der Woude 1983), which indicate that the river dune was covered with deciduous woodland vegetation, surrounded by alder carr and eutrophic marshes. There are indeed indications of human impact. For instance, the diagram of Voorrips (Louwe Kooijmans 1974, 138-143; fig. 14.2) indicates human impact consisting of a decrease in *Fraxinus*, presence of Cerealia-type pollen and high percentages of grasses and both upland and wetland herbs. From this, it was concluded that people lived on the slope of the dune without disturbance of the vegetation on the top of the dune (Louwe Kooijmans 1974, 139). The diagram of Van der Wiel (1982; fig. 14.2) clearly shows human impact during phase Vlaardingen 1b as well, including a decrease in *Quercus* and increase in cereal pollen, 'weeds' and pioneers growing on nitrogenous wet soils (Van der Wiel 1982, 79). The pollen cores of Van der Woude (1983), sampled at greater distances from the river dune up to several kilometres away, do not give precise information on human impact during phase Vlaardingen 1b. Bakels (1981) has published a selection of macro-remains from one of the same sample boxes that will be presented below (M86). She has concluded that human impact resulted in eutrophication of the environment and development of open patches. The excavation yielded a small quantity of carbonised crop plants from this phase, including grains and chaff remains of emmer wheat (*Triticum dicoccon)* and naked barley (*Hordeum vulgare* var. *nudum*) (Bakels 1981).

The archaeobotanical analysis presented here is supplementary to the earlier archaeobotanical studies. It is based on analysis of pollen and seed diagrams from two sample series from the Vlaardingen 1b refuse layer, M86 and M87, taken near to the sample location of Van der Wiel. An additional single sample collected next to M86 will also be discussed. The relative high location of the sample series on the slopes of the dune enables to investigate the human impact nearby the actual activity zone in better detail than most other studies. The comparison of samples located at increasing distance away from the dune moreover enables to investigate how distance influences the evidence of human impact. The research questions to be addressed are: how did people influence the natural vegetation, how strong is the evidence of human impact, and how does human impact relate to the neolithisation process and site function.

14.2 Materials and methods

The sample series M86 and M87 (boxes measuring 20 (l) × 20 (w) × 10 (d) cm) were collected during excavation from the eastern section of unit B, trench 25 (fig. 14.3). M86 is located 3 to 4 metres higher on the slope than M87 and is located in the middle of the refuse layer, while M87 is located near its outer edge (fig. 14.2). During phase Vlaardingen 1b, the lower edge of the dry surface of the dune was located *c*. 2.5 metres higher than M86 at *c*. 2.55 m -NAP. Analysis of the samples took place in the middle 1970's. W.J. Kuijper prepared pollen samples with a volume of 1 cm^3 and a sample interval of 2 cm according to the standard methods (Fægri/Iversen 1964), and A. Louwe Kooijmans-Bouhuijs identified pollen and spores. The pollen data were converted into percentages. The pollen sum consists of 300 to 400 upland pollen grains (upland trees, shrubs, herbs, spore plants and crop plants). W.J. Kuijper also analysed samples of macro-remains with a volume of 50 cm^3 after sieving on a 0.25 mm sieve.[1] Sample M49 was collected near sample M86. Botanical macro-remains from this sample were retrieved from residual material that remained after sieving of an unknown volume of soil (mesh width unknown). Data of both pollen and seeds of M86 and M87 were analysed with the software programs Tilia (2.0.b.4) and TGView (2.02) (Grimm 1991-1993, 2004). Species names are according to Van der Meijden (1996). The classification of taxa in ecological groups is based on Schaminée *et al*. (1991-1995) and on interpretation of the vegetation. Complete information on the materials and methods of archaeobotanical research at the Hazendonk will be published in the future (Out in prep.).

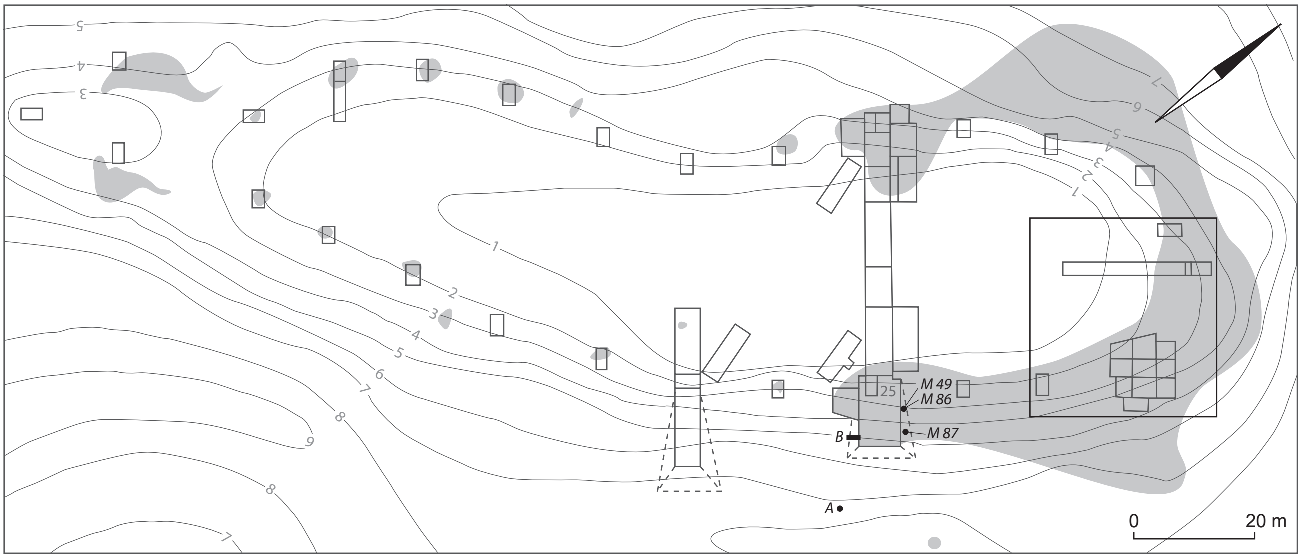


Figure 14.2 Site map of the Hazendonk (after L. Amkreutz) with the provisional extent of the refuse layer of phase Vlaardingen 1b in grey based on the distribution of relevant pottery in the excavation trenches and the presence of archaeological indicators in cores (partly based on Van Dijk *et al.* 1976), the location of the palisade and the location of the samples and cores discussed in the text.
A = the core of Voorrips (Louwe Kooijmans 1974)
B = the core of Van der Wiel (1982)

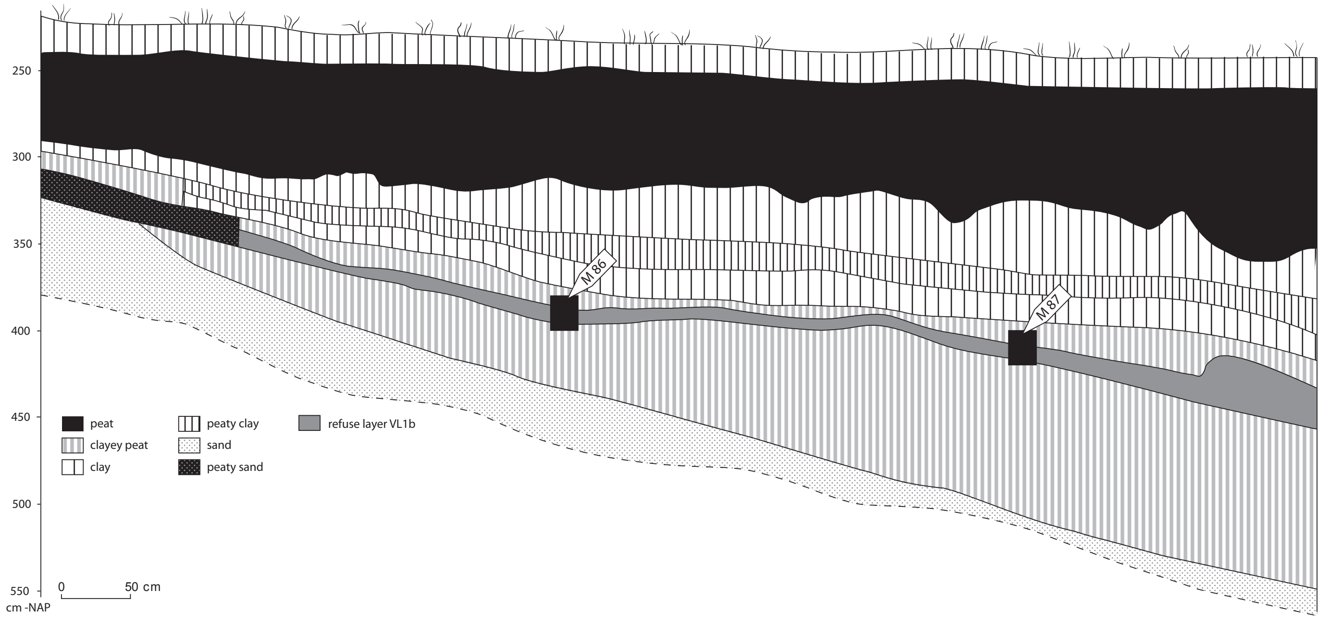


Figure 14.3 Simplified drawing of the eastern section of trench 25, showing the location of the sample series M86 and M87. The upslope sediments are sandier than the downslope sediments. The lower clayey peat represents a complex of more or less peaty clay deposits, of which the upslope sediments are relatively peaty.

14.3 Results

Table 14.1 shows the lithostratigraphy of M86 and figure 14.4 shows a selection of pollen and seeds from M86 (cf. Bakels 1981).[2] The local vegetation at the sample location during phase Vlaardingen 1b probably consisted of alder carr with *Viburnum opulus* and *Cornus sanguinea*. Well-represented herbs are *Veronica beccabunga*-type, *Juncus effusus* and *Urtica dioica*. Human impact resulted in decrease in *Quercus*, *Fraxinus*, *Alnus glutinosa*, *V. beccabunga*-type, *J. effusus*, *U. dioica* and *Plantago lanceolata*, and in a strong increase in dryland anthropogenic indicators (cf. Behre 1981) including Cerealia-type, *Chenopodium album*, *Solanum nigrum* and *Stellaria media*. The diagram also shows a moderate increase in ferns, grasses, sedges and wetland taxa, including *Sparganium* spec., *Filipendula ulmaria*, *Symphytum* spec., *Ranunculus sceleratus* and *Rorippa amphibia*. Together, these changes indicate disturbance of the oak vegetation and of the alder carr, increased presence of open patches, and eutrophication that was probably caused by human dumping of waste. The macro-remains do not include crop plants or carbonised food plants. The only carbonised finds are two seeds of *Mentha aquatica/arvensis* (sample depth unknown).[3] Poaceae and Cyperaceae show a strong increase at the end of occupation, which was probably the result of initial recovery of the vegetation as well as of the rising ground water level. After occupation, *Quercus* increases, certain shrubs increase (*Rhamnus cathartica*, *Ligustrum* and *Sambucus*) and the upland herbs decrease or disappear, indicating recovery of the vegetation. In the wetland vegetation, *Alnus*, *Salix*, *Lythrum salicaria* and *Mentha aquatica/arvensis* increase strongly, and *Sparganium erectum*, *Solanum dulcamara* and *Galium*-type increase as well, while Poaceae and Cyperaceae gradually decrease. The changes of these wetland taxa can be explained by the decrease in human impact and the increase in the water level, as indicated by the presence of clay.

Table 14.2 shows the lithostratigraphy of M87, and figure 14.5 shows a selection of pollen and seeds from M87. The local vegetation probably consisted of alder carr. The amount of sand and archaeological refuse is smaller in M87 than in M86, indicating that M87 is located further away from human activity. At the start of occupation, *Quercus* decreases and *Fraxinus* shows a peak. *Ulmus* was probably more common nearby M87 than at M86, since the percentage of *Ulmus* is higher in M87. Chenopodiaceae, *Artemisia*, Cerealia-type and *Solanum nigrum* clearly indicate the period of human occupation of the dune, although the upland herb signal is weaker than in M86. In the wetland vegetation, *Alnus* decreases while Poaceae, Cyperaceae, *Urtica dioica*, *Lythrum salicaria* increase strongly. After occupation,

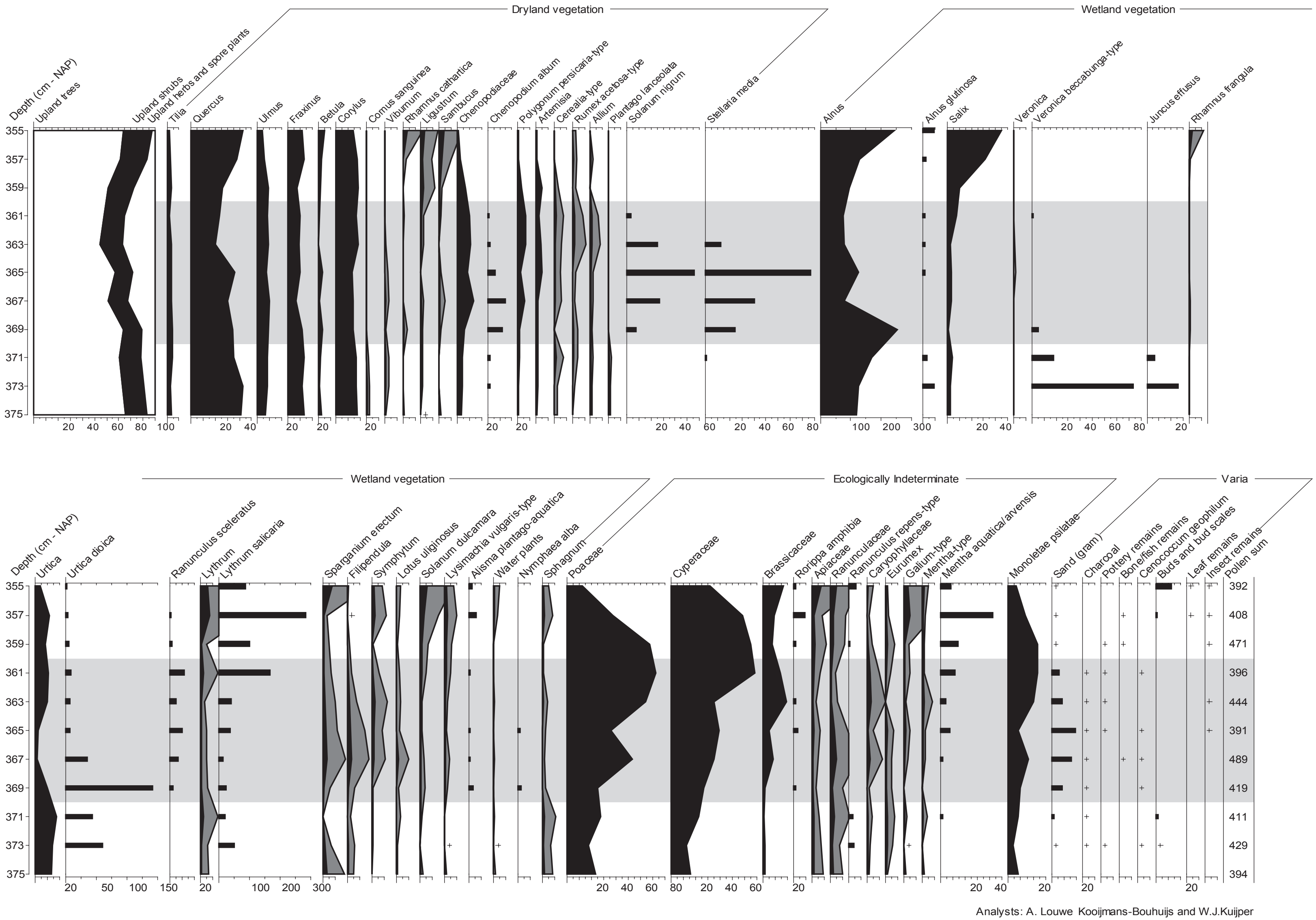
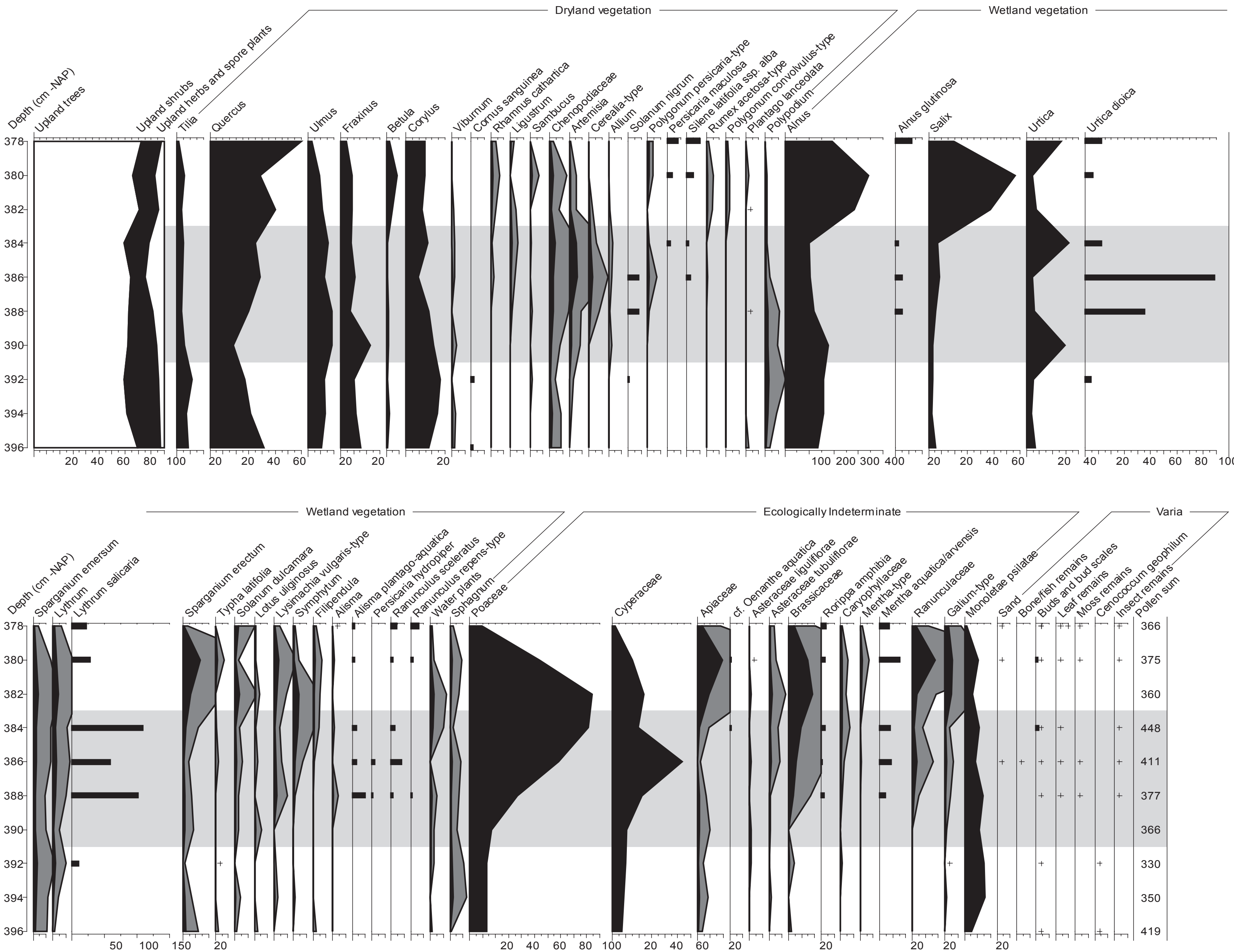


Figure 14.4 Selected taxa from M86. Curves show percentages of pollen and spores while histograms show numbers of other remains. Exaggeration of curves, if applied, is fivefold. The grey zone shows the occupation layer as recognised by changes in the diagram.
+ in pollen curves = present
+ in non-pollen curves = 1-5/few
++ in non-pollen curves = 5-10/several



Analysts: A. Louwe Kooijmans-Bouhuijs and W.J. Kuijper

Figure 14.5 Selected taxa from M87. See figure 3 for legend.

depth (m –NAP)			sediment
3.59	–	3.56	slightly clayey peat
3.62	–	3.60	peat rich in charcoal
3.70	–	3.63	sandy peat
3.75	–	3.71	peat; charcoal at 3.73 to 3.72 m -NAP

Table 14.1 Lithostratigraphy of M86.

depth (m –NAP)			sediment
3.83	–	3.78	clayey peat
3.89	–	3.84	peaty sand with charcoal and a bone fragment
3.91	–	3.90	sandy peat
3.97	–	3.92	peat with Phragmites remains

Table 14.2 Lithostratigraphy of M87.

Quercus and *Betula* increase, some of the upland shrubs increase (*Rhamnus cathartica*, *Ligustrum* and *Sambucus*), and herbs that showed high percentages during occupation decrease. In the wetland vegetation, *Alnus*, *Salix* and various herbs such as *Sparganium erectum*, *Lysimachia vulgaris*-type, Apiaceae, Brassicaceae, Ranunculaceae and *Galium*-type increase after occupation, reflecting the end of occupation and the sedimentation of clay.

The macroremains from sample M49 (table 14.3) contain 24 taxa representing upland and wetland trees and herbs as well marsh vegetation, similar to the vegetation represented in M86 and M87. Interestingly, M49 provides new information as well, since it contains many seeds (*s.l.*) of *Quercus* spec., *Prunus spinosa*, *Cornus sanguinea* and *Rubus fruticosus,* probably indicating the nearby presence of these taxa. Collection of these taxa by people or animals cannot be excluded, even as consumption followed by excretion, but these are considered as less probable explanations here due to the large variation of taxa in the sample.

The diagrams, clearly showing the start and end of occupation, do not give any indications that phase Vlaardingen 1b represents a multi-phased occupation period. This preliminary conclusion however needs confirmation from further archaeological research since pollen and seed diagrams do not necessarily indicate sub-phases of occupation (see Out 2008 where the diagrams of the comparable site of Brandwijk-Kerkhof do not allow distinguishing the sub-phases of a multi-phased refuse layer). Some of the archaeological refuse was found below and above the occupation horizon as distinguished in the diagrams, which could indicate that occupation lasted longer than assumed. The refuse distribution could alternatively be explained by local vertical transport of refuse (cf. Amkreutz

taxon	number
Quercus spec., cupulae	20
Quercus spec., cupulae with content	17
Quercus spec.	3, 2 j.
Prunus spinosa	1
Cornus sanguinea	4
Rubus fruticosus	3
Urtica dioica	7
Chenopodium album	1
Persicaria maculosa	3
Silene latifolia ssp. album	1
Solanum nigrum	59, 1 c
Stellaria media	4
Alnus glutinosa	19
Alnus glutinosa, cones	21
Alnus glutinosa, fragments of catkins	2
Alisma plantago-aquatica	2
Carex acutiformis	4
Carex riparia	31
Hypericum cf. tetrapterum	1
Oenanthe aquatica	2
Solanum dulcamara	6
Sparganium erectum spp. erectum	18
Stachys palustris	8
Persicaria hydropiper	2
Ranunculus repens-type	24
Ranunculus sceleratus	1
Nymphaea alba	2
Mentha aquatica/arvensis	6
Buds	72
Moss remains	+
Charcoal	+
Bone/fish remains	+
Pottery remains	+
Insect remains	++
Cocoons	++
Trichoptera, cases of larvae	+

Table 14.3 Macroremains from sample M49, trench 25, phase Vlaardingen 1b.
+ = 1-5
++ = 5-10
j. = juvenile
c = carbonised
x, y = x includes y

et al. this volume). This vertical transport could have affected pollen and seeds as well, but the curves in the diagrams, likely to represent the succession of the vegetation, do not give any reason to assume that vertical transport played a key role in the formation of the pollen and seed assemblages in the soil.

14.4 Discussion

14.4.1 Natural vegetation

The diagrams of M86 and M87, both of which cover the period before, during and after the Vlaardingen 1b occupation phase for the southern end of the river dune, give very similar results. The natural vegetation before occupation consisted of deciduous forest vegetation dominated by oak on the higher parts of the slope, alder carr with *Viburnum* and *Cornus sanguinea* on the lower parts of the slope and marshes surrounding the river dune (fig. 14.6a). The data do not precisely clarify whether oaks were part of the alder carr on the slope of the dune or not. The diagram of M87 shows relatively few macro-remains, possibly due to the presence of dense vegetation resulting in low seed production. After occupation, a small channel probably became active at close distance to the dune, as indicated by the deposition of clay, local presence of *Salix* and high values of wetland taxa.

14.4.2 Human impact

The diagrams reveal that human activity led to a number of changes in the local vegetation. It is highly likely that people deliberately felt trees of *Quercus* and *Alnus*, which resulted in the development of secondary vegetation, as shown by a change in the composition of the shrub vegetation that shifts from *Viburnum opulus* and *Cornus sanguinea* to *Rhamnus cathartica*, *Ligustrum vulgare* and *Sambucus nigra*. Furthermore, human activity resulted in an increase in taxa in the dryland and wetland herb vegetation indicative of clearance, disturbance and eutrophication, in an increase in Poaceae and Cyperaceae indicative of more open vegetation, and in the presence of cereal pollen (fig. 14.6b). The cereal pollen does not necessarily indicate the presence of fields, but may instead represent processing of cereal products, since most pollen of the two autogamous taxa that are involved, emmer and naked barley, is released during threshing (Robinson/Hubbard 1977; Zohary/Hopf 2000). The end of occupation is characterized by peaks of *Alnus*, *Salix*, *Sparganium erectum*, *Solanum dulcamara*, *Mentha aquatica/arvensis*, Apiaceae, Ranunculaceae and *Galium*-type (fig. 14.6c). Some of these peaks clearly indicate recovery of the vegetation (*e.g. Alnus*), while others are related to changing environmental conditions (*e.g. Salix*, as discussed above). Interestingly, *Plantago lanceolata* is best represented before and after occupation instead of during occupation (cf. Louwe Kooijmans 1974, 139). Instead of representing an anthropogenic indicator, it here represents the natural vegetation of unstable environments such as a riparian zone (cf. Groenman-Van Waateringe 1968). Overall, the results on human impact confirm those from earlier investigations (see introduction).

The four metres distance between M86 (relatively close to the river dune) and M87 (relatively far away) influence the anthropogenic signal. For the upland vegetation, the signal of anthropogenic influence is stronger in M86 than M87, as can be clearly observed by comparing the percentage of upland herbs and spore plants, which is 20-25% in M86 and 15% in M87. This difference reflects the shorter distance from M86 to the assumed location of human activities. This result is confirmed by the diagram of Voorrips (Louwe Kooijmans 1974), showing an even smaller upland herb percentage of 10%.[4] In addition, in M86 seeds of upland herbs are also better represented during occupation than in M87 (*Chenopodium album*, *Solanum nigrum* and *Stellaria media*). In contrast, the diagram of M87 shows higher values than M86 of *Urtica*, *Lythrum* and *Sparganium emersum*-type that prefer relative moist conditions. At the lower part of the slope human activity thus comes to expression in the wetland herb vegetation. The decrease in the evidence of human impact on the upland vegetation over a distance of only several metres indicates that the human impact must have been restricted. Furthermore, the presumably small size of the pollen catchment basin (as indicated by the local presence of trees and shrubs) and the presence of local vegetation that would have prevented spread of pollen no doubt played a role as well (Bunting *et al*. 2005; also discussed in Out in prep.). In contrast to the Hazendonk, the evidence of human impact at Brandwijk, a similar Middle Neolithic dune site, remained equal over a distance of 20 metres, presumably caused by the fact that the vegetation was more open than at the Hazendonk (Out 2008, 37).

The extensive spread of the refuse layer, the trampling zone and the presence of the palisade, as well as the short distance between the zone of human activity and the sample series, gave rise to the expectation that the evidence of human impact during the Vlaardingen 1b phase would be considerable. However, the diagrams of M86 and M87 give only moderate indications of deforestation. A core sampled at approximately the height of M86 at the southeastern side of the river dune shows similar evidence of slight human impact on the upland vegetation (up to 15% of upland herb pollen and fern spores).[5] The moderate strength of human impact during this phase is furthermore approximately comparable to the two other main occupation phases at the site, phases Hazendonk 1 and 3 dating to the Middle Neolithic (Out in prep.). The percentages of upland vegetation together with the macro-remains in sample M49 indicate that woodland vegetation remained present on the

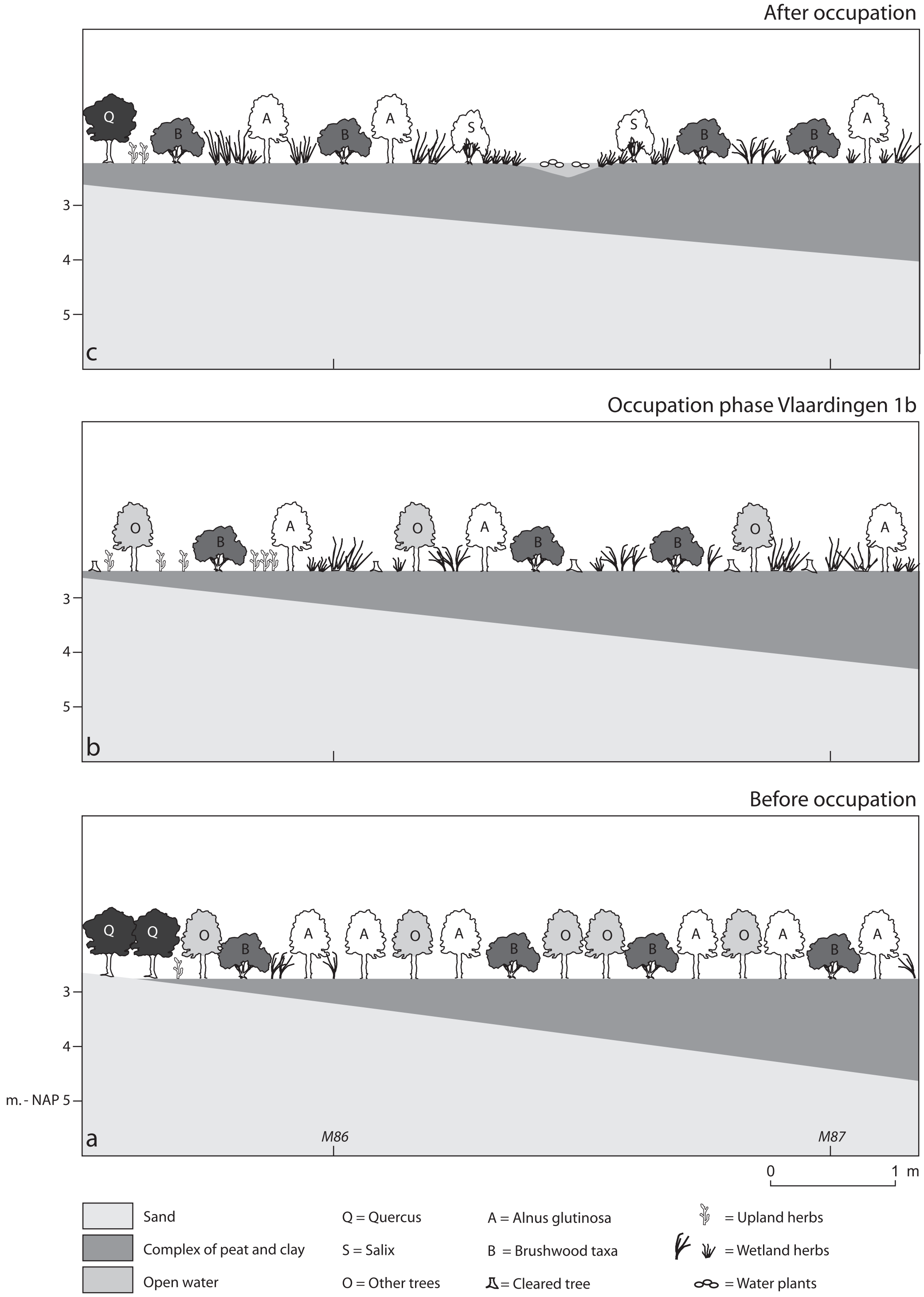


Figure 14.6 Reconstruction of the vegetation on the southern slope of the Hazendonk near the sample series M86 and M87 before, during and after occupation phase Vlaardingen 1b. The vegetation symbols are not scaled. Other trees include *Fraxinus excelsior*, *Ulmus* spec. and *Acer campestre*. See the text for brushwood taxa (shrubs). The upper figure, representing the situation after occupation, shows nearby presence of open water. Open water was not present at the precise given location, but at a location slightly further away from the dune.

top of the dune during phase Vlaardingen 1b (cf. Louwe Kooijmans 1974, 139). It is however not possible to precisely reconstruct the scale of deforestation on the higher parts of the slope or within the palisade.

It is not sure whether arable farming was practiced on the Hazendonk itself during phase Vlaardingen 1b or indeed most other occupation phases. The presence of Cerealia-type pollen can be explained by processing activities, while the presence of cereal macro-remains can be explained by the import of cereals from elsewhere. There is as yet no evidence of flint artefacts with sickle gloss (cereal gloss in a longitudinal direction caused by cutting cereal stalks, Van Gijn pers. comm. 2007), an absence that could be interpreted as an argument against local crop cultivation, especially as other flint tools are present.[6] However, the use-wear results are difficult to interpret, and do not altogether exclude sickle gloss (*ibid*.). The significance of sickles-absence can furthermore be doubted since crops could have been harvested in other ways than with sickles. There are no features indicative of tillage, but this does not represent any evidence against local arable farming since absence of such features can be explained by soil formation processes such as colluviation and flooding, and possibly by erosion of the dune due to recent disturbance of its top.

The pollen diagrams, with evidence of only limited deforestation during most phases including phase Vlaardingen 1b, at least strongly indicate that the presence of fields with a surface of several hundreds of square metres is very unlikely. Instead, small arable plots up to tens of square metres could have been present, with limited economical importance compared to other food sources, as was implied as a possible scenario for the Hazendonk already in the early stages of research (Bakels 1981, 1986). A comparable suggestion about small-scale cultivation has been made recently too, for the Middle Neolithic sites Brandwijk-Kerkhof and Swifterbant (Cappers/Raemaekers in press; Out 2008, 38). Crop products could alternatively have been imported from southern Pleistocene sand soils (cf. Bakels 1986), which is also a possible scenario for Brandwijk-Kerkhof. Import of crop products implies that clearances at the Hazendonk were used for purposes other than arable farming. The available evidence does not enable a distinction to be made between small-scale local arable farming and import. Future research may give more information on the function of the enclosed area and the possible presence of a small field within it. A more detailed discussion on arable farming at the Hazendonk will be published in Out (in prep.), with special attention to the material of phase 1 that stands out from the other phases.

14.4.3 Relation to the neolithisation process

There is clearly recognisable evidence of human impact on the vegetation on and around the southern slope of the Hazendonk during phase Vlaardingen 1b. However, the impact appears to have been relatively slight, and as sampling took place in the refuse layer indicative of local human activity, which is to say in or very near the zone of strong disturbance, we can assume that the effect which the humans had on the dune vegetation really was restricted. This is supported by the rapid decline in the indicators of human impact on the upland vegetation, which decrease noticeably within only four metres of the refuse spread. Sampling at certain locations at the western side of the river dune, where refuse of phase Vlaardingen 1b is scarce, would therefore probably not have yielded a recognisable signal at all. The indications of deforestation in the main diagram of M87 are nevertheless stronger than at the earlier, Late Mesolithic/Early Neolithic non-agricultural sites Hardinxveld-Giessendam Polderweg and Bruin, and the early phases of the semi-agricultural site Brandwijk-Kerkhof that are located on dunes in the same region. The late phases at Brandwijk-Kerkhof show evidence of human impact that is comparable with the evidence at the Hazendonk (Bakels/Van Beurden 2001; Bakels *et al*. 2001; Out 2008). The data thus show a trend that deforestation increases with ongoing neolithisation. However, other factors than neolithisation clearly influence the signal of human impact as well, such as site function, sample location and occupation intensity (cf. Out in prep.).

The limited scale of human impact during phase Vlaardingen 1b, and the similarity in the degree of disturbance with the earlier, Middle Neolithic occupation phases at the Hazendonk, is unexpected when considering the small distance between the sample series and the zone of human activity. The results are also unexpected when taking into account that the Vlaardingen Group represents the Late Neolithic and is considered as corresponding with the consolidation phase of the neolithisation process (Louwe Kooijmans 1998). The restricted evidence of human impact is however no surprise at all in view of the subsistence strategy of the occupants of the Hazendonk, the considerable indications of a specific site function as a specialised hunting camp, and the limited role of agriculture (see introduction). Thus, even well-established Late Neolithic occupation at Dutch wetland sites can give limited evidence of human impact, so limited that it could well remain undetected when sampling too far away from the activity zone. In other words, the Hazendonk studies discussed here highlight that there is probably much low-level human impact taking place during neolithisation that we are not detecting, something which we should take into account in a wider research context.

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Notes

1 *Ranunculus repens*-type represents *R. acris/lingua/repens* but it probably concerns *R. repens* here. *Veronica beccabunga*-type represents *V. anagallis-aquatica*, *V. beccabunga* and *V. catenata*.

2 The complete results of both sample series will be published completely in Out in prep.

3 The seeds were found in the material that remained after preparation of the pollen samples.

4 The diagram of Voorrips (Louwe Kooijmans 1974) has been recalculated based on an upland pollen sum (Out in prep.), which makes the percentages comparable with the diagrams presented here. The diagram of Van der Wiel (1982) that is based on the same pollen sum would also be suitable for comparison, but does not contain a main diagram with a curve of the upland herb percentage.

5 Core 2, to be published in Out in prep.

6 This conclusion is based on analysis of all the flint except for the material from unit C.

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