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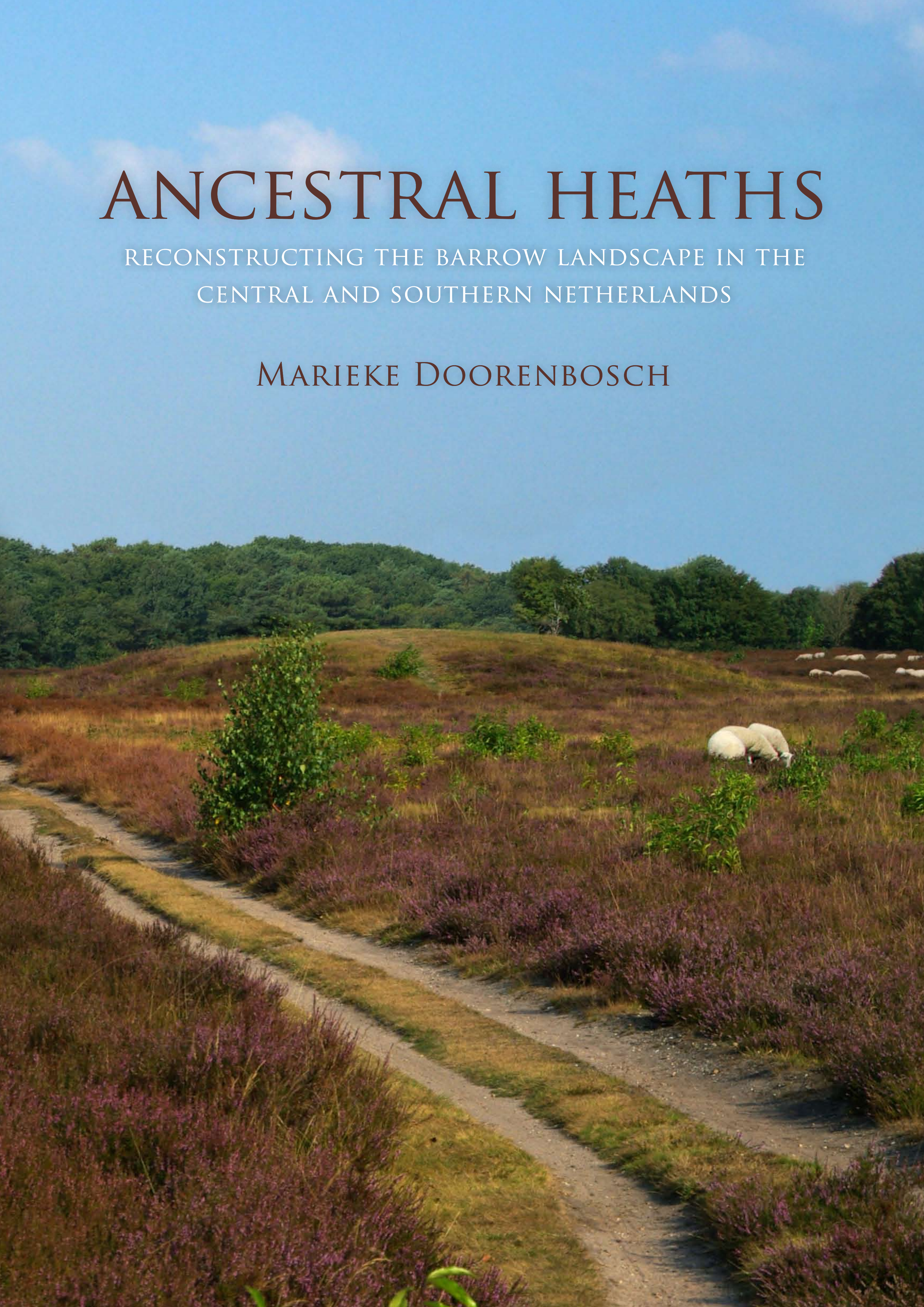
RECONSTRUCTING THE BARROW LANDSCAPE IN THE CENTRAL AND SOUTHERN NETHERLANDS

MARIEKE DOORENBOSCH



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S·N·M·A·P

Contents

Part One

This thesis is divided into three parts. Part one (Chapters 1, 2 and 3) concerns the background of this research, beginning (Chapter 1) with an overview of the development of the palynological research of barrows. Following the overview is an assessment of what data are available (Chapter 2) and what is still missing (Chapter 3) from the palynological research of barrows.

Part two will go further into the methodology behind the palynology of barrows. Chapter 4 gives an overview of sampling techniques used in this study. Chapter 5 discusses the theory of vegetation history reconstruction through the use of pollen diagrams derived from mineral soils. In addition the relation between time and depth in mineral soils will be discussed in this chapter. In Chapter 6 the so-called pollen sum that is used in palynological analyses of barrows will be examined and reconsidered. Chapter 7 concerns the determination of size of the open place a barrow was built in. Three methods to determine the extent of an open space are described and discussed.

In part three of this thesis (Chapters 8-14) the methodological theories described and discussed in part two are applied to reconstruct the barrow landscapes of five case study areas. Each case study area is dealt with in a separate chapter (chapters 8-12), including the presentation of palynological analyses of several individual barrows and/or barrow complexes. In Chapter 13 the results of all case studies are summarized and discussed, and the last chapter (14) submits answers to the research questions put forward in this thesis.

Chapter 1

Introduction: why study the environment of barrows?

1.1 The academic significance of environmental barrow research

Barrows, *i.e.* burial mounds, are amongst the most important of Europe's prehistoric monuments. In the European landscape today hundreds of thousands of them are still visible, and considering the large number of barrows that have disappeared over time, it is not difficult to imagine the great importance barrows must have had. Across Europe, barrows still figure as a prominent element in the landscape. In Denmark alone, more than 80,000 barrows are known (Johansen *et al.* 2004). Many barrows in Europe have been excavated, revealing much about what was buried inside these monuments. Little is known, however, about the landscape in which the barrows were situated. Palynological data, carrying important clues on the barrow environment, are absent for most of the excavated barrows in Europe. In the Netherlands however, the opposite is the case, with palynological data being available for hundreds of excavated barrows, a fact which places the Netherlands as a very important centre for the environmental research of barrows.

Some 3,000 barrows are presently known in the Netherlands (Bourgeois 2008). Burial mounds were built from the 4^{th} millennium BC until around 500 year BC, with most being constructed during the 3^{rd} and 2^{nd} millennium BC. So many barrows were built during this period that they must have visibly dominated the landscape. Many of these barrows have been the subject of archaeological research in the Netherlands. In 1906, Holwerda was the first to begin excavating barrows near Hoog Soeren, the Veluwe (Holwerda 1907). Holwerda also did much to popularize barrow archaeology, bringing it to the attention of the public. Van Giffen, a contemporary of Holwerda, pioneered the quadrant method of barrow excavation. With the quadrant method, the barrow is divided into four quadrants and the opposing quarters are removed in order to identify internal features and expose a continuous profile of the object through its centre along intersecting axes (see figure 1.1). Van Giffen involved palynology, determination of bones and seeds, geology and C^{14} dating in his archaeological research (Louwe Kooijmans 1979), in large part due to his training and background. After the Second World War Glasbergen en Modderman continued to excavate numerous barrows. Around 1970 it was realised that burial mounds were valuable archaeological monuments that needed protection, which led to the mounds being listed as cultural heritage monuments protected by the state. Since then very few barrows have been excavated and it was thought for a long time that there was more than enough known about burial mounds.

Since 1906 around 800 barrows have been excavated. These excavations have contributed not only to the knowledge we presently have on barrows, but also to what we know of prehistoric man. However, this information has nowadays become dated. In the past barrows were solely interpreted as burial places for

Figure 1.1. An example of a barrow in which one quadrant has been excavated according to the quadrant method pioneered by van Giffen. The excavated barrow in the picture is located at the Echoput, near Apeldoorn (see chapter 8.1). Photograph by Q. Bourgeois.

prestigious individuals or martial chiefs, but, based on the special and sometimes exotic objects that are often found in barrows, especially barrows from the 3rd and 2nd millennium cal BC, there is growing evidence pointing to barrows having been highly important ritual places with a specific cultural value. The importance of barrows in the past was emphasised by the fact that they were often re-used again for burials and other ritual practices for hundreds of years and that barrows formed in their entirety highly visible barrow landscapes. However, the specific social and ideological significance of barrows is still unclear. What is further lacking is information on the landscape surrounding the barrows. While local vegetation reconstructions from many barrows in the Netherlands are available, a reconstruction of the total landscape around the barrows has yet to made, without which it would be difficult to understand their role in the prehistoric cultural landscape. To improve our knowledge of barrows with respect to the problems mentioned above, the project 'Ancestral Mounds' was started. The following research questions were formulated (Fontijn 2007):

1. What was the social and ideological significance of barrow graves? In what way do they differ, in terms of content, location, and landscape setting, from contemporaneous other types of burials and ritual depositions? What does this tell us about the social roles of the deceased buried in barrows?
2. What was the significance of barrows as landscape monuments? How were they embedded in the by then emerging agrarian landscape and how did their presence structure the landscape of later generations?

The 'Ancestral Mounds' project is divided into three PhD-projects, each focusing on a different level of analysis:

Project one is pitched at the level of the grave(s) inside the burial mounds. What was the social and ideological identity of the dead? This will be investigated by analysing the life-cycles of all artefacts found in burial places (Wentink in prep.).

Project two focuses on the barrow groups (Bourgeois 2013). How and why did barrows come to form entire landscapes?

Figure 1.2. Two barrows at the Zuiderheide, near Hilversum.

Project three, which is the subject of this thesis, studies the barrow environment. What did a barrow landscape look like and what was the role of barrows in this landscape? In this thesis a detailed vegetation history around barrows is reconstructed in order to get a better impression of what role barrows played in their environment. The research questions and methods will be discussed more in detail in Chapter 3.

1.2 The societal significance of environmental barrow research

Besides the academic concern for doing research on barrows in the Netherlands, there is also a societal concern. The Dutch public and landowners are very interested in the barrows in their region. A tourist route in a nature reserve may pass several burial mounds (see figure 1.2 for an example), with only a small sign next to the barrow indicating the presence of a burial mound (see figure 1.3). It is also often the case that very little information about the barrow is available. Owners of areas with barrows have expressed a desire for more information about the history of these barrows, and in some cases they want to show what the barrow landscape looked like at the time of the barrow's building. Nature reserves such as the *Staatsbosbeheer* and *Kroondomeinen* are interested in reconstructing barrow landscapes and including the burial mounds in their management and development of the landscape. But in order to carry out this management, they need to know what the barrow environment looked like.

The archaeological value of the barrows is not always clear to the public, as evidenced by the disturbance of several barrows in recent years. For example in Rhenen-Elsterberg a barrow had been dug into to presumably make a place for a shelter (Arnoldussen *et al.* 2009). Greater awareness of the archaeological value of barrows could prevent such unfortunate unwitting vandalism from occurring.

Figure 1.3. A standard Dutch information sign at barrow 2 at the Echoput, near Apeldoorn. Photograph by A. Louwen, taken during the excavation campaign in 2007 (see chapter 8.1).

Many barrows in the Netherlands are protected. However, only the barrow itself is considered a monument, although there are some exceptional cases where the protected area around the barrow is extended to a maximum of 10 metres. Since the role of the barrows in the landscape is not very clear at the moment, it might be desirable to have the monumental area increased. Ceremonial post alignments that are associated with the barrows for example may be situated outside the 10 m zone (Fokkens *et al.* 2009b). In that case not only the barrow itself was important, but also the area around it.

Chapter 2

Environmental research on barrows, an overview so far

In this chapter an overview of previous environmental barrow research is given. This chapter starts with a general overview of the Holocene vegetation history of the Netherlands, followed by a more specific overview of environmental barrow research.

2.1 The vegetation history of the Netherlands in the Holocene

Before looking into detail at barrow landscapes it is useful to provide a sketch of the regional vegetation development during the second part of the Holocene (from the Subboreal period onwards), the period in which barrows were built. This vegetation development is mostly derived from pollen records preserved in peat and lake sediments. The following vegetation development will focus on the central and southern Netherlands, this research's area of interest (see section 3.2).

The Holocene is divided into periods based on artefact remains, the vegetation history of the Holocene, however, is divided into climatic zones based on peat stratigraphy (Blytt-Sernander) and on data from pollen cores. Three separate pollen zone descriptive schemes (formulated individually by Firbas, Jessen/Iversen, and the *Rijksgeologische Dienst* [RGD, the Dutch State Geological Service]) are commonly used to describe the Holocene vegetation development in the Netherlands (see table 2.1).

The first barrows were built during the Subboreal period. A deciduous forest dominated the Netherlands during the preceding Atlantic period. *Quercus*, *Tilia*, *Ulmus* and *Corylus* were the main forest species in the drier regions, with also *Fraxinus* increasing its presence throughout this period. In the wetter areas *Alnus* was the dominant species. *Pinus*, a coniferous tree that had been present in large numbers in the preceding periods, rapidly decreased during the Atlantic and was almost absent in the Netherlands.

During the Subboreal, which correlates with the Neolithic and the Bronze Age for most of the Netherlands and pollen zone VIII (in the schemas of Firbas and Iversen), several changes in vegetation occurred. At its start there is a decline of *Ulmus.* In large parts of Northwest Europe this was a very rapid decline, also referred to as the *Ulmus* fall. This decline was not as pronounced in the Netherlands, but still a decrease of a few percentages that can be seen with respect to the Atlantic. *Tilia* also decreased and almost disappeared at the end of the Subboreal, a process that started in the north of the Netherlands and proceeded to the middle and south of the Netherlands (Waterbolk 1954). This period is also characterised by the appearance of *Fagus*. The Subboreal is also the period where man seriously started to interfere with the landscape. The character of the vegetation changed. Natural forests were cleared for agricultural activities. In some places the forest could recover, but in others a *Calluna*-heath established

years (cal BC)	Archaeological period	Blytt Sernander	Firbas (1949)	Jessen/ Iversen (1935-1941)	RGD	Vegetation development according to general pollen diagrams
	Modern History	Subatlantic	X	IX	Vb2	Anthropogenic indicators increase
AD 1500	Medieval Period		IX		Vb1	*Fagus* >5% *Carpinus* >1%
AD 500	Roman Period					
12	Late Iron Age				Va	*Fagus* >5% *Carpinus* <1%
250	Middle Iron Age					
500	Early Iron Age					
800	Late Bronze Age	Subboreal	VIII	VIII	IVb	*Fagus* >1%) *Tilia* decreases
1100	Middle BA B					
1500	Middle BA A					
1800	Early Bronze Age					
2000	Late Neolithic B				IVa	*Ulmus* decreases (<5%) *Fagus* increases Increase anthropogenic indicators
2500	Late Neolithic A					
2900	Middle Neolithic					
3750		Atlantic	VII	VII	III	*Querus*, *Ulmus*, *Tilia* and *Alnus* dominant *Pinus* decreases
4200	Early Neolithic					
4900	Mesolithic		VI			
7000		Boreal	Vb	VI	II	*Corylus, Quercus* and *Ulmus* dominant, *Alnus* and *Tilia* increase, *Pinus* decreases
			Va	V		*Pinus* dominant, but decreasing *Quercus*, *Ulmus*, *Corylus* increase
8000		Preboreal	IV	IV	I	*Pinus* and *Betula* dominant
10000						

itself. Natural forests alternated with a cultivated landscape, such as fields, pasture land and settlements.

The Subatlantic period that followed the Subboreal started around 800 cal BC (when the Subboreal climate deteriorated) and continues to the present day. *Fagus* and *Carpinus* expanded and *Quercus* declined. *Tilia* and *Ulmus* have almost disappeared. Herbs became more prevalent, which seemed to be favoured by human influence. *Artemisia, Plantago,* Cerealia and grasses gained importance. In the early Middle Ages, also known as the Dark Ages, the vegetation changed. After the fall of the Western Roman Empire, during the Migration Period (300-600 cal AD), human pressure on the vegetation seemed to lessen. Forests were able to recover in the South and Southeast of the Netherlands, while a concurrent decline of human influence was almost absent in the northern Netherlands (Janssen and Ten Hove 1971, Renes 1988, Bunnik 1999). For example in the loess area in the Netherlands between the Rhine and the Meuse *Corylus* and *Quercus* could expand first, succeeded by *Fagus* and *Carpinus.* In the wetter areas *Alnus* was able to expand enormously (Bunnik 1999). During the Merovingian and Carolingian dynasty (ca. 600-900 cal AD) human cultivation activities increased again and in the late Medieval Period most of the natural forest had disappeared due to forest clearing. Due to (agri-) cultural activities, the soil impoverished and *Calluna*-heath could establish itself at great scale. The heath was exploited (grazing, sod cutting, etc.) and was therefore able to expand. From the 16th century onwards the forest was able to regenerate, mostly due to the planting of trees. *Pinus* was planted in enormous amounts in the 19th century, and at present Dutch forests consist of about 20% deciduous forest, 20% coniferous forest and 50% of mixed forest. (Waterbolk 1954, Janssen 1974, Berendsen 2004, Bastiaens and Deforce 2005).

2.2 Environmental research on barrows

2.2.1 An overview

There are several ways to investigate the prehistoric landscape in which the barrows were situated. The appearance of a landscape is for a great deal determined by the vegetation that is in it. No understanding of a barrow landscape can be considered complete without knowledge of its vegetation. Palynological analysis is a common way of reconstructing a landscape's vegetation in the past. In an ideal scenario pollen analysis can be applied to a deposit that has accumulated over time, such as peat or lake mud. The pollen rain that precipitated on the surface was embedded in the deposit as it built up. In this way the peat or the sediment in a lake became an archive of vegetation history for the surrounding area. When pollen precipitates onto a soil surface there is no incorporation by layers built on top of the surface and it is very likely that pollen grains on the surface will be corroded or washed away. However, after construction of a barrow, the surface containing the pollen precipitation was covered and protected from the air, reducing microbiological activity and thus corrosion of the pollen grains. In addition, the tumulus will prevent new pollen from precipitating on the old surface. The old surface under the barrow is often still recognizable as a darker layer and can be sampled for pollen analysis. Besides the old surface, the sods of which the barrow is constructed are also suitable for pollen analysis, since they also contain the upper part of the soil profile (Waterbolk 1954, van Zeist 1967b). This topic will treated more fully in Chapter 4.

Table 2.1. An overview of commonly used pollen zones for the Holocene period and the general vegetation development in the central and southern Netherlands per zone. RGD= Rijks Geologische Dienst.

Soils in Neolithic barrows were first investigated in Denmark by Müller and Sarauw (Müller 1884, Sarauw 1898). As mentioned in Chapter 1, van Giffen initiated investigations into the environmental aspects concerning barrows in the Netherlands and the first pollen analysis of barrows dates from before World War II. The ideas of van Giffen were carried out and improved upon by Waterbolk (1954). The barrow database, and barrow interpretations, was later enlarged through contributions made by van Zeist (1955), and Groenman-van Waateringe and Casparie (1980). Barrow palynology was practiced mainly in the Netherlands, although barrows in regions outside the Netherlands were also subjected to palynological analyses. For example in Belgium barrows were palynologically investigated by Groenman-van Waateringe (1977) and van Zeist (1963), and in Denmark by Andersen (1988); Averdieck (1980) and Groenman-van Waateringe (1979) investigated several barrows in Germany, Dimbleby and Evans (1974) in England and Groenman-van Waateringe (1983) in Ireland. Knowledge and ideas about barrows and their environment have evolved during the last century. These developments will be discussed in the coming sections.

2.2.2 Pollen analyses for dating purposes

Palynology was at first primarily used to date peat and sediment sequences. A general reference pollen diagram representing the vegetation history of the Netherlands during the Holocene, based on pollen data from mainly peat and lake deposits, can be divided into pollen zones (see table 2.1). Pollen spectra from undated sediment layers can often be fitted into a certain pollen zone and thus be linked to a certain time period. This method of dating is most reliable when multiple pollen spectra or a local pollen diagram is provided instead of a single pollen spectrum in order to create as much overlap with the reference pollen diagram as possible. In addition, this technique was extended to the dating of various archaeological objects and sites. An object that was found embedded in a sediment can be linked to a certain depth in the pollen diagram obtained from this sediment and therefore to a certain age, when the exact original location of the object in the sediment is known.

Palynological dating has also been applied to barrow research. When grave goods are absent, dating a barrow is difficult. When Waterbolk first derived palynological data from the old surfaces beneath numerous barrows in the Netherlands, they were used for dating purposes. Two barrows near Apeldoorn, extensively described and discussed in Chapter 8 of this thesis, were first palynogically dated to a pollen zone known to be contemporaneous to the Iron Age. This dating was later confirmed by the radiocarbon dating of charcoal from the ring ditches surrounding the barrows (see Chapter 8). However, dating barrows using palynological data has not always been completely accurate. For example, a large group of barrows at Toterfout-Halve Mijl has been chronologically ordered mostly based on their pollen spectra by Waterbolk (1954). Bourgeois, however, has shown that the chronological sequence of these barrows should probably be different, on the basis of radiocarbon dates and the surrounding features (Bourgeois 2013; see also Chapter 11).

Dating by palynological analysis is a form of relative dating, since chronologic checkpoints from other sources are needed. Presently, absolute dating methods like radiocarbon dating and OSL dating have displaced palynological dating to all intents and purposes. However, the method still finds application on occasion, when no datable material is available.

2.2.3 The reconstruction of local vegetation: regional and cultural differences

Besides dating, pollen data have also been used to reconstruct vegetation in the vicinity of the barrows at the time the barrows were built, providing information on the agricultural systems used by prehistoric man. In addition, these palynological analyses were used to show differences in land use (Waterbolk 1954, Van Zeist 1959, 1967a). Two different agricultural systems– the Iversen landnam and Troels-Smith landnam- can be distinguished during the Neolithic. These types of land use are named after the two Danish scientists who first described them. The Iversen landnam is a Neolithic land occupation phase (in the Middle Neolithic B), describing the clearance of the primeval forest by burning and cutting trees. The Iversen landnam was first described by Iversen (1941, 1973), based on the results of palynological analyses of Danish small lakes. The Iversen landnam consists of three phases, which can be recognised in the pollen diagrams as follows:

Phase 1: The first phase represents the actual forest clearance by cutting and burning: at first *Ulmus* declines, followed by the decrease of *Tilia and Quercus.* The pioneer tree *Betula* shows an increase.

Phase 2: This phase corresponds with the agricultural phase, involving grazing and crop cultivation. Anthropogenic and grazing indicators show a maximum; particularly *Plantago lanceolata*, but also Cerealia, Poaceae and *Rumex acetosella*.

Phase 3: The third phase represents the abandonment of the pastures and fields, allowing regeneration of the forest. This is shown by a maximum of *Corylus*, the increase of mainly *Quercus*, *Fraxinus* and *Tilia* and the decrease of *Betula*. Anthropogenic and grazing indicators decrease and disappear almost completely.

Troels-Smith introduced a second type of Neolithic occupation in Denmark, prior to the Iversen landnam (Troels-Smith 1953). He found various agricultural indicators, such as cereal pollen, contemporaneous with the *Ulmus* decline (around 3750 cal BC, see table 2.1). Troels-Smith suggested that the fall of the elm curve reflected pollarding of the trees for the purpose of cattle fodder. Together with the absence of pastures, deduced from very small numbers of *Plantago lanceolata*, Troels-Smith concluded that a farmer culture existed preceding the Iversen landnam, mainly based on small-scale arable farming with livestock kept within enclosures throughout the year.

The investigations and interpretations offered by Iversen and Troels-Smith triggered similar investigations in the Netherlands. In pollen diagrams derived from peats in the province of Drenthe (in the north of the Netherlands) named Bargeroosterveen, Emmen and Nieuw-Dordrecht, the two types of landnam were shown to have occurred (Van Zeist 1959, 1967a). In the period between ca. 3700 cal BC and 2800 cal BC the *Ulmus* decline can be seen, together with low percentages of *Plantago lanceolata.* The data reflect the type of land use described by Troels-Smith, characterised by small forest clearances and cattle kept within enclosures. In the period after ca. 2800 cal BC an increase of *Plantago lanceolata* can be observed, signalling the Iversen-landnam, with rather large cleared forest areas mostly used for grazing.

Van Zeist compared these pollen diagrams with spectra from Neolithic grave monuments. Grave monuments from three Neolithic cultures were investigated: megalithic tombs built by people from the oldest culture, the Funnel Beaker Culture (FB) (ca. 3400-2900 cal BC, van den Broeke *et al.* 2005, 28) and barrows built by people belonging to the later Protruding Foot Beaker Culture (PFB) (ca. 2900-2500 cal BC, van den Broeke *et al.* 2005, 28) and the Bell Beaker Culture

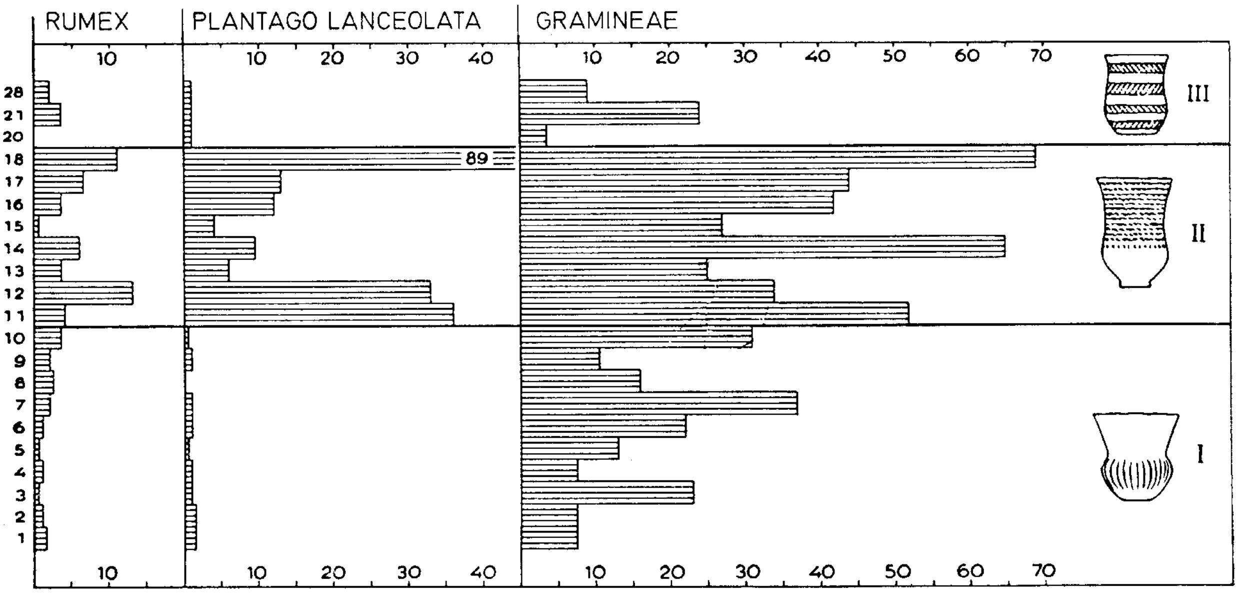


Figure 2.1. Cultural differences shown in barrow pollen spectra. I= Funnel Beaker Culture, II= Protruding Foot Beaker Culture, III= Bell Beaker Culture. Figure after van Zeist (1959, figure 11).

(BB) (ca. 2500-2000 cal BC, van den Broeke *et al.* 2005, 28). Pollen spectra from the FB grave monuments showed low values of *Plantago lanceolata*, *Rumex* and Poaceae, indicating a Troels-Smith landnam. Pollen spectra from the PFB burial mounds showed in general high percentages of *Plantago lanceolata*, *Rumex* and Poaceae, corresponding to the Iversen landnam. Pollen spectra from the BB mounds were very similar to those of the FB, characteristic of the Troels-Smith landnam. Van Zeist ascribed the Troels-Smith phase in the Bargeroosterveld diagram between ca. 3700 cal BC and ca. 2800 cal BC and the Funnel Beaker Culture and the Iversen phase after ca. 2800 cal BC to the Protruding Foot Beaker Culture (see figure 2.1). The Troels-Smith landnam used by the farmers of the Bell Beaker Culture was not shown in the Bargeroosterveld diagram. Van Zeist explained this by the dominating activities of the people of the Protruding Foot Beaker Culture (Van Zeist 1959).

Waterbolk also noted in his thesis that the maxima of herbs (like *Plantago, Rumex*, Poaceae, *Dryopteris*-type, Asteraceae and Caryophyllaceae) he found in the pollen spectra from barrows must have been caused by activities of the Corded Ware Culture, also known as the Protruding Foot Beaker Culture, who apparently practised an Iversen landnam (Waterbolk 1954).

For the Early and Middle Bronze Age Period van Zeist suggested a difference in farming practice between the north and the south of the Netherlands, based on the pollen spectra from barrows (Van Zeist 1967a). In the northern part of the Netherlands barrow pollen spectra showed high values for *Plantago lanceolata*, *Rumex* and Poaceae, comparable to the spectra from the Protruding Foot Beaker Culture (*e.g.* Iversen landnam). In barrows in the south of the Netherlands, especially those belonging to a regional culture called Hilversum Culture, the percentages of *Plantago*, *Rumex* and Poaceae were considerably lower than in the north, suggesting that the farming practice more resembled that of the Funnel and Bell Beaker Culture (*e.g.* Troels-Smith landnam). Van Zeist found that these differences in agricultural practice interestingly coincide with differences in culture between the north and the south of the Netherlands, namely the culture of the Barbed-wire Beakers in the north and the Hilversum Culture in the south.

The theory that these differences in land use were culturally bound was criticised by Casparie and Groenman- van Waateringe (1980). Their article (re)analysed many pollen spectra from barrows north and south of the IJssel river (see figure

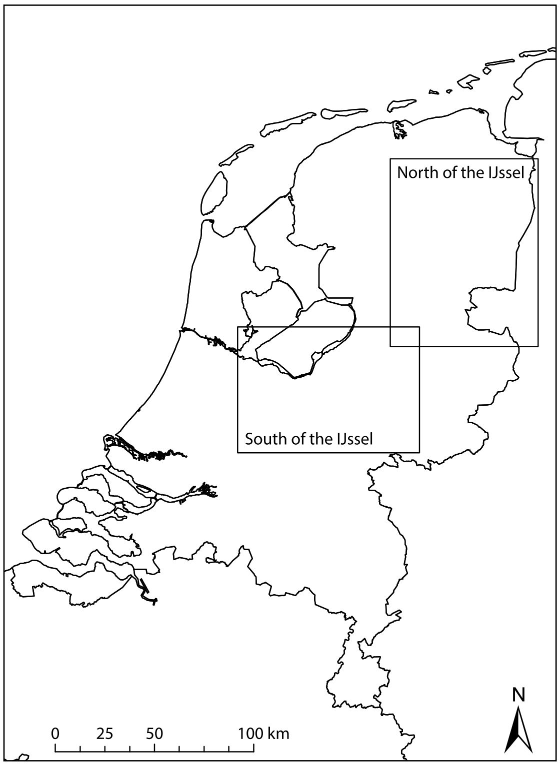


Figure 2.2. The areas north and south of the IJssel examined by Casparie and Groenman-van Waateringe (1980).

2.2) and compared them to the peat pollen diagrams from Bargeroosterveen, Emmen and Nieuw-Dordrecht (Van Zeist 1959, 1967a).

The differences between the Funnel Beaker and Protruding Foot Beaker period ascertained by van Zeist in the peat diagrams were, according to Casparie and Groenman-van Waateringe, not the result of differences in type of land use, but of soil conditions and nature of the cleared forest. The FB people living near the sampling sites apparently preferred to reclaim the *Ulmus*- and *Tilia*-rich forests that were present on soils relatively rich in nutrients. These forests were mainly situated on cover sand deposited on a weathered boulder-clay ridge. Because of this boulder-clay in the subsoil, the sandy soils were loamy and moist to wet. When the clearings were abandoned no great expansion of *Plantago lanceolata* took place here. Rather than explain this by the type of landnam activity, Casparie and Groenman- van Waateringe explained the absence of a *Plantago lanceolata* resurgence was due to the compactness of the soil (Casparie and Groenman-van Waateringe 1980, 59):

> *"It is conceivable that the loamy to very loamy soils of the boulder-clay ridge became compacted very readily, a process that checked considerably the establishment of Plantago lanceolata."*

The PFB people also cleared forest that had developed on cover-sand that was generally considerably poorer in nutrients, more drought-susceptible and far less loamy. Especially the latter was more in favour of *Plantago lanceolata,* which was able to expand here. So, Casparie and Groenman-van Waateringe explained the differences between the FB and PFB period as a result of which type of forest was cleared (rich versus poorer) and the condition of the soil (loamy versus less loamy and wet versus drier). In the period of the Bell Beaker (BB) Culture, *Tilia* shows a definitive decline, with an expansion of *Corylus*, *Pteridium*, Poaceae and *Plantago lanceolata* indicating the clearance of already degraded forest.

In addition, pollen spectral differences between barrows belonging to the FB and BB period on the one hand *(e.g.* low values for herbaceous plants, ascribed to the Troels-Smith landnam) and PFB period on the other (*e.g.* relatively high values for herbaceous plants, ascribed to the Iversen landnam) described by van Zeist (1967a) were not as explicit in Casparie and Groenman-van Waateringe's results. Within each culture, pollen spectra showed considerable differences, therefore the pollen spectra alone could not be used to culturally isolate a group. The differences van Zeist found in barrow pollen spectra were more likely to be due to dissimilarities in soil type, since all PFB barrows were located on the Drents plateau (Drenthe, northern Netherlands) and the BB barrows were located on the Veluwe (central Netherlands). Casparie and Groenman-van Waateringe did in fact find some differences between barrow pollen spectra from the Drents Plateau (north of the IJssel) and the Veluwe (south of the IJssel). The northern barrow pollen spectra showed an earlier and more pronounced expansion of heath than the southern spectra. These differences were ascribed to differences in the hydrological situation. The northern barrows were nearly all situated on the Drents Plateau, where soils were influenced by the presence of impervious boulder-clay not far below the surface.

> *"It was therefore precisely here, that disturbance of the vegetation cover and agricultural activities resulted in rapid exhaustion of the soil and a very drought-sensitive topsoil, that in many places facilitated rapid expansion of the heath."* (Casparie and Groenman-van Waateringe 1980, 60)

In the area south of the IJssel the barrows analysed by Casparie and Groenman-van Waateringe (1980) were situated on the Veluwe. The Veluwe is a landscape consisting of pushed moraines, cover sands and fluvio-glacial material of porous nature, where water seeps down more easily. As a result the soils are much drier than on the Drents Plateau. According to Casparie and Groenman-van Waateringe the forest was therefore probably more open at the Veluwe with a well-developed undergrowth of herbaceous plants sufficient for grazing. Grazing pressure caused a gradually opening up of the woodland, allowing grasses and heath to expand. The research by Casparie and Groenman-van Waateringe showed that differences in land use were not culturally bound. As Casparie and Groenman-van Waateringe concluded:

> *"It seems more likely that prehistoric man adapted his methods of reclamation to a great extent to the possibilities available, and in such a way that no culturally-linked pattern is evident." (Casparie and Groenman-van Waateringe 1980, 62)*

2.3 Vegetation reconstructions of the barrow environment: open spaces in the landscape

It has become clear from research that most of barrows in the Netherlands were built in open spaces. These open spaces might have been small or large. Waterbolk (1954) mentioned that practically all barrows were built in an open space without deliberate clearance of the area. Van Zeist (1967a) suggested after analysis of pollen data from several Neolithic and Bronze Age barrows in the Netherlands that they were constructed in either small clearings (Troels-Smith landnam) or larger clearings (Iversen landnam). Casparie and Groenman- van Waateringe concluded from their research (1980):

"The environment in the immediate vicinity of a barrow varied from only slightly degraded forest to extremely degraded, heath-rich vegetations, with all possible intermediate stages."

De Kort palynologically investigated several barrows in the Netherlands. For a cemetery complex in North Brabant called Oss-Zevenbergen (see for an extensive description and discussion Chapter 12) he concluded that all barrows he investigated were erected in an open place covered with heath vegetation. This open place was probably already present before the oldest barrow was constructed and continued to be present during the period the barrows were built (*e.g.* from the late Neolithic until the Iron Age) (de Kort 2009, 166, 169). In another cemetery complex near Slabroek in North Brabant, an urn field that also contained some barrows that probably dated to the Bronze Age, de Kort found that the oldest barrow was built in a small open place with heath vegetation (see also chapter 12). The heath at this open place probably expanded during the Bronze Age when the younger barrows were built (de Kort 2010, 64).

Barrows in regions besides the Netherlands were also found to have been built in open places. Andersen found indications that in the Vroue area, West Jutland (Denmark), Early Neolithic barrows were built in natural woodland with heath patches (Andersen 1994-95). Later on trees became increasingly scarce and open spaces became larger. For Early Bronze Age barrows in Thy, Denmark, Andersen found indications that they were built in a rather treeless landscape, with remnants of woodlands that probably had been in the area some time before the barrows were built (Andersen 1996-97). It has been suggested that burial mounds in southern Sweden were built in a rather open landscape, with forest cover estimated at 20-40%, falling to 10% in the immediate surroundings of the barrow itself (Hannon *et al.* 2008).

The open spaces barrows were built in have mostly been interpreted in terms of prehistoric man's land use. Let us now focus on the open space itself and its relation to the barrow. First an overview of possible open spaces and their origin will be given, than follows an overview of open spaces in which barrows were built.

2.3.1 An overview of open spaces

Natural open spaces

The general view is, as has been described in section 2.1, that a closed canopy forest developed in the beginning of the Holocene in Western and Central Europe. When human interference with the landscape, the density of the forest decreased and open spaces were created. There is, however, an alternative hypothesis: a half-open park-like landscape, described by Vera (1997) as a landscape consisting of a continuous grassland with clumps of shrubs and forest. Vera claims that the initial Holocene vegetation of Western and Central Europe was not a closed forest system, but a half-open-park-like landscape. He points out that *Quercus* and *Corylus* would not be able to flower and regenerate in closed forests, while these species were continuously present in considerable numbers in Central and Western Europe since the last ice age. Vera's suggested type of half-open-park-like landscape was created and maintained by large herbivores, in a process he calls the theory of cyclical vegetation turnover (Vera 1997).

In Vera's cyclical vegetation turnover, thorny shrubs establish themselves in the grassland. In these clumps of thorny shrubs trees could grow, protected from grazers by the thorns. The trees developed into a forest, which would degenerate back into grassland again due to large herbivores and climatic events such as drought and storms. The process could start over again, with the establishment of thorny shrubs in the grassland (Vera 1997).

Mitchell (2005) tested the hypothesis of Vera that large grazers kept the forest open. He compared palynological data of *Quercus* and *Corylus* from Ireland, where only two large herbivores were present during the Early Holocene, to that from other European countries with a greater assortment of large herbivores (Mitchell 2005). He found no obvious differences in *Quercus/Corylus* regenerative progression and concluded that large herbivores would have had little impact on the abundances of *Quercus* and *Corylus*. Mitchell also argued that, based on data from small forest hollows in Europe and eastern USA, opening up of the forest canopy was mainly artificial and caused by human activities.

Nevertheless, other researchers join Vera in believing that the natural structure of the northwest European forest in the Early Holocene was probably more open than previously thought. Svenning stated that closed forest would be predominant in 'normal' uplands, but with longer-lasting openings (Svenning 2002). These openings would have mainly occurred on floodplains, on calcareous or poor, sandy soil and in the continental interior of northwest Europe. At these locations the appropriate conditions would have existed for the presence of open vegetation like open woodland, scrub, heath and meadows. Fire would probably have been an important agent involved in the maintenance of this vegetation. Bradshaw *et al*. also argued that closed forest theory alone is not a perfect model for the Early Holocene vegetation structure (Bradshaw *et al.* 2003). They agreed that closed forest canopy is the dominant vegetation type, but they also argued that some parts of the landscape were open. This openness might have been created and maintained by events like floods, fires and wind throw. A combination of fire and grazing pressure may have created proper circumstances for regeneration of *Quercus* and *Corylus*. Whitehouse and Smith discussed that other proxy indicators may provide useful information that contributes to this subject (Whitehouse and Smith 2010). They showed, using beetle records from archaeological and palaeoecological sites in Britain, that the early Holocene was characterized by quite open woodland and that locally open areas may have played an important role. They found little evidence that those open areas were maintained by grazing activity of large herbivores, and proposed that other disturbance factors were probably of more importance.

To conclude, there are numerous indications that the west European Holocene landscape was probably more open than previously thought.

Fabricated open spaces: forest clearance

The landscape started to change rapidly with the onset of prehistoric man's interference. During the Neolithic, man switched from a hunter-gatherer strategy to an agricultural strategy. Farmers started to plant their own food and began to keep their own animals. This change to crop cultivation and animal husbandry had great impact on the vegetation and consequently on the landscape. Agricultural practise required open spaces for arable fields and livestock too, needed pasture to graze in. Forests were cleared and from the period of around 4100 cal BC, human influence becomes visible in palynological research in the form of cereal pollen grains and weeds from both arable and pasture land (Louwe Kooijmans 1974, Out 2009, Chapter 8 in this thesis). From 3000 cal BC there is a pronounced human impact on the environment. Both agriculture and stock breeding were practised on a large scale. For agriculture open space was needed on the most fertile grounds. Forest areas were cleared, notable in palynological records by the rapid decline in trees, the increase of herbs growing in open vegetation and indicators for cultivation, such as cereal pollen (Louwe Kooijmans 1974).

The influence of human activity on the landscape was mainly notable in pollen spectra by the presence of anthropogenic indicators (Behre 1986). Bakker for example, reconstructed the emergence and expansion of agriculture on the Drenthe Plateau (eastern Netherlands) by using the indicator-species approach in combination with the use of modern pollen/land-use relationships (Bakker 2003). Bakker demonstrated that the first small-scale arable farming and livestock foddering took place on the Drenthe Plateau in the Subboreal (4050-3450 cal BC, according to Bakker 2003). An increase of Poaceae, Cyperaceae, *Calluna, Plantago lanceolata* and *Rumex acetosa*-type indicate the presence of various types of grass-rich vegetation, probably maintained by livestock. The appearance of Cerealia indicates the presence of arable fields. In the following phase (3450-2600 cal BC, Bakker 2003) more widespread clearances occurred, especially in the rich and higher forest. The further increase of Cerealia indicates the increased importance of arable fields.

After a period of decreased human influence on the vegetation during 2600-1770 cal BC (Bakker 2003), a more extensive clearance of the forest and their replacement by agricultural fields can be seen in the later phase of the Subboreal (1770-800 cal BC, Bakker 2003). Cleared forest areas could be used for crop cultivation for several years until the soil was exhausted. On these fallow fields grasses were able to expand and could be used as pasture (Groenman-van Waateringe *et al.* 1968). Grazing animals prevented the forest from regenerating and besides grasses heath was able to establish itself on the abandoned fields. Bakker (2003) showed that in the Subatlantic (800 cal BC-1500 cal AD), the exhausted and abandoned fields on the Drenthe Plateau were dominated by *Calluna* and extensive heath fields dominated the landscape. Heath was also grazed and maintenance and expansion of the heath was ascertained. The maintenance of these heath areas will be further discussed extensively in Chapters 8-13. Forest clearance might also have taken place for the sole purpose of providing pasture for grazing.

Forest clearings could have been accomplished by tree felling. Felled wood and other vegetation from the forest clearances could have been used as raw material, as fuel and served to cattle. As a raw material wood could serve as construction material for several structures in a settlement, such as houses, sheds, fences and palisades. Bakels for example showed that Linearbandkeramik settlements in the southern Netherlands (ca. 5300-4900 cal BC) used large quantities of wood. For a settlement of 200-250 houses that were built over a period of about 400 years, a woodland area of 50-1000 ha was needed (Bakels 1978). Wooden structures have also been found in association with barrows. Barrows were for example often encircled by wooden posts in the form of palisaded ditches (Late Neolithic), widely spaced post circles (1800-1400 cal BC) and closely spaced post circles (1700-1300 cal BC) (Bourgeois 2013, 34-36). Besides its use as fencing, wood was also used for the pyre when a body was cremated and in some cases a body was buried in a wooden coffin or a burial chamber constructed of wood (Bourgeois 2013).

Another method of forest clearing is burning. The deliberate use of fire to manipulate the vegetation in prehistory has been suggested by several authors (Mellars 1976, Simmons and Innes 1987, 1996a). Simmons and Innes suggest that fires were a deliberate tactic for resource management as early as the Mesolithic (Simmons and Innes 1996b). The resultant opening up of the landscape would have facilitated hunting by improving the sight and/or making the landscape more attractive for certain game species.

A combination of cutting and burning wood is applied in the so-called slash and burn agriculture. The forest is felled and the wood is left to dry, to be later burned. With this technique the soil is mixed with ash, enhancing the soil's fertility for crop cultivation. It has been suggested that slash and burn agriculture was already taking place in the Neolithic, as Iversen connected Neolithic forest clearance (*e.g.* Iversen landnam, see section 2.2.3) with slash and burn (Iversen 1941). Large amounts of charcoal in soil samples may be taken as indication of the use of fire. Odgaard suggests that charcoal layers found in soil samples indicate the use of fire in clearing woodland (Odgaard 1994). Andersen mentions deformed tree pollen grains found in Neolithic barrow soil samples (Andersen 1994-95). The deformed tree pollen grains were interpreted as an indication that trees had been felled and burned, when lying on the ground (Andersen 1992, 1994-95). However, deformed pollen grains were mixed with non-deformed herbaceous pollen grains, indicating that regeneration of the burnt area had already started. Therefore, in this case burning of the trees had already taken place sometime before the barrows were built. In some barrows in the north of the Netherlands high concentrations of charcoal particles were found, indicating that the local vegetation was burned intentionally before the barrow was built (Casparie and Groenman-van Waateringe 1980). Hannon *et al.* (2008) also found charcoal particles in most of the barrows they investigated on Bjäre Peninsula, southern Sweden. They concluded that slash and burn agriculture was practised in the area.

2.3.2 Which open spaces were chosen for the building of barrows?

Open spaces, whether created by man or by nature, were present in the Neolithic landscape. Since the Neolithic, man's interference with the landscape grew in range and magnitude. Forests were cleared and over time the vegetation became more and more open. During the Neolithic period erecting barrows in open spaces was already an established practise. Choice in open spaces was in all likelihood limited at that time, although the landscape may have been more open than previously thought (see section 2.3.1). In the Bronze and Iron Ages, the availability of open space was certainly greater. However, what do we know about the open spaces in which a barrow was set? Open spaces were created by man, but where these open spaces also chosen as building site for a barrow?

Barrows in arable fields

Cleared forest areas, mostly used for agriculture (see section 2.3.1), may have been chosen as sites for constructing barrows in. Some barrows were probably built on arable land that had recently or since a longer period been abandoned. Casparie and Groenman-van Waateringe (1980) found that, especially in the northeast of the Netherlands (Drenthe; see figure 2.3), the open spaces where barrows are placed were previously used as arable land, and that they were probably already long abandoned before the barrows were built. The open spots might originally have been cleared for agricultural purposes, but at the time the barrows were built the agricultural fields were no longer in use. In the central Netherlands (Veluwe, Gooi and Utrechtse Heuvelrug; see figure 2.3) indications for arable land are scarce. Casparie and Groenman-van Waateringe (1980) noted the difficulty in establishing with certainty whether an area had been used for crop cultivation, but concluded that in general, barrows were seldom constructed on or in the vicinity of arable land then in use.

Research outside the Netherlands has shown that barrows were not often built on arable land. Andersen (1994-95) found indications that mounds in Denmark were often built at sites that were less intensively exploited than areas in the near

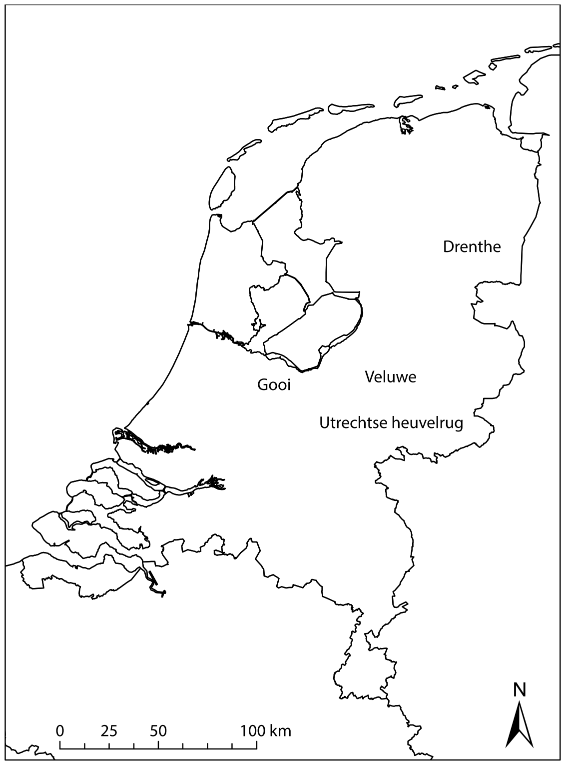


Figure 2.3. The Drenthe, Veluwe, Gooi, and Utrechtse Heuvelrug regions.

vicinity. Pollen spectra from some barrows in the Vroue area, (West Jutland, Denmark) dating to the Middle Neolithic, showed traces of agriculture, but on the whole the pollen spectra from barrows in the Vroue area showed no evidence of agricultural practice. In Thy (West Jutland, Denmark) Andersen concluded that the Early Bronze Age barrows were built in pastureland and that only some of the barrows were built in recently cleared coppice wood that had been used for cereal cultivation prior to the barrow building. Lawson *et al.* suggests that there seems to be a correlation between soils and the distribution of barrows in Norfolk (Southeast England), where barrows were placed on agriculturally poor, light soils (Lawson *et al.* 1981). Altogether there seems to be a preference for building a barrow on a location that had not been used as arable land recently. It has even been suggested that barrows were preferably built on marginal land, so that no (economic) valuable land that could be used for cultivation was wasted (Ovrevik 1990, Field 1998). However, as Downes mentioned, this marginal land might have been very useful for other purposes (boggy ground could have served as source for fuel for example) and not have been as insignificant as assumed (Downes 1994)

Barrows in pastoral zones

The change in the Neolithic to a more agricultural way of living also included the raising of livestock. Farming communities became more and more dependent on livestock to provide meat, dairy products, manure and wool, leather or other raw materials, as well as for pulling ploughs. Livestock needed pasture for grazing, at least for part of the year. They might have been grazing in natural open places in the forest. Groenman–van Waateringe found, however, that a Neolithic farmer had to open up the forest, since woodland composed of less than 30% grasses was not suitable for grazing (Groenman-van Waateringe 1993). Adams also mentioned that forest cover needed to be less than 50% (Adams 1975). Forests were cleared

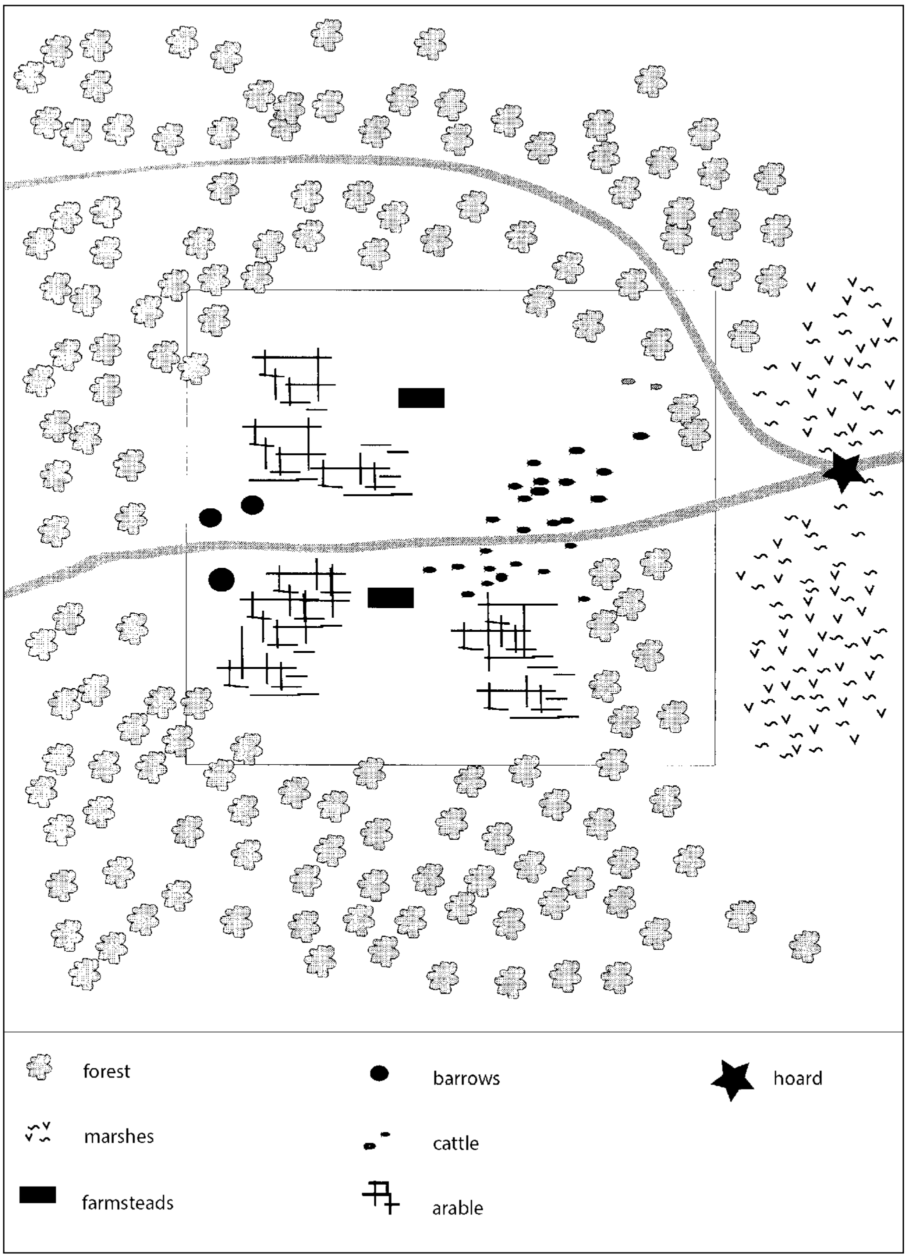


Figure 2.4. It was often assumed that barrows were located close to settlements. This figure shows a schematic drawing of two Bronze Age households, with barrows located at the settlement site. Figure after Fokkens (2005b, figure 20.3A).

for crop cultivation, but possibly also to create grazing areas for cattle. In addition, abandoned fields might have served as pasture (Groenman- van Waateringe *et al.* 1968).

Were spaces that were used as pasture also used to build barrows? Recent new research on the Vorstengraf barrow in North Brabant (see also section 12.1) shows that this barrow was probably built in an open space already present long before the building took place. This open space was covered with heath vegetation during that entire period, which might have lasted for several centuries. De Kort concluded that this heath vegetation had been used as pasture, with probably sheep grazing in the open spot. This might indicate that the barrow cemetery, where besides the Vorstengraf several other barrows are located, was deliberately kept open, while grazing prevented tree species from establishing and forest gradually covering the open place (de Kort 2002). Casparie and Groenman-van

Waateringe (1980) found some indications that barrows were built on pasture land, however, they conclude that it is extremely difficult to determine this with certainty (Casparie and Groenman-van Waateringe 1980).

The practise of mounds construction on pasture land also finds support outside the Netherlands, for example in Orkney (Bunting and Tipping 2001) and Thy, Denmark (Andersen 1996-97). Odgaard reports that two barrows that were built in *Calluna* heathland in Jutland (Denmark), where grazing had probably taken place (Odgaard 1988). Karg concluded that the heathland where the barrows in Skelhøj were built had been used as pasture as a form of heath management (Karg 2008).

Open spaces created for barrow building

There is also the possibility that open spaces were created for the purpose of barrow construction. Some barrows had been constructed in an area where the local vegetation was destroyed by fire shortly before the barrow was constructed. Samples from these barrows consisted almost exclusively of charcoal particles, which may indicate that the area was cleared intentionally before a barrow was constructed. This intentionally burning of the area could have been some kind of ritual activity. However, it may also represent a certain phase in the landnam and have no direct connection to the burial. Casparie and Groenman-van Waateringe (1980) could not find evidence of forest clearance for the purpose of burial of the dead.

Barrows and settlements

It is often assumed that barrows were built close to settlements (see figure 2.4). For the Middle Bronze Age Roymans and Fokkens argued that barrows were constructed in the near vicinity of the houses (Roymans and Fokkens 1991). Barrows were assumed to be family graves and families buried their deceased relatives underneath a barrow close to their settlement. This theory is mainly based on the settlement excavated in Elp, where a Bronze Age barrow and several flat graves were situated close to several houses remains. This cemetery was assumed to be in use by the inhabitants of the settlement (Waterbolk 1964). Bourgeois and Fontijn tested the hypothesis of Roymans and Fokkens by re-analysing the data from the only 15 sites where traces of both houses and barrows dating to the Middle Bronze Age were found in close association (Bourgeois and Fontijn 2008). The houses and barrow of Elp seem to be contemporaneous, which also applies for three other sites Bourgeois and Fontijn analysed. They showed however, that most barrows that were found in Middle Bronze Age settlements were much older than the houses in question, with Elp forming an exception rather than the rule. Middle Bronze Age barrows were not built close to houses, but Middle Bronze Age houses were often built close to already existing barrows, which were then re-used by the residents of the settlement. They emphasize however, that the number of sites that could be used for such analyses is very low and that no firm conclusions can be drawn yet. For the Late Neolithic and Early Bronze Age barrows there is hardly any evidence that they were built close to houses. Casparie and Groenman-van Waateringe (1980) mention some PFB barrows were built on abandoned settlement areas, based on artefact finds. In fact there are very few examples of Late Neolithic and Early Bronze Age settlements, making it difficult to draw any conclusions on the relation between burial mounds and settlements in the Late Neolithic and Early Bronze Age.

On the one hand one could expect that barrows were placed close to a settlement, where one lived close to one's deceased ancestors. On the other hand, the place a burial mound was located in could be seen as a ritual and/or sacred area that would be kept separate from the world of the living.

2.3.3 What was the size of the open spaces barrows were built in?

Barrows were built in open spaces in the forest. It is likely that open spaces in Neolithic times were smaller than in later periods, since prehistoric man created more and more openness in the forest during the Holocene. However, there is not much known about the size of the open places that were used to build burial mounds. Sods were used to construct a burial mound. These sods were most likely taken from the near surroundings of the place where the barrow was planned (Waterbolk 1954, van Zeist 1967a). This suggests a larger open place was necessary than just the size of the barrow. Jonassen concludes that in a forest non arboreal pollen (NAP) shows values of approximately 10%, but that a few hundred metres from the forest values rise up to about 100% NAP. Spectra with NAP of 100-500% could indicate an open landscape in a forested area with forest at a distance of about 1 km (Jonassen 1950, 71-72). Waterbolk (1954) estimated the size of the open space around the Neolithic barrows at a few to tens of hectares. De Kort estimated in his MA-thesis that the size of the open space that was needed to take sods from to build the Vorstengraf barrow in Oss was about 1.5 ha (de Kort 1999; see also Chapter 12).

Conclusions

A large amount of vegetation data of barrows is available, as has been described in the previous paragraphs. The data that informs us on how the barrow landscape looked like is still limited, however, and many questions about the barrow environment remain. The next chapter will be on this subject.

Chapter 3

Barrow research, missing data

3.1 Research questions

The barrows of the Netherlands have been the source for many reconstructions of prehistoric local vegetation. Barrows were built in open spaces, in areas that could have been used for several purposes before the construction of the barrow (see previous chapter). And yet, what the total landscape around the barrow looked like during the barrow's construction, and the history of the area prior to the barrow's erection, represents a great lacuna in the history of barrow research. This lack prompts the first research question:

1. What did a barrow landscape look like and what was the vegetation (history) around barrows?

   Was the origin of the open space (*e.g.* how the open space originated and its original function) influential, affecting the builder's choice on the barrow's setting? Hardly any evidence supports the idea that the barrows were built in areas that were cleared for burial rite activities. The open place that a burial mound was raised in probably had a longer existence as an open space, before becoming the site of a burial mound. It might have been used for crop cultivation or as pasture, or the open space might have served as a settlement location. It has been suggested that the barrow builders had a preference for ancestral grounds, land that has been used by their ancestors. In several cases indications have been found that barrows were built on a location with a history of pasture (see section 2.3.2). This conscious decision, if true, suggests there might be a relation between barrows and pastoral zones. The second research question has been formulated as follows:

2. Were barrows built on ancestral grounds? What is the relationship with pastoral zones?

   In addition to our ignorance on the origin of open spaces, what also is unknown is the size of the open spaces. The size of the open space is important for the understanding of the role of barrows in the landscape, for knowing the size of the open space tells us something about the visibility of the burial mound and the barrow landscape: Were they built in small open spaces with a short distance to the forest, where surrounding forest probably prevented the sight from and towards the mound? Alternatively, were they built in large open areas, so they were well visible from the environment and offered a good view towards the surroundings? In addition, the size tells us about the method by which it was cleared and the energy requirements in maintaining the open space.

3. What was the size of the open space barrows were constructed in and what was the distance to the forest?

   The previous research questions lead to the last research question, concerning the role of barrows in the landscape.

4. What was the role of barrows in the landscape? How can the history of the barrow environment be linked to that of the natural and cultural landscape in the surroundings?

   Since there is a public interest in knowing more about barrows (see Chapter 1), an additional research goal can be appended to the research questions described above:

5. Supplying Staatsbosbeheer and other authorities with advice and suggestions, to aide in reconstructing the original environment around barrows for purposes of tourism.

3.2 Research area

The research area encompasses the southern and central Netherlands (see figure 3.1). This area was chosen for the numerous barrows found there and for the time periods (from the late Neolithic to the Middle Bronze Age [2900-1100 cal BC, see table 2.1]) that are represented by these barrows. Previous excavations in these regions have yielded a lot of data, which will be reconsidered in this research project (Waterbolk 1954, Casparie and Groenman-van Waateringe 1980). In addition, the owners of nature reserves in this region are very interested in the role that barrow research in the development of cultural tourism and adequate heritage management.

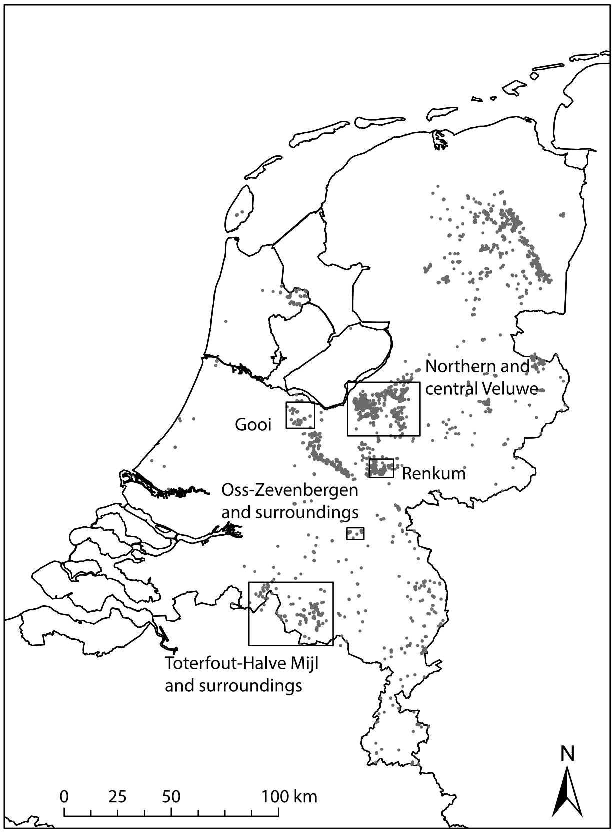


Figure 3.1. An overview of all case-study areas and all known barrows in the Netherlands. Boxes indicate the areas presented in the case-studies. Figure after Bourgeois (2013), figure 1.4.

3.3 Research methods

Below a brief overview is given of the methods used to answer the research questions. The methodology is further discussed in detail in part two of this thesis (Chapters 4-7).

RQ1 and RQ2: What did the barrow landscape look like and were barrows built on ancestral grounds?

Vegetation reconstructions (RQ1) were made using data derived from pollen analyses taken from barrow sites. These environmental reconstructions provide information about the prehistoric land-use that was in practice before and at the time the barrows were built (RQ 2). Extant data sets were explored and reconsidered in five case-studies (Chapters 8-12). To expand the original data sets additional sampling of barrows was undertaken as well (Chapters 8 and 12). In addition to single pollen spectra, pollen diagrams from the soils underneath the barrows were made. From these diagrams vegetation development in the barrow landscapes through time could be reconstructed. Despite possible factors of disturbance (see Chapter 5), buried mineral soils appear to be suitable for pollen analysis, as has been demonstrated by past researches. For example in Harreskov, Jutland, where Odgaard and Rostholm obtained a pollen spectrum from a fossil soil found under a barrow (Odgaard and Rostholm 1987). The diagram showed a clear vegetation development, corresponding to the development shown by a peat diagram. Calibration of these pollen diagrams is necessary to determine the time-depth relation. Until present a calibration value of 10 cm per 300 years was used, defined by Dimbleby, based on a buried soil in Suffolk (East of England; Dimbleby 1985). A calibration based on pollen diagrams of Dutch Pleistocene sandy soils with known age is necessary for this research. The necessity of this calibration is further explained and discussed in Chapter 5. Besides pollen diagrams, single pollen spectra were used to compare the ancient surface data from clusters of barrows of differing ages belonging to one barrow group.

RQ3: What was the minimum size of the open spaces?

Barrows were constructed with sods, probably taken from the immediate vicinity of the barrow. The number and size of these sods that were used to build the barrow can provide information about the minimum size of the open area around the barrow. Pollen data from sods were compared to pollen data from the old surface, to ascertain whether the sods were taken in the immediate surroundings of the barrow (Chapter 7).

The vegetation reconstructions undertaken provide information about the size of the open spot. The ratio of arboreal to non-arboreal pollen was used to estimate the distance of the barrow to the forest edge (Chapter 7). To refine these reconstructions, a recent open area surrounded by forest with known vegetation cover was sampled at increasing distances from the forest border. These pollen spectra were used to calibrate the barrow pollen data.

RQ 4: What was the role of barrows in the landscape?

The answers to research questions 1, 2 and 3 provide the foundation from which RQ 4 can be posed. To understand the role of the barrows in the landscape it is necessary to know what the landscape looked like and what vegetation was present at and around the barrow site prior to and at the time the barrows were built (RQ1). To link the barrow landscape to the natural and cultural surroundings, the origin of the open area, and what it was used for, should be reconstructed (RQ2).

The reconstruction of the size of the open area (RQ3) gives valuable information about the role of barrows in a wider landscape, while providing welcome insights on the visibility and impact of a barrow on its surroundings (chapter 13).

RQ5: Cultural tourism

To reconstruct barrows and their original environments in nature reserves requires a detailed vegetation history of the barrow landscape. The outcomes of this thesis research will provide the owners of these areas with information that they may use to include the barrows in their management and development of the nature reserve areas (Chapter 14).

Part Two

Methodology

The methodology of palynological research can be rather complicated and requires some exposition before palynological results can be interpreted appropriately. The technique of sampling a barrow and its surroundings, and the chemical analysis of the soil samples, is described in Chapter 4. Vegetation reconstruction of the barrow's locale does not follow as a matter of course from the soil samples taken from those barrows. The theory underpinning the palynological research of soil profiles is discussed in Chapter 5. The expression of palynological data in percentages is common to palynology, enabling comparison of different sites and time series with one another. These percentages are fractions of an arbitrarily chosen pollen sum. Which pollen sum will be used in this research and the theory behind this choice is explained in Chapter 6. One of the main research questions concerns the size of the open place a barrow was built in. Chapter 7 discusses three methods that can be used to determine the extent of the open area around a barrow.

Chapter 4

Sampling and treatment of soil samples

4.1 The sampling of barrows

As has been shortly explained in Chapter 2, pollen analysis has been proven to be a good method for reconstructing past barrow landscapes. Pollen grains precipitate onto the surface every year and are more or less evenly distributed in the top soil. Pollen disappears due to corrosion and outwash, but normally there is an equilibrium between the precipitation and disappearance of pollen. Therefore, the pollen grains in de topsoil represent the surrounding present-day regional and local vegetation. After a barrow was built, the surface underneath the barrow with the pollen from the period the barrow was built in, including the previous years' precipitation was sealed from the air (see figure 4.1). New pollen was prevented from precipitating onto the old surface and the corrosion and outwash of the pollen under the barrow was reduced. Analyses of the pollen grains in the old surface underneath a barrow provide information about the vegetation of the barrow's locale before the barrow was built. This principle can been used to reconstruct the landscape around barrows. In the following paragraphs a description will be given of the methodology of the barrow sampling. A more detailed discussion about the preservation of pollen grains in the soil underneath and in barrows is given in Chapter 5.

4.1.1 The sampling of the old surface

The old surface underneath a barrow, *i.e.* the surface people lived on at the time the barrow was built and consequently the surface the pollen grains precipitated on in that period, is often still recognisable as a darker greyish layer in the soil

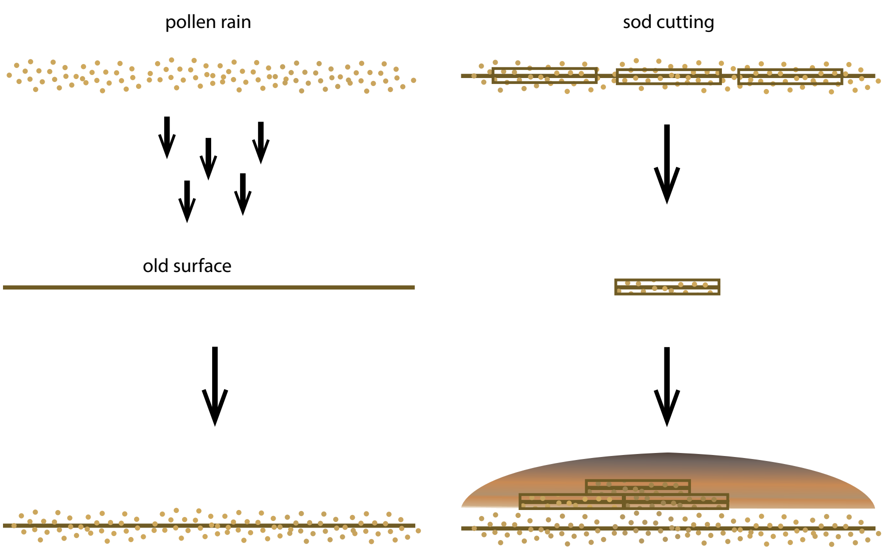


Figure 4.1. A schematic illustration of pollen precipitation and how pollen grains are preserved in the old surface underneath a barrow and in its sods.

a b

Figure 4.2. Two examples of a sod-built barrow with visible sods. The barrow in figure 4.2a is barrow 7 at Oss-Zevenbergen (see chapter 12.1.1). Photograph by Q. Bourgeois. The barrow shown in photograph 4.2b is barrow 2 at the Echoput (see chapter 8.1). Figure by Q. Bourgeois.

profile. Sampling of the old surface can be accomplished by collecting about 10 cm^3 of soil by cutting a piece of soil out of a clean section of the barrow of about 1 cm high, 5 cm broad and 2 cm deep. Care must be taken to sample from the old surface itself and not from the building material above.

4.1.2 The sampling of sods

A barrow is usually constructed of sods (see figure 4.1). Strips of sod of an average width of 10-25 cm were taken from the upper part of the soil and placed upside down when building the barrow. The sod-structure of the barrow is in some cases still visible in a barrow (see figure 4.2). The pollen grains in the old surface of the sods represent the vegetation that was present at the sod location at the time just before they were taken. It is tempting to assume that these sods were taken in the close surroundings of the location where the barrow was built, but comparing the sods' pollen spectra with the old surface's spectra should substantiate such assumptions. Sampling of the sods is possible when they are clearly recognisable in the soil section and should be carried out in the same way as the sampling of the old surface.

4.1.3 The sampling of the soil profile underneath barrows

A new approach in the palynological research of barrows was applied in this investigation: sampling the soil profile underneath the barrow. About 10 cm^3 (height × width × depth ≈ 1×5×2 cm) of soil was collected every centimetre downwards in the soil profile as exposed in a clean section, containing at least the entire A (the old surface), B and as much of the C horizon as possible (see figure 4.3). The series of samples was used to make a pollen diagram representing the vegetation development in the period before the barrow was built. The reliability and value of pollen diagrams from mineral soils underneath a barrow will be discussed in Chapter 5.

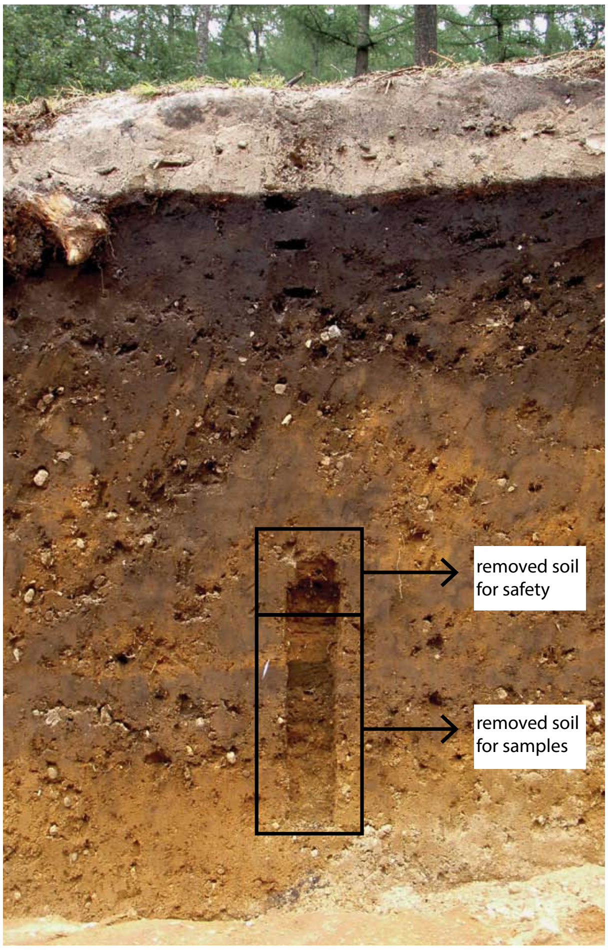


Figure 4.3. The sampling of a soil profile of mound 1 at the Echoput. The top 10 cm is removed to allow for clean pollen sampling. Figure by J.W. de Kort/M. Doorenbosch.

4.1.4 The sampling of ditch fills

Sampling of the old surface underneath a barrow is not always possible as is the case when dealing with an urnfield. In urnfields the cremated body was buried in an urn under a much smaller barrow, usually with a diameter of 4-6 m. A ditch was dug surrounding the urn and the soil material that came from the ditch was put on top of the urn, creating a small barrow. Most of the barrows in urnfields have disappeared, but the ditch is often still recognisable as a darker discolouration in the soil. In this case, given that the old surface is gone, the best option for pollen analysis is to sample the ditch fill.

A similar case is presented by larger barrows levelled in historical times, where circular structures such as ditches, may be the only features left. However, what can be deduced from the pollen spectrum of a ditch fill? This is highly dependent on what happened to the ditch after it was dug. When was the ditch filled and how deep was it? If the ditch was open, pollen could precipitate on the bottom of the ditch. When the ditch was filled, *i.e.* when the bottom of the ditch was buried, the latest pollen precipitation was archived. When the ditch was filled slowly, new pollen could infiltrate again and reach the bottom of the fill easier than when the ditch was filled fast. In addition, the material that filled the ditch contained both older and younger pollen. In all cases the pollen grains at the bottom of the ditch would probably provide the most reliable information about the period that is closest to the period the urn was buried or the barrow was built.

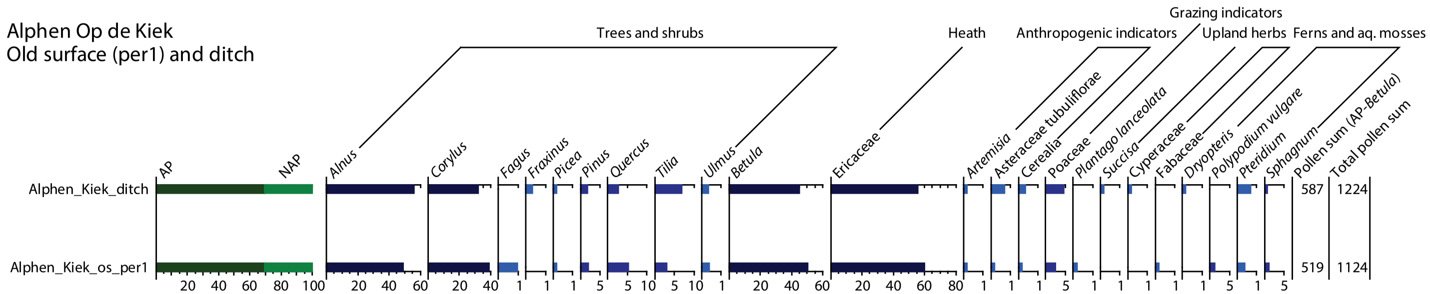


Figure 4.4. Pollen spectra of the 'Op de Kiek' barrow. A spectrum of the old surface and a spectrum of the surrounding ditch are shown. Pollen spectra of the two samples are quite similar. Spectra are given in % based on a tree pollen sum minus Betula pollen. In the total AP (=arboreal pollen) Betula is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.

The reliability of the pollen grains in the ditch fills representing the 'urn/ barrow period' has been confirmed by several investigations. Bakels for example compared the pollen composition of ditch fills with control samples, taken from the undisturbed subsoil next to the ditches and taken from the soil on top of the ditches (Bakels 1975). The control samples from the undisturbed subsoil did not contain any pollen, making it unlikely that older pollen that was already present in the subsoil (the material the ditch was filled with) influenced the pollen composition of the ditch fill. The control samples from the soil above the ditch showed a different and younger pollen composition than the ditch fill, indicating that infiltration of younger pollen from above is negligible. In addition, ^{14}C dates from the ditches were in agreement with the age indicated by the pollen composition of the ditch fill.

Another example is given by Casparie and Groenman-van Waateringe (1980). This example concerns the ditch around barrows from the Middle Bronze Age period ("Alphen Op De Kiek"). Samples were taken from both the old surface and the ditch fill. Pollen spectra of the two samples are quite similar (see figure 4.4), indicating that they indeed represent the same period, the period the barrow was built.

4.1.5 The sampling of posthole fills

Another rather new approach was applied by taking samples from the filling of postholes found in the neighbourhood of barrows. In figure 4.5 a hypothesis is described to explain the pollen spectrum derived from such a posthole fill and how it would be interpreted. Before the post was placed a surface was present where pollen grains could precipitate on. Pollen could infiltrate into the soil and pollen stratification, as has been described in section 4.1.3 and Chapter 5, could be the result. When the post was going to be placed a hole was dug into this soil. The soil material coming out of the hole contains the pollen grains that were previously present in these stratigraphic layers, now mixed up, representing different times of periods before the hole was dug. The post was placed into the soil and it is very likely that the remaining hole was filled with the soil material that came out of the hole in the first place. This soil material contains a mixture of pollen grains. The soil next to the post continued to develop, with new pollen precipitating on and infiltrating into the soil. In time, the length of which is usually unknown, the post will decay or be pulled out. A post could have decayed due to the attack of soil fauna and fungi. When a post has decayed the part of the post that was below surface would have been slowly filled up with mostly material from above. Sediment from above would probably have filled the spaces that emerged due to the decay since the soil will most likely collapse a little. Younger pollen could infiltrate into the soil with this incoming sediment. In addition younger pollen probably has infiltrated with the micro-organisms that were responsible for the decay. The postpipe will still be visible as a darker coloration in the soil. The sediments of which this postpipe consists will most likely now contain a mixture of pollen that mostly represents the period when the post was subject of decay. With the post decayed, soil development can now also take place from the surface downwards at the location the post was placed. New pollen precipitates also on this location and will be transported downwards. However, when the postpipe itself is still clearly visible in the soil profile, most likely some distance below the surface as a darker coloration of the soil, it is probable that the soil development has not reached this depth yet. Assuming that the transportation of pollen grains downwards into the soil is correlated to the soil development (as will be discussed in Chapter 5), it is also likely that newly precipitated pollen grains (*i.e.* pollen

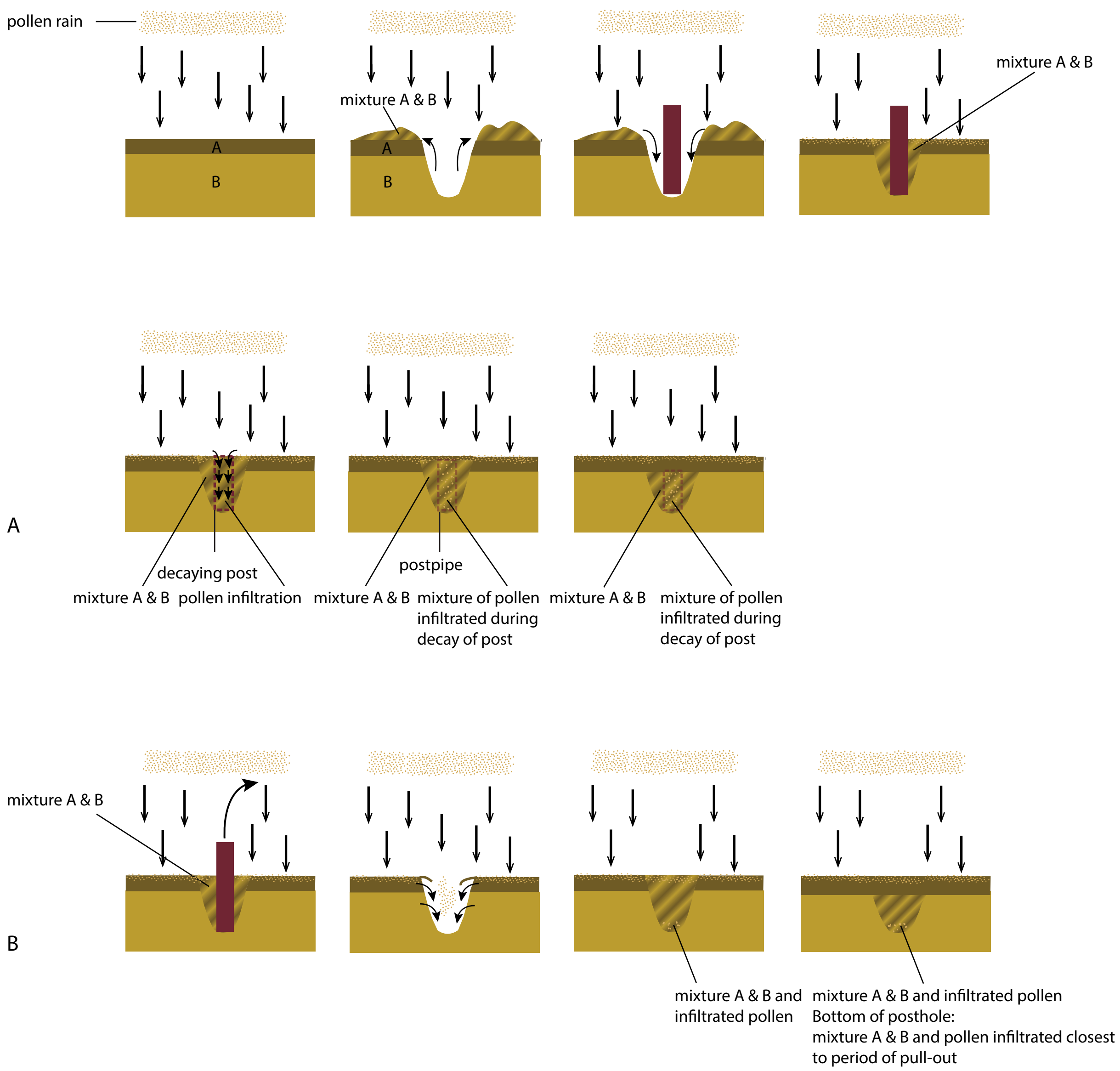


Figure 4.5. An illustration that shows the theory of pollen distribution in postpipes and posthole fills. A: decaying of the post. B: pulling out of the post.

grains that precipitated on the surface since the post had disappeared) did not reach this depth yet. A sample that is taken in the centre at the bottom of this clearly visible postpipe contains then pollen grains that were present during the decay of the post. The pollen spectrum would then represent a mixture of time periods, but only (or at least mostly) from the time after the post was placed, when it was subject to decay, until the post had completely decayed. A possible dating based on the pollen spectrum would give a *terminus post quem* date.

When a post had been pulled out of the soil a hole was left behind. It is likely that the hole collapsed and that sediment from the sides and from above filled up at least part of the hole. The filling of this hole now contains pollen that is mixture of pollen that was originally present in the posthole-fill (older than the pulling out of the post) and younger pollen that precipitated on the soil after the post was placed. The situation is now comparable to when a ditch was dug (see section 4.1.4). When the post was immediately backfilled, the latest pollen precipitation was archived underneath. When the posthole was filled slowly, new pollen could infiltrate again and rejuvenate the pollen spectrum more easily than when the posthole was filled fast. When a post has been pulled out, the place where the post was present can often not be distinguished from the original post hole in which the post was placed. Pollen grains at the centre of the bottom of the post hole will probably provide information about the period that is closest to the period that the post was pulled out. An example of sampling posthole fills and the interpretation of their pollen spectra will be discussed in section 8.1.

Based on the hypothesis above it is best to take samples from the centre of the bottom of the postpipe or from the centre of the bottom of the posthole fill, providing a *terminus ante quem* date for the placing of the post.

4.2 Chemical treatment and analysis of palynological soil samples

Pollen was extracted by adding potassium hydroxide (KOH) to 1 cm^3 of the sediments to remove humic acids. To every sample one to five *Lycopodium* tablets were added as a marker, in case pollen concentrations need to be calculated. Heavy liquid separation, using a mixture of bromoform ($CHBr_3$) and alcohol with a specific gravity of 2.0, was performed to separate the inorganic material from the organic material. Finally the samples were acetolysed with a mixture of sulphuric acid (H_2SO_4) and acetic anhydride, to remove the large plant remains. Grains were identified with the aid of the keys of Beug (2004), Faegri and Iversen (Faegri and Iversen 1989), Moore *et al.* (1991), Punt *et al.* (1976, 1980, 1981, 1984, 1988, 1991, 1995, 2003, 2007, 2009) supplemented by Reille (1992, 1995, 1998), several lists set up by van Geel (van Hoeve and Hendrikse 1998) and the reference collection of the Faculty of Archaeology of Leiden University. The spectra were calculated using a pollen sum of ∑AP–*Betula* (Van Zeist 1967a). A minimum of 300 arboreal pollen grains (excluding *Betula*) per sample were counted. For more information about the pollen sum see section 4.3. Pollen spectra and diagrams have all been plotted with the Tilia software, version 1.7.16 (Grimm 1992).

Chapter 5

The palynology of mineral soil profiles

5.1 The theory behind the palynology of mineral soils

Pollen grains are very resistant to decay and often well preserved across a range of circumstances. They can, however, be subject to degradation. Pollen is best preserved under waterlogged (anaerobic) conditions. In aerobic conditions pollen grains oxidize, causing thinning of the sporopollenin wall of the grains (Havinga 1964). Besides oxidation, the degradation of pollen by biological activity such as bacterial attack is probably at issue under aerobic conditions (Havinga 1967, 1984). In addition, pollen can be mechanically damaged during transport (Holloway 1989). When pollen grains have precipitated on the surface of a mineral soil, and hence under aerobic circumstances, they will be subject to corrosion and they will wash away (outwash). However, there will be an equilibrium between the disappearance of pollen grains due to corrosion or outwash and the supply of pollen to the surface. In addition pollen grains are incorporated into the faeces of the soil fauna that is responsible for the decomposition of the litter layer on the soil (van Mourik 2003; this process of incorporation will be discussed in detail in the following paragraphs). Faeces provide good conditions for preservation of pollen grains. As a consequence the top soil will contain an assemblage of pollen grains that represents the surrounding vegetation. After construction of a barrow the surface containing this pollen assemblage has been covered and protected from the air, reducing microbiological activity and thus corrosion of the pollen grains. In addition, the outwash of pollen has been diminished. Therefore, the construction of a barrow provides good circumstances for preservation of the pollen grains in the top soil underneath a barrow that had been precipitated on the surface shortly before the barrow was built. This allows for reconstructing the vegetation of the barrow building period by sampling the old surface underneath and the sods from the barrow as has been described in sections 4.1.1 and 4.1.2.

As explained in section 4.1.3, a pollen sequence can be extracted from the soil profile underneath a barrow providing a pollen diagram that shows a vegetation development from the period before the barrow was built. Ideally pollen diagrams are derived from samples taken from peat or lake sediments. The formation of peat and lake sediments is well known. Both peat and lake sediments are formed by accumulation processes. Peat is formed by the accumulation of partially decayed vegetation matter. Organic materials can accumulate when the production of biomass is greater than its chemical breakdown. Lake sediments consist of accumulated organic and inorganic material, forming layers containing an environmental archive. In both peat and lake sediment pollen was caught in each layer. There is hardly any vertical movement of material and therefore pollen from the lower layers represents the oldest vegetation. The anaerobic condition found in both peat and lake sediment enable good preservation of pollen grains, in contrast to mineral soils. Mineral soils do, however, often show a pollen stratigraphy. Several investigations have shown that mineral soil pollen grains can provide a vegetation history (Havinga 1963, Munaut 1967, Dijkstra and van

Mourik 1995, van Mourik 2003). Van Zeist (1967) published a mineral soil pollen diagram with a clear vegetation development that generally corresponded to the known vegetation history of the Netherlands, which was reconstructed from peat pollen analysis. The value of mineral soil diagrams has been the subject of much discussion. This discussion has mainly revolved around two issues: the conservation of pollen grains in a mineral soil, and the distribution of pollen grains in a mineral soil. Does pollen show a real stratigraphic organization and can they be used to reconstruct a vegetation development? Several theories have been suggested about the processes taking place in a mineral soil that influence the distribution of pollen in the soil and their possible stratigraphy. It was thought for some time that a similar process of accumulation like in peat and lakes also took place in mineral soils (Beijerinck 1933, Benrath and Jonas 1937, Florschütz 1941). However, Dimbleby (1952, 1957, 1961) and Havinga (1962) concluded that processes of sand accumulation by drifting or by soil fauna are of minimal significance for the development of pollen stratigraphy, since the pollen concentration decreased significantly with depth. Munaut similarly disagreed with the theory, showing in his thesis that most Pleistocene cover sands do not contain contemporary pollen from this period and pollen grains from other periods must have infiltrated into these layers (Munaut 1967, 136-137). There is indeed an influx of organic material in mineral soils, but it are soil forming processes and not accumulation processes that cause decomposition and transportation of pollen material deeper into the soil. Other theories involved the infiltration of pollen into the soil as the underlying process that causes pollen distribution in the soil.

Mothes, Arnoldt and Redman thought percolating water to be the cause of pollen grain infiltration into the soil (Mothes *et al.* 1937). Their experiments showed a selective penetration of pollen grains, with large pollen grains such as *Pinus* being transported much more slowly than smaller pollen grains such as *Quercus*. Mothes *et al.*'s conclusions are discussable, since their laboratory situation was not adequately representative of natural conditions. According to Munaut (1967, 138) they ignore the influence of organic material in the soil. He states that pollen grains are incorporated into aggregates of organic material and very fine mineral particles, causing pollen grains not being able to move around freely in between the soil particles. In addition, Munaut showed that the infiltration speed differed between sites with comparable soil types, which should not be the case when percolating water had been responsible for this (Munaut 1967, 138-139). Firbas *et al.* and Trautman considered percolating water as cause for selective infiltration of pollen into the soil as well (Firbas *et al.* 1939, Trautmann 1952). However, Munaut found no examples of the expected high concentration of small pollen grains at the lowest parts of the soil and has mentioned that the differences in the diagrams these authors based their conclusions on, could very well be the result of differences in local vegetation (Munaut 1967, 144-145).

Havinga, like Munaut, disagreed with the theories of percolating water being the main cause of pollen distribution into the soil (Havinga 1962). In his thesis he explained the distribution of pollen grains into the soil by intense biological activity during the homogenization phase preceding soil formation, especially podsolization. Pollen are incorporated in the faeces of burrowing animals such as earthworms and transported into the soil by these animals. A mixture of older and recently precipitated pollen grains is the result. During this phase pollen grains disappear due to corrosion and the pollen assemblage is constantly rejuvenated. During the podsolization phase the homogenization depth decreases due to decrease of biological activity and pollen below this homogenization depth was preserved (see figure 5.1). At the top the process of rejuvenation of the pollen assemblage continues and a pollen profile with at the bottom older and at the top

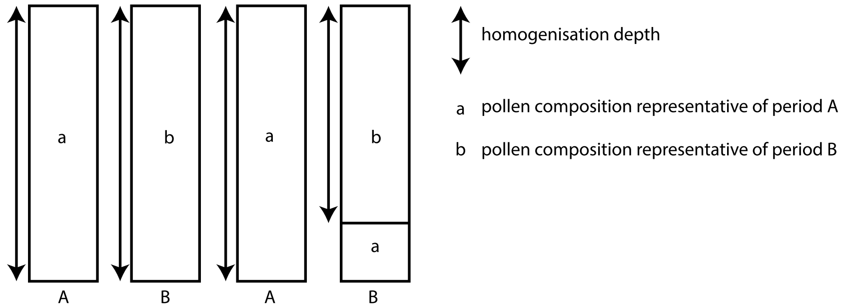


Figure 5.1. The change of a pollen profile under the influence of homogenisation. On the left: the homogenisation depth is the same during period B as during the preceding period A. On the right: the homogenisation depth is less during period B than during period A. The pollen composition a represents the vegetation during the older period A, while the pollen composition b represents the vegetation during the younger period B. Figure after Havinga (1962, figure 4).

younger pollen assemblages evolves. This means that during the homogenization phase and cases of incipient soil formation a homogenous pollen assemblage is present, showing a similar vegetation pattern in the top as well as deeper in the soil.

Havinga also discussed selective corrosion of pollen grains in mineral soils. Selective corrosion could be responsible for changes in a pollen profile, mistakenly interpreted as changes in vegetation. Selective corrosion would more easily take place in sandy soils than in peat. Based on differences between pollen diagrams of a mineral soil and a peat bog Havinga concluded that *Quercus* pollen is largely destroyed in sand under dry conditions (Havinga 1962, 70-76), but these differences could also have been the result of local vegetation differences, caused by edaphic differences between the soil types (Munaut 1967, 145). Havinga showed that pollen grains that have been oxidized are more easily destroyed by subsequent microbial attack (Havinga 1964). Later on, Havinga tested selective oxidation in a laboratory situation, showing a relation between corrosion by oxidation and the amount of sporopollenin in a pollen grain (Havinga 1967, 1984). This implies that some pollen grains are more susceptible to oxidation hence corrosion than other pollen grains, causing selective corrosion. Havinga emphasises that his investigations were not carried out under perfectly natural conditions. However, differences in susceptibility for corrosion should be accounted for when interpreting pollen spectra from mineral soils.

Munaut (1967) agreed with Havinga that the depth of infiltration of pollen grains into the soil is related to the depth of homogenization by biological activity. However, he found no homogenous pollen profiles as described by the theory of Havinga, not even in little developed soils. He also found sharp transitions from one to another pollen association (Munaut 1967, 141). The research of Munaut also showed that in less developed soils, those with high biological activity, the infiltration speed of pollen is higher and the disappearance of older pollen spectra by microbial attacks is more pronounced. Despite this, Munaut concluded that biological activity is not the only driving mechanism behind the pollen distribution. He assumed that the most likely explanation is a combination of both percolating water and biological activity being responsible for the distribution of pollen in the soil (Munaut 1967, 141-142), as was suggested by Erdtman (1943). Munaut concluded that percolating water could be primarily responsible for the depth of pollen distribution, but that the biological activity is probably responsible for the activation, delay and stop of this process. Pollen grains are incorporated into organic aggregates by soil fauna and thereby fixed at a certain level in the soil. When a pollen grain is freed from its organic aggregate by microbial attack it can be transported deeper into the soil by percolating water and decomposed or re-incorporated again. According to Munaut this explains the higher infiltration speed and shorter vegetation history in less developed soils, where humic complexes are less stable and easier to decompose by microbial attack. However, Guillet states that soil infiltrating water could not be responsible for pollen transport because pollen grains have hydrophobic properties and their mean grain size does not allow vertical transport in single grain conditions through soil pores (Guillet 1970). Van Mourik (1985, 1986) continued the discussion about pollen infiltration and conservation in mineral soils (van Mourik 1985, 1986). He studied pollen and spores micromorphologically in thin sections from several mineral soils. Like Havinga, he concluded that the distribution of pollen in various mineral soils is directly correlated with the distribution of soil fauna activity. Pollen grains incorporated into faunal excrements, were protected from decay. Van Mourik did not find free pollen grains in the pores of the soil, as would be expected if transport by percolating water, as suggested by Munaut, had taken place. In addition van Mourik differentiated syn-sedimentary and post-sedimentary pollen; syn-sedimentary pollen being present in the sediment when deposited and post-sedimentary pollen being that which is brought into the sediment by soil fauna during soil formation, both being present in excrement. Syn-sedimentary pollen would be present in a constant concentration throughout the sediment and give information about the vegetation present at the time of sediment deposition, while post-sedimentary pollen would decrease in concentration with depth and give information about the vegetation present at the time of soil formation. This could be much later then the time of deposition. They can be differentiated from each other because excrement containing syn-sedimentary pollen is randomly distributed in the matrix, while the excrement containing post-sedimentary pollen is mainly concentrated in burrow [1]channels. A good interpretation of mineral soil pollen diagrams makes the distinction between syn- and post-sedimentary pollen.

The topic of distribution and conservation of pollen grains in a mineral soil has also been the focus of recent studies. Davidson concluded that the activity of soil fauna, mainly earthworms, is an important factor in the redistribution of pollen (Davidson *et al.* 1999). Pollen that has been precipitated on the soil surface is consumed, digested and excreted by soil fauna. He claimed that the depth of incorporation of the pollen grains is dependent on the depth of the soil fauna activity. However, he also stated that the result is a mix-age pollen assemblage and that age-stratification of pollen assemblages is only possible in the top surface organic horizon of a podzol or soils with accumulating organic horizons like peaty soils. Van Mourik showed that the vegetation development from heathland to closed (planted pine) forest was recorded in pollen assemblages in undisturbed acid soil profiles that had developed underneath the forest at several locations in the Netherlands (Dijkstra and van Mourik 1995, Dijkstra and van Mourik 1996, van Mourik 2003). These soils could develop after plantation of a pine forest on a former heath area. Pollen zonation was already visible in the organic top layer (F, H and A horizons, see figure 5.2) of the soil. The pollen content of terrestrial humic soils like these is post-sedimentary (van Mourik 2001), meaning that the pollen assemblage represents the vegetation that was present during the development of these soils, since they infiltrated into the soil during this process. Micromorphological observations of thin sections from these soils revealed that when pollen grains precipitated on the surface, they were incorporated in excrements from soil fauna in the upper part of the F horizon. The pollen grains were then released again in the lower part of the F horizon and the H and A horizons. Then they were reincorporated again in small excrements of soil fauna. These excrements, which are very stable and are only slowly decomposed by

1 Soil fauna burrows channels while moving through the soil leaving their excrements behind in these channels.

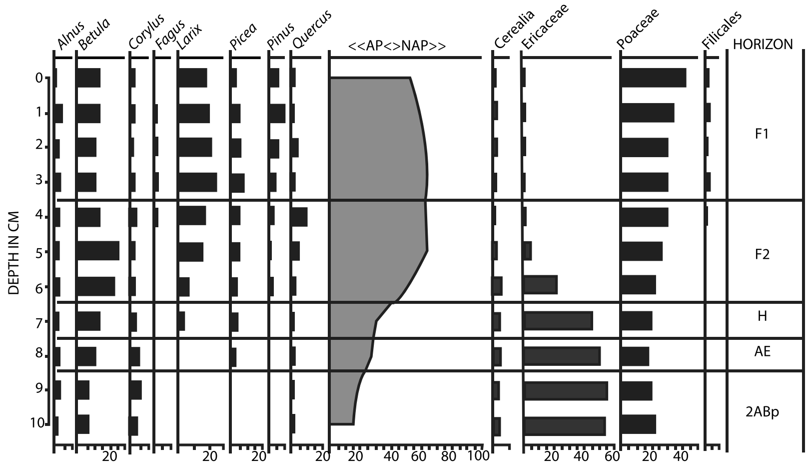


Figure 5.2. Pollen diagram from a micropodzol that had developed underneath a Larix forest. Incipient pollen zonation is visible in the top organic layer (F, H, AE and AB horizons). Figure after van Mourik (2001).

fungal attack, preserved good conservation conditions for pollen grains. Pollen grains that were not reincorporated were destroyed by microbial consumption (van Mourik 2003). When soil-mixing animals were absent a pollen stratification representing the vegetation development was present. In layers where soil-mixing animals were present pollen were easier oxidized and the pollen distribution was more even throughout the soil layer (Dijkstra and van Mourik 1996). Pollen grains are transported deeper into the soil, into the B-horizon or even the C-horizon by the activity of soil fauna like earthworms. Since they show a retrogressive activity during the soil formation the oldest pollen assemblages will be found at the lowest parts (van Mourik 1999).

How can this principle of mineral soil pollen palynology be used in the palynological research of barrows? During pedogenesis pollen grains are transported deeper into the soil. However, this process is interrupted when the soil was covered by a burial mound and the soil was well preserved until excavation. The soil profile that had developed before the barrow was built is often still recognizable. This indicates that after the construction of the barrow the soil profile had not or hardly been disturbed. This furthermore indicates that the pollen profile that was present in the soil before the barrow was built was also preserved. When a barrow was built the soil was sealed away from outside influences. As a consequence, biological activity decreased, creating a more stable environment for pollen conservation and preventing homogenization of the soil that would consequently disturb the soil profile. In addition, the barrow also prevented pollen from precipitating on the soil. Podzols found underneath barrows have often developed in the top of Pleistocene cover sands. These sediments were originally free from pollen (Koster 1978), so the pollen content of the soil underneath barrows is mainly post-sedimentary (van Mourik 2001). This means that pollen infiltrated into the soil during pedogenesis. Infiltration of younger pollen grains into the soil can alter the composition of the pollen assemblage and as a consequence the interpretation on which the vegetation reconstruction is based. It is likely that there is a mix of pollen grains of different ages in each zone, but it is also likely that the majority of the youngest pollen grains will be in the top the soil and the deeper into the soil the higher the average age of the pollen grains will be.

In conclusion, based on the results of previous investigations described above it seems to be possible to read a rough vegetation history from a mineral soil pollen diagram from underneath a barrow, however, with the usual caveats.

5.2 The time represented in a mineral soil pollen diagram

What stretch of time is represented in pollen diagrams derived from mineral soils is important for dating and linking a vegetation development to a certain period. The duration of the downward movement of pollen in the soil indicates the period that is represented in a mineral soil pollen diagram. For the most part, it is not possible to date the soil using dating techniques like ^{14}C or OSL (optically stimulated luminescence). It has been suggested, however, that the infiltration speed of pollen grains into the soil can be generalised. Dimbleby (1985) suggested that the average rate of downward movement of pollen in a mineral soil is about 10 cm in 300 years. Although he stated that this rate could vary according to prevailing pedological conditions, this average rate is still often used in the interpretations of mineral soil pollen diagrams (Groenman- van Waateringe 1986, de Kort 2002). As has been explained in the previous paragraph, the downward movement is dependent on the activity of the soil fauna, which is active during pedogenesis. The speed at which soil fauna moves through the soil distributing the pollen grains incorporated in their excrements is highly dependent on several factors such as the hydrology, the acidity, and compaction of the soil. As a consequence it is highly unlikely that the speed at which soil fauna distributes pollen grains into the soil is similar across different locations. The 300 years in 10 cm Dimbleby found may very well have been true in that particular situation, this cannot however be applied to every mineral soil. A few examples now follow of cases that contradict 10 cm/300 years downward rate of pollen in mineral soils.

Example 1: The Laarder Wasmeren area

That the formation of a podzol is a complex process and can differentiate even in a small area can be seen in the Laarder Wasmeren (LWM) area. The Laarder Wasmeren area is a nature reserve in the Netherlands (see figure 5.3). The area had been used to discharge waste water in the 20th century, polluting the area with heavy metals and toxic organic compounds. In 2003, remediation of the area

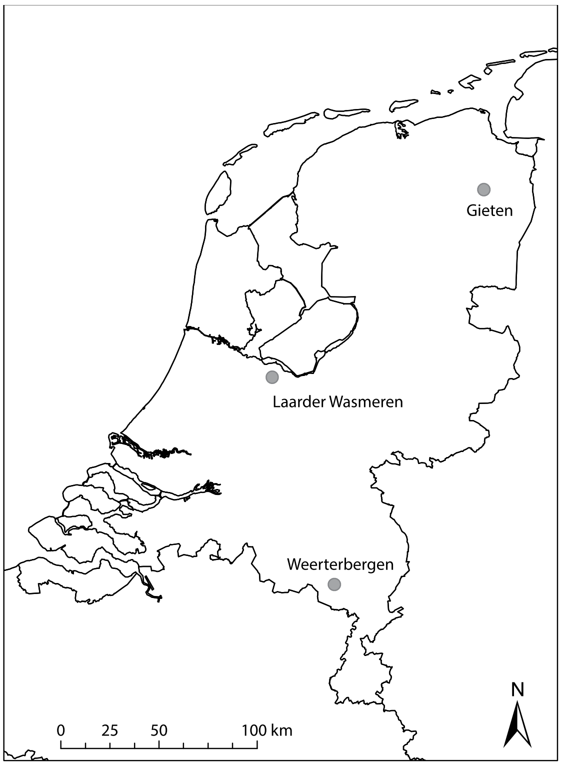


Figure 5.3. Location of the nature reserve area Laarder Wasmeren, Weerterbergen and Gieten.

started by ending the discharge and thus draining the area, and subsequent removal of polluted sludge and soil. Underneath this soil a Holocene drift sand landscape was discovered. The complex stratigraphy and genesis of this landscape, with four drift sand phases, two lacustrine phases and five phases of soil formation, was studied in detail by Sevink *et al.* (in press) who investigated several representative soil profiles in the area. The soil profiles showed three or four podzols on top of each other separated by layers of drift sand. Every time, during a period with stable conditions, soil formation led to the development of a podzol, which was buried under drift sand during the next phase of landscape instability. During the stable phase, the local vegetation caused a constant precipitation of pollen grains on the soil surface. Over time these pollen grains were transported deeper into the soil by soil fauna as has been explained above. Due to unstable conditions that probably resulted from land use impacts, vegetation would become scarce and under the influence of wind the topsoil of bare surfaces was blown away. When the surface of the LWM area was being covered by sand, pedogenesis and pollen distribution in the soil stopped. When circumstances were stable again vegetation could establish itself on the newly deposited sand and pedogenesis and pollen transportation could take place again. The pollen spectra that are recorded in a buried soil thus represent the vegetation history of the stable period until the surface was being covered. Likewise, pollen spectra from the soil underneath a barrow represent the vegetation history of the landscape in the period before the barrow was built. The duration of this period is dependent on the time the soil had to develop. The buried soils in the LWM area, unlike the soil underneath barrows, could be dated. This was accomplished by taking OSL samples. The various phases that formed this landscape could be dated providing information about the length of the period that is represented by the pollen record in which a certain vegetation development has taken place. In addition all major soil profiles have been sampled for pollen analysis. Monoliths were taken from the profiles and from these monoliths every second centimetre a sample of 1 cm was taken for analysis. For an exact overview of the site, sample locations and methods of preparation see Sevink *et al.* (in press). Prepared slides were provided by van Geel to the author of this thesis for pollen analysis. For this research two profiles have been selected to analyse. Profile II and Profile V consist of respectively four and three podzol soils on top of each other.

Based on the OSL dates a reconstruction of soil formation and drift sand phases in time could be made. For a detailed discussion see Sevink *et al.* (in press). A summary of these results is shown in figure 5.4. Profile II consists of four podzols. The first phase of soil formation (S1) has taken place in Pleistocene cover sand, deposited around 11500 years BP. A drift sand phase took place broadly between 6500-8500 years BP, which means that the development of S1 could have taken 3000-5000 years. In the drift sand layer D1 a second soil (S2) could develop. This soil was covered by a new drift sand layer approximately around 5800-6400 years BP, after which the development of S2 stopped. This indicates that the time span S2 represents has a length of approximately 100-2400 years. According to Sevink *et al.* (in press) the soil phase S2 was probably rather short (a few hundred years), based on the poor development of the podzol.

The second drift sand period started around 5800-6400 years BP. In this sand layer, S3 developed until it was covered by a third sand layer (D3). D3 was deposited between approximately 4800-5300 years ago. This leaves 500-1600 years for soil phase S3. A fourth podzol (S4) could develop in D3 until it was covered by another, more regional phase of aeolian activity (D4), which dates from the Late Middle Ages or even more recent. However, D4 is missing in LWM

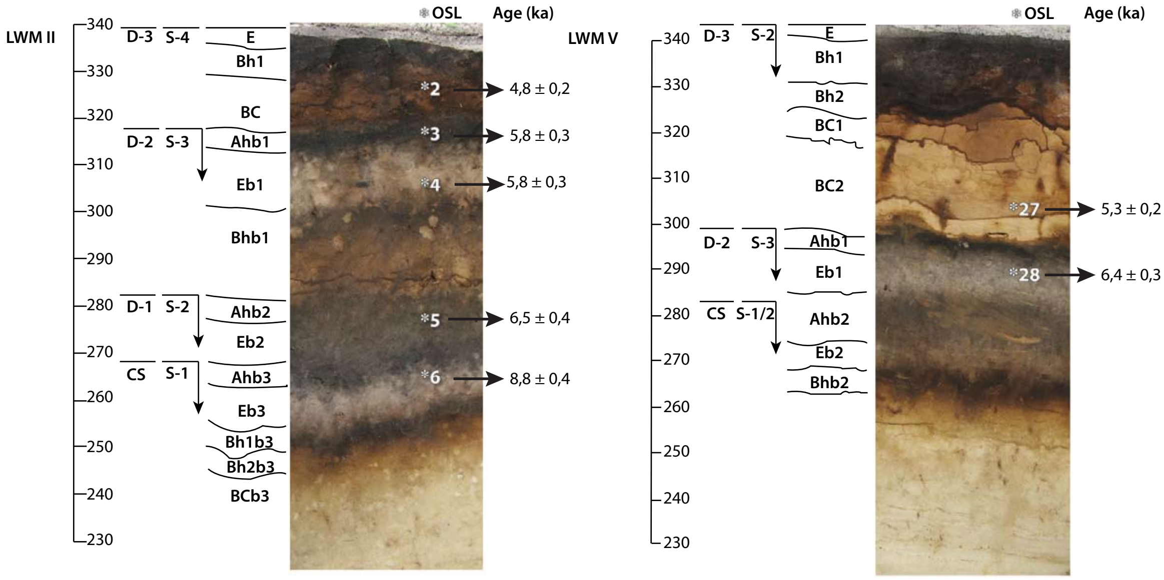


Figure 5.4. Cross sections of the Laarder Wasmeren II and V profiles with the according soil formation and drift sand periods. The location of the samples for OSL dating have been indicated with the corresponding OSL dates (see also figure 5.6). Figure after Sevink et al., in press., figure 5 and 7.

II and hence information about the exact time span of S4 in LWM II is lacking. Profile IV consists of 3 podzols. In this profile S1 and S2 have merged together, representing a period of about 3100-7400 years. The results of the pollen analysis are shown in figure 5.5a and 5b. The vegetation development shown by the pollen diagram will be discussed in detail in section 10.2. Since both profiles are situated close together and both represent the same soil development phases they would be expected to be identical. The vegetation development shown by the pollen diagrams derived from the two profiles is indeed similar. However, the time represented per centimetre in each profile is not alike (see figure 5.6 and table 5.1). S3 in profile II and V represent the same period of time (500-1600 years), but the thickness of S3 in profile II is 27.5 cm, while only 14 cm in profile V. The Dimbleby factor of 30 years per centimetre could be applicable to profile II (this would indicate that soil phase S3 would have taken around 825 years), but not to profile V. When applying the Dimbleby-factor to profile V, the middle podzol would have been estimated to represent about 400 years, while according to the reconstruction by Sevink *et al*. this podzol represents about 500-1200 years (Sevink *et al.* in press.). Koster (2005) has argued that the rate of pedogenesis in drift sands is highly dependent on the origin of the drift sand. Drift sand can consist of former A and E horizon material (like S2), in which a new podzol can form relatively fast. When the deposited sand originally was C material, development of a podzol is a much slower process (like S3 and S4).

Profile LWM, soil phases		Estimated time per soil fase based on OSL (yr)	Thickness of deposit (cm)	Estimated year/cm
LWM-II-4	S4 in D3	?	25-0 cm	
LWM-II-3	S3 in D2	500-1600	52,5-25 cm	18-58
LWM-II-2	S2 in D1	100-2400	66-52,5 cm	7.4-177
	S1 in coversand	3000-5000	x-66 cm	
LWM-II-1				
LWM-V-4	S4 in D3	?	43-0 cm	
LWM-V-2	S3 in D2	500-1600	57-43 cm	36-114
LWM-V-1/2	S1/2 in coversand/D1	3100-8000	x-57 cm	

Table 5.1. The estimated time that is represented per centimetre in every soil phase of Laarder Wasmeren II and V.

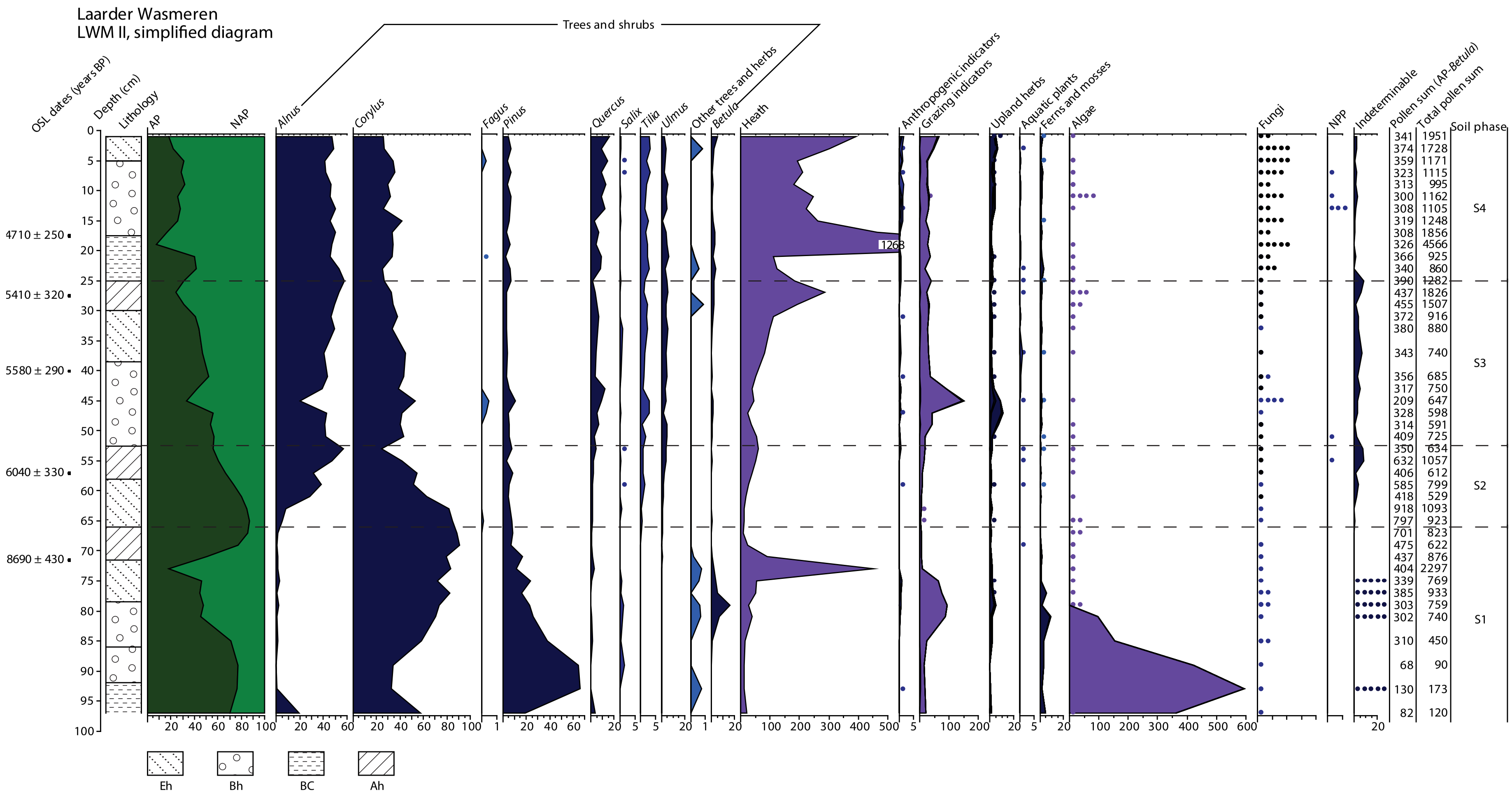


Figure 5.5a: LWM II.

Figure 5.5a-b (this page and next page). Simplified pollen diagrams of the Laarder Wasmeren. Spectra are given in % based on a tree pollen sum minus Betula pollen. In the total AP (=arboreal pollen) Betula is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.

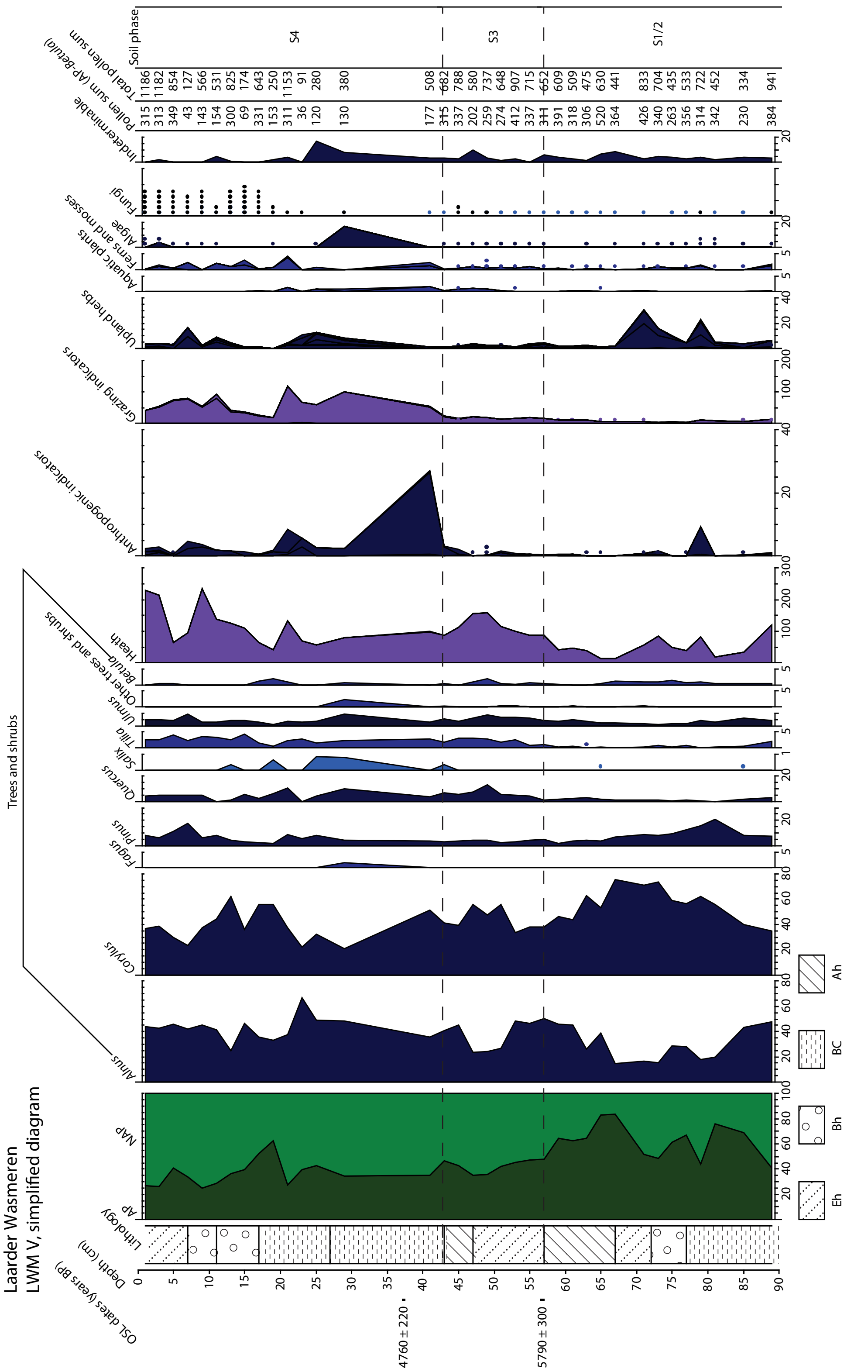


Figure 5.5b: LWM V.

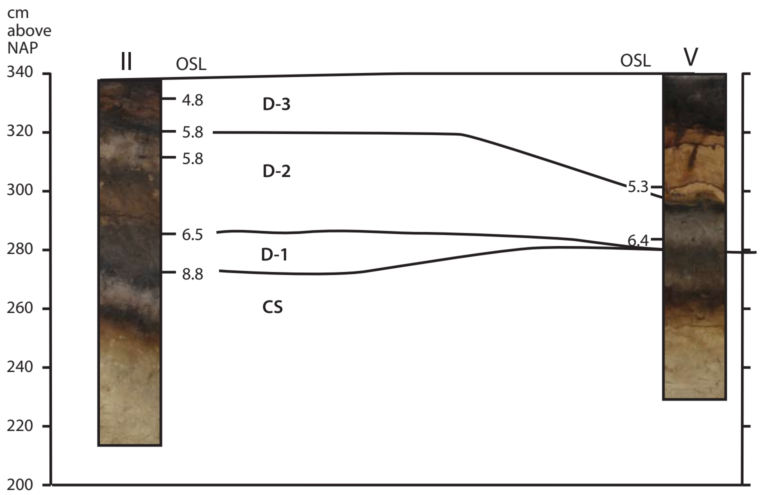


Figure 5.6. Cross sections of LWM II and V with profiles, phases and OSL datings. Figure after Sevink et al., in press., figure 2A.

Example 2: Gieten

A 70 year old forest soil in the forestry of Gieten (the Netherlands, see figure 5.3) was investigated by van Mourik (van Mourik 2003). The age of the soil is known because a former heath area (originally formed on Pleistocene cover sand) which had been used for sod taking, had been deeply ploughed to prepare 'fresh' parent material after which the area had been reforested around 1930. After plantation of *Larix* and *Fagus* trees a forest soil started to develop. This forest soil is described by van Mourik as 'micropodzol' with well-developed humus forms (mormoders). At the time of the investigation the soil formation had reached a depth of 10 centimetres. During the formation of this soil pollen grains had been distributed in this soil by the soil fauna by processes of incorporation, release and reincorporation into faeces as has been described in the previous paragraph. The soil profile was palynologically investigated and showed the vegetation development since the reforestation. With an age of 70 years and a decimetre in depth it is implied that every cm of soil represents an average of 7 years.

Example 3: Weerterbergen

In another study van Mourik *et al.* (2010, 2012a) investigated a polycyclic Holocene soil-drift sand sequence near Weerterbergen (the Netherlands, see figure 5.3). The investigated profile shows a sequence of four phases with drift sand deposits in which podzols had developed. Two nearly identical profiles are involved in this research. In 2002 a profile was sampled for OSL dating. The OSL ages were used to compare the different soil phases and the time they represent (see table 5.2). The youngest soil formation phase shows an average of 18 yr/cm, while the next two phases respectively show 16.7, 75 and 266 yr/cm. Once again, these data differ from the Dimbleby-factor as well.

Table 5.2. The OSL dates of the Weerterbergen profile and the according estimated time that is represented per centimetre in every soil phase (based on van Mourik et al. 2010, 2012a and van Mourik pers.comm., September 2013)

Profile Weerterbergen, soil formation phases	Estimated time per soil formation phase based on OSL	Thickness of soil phase (cm)	Estimated year/cm based on OSL
4	90	5	18
3	250	15	16.7
2	3370	45	75
1	5320	20	266

Conclusions

These examples show that the 'Dimbleby-factor' of 1 cm/30 years cannot be used as standard. The thickness of a soil and soil pedogenesis is probably highly dependent on local circumstances. These circumstances are variable through time and place, even very locally. Hence, the vegetation developments from soil profiles underneath barrows below cannot be placed in time without additional dating.[2] To estimate the age of a soil underneath a barrow dating techniques are necessary.

The best technique for dating phases of soil formation is probably OSL (van Mourik *et al.* 2010, van Mourik *et al.* 2011, Sevink *et al.* in press). However, in order to do this at least two podzols should be present on top of each other. This is usually not the case underneath barrows. Radiocarbon dating of organic soil layers might also be possible, although precaution should be taken when interpreting these dates. This is clearly shown by the study of van Mourik described in example 3, where in addition to OSL radiocarbon dates have been determined based on samples from different fractions (humin and humic acid, see van Mourik *et al.* 2010) of the soil organic matter taken from the buried A horizons in this profile. The OSL samples provided ages of the sedimentation and soil formation phases. The radiocarbon dating however did not correspond with the OSL dating, which is probably due to the presence of older charcoal particles in organic aggregates, causing an overestimation of the ^{14}C age. Underestimation of the ^{14}C age is possible when younger organic particles have infiltrated. Van Mourik concludes that due to the complexity organic matter of the soil radiocarbon ages of buried horizons cannot be used to date drift sand and soil formation phases (van Mourik *et al.* 2010).

5.3. Absence of pollen grains in barrows

As has been described in section 5.1 the soil underneath barrows (and the soil the barrow has been constructed of) often provides good pollen preservation conditions and consequently contains fossil pollen. Professor Waterbolk (University of Groningen) for example, who has palynologically investigated a great number of barrows, has never encountered barrow sediments that did not contain pollen grains (H.T. Waterbolk pers.comm., August 2011). However, pollen is not present under/in every barrow. In this study we have encountered the problem of a total absence of pollen grains even under comparable conditions. In Chapter 8 (Case studies) the palynological results will be discussed of several barrows that did contain pollen. One of these case studies concerns two barrows in the region of Apeldoorn at a location called the Echoput, excavated in 2007. The Echoput barrows did contain reasonably preserved pollen, sufficient for a vegetation reconstruction that will be discussed in section 8.1. Close to the Echoput barrows, about four kilometres to the northeast, three more barrows situated at a location called the Wieselse Weg (WW) were excavated in 2008 and 2009 (Fontijn and Louwen in prep.). Given that the WW barrows are situated in the same geographic region as the Echoput barrows, it was expected that they would contain pollen. However, in contrast to the Echoput, the WW barrows had little or no pollen. An explanation for the absence of pollen in the WW barrows could possibly be found in the differences in soil texture between the two locations. Although in general soil textures were very similar (the soil at both locations was classified as

2 In order get an even more exact image of the time represented in a mineral soil pollen diagram, one should also account for syn- and post-sedimentary pollen (see section 5.1, p.50-51).

Figure 5.7. The locations of the barrows that have been used for grain size analysis.

an Umbric Podzol (ISRIC-FAO 2006[3]) (Dutch classification: Holtpodzol, gY30 [see Bodemkaart van Nederland[4]], according to soil scientist J. Boerma the soil of the Echoput barrows was loamier than the soil at the Wieselse Weg. In addition, the podzol underneath the WW barrows was much harder to recognize. Contrary to the barrows of the Echoput sods were not recognizable and also the old surface was hard to detect. Possibly the soil on which the WW barrows were constructed consisted of a somewhat coarser sediment than the Echoput barrows, favouring a better aeration of the soil which caused the pollen grains of the WW barrows to be subject of oxidation (Havinga 1984). Besides oxidation, pollen grains were more easily outwashed as a consequence of a higher susceptibility of the soil. To test this hypothesis, soil samples of the Echoput and the WW barrows were selected and analysed for grain size. In addition, soil samples from a barrow with a well-preserved soil profile and well-preserved pollen from another region, Barrow 7 from the barrow group of Oss-Zevenbergen (section 12.1), were analysed for comparison (see figure 5.7). Can the results of sediment observations be used to determine in advance the utility of conducting pollen analysis? Eight soil samples from the WW barrows, eight samples from the Echoput barrows and four samples from the Oss-Zevenbergen barrow were selected and analysed for grain size by the Sediment Analysis Laboratory of the Free University Amsterdam with a Laser Particle Sizer Helos KR Sympatec. An overview of the selected samples is given in table 5.3.

A summary of the results is shown in figure 5.8. This figure shows the distribution frequency q3 of all samples plotted against particle size. To discuss the results in detail, percentages per classification of the three sites have been compared with each other (see table 5.4a-b). Figure 5.8 and table 5.4a show that there are hardly any differences between the Wieselse Weg and the Echoput

3 All soil types have been classified according to the World Reference Base (ISRIC-FAO 2006), unless indicated otherwise.
4 Bodemkaart van Nederland 1:50.000 toelichting kaartblad 33 west Apeldoorn, p. 27, 67-8.

barrows. This is also demonstrated in table 5.4b, which shows the statistical results. No significant differences can be detected between WW and Echoput, with exception of the Middle Coarse Sand fraction. However, almost all fractions

Nr.	Location	Barrow	Sample location	Sample name
1	Echoput	barrow 1	sod 1	MT 266
2			sod 2	MT 267
3			old surface 1	MT 268
4			old surface 2	MT 269
5		barrow 2	sod 1	VNR 99
6			sod 2	VNR 100
7			old surface 1	A2.1 old surface 2
8			old surface 2	A2.1 old surface 1
9	Wieselse Weg	barrow 1 (p101)	profile west	sample 1
10				sample 5
11		barrow 2 (p201)	profile west	sample 1
12				sample 5
13		barrow 3 (p301)		MT 801
14				MT 802
15				MT 803
16				MT 804
17	Oss-Zevenbergen	barrow 7	sod 1	VNR 275
18			sod 2	VNR 276
19			sod 3	VNR 277
20			sod 4	VNR 279

Table 5.3. Overview of samples that have been analysed for grain size.

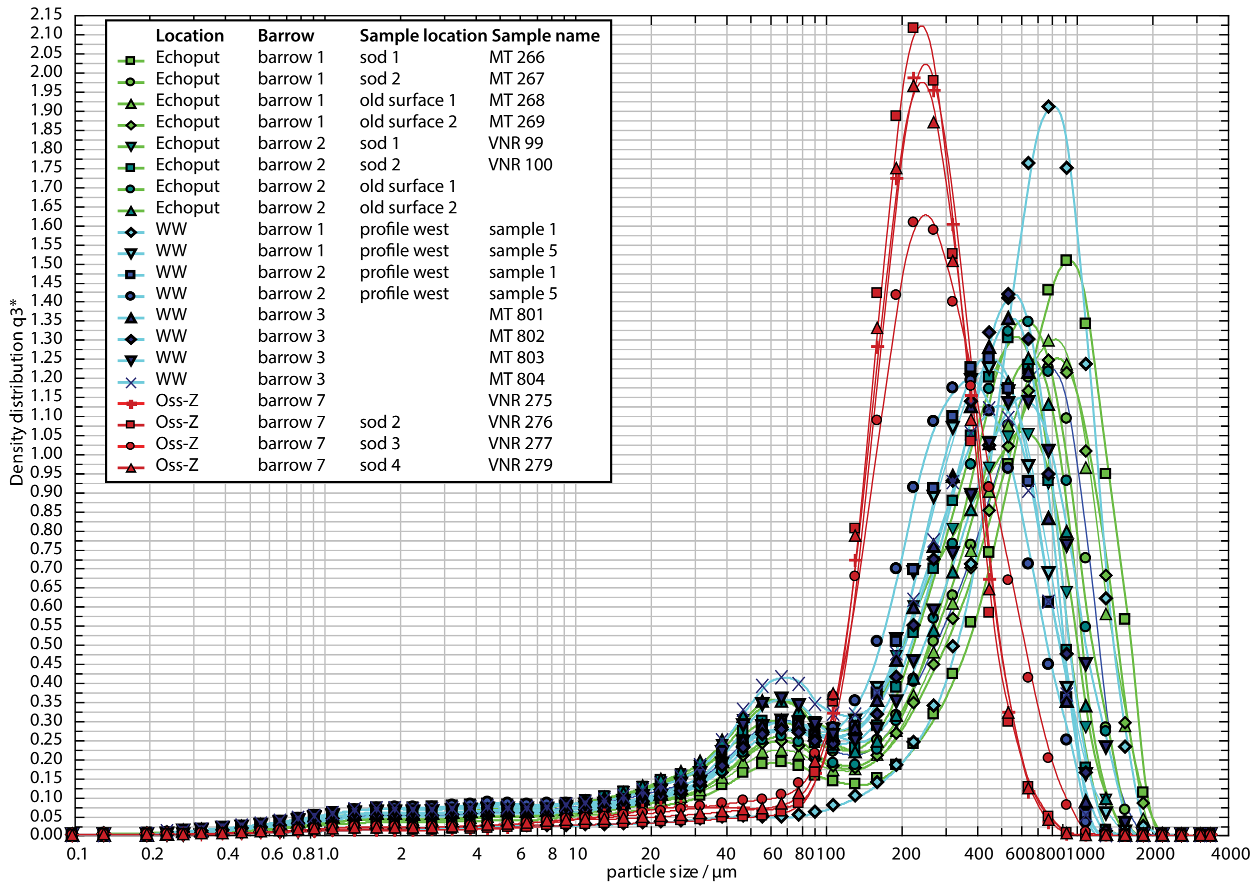


Figure 5.8. Results of the grain size analyses, showing the density distribution q3 versus the particle size (µm).

% Clay (<8 µm)			% Very fine Silt (8-16 µm)			% Fine Silt (<16-32 µm)			% Coarse Silt (32-63 µm)		
WW	**Echoput**	**Oss-Z**	**WW**	**Echoput**	**Oss-Z**	**WW**	**Echoput**	**Oss-Z**	**WW**	**Echoput**	**Oss-Z**
7,82	6,69	2,56	2,6	2,67	1,23	4,07	4,4	1,48	8,82	8,37	1,9
6,71	5,1	2,67	2,28	1,82	1,33	3,5	2,81	1,84	7,65	5,73	2,52
5,59	6,72	1,75	1,96	2,71	0,81	3,06	4,26	1,02	6,16	7,32	1,33
6,45	6,83	1,72	2,18	2,69	1,36	3,28	4,14	2,06	6,65	8,01	2,08
8,12	5,11		2,55	1,93		3,36	2,88		6,48	5,58	
7,93	4,79		2,47	1,84		3,2	2,73		6,57	5,11	
6,57	5,98		2,15	2,42		3,08	3,65		6,48	6,81	
1,94	4,05		0,78	1,59		1,03	2,38		1,37	4,43	

% Very fine sand (63-125 µm)			% Fine sand (125-250 µm)			% Middle coarse sand (250-500 µm)			% Coarse sand (500-1000 µm)		
WW	**Echoput**	**Oss-Z**	**WW**	**Echoput**	**Oss-Z**	**WW**	**Echoput**	**Oss-Z**	**WW**	**Echoput**	**Oss-Z**
10,76	8,59	6,73	13,35	8,9	43,4	28,93	23,16	38,86	22,89	33,11	3,83
9,05	6,5	6,95	9,9	8,31	35,67	24,18	25,85	38,35	30,56	36,44	10,56
7,56	7,61	6,05	11,45	10,67	46,32	30,61	28,51	39	31,85	30,32	3,71
8,21	9,22	5,82	12,61	12,77	42,44	30,63	25,13	40,86	28,97	27,73	3,67
8,23	6,22		18,38	7,43		34,18	19,13		18,23	34,74	
8,16	5,77		13,86	7,63		33,51	20,4		23,59	36,18	
8,42	7,62		14,06	8,79		32,66	20,94		24,57	34,49	
1,81	4,84		4,95	5,24		19,05	15,14		51,14	38,17	

% Very coarse sand (1000-2000 µm)		
WW	**Echoput**	**Oss-Z**
0,75	4,12	0
6,16	7,45	0,11
1,77	1,88	0
1,02	3,49	0
0,48	16,97	
0,72	15,55	
2,03	9,31	
17,93	24,16	

Table 5.4a. Results of the grain size analyses in percentages per grain size.

of Oss-Zevenbergen show significant differences compared to both the Wieselse Weg and Echoput. The soil underneath the Oss-Zevenbergen barrow 7 consists mostly of fine sand, while the sediments of the other two sites mainly consist of middle coarse and coarse sand.

The finer composition of the Oss-Zevenbergen sediment could be part of the explanation why pollen grains have been well preserved. However, this does not count for the difference in conservation between the Wieselse Weg and Echoput. Based on these results it is unlikely that differences in particle size of the sediment are the main causes for differences in pollen conservation. Another possible

C	Echo	Oss	VFSi	Echo	Oss	FSi	Echo	Oss
WW	x	***	WW	x	***	WW	x	*
Echo		***	Echo		***	Echo		**
CSi	Echo	Oss	VFSa	Echo	Oss	FSa	Echo	Oss
WW	x	***	WW	x	x	WW	x	***
Echo		***	Echo		x	Echo		***
MCSa	Echo	Oss	CSa	Echo	Oss	VCSa	Echo	Oss
WW	*	***	WW	x	**	WW	x	x
Echo		****	Echo		****	Echo		**

*Table 5.4b. Results of the statistic analyses (tested with unpaired t-test) after grain size analysis. x means not statistically different, * means statistically different p<0,05), ** means statistically different (p<0,01), *** means statistically different (p<0,001), **** means statistically different (p<0,0001).*

explanation for the relatively good pollen conservation of the Echoput barrows is the locally wet conditions of the Echoput area (Fontijn 2011a, 30) compared to the much drier conditions of the Wieselse Weg. The soil at the location where the Echoput mounds are situated contains some loam which is practically absent at the Wieselse Weg. Although loam has not been shown by grain size analysis, loam might have been present somewhat deeper in the subsoil, causing moist conditions at the Echoput. These moist conditions at the Echoput site could have provided favourable conditions for pollen conservation, reducing the availability of oxygen and the (micro)biological activity (Havinga 1962, 1984), where at the Wieselse Weg the drier conditions favoured the degradation of pollen grains. The soil in Oss-Zevenbergen is also dry, but much poorer in nutrients, which also reduces microbial activity.

Conclusions

The purpose of the soil texture measurements described in the previous section was to determine whether the presence or absence of pollen grains in a soil could be predicted with these relatively simple and quick measurements. However, based on the results it is not possible to differentiate a pollen containing sediment from a non pollen containing sediment only by judging the texture of the sediment. Further research is recommended.

Chapter 6

The pollen sum

The absolute number of pollen grains found per sample can differ significantly per sediment. To be able to compare pollen spectra, pollen types are usually expressed as percentages of a pollen sum. The pollen sum used can be a total pollen sum, so with all pollen types included, or it can be based on a selection of pollen types. The pollen sum should be chosen in a way to get the most representative reflection of the vegetation composition that produced the pollen. To quote Faegri (1966, 136): "*Pollen sums must be adapted to the problem they are supposed to elucidate, and then the basic rule is extremely simple: the pollen sum should contain the pollen taxa from those plants that are of interest in elucidating the actual question*." For example, when tree abundance in a forest area is of main interest, the pollen sum should only include arboreal pollen taxa and exclude herbal taxa, because the variation in herbal abundance would influence the percentages of the arboreal taxa that are unrelated to differences in tree abundance. However, in areas with little forest, herbal vegetation is of much more importance and when interested in the ratio between arboreal and non-arboreal vegetation herbal taxa should be included in the pollen sum. It would therefore be expected that in barrow palynology the pollen sum would include both arboreal and non-arboreal taxa. However, the pollen sum used in the palynological studies is a tree pollen sum minus *Betula* ∑AP-B. According to van Zeist this is the most appropriate sum to use. *Betula* and herbs are excluded because they grow locally at a barrow site and when they are included pollen percentages strongly fluctuate between barrow pollen spectra, even between samples from the same barrow (van Zeist 1967a). *Betula* is a pioneer tree (see figure 6.1); it settles and flowers easily in an open space and can therefore, like herbs, vary significantly at short distances. The consequence of using relative

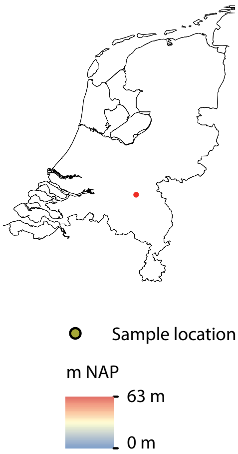
Figure 6.1. Young Betula trees appearing as pioneer trees 6 years after the excavation of barrows at Oss-Zevenbergen. Photograph by R. Jansen.

numbers is that the change in one species affects the percentage of a species that does not change at all. Therefore, to reflect the regional vegetation best species that can vary locally should be left out of the pollen sum. Van Zeist tested several pollen sums for two tumuli originating from the same period and situated in the same area. It is expected that these spectra look very similar at least concerning the regional vegetation. He concluded that ∑AP-B was the most suitable pollen sum indeed. Since then ∑AP-B was commonly used in barrow palynology. However, this pollen sum has only been tested once and needs to be reconsidered.

6.1 Slabroek

As explained above, to get a reliable image of the regional vegetation, species that grow locally on a barrow site should be left out of the pollen sum, since their frequency can differ greatly at short distances. In a barrow pollen spectrum non-arboreal species are in general species that grew close to the sample site. Arboreal species however do not necessarily solely reflect regional vegetation. Van Zeist concluded that besides herbal species, *Betula* is also a local species and should therefore be excluded from the pollen sum (van Zeist 1967a). However, how can regional vegetation be best ascertained? Pollen diagrams derived from peat are assumed to give a reliable image of regional vegetation. As has also been explained in section 4.1.3, peat is an accumulation of organic material and in each layer pollen grains are caught. Peat provides conditions for good preservation of pollen grains, and since there is no vertical movement of pollen, each layer of peat reflects the vegetation from the period the pollen was caught. By comparing barrow pollen spectra with a contemporaneous pollen spectrum from peat from the same area it should be possible to determine the local vegetation of the barrow site, which can then be excluded from the pollen sum. The peat spectrum gives information about the regional vegetation of the barrow landscape. Species in the

Figure 6.2. Location of Slabroek, the Venloop. Oss-Zevenbergen, Echoput and Hijken.



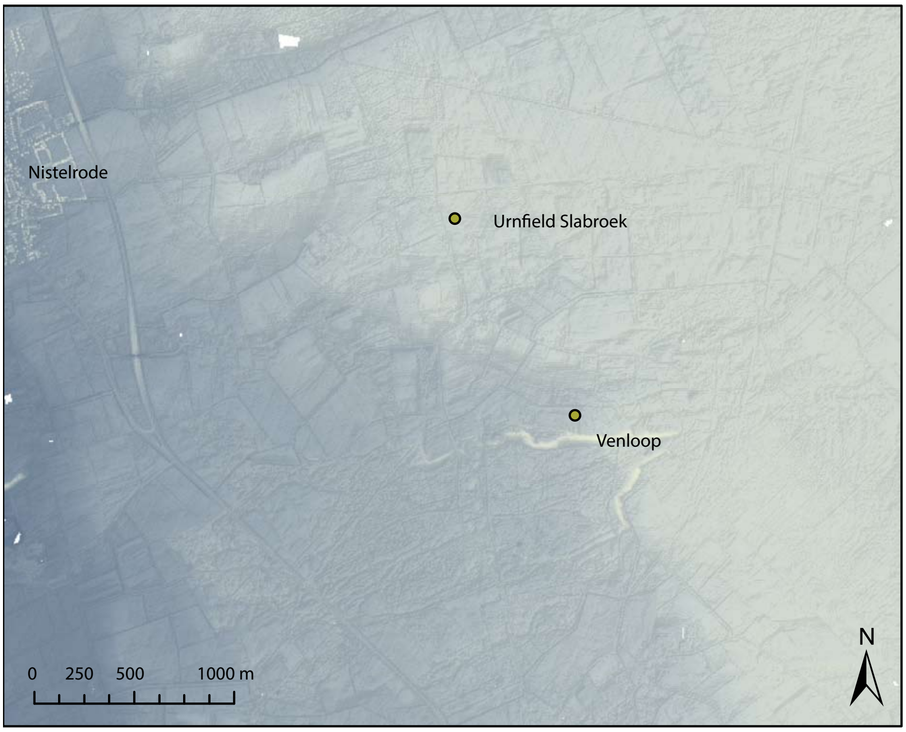


Figure 6.3. Map with the location of the urnfield at Slabroek and the Venloop. The map is based on digital elevation model of the AHN (copyright www.ahn.nl).

barrow pollen spectrum that differ greatly from the peat spectrum probably are part of the local vegetation at the barrow site. These species can then be excluded from the barrow pollen sum.

To examine this theory a case study was conducted with data from a nature reserve area called the Maashorst, situated in the province of North Brabant, the Netherlands. A prehistoric urnfield at 'Uden-Slabroekseheide' (see figure 6.2 and 6.3) was investigated in 1923 by Remouchamps. He discovered 38 barrows from the Iron Age and Early Roman Period (Remouchamps 1924). Due to plans to change the area into a nature reserve and to reconstruct the urnfield, the area was reinvestigated by Archol (the excavation unit of the Faculty of Archaeology, University of Leiden, The Netherlands) in 2005 (van Wijk and Jansen 2005b). In 2010 it was decided to excavate the remainder of the urnfield area (Jansen and Louwen in prep.). During this last excavation several ring ditches were found. Two of these ring ditches (43 and 12, see figure 12.17 for the exact locations of the ditches), originally encircling the urnfield barrows, were sampled for pollen analysis. Their history as a pollen trap is the same as that of a ditch around a barrow. Pollen samples taken from the bottom of the ditch fill were analysed (as representing the vegetation of the area at the time of the digging of the ditch, see section 4.1.4). Samples were prepared as described in section 4.2. The pollen spectra from the ditch fills are shown in figure 6.4, percentages are based on a tree pollen sum minus *Betula*.

About one kilometre from the urnfield at Uden-Slabroekseheide, van Mourik (2011) analysed a peat core taken from the Venloop (van Mourik *et al.* 2012b). The pollen diagram from the Venloop as it has been published by van Mourik is shown in figure 6.5; percentages are based on a *total* tree pollen sum. It shows the development from a wetland to a peat to a deforested agricultural landscape. The start of the peat accumulation was ^{14}C dated 750-410 cal BC, which is the start of zone 2 in the diagram and is contemporaneous with the urnfield period of Slabroek, which can be placed in the Early Iron Age (800-500 cal BC, see table 2.1) (Jansen and Louwen in prep.). Since vegetation in the pollen diagram does

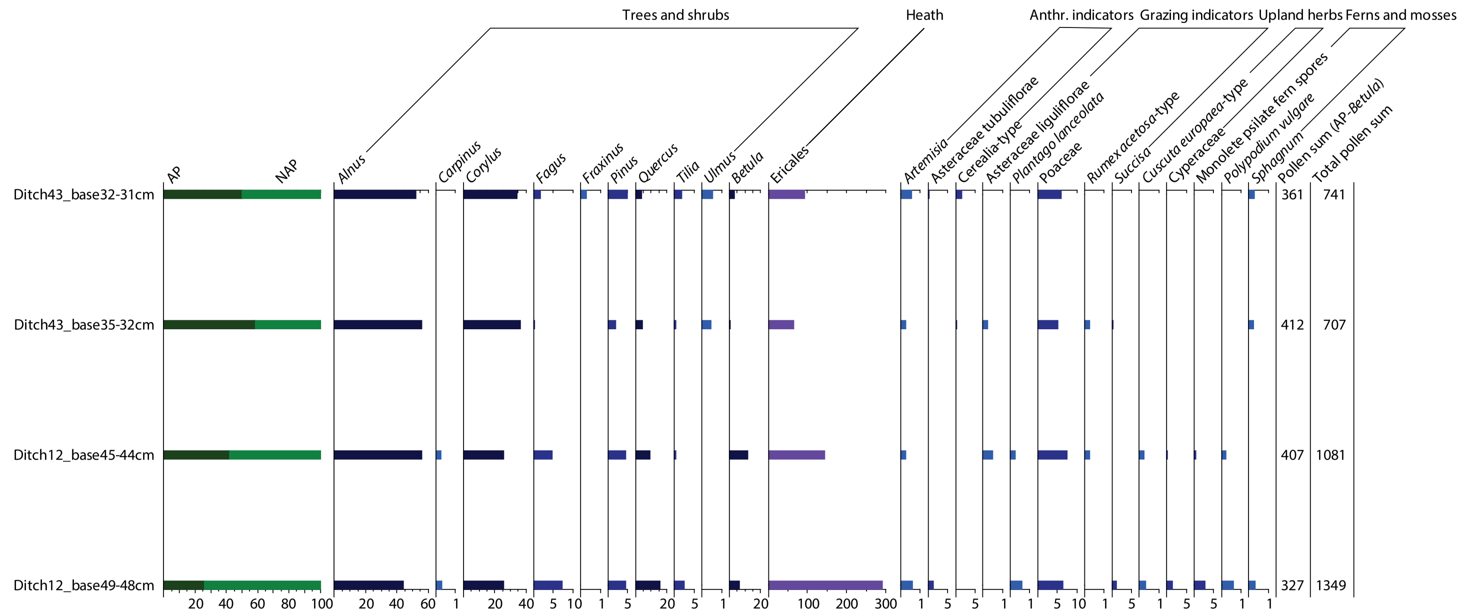


Figure 6.4. Pollen spectra of the samples taken from the ditches 12 and 43 of the urnfield at Slabroek. Spectra are given in % based on a tree pollen sum minus Betula pollen. In the total AP (=arboreal pollen) Betula is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.

not seem to vary greatly around this period (see figure 6.4), a more exact dating of the ditches is not necessary and their pollen spectra can be compared with the pollen diagram.

The pollen spectra from the two ditch fills and the pollen diagram from the Venloop peat core provide information about the local and regional vegetation in the area in the Early Iron Age. By comparing the Venloop pollen diagram with the ditch pollen spectra it is possible to determine regional and local vegetation and therefore which pollen sum should be used to best display this in the ditch pollen spectra. To be able to compare the peat diagram with the ditch pollen spectra percentages should be based on a similar pollen sum. In table 6.1 average percentages of zone 2 of the peat diagram (VL) and percentages of both ditch pollen spectra (43 and 12) are shown based on similar pollen sums and tested with several pollen sums. The first pollen sum tested is ∑AP-B that, according to van Zeist, should show similar percentages of tree pollen between both the ditch spectra as well as the peat diagram. What can be seen is that there are clear differences in percentages of *Quercus* and *Corylus* between the ditch spectra and the peat spectrum. When *Betula* is included in the pollen sum the differences do not disappear. The assumption that *Alnus* is overrepresented in the Venloop diagram is easily made, as this is a dominant species in the wetland shown in the diagram. When *Alnus* is left out of the pollen sum however, differences in *Corylus* and *Quercus* become greater. Several pollen sums have been tested, shown in table 6.1, but no pollen sum could be found to match the ditch spectra to zone 2 of the peat diagram. Based on these results it is not possible to come to a conclusion about which pollen sum is most suitable for barrow pollen analysis and in section 6.3 another case-study is carried out.

Furthermore, the origin of the differences between Venloop and the ditch spectra is not clear. This could indicate that the ditch spectra and zone 2 of the pollen diagram are not contemporaneous and that they reflect two periods with different vegetation composition. However, based on the ^{14}C-dating of the diagram and

Pollen	**∑AP-*Betula***					**%total AP**				
sum	*Alnus*	*Betula*	*Corylus*	*Pinus*	*Quercus*	*A*	*B*	*C*	*P*	*Q*
Ditch 12	55.8	11.8	25.6	4.4	9.1	49.9	10.5	22.9	4.0	8.1
Ditch 43	52.4	3.0	34.1	5.0	4.2	50.8	3.0	33.1	4.3	4.0
Venloop	66.2	25.0	7.4	1.5	19.1	55.1	20.8	6.1	1.2	15.9

Pollen	**% total pollensum**							**%total sum-heath**				
sum	*A*	*B*	*C*	*P*	*Q*	*%AP*	*%NAP*	*A*	*B*	*C*	*P*	*Q*
D12	21.0	4.4	9.6	1.7	3.4	42.1	57.9	45.7	9.7	20.9	3.6	7.4
D43	25.5	1.5	16.6	2.4	2.0	50.2	49.8	46.8	2.7	30.4	4.5	3.7
VL	43.3	16.3	4.8	1.0	12.5	81.7	18.3	44.6	16.8	5.0	1.0	12.9

Pollen	**%AP-Alnus**					**%AP-B-A**					**%AP-B-C**				
sum	*A*	*B*	*C*	*P*	*Q*	*A*	*B*	*C*	*P*	*Q*	*A*	*B*	*C*	*P*	*Q*
D12	99.6	21.1	55.7	0.4	16.2	126.1	26.7	57.8	0.6	20.6	74.9	15.8	34.3	0.3	12.2
D43	103.3	6.0	67.2	9.8	8.2	109.9	6.4	71.5	10.5	8.7	79.4	6.4	71.5	10.5	8.7
VL	122.5	46.3	13.6	2.7	35.4	195.7	73.9	21.7	4.3	56.5	71.4	27.0	7.9	1.6	20.6

Table 6.1. Pollen percentages of the samples taken from the ditches 12 and 43 at the urnfield at Slaboek and the average percentages of zone two of the Venloop pollen diagram.

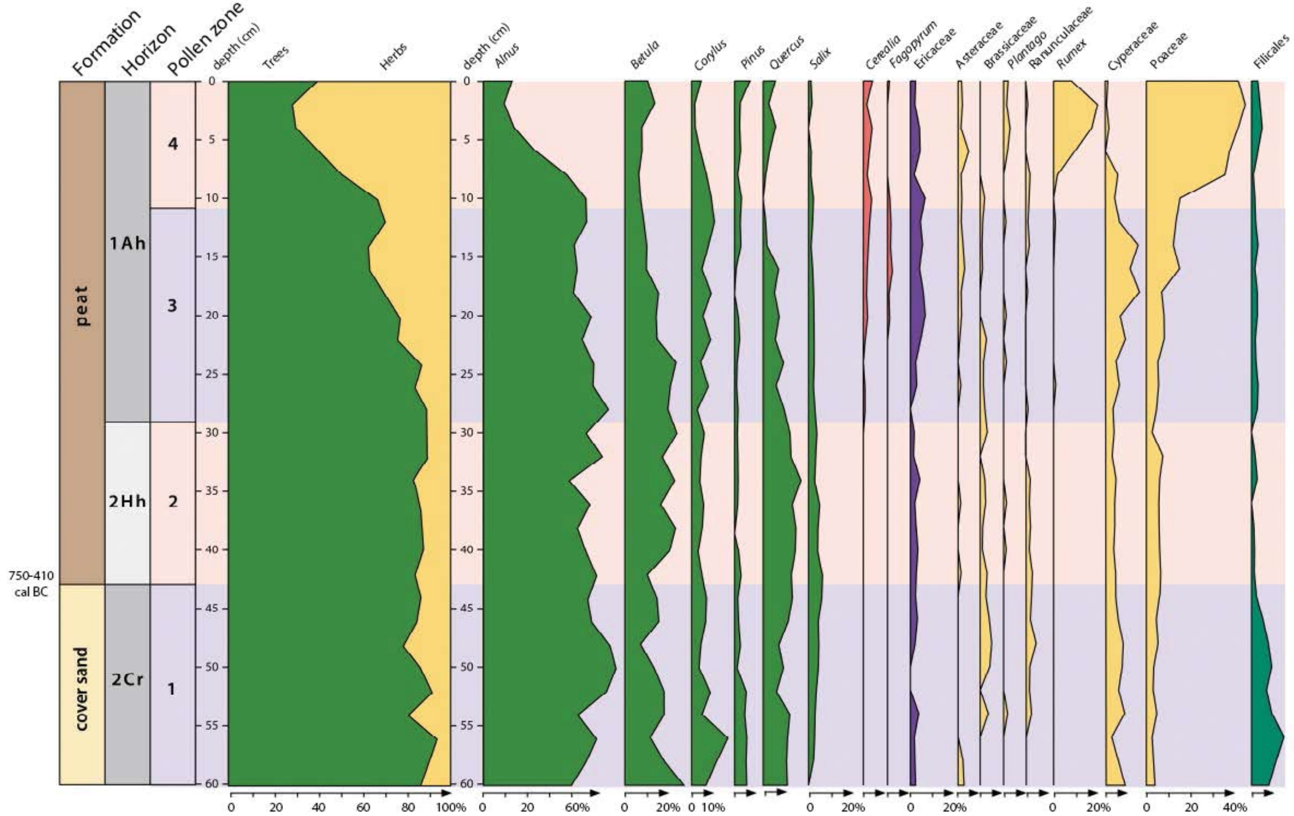


Figure 6.5. Pollen diagram of the Venloop. Figure after van Mourik (2012, figure 5).

the minimal change in vegetation around this ^{14}C-date and the rather narrow archaeological dating of the ditches, this is not very likely.

Another possibility is that the distance between the Venloop and the urnfield is too great. This would imply that the Venloop diagram and the ditch spectra both show local vegetation, since they are only one kilometre apart from one another. This is surprising in regard to the peat diagram, since the assumption has always been that pollen diagrams derived from peat reflect regional vegetation composition. This would have implications for reconstructions of regional vegetation history in the Netherlands, which are mainly based on peat and lake sediment analyses. To (dis)prove this further research is necessary.

6.2 Contemporaneous barrow pollen spectra

In this paragraph another approach to reconsider the pollen sum ∑AP-*Betula* will be discussed. First the data used by van Zeist will be re-inspected in detail. Van Zeist based his conclusions on the results of pollen analysis of two contemporaneous barrows at Hijken. Since these two tumuli originate from the same period and are situated in the same area it is expected that their pollen spectra are similar. The original complete spectra of the barrow cemetery of Hijken were published in van Zeist (1955). Pollen percentages based on several pollen sums are shown in table 6.2. In addition the standard deviation is calculated based on the pollen percentages from both barrows to show the variation in the data. The lower the standard deviation, the less variation in pollen percentages is present. Van Zeist only looked at two species, *Alnus* and *Corylus*. His conclusion that least variability is shown when a tree pollen sum minus *Betula* is used is true concerning *Alnus*. Other arboreal species, including *Corylus*, however are least variable when a total pollen sum[5] is used. In addition, percentages of the non-arboreal species *Calluna* and Poaceae are least variable with a total pollen sum. This still does not exclude n th*Betula* as the best pollen sum to use, since it is very unlikely that *Alnus* was growing on the barrow site, being more likely to have grown at the lake side about five kilometres from the barrows (van Zeist 1955). Differences in the other species should then be caused by locally varying appearance, meaning that especially *Betula* trees were growing on the barrow site. This is very likely, since *Betula* is a very common tree in heathland areas. When *Betula* is included in the arboreal pollen sum the variability of *Alnus* indeed increases. The lower variability of other arboreal species with a total pollen sum can be explained by the high numbers of *Calluna*, suppressing the percentages of species present in a lower abundance. The higher variability of percentages of *Calluna* and Poaceae with ∑AP-*Betula* can, as has been explained by van Zeist, be caused by local differences (van Zeist 1955).

Another case study used to investigate the pollen sum is located at the Echoput near Apeldoorn, the Netherlands. Two barrows were excavated and samples were taken from the old surface and some sods of both barrows for pollen analysis. The barrows both dated to the 4th or 3rd century cal BC, and were probably built at the same time or one relatively quickly after the other one (Fontijn 2011b, 153). For a full description of the site, the barrows, sampling for pollen analysis and a more detailed discussion of the results, see Chapter 8, case-study Echoput. The results of the pollen analysis are shown in table 6.3. Percentages are based on several pollen sums. It is expected that both barrows, since they were built in the same period, show a comparable regional vegetation pattern and even locally they are not expected to differ greatly since they were built less than 20 m apart from each

5 The total pollen sum includes all arboreal pollen taxa, all herbal pollen taxa and all spores from ferns and mosses.

		% AP-*Betula*						
		Alnus	Betula	Corylus	Quercus	Tilia	Calluna	Poaceae
Tum 5	**o.s.**	64.5	14.1	22.4	6.8	3.4	39.5	51.8
	sod 1	61.8	31.9	16.1	19.0	0.8	53.9	21.7
	sod 2	65.9	13.5	23.6	6.6	2.4	107.1	26.4
Tum 6	**o.s.**	65.2	25.1	20.0	10.4	3.0	50.4	66.0
	sod 1	61.3	38.3	20.2	15.2	0.8	98.8	27.4
	sod 2	70.4	82.5	18.5	7.9	0.6	50.3	41.7
	sod 3	66.4	56.5	22.1	7.5	1.3	65.7	48.3
	S.D.	3.1	24.8	2.6	4.8	1.2	26.1	16.1

		% total AP						
		A	B	C	Q	T	Ca	P
Tum 5	**o.s.**	56.5	12.4	19.6	6.0	3.0	34.6	45.4
	sod 1	46.9	24.2	12.2	14.4	0.6	40.9	16.4
	sod 2	58.0	11.9	20.8	5.8	2.1	94.4	23.3
Tum 6	**o.s.**	52.1	20.1	16.0	8.3	2.4	40.3	52.8
	sod 1	44.3	27.7	14.6	11.0	0.6	71.4	19.8
	sod 2	38.6	45.2	10.1	4.3	0.3	27.6	22.8
	sod 3	42.4	36.1	14.1	4.8	0.8	42.0	30.8
	S.D.	7.3	12.2	3.8	3.7	1.1	23.8	13.8

		% total pollen sum						
		A	B	C	Q	T	Ca	P
Tum 5	**o.s.**	8.9	1.9	3.1	0.9	0.5	5.4	7.1
	sod 1	26.8	13.8	7.0	8.2	0.3	23.4	9.4
	sod 2	16.6	3.4	6.0	1.7	0.6	27.0	6.7
Tum 6	**o.s.**	11.5	4.4	3.5	1.8	0.5	8.9	11.6
	sod 1	20.4	12.7	6.7	5.1	0.3	32.8	9.1
	sod 2	22.9	26.9	6.0	2.6	0.2	16.4	13.6
	sod 3	18.9	16.1	6.3	2.1	0.4	18.7	13.7
	S.D.	6.3	8.9	1.6	2.6	0.1	9.7	2.9

		% total pollen sum-Heath						
		A	B	C	Q	T	Ca	P
Tum 5	**o.s.**	9.4	2.1	3.3	1.0	0.5	5.7	7.5
	sod 1	35.0	18.0	9.1	10.7	0.5	30.5	12.3
	sod 2	22.8	4.7	8.2	2.3	0.8	37.0	9.1
Tum 6	**o.s.**	12.6	4.8	3.9	2.0	0.6	9.7	12.7
	sod 1	30.3	18.9	10.0	7.5	0.4	48.8	13.5
	sod 2	27.4	32.1	7.2	3.1	0.2	19.6	16.2
	sod 3	23.3	19.8	7.7	2.6	0.5	23.0	16.9
	S.D.	9.2	10.9	2.5	3.6	0.2	15.2	3.4

		% AP-*Alnus*						
		A	B	C	Q	T	Ca	P
Tum 5	**o.s.**	129.8	28.4	45.2	13.7	6.9	79.6	104.2
	sod 1	88.3	45.5	23.0	27.1	1.1	77.0	31.0
	sod 2	138.2	28.4	49.6	13.9	5.0	224.8	55.5
Tum 6	**o.s.**	108.8	41.9	33.4	17.4	5.0	84.1	110.2
	sod 1	79.6	49.7	26.2	19.8	1.0	128.3	35.5
	sod 2	62.8	73.6	16.5	7.0	0.5	44.9	37.2
	sod 3	73.7	62.7	24.5	8.3	1.4	72.9	53.5
	S.D.	28.9	16.8	12.2	6.9	2.5	59.6	32.9

		% AP-*Betula-Alnus*						
		A	**B**	**C**	**Q**	**T**	**Ca**	**P**
Tum 5	**o.s.**	181.4	39.7	63.1	19.2	9.6	111.3	145.6
	sod 1	162.0	83.5	42.1	49.7	2.1	141.4	56.8
	sod 2	193.0	39.6	69.2	19.4	7.0	313.8	77.4
Tum 6	**o.s.**	187.4	72.1	57.5	29.9	8.6	144.8	189.7
	sod 1	158.3	99.0	52.1	39.4	2.1	255.2	70.7
	sod 2	238.2	279.1	62.5	26.7	2.0	170.3	140.9
	sod 3	197.9	168.5	65.8	22.3	3.9	195.8	143.8
	S.D.	26.6	85.8	9.3	11.4	3.3	71.4	49.5

		% AP-*Betula-Corylus*						
		A	**B**	**C**	**Q**	**T**	**Ca**	**P**
Tum 5	**o.s.**	83.1	18.2	28.9	8.8	4.4	51.0	66.7
	sod 1	73.7	38.0	19.2	22.6	1.0	64.3	25.8
	sod 2	86.2	17.7	30.9	8.7	3.1	140.2	34.6
Tum 6	**o.s.**	81.5	31.4	25.0	13.0	3.8	63.0	82.5
	sod 1	76.8	48.0	25.3	19.1	1.0	123.7	34.3
	sod 2	86.4	101.2	22.7	9.7	0.7	61.8	51.1
	sod 3	85.3	72.6	28.3	9.6	1.7	84.4	61.9
	S.D.	4.9	30.6	4.0	5.6	1.5	34.5	20.6

Table 6.2. Pollen percentages of Hijken.

other. Samples originate from the old surface and from several sods of which the barrows were constructed. Pollen spectra from the sods could possibly show some dissimilarity in local vegetation, since they could originate from a wider area. Pollen spectra from the old surface samples however, should be identical, since the barrows were built very close together.

As can be seen in table 6.3 differences between arboreal pollen spectra are smallest when a total pollen sum is used. This also counts for *Alnus*, in contrary to the pollen spectrum of *Alnus* in the Hijken barrows (see 6.2). Since pollen spectra are expressed in percentages, species that occur in large numbers have great influence on percentages of other species when this species is included in the pollen sum. In this case, when *Calluna* is included in the pollen sum, the percentages of other species automatically decrease, since very high numbers of *Calluna* pollen have been found in the Echoput samples. With these large numbers of *Calluna* included in the pollen sum the variance of other species automatically decreases. To avoid this effect *Calluna* should be left out of the pollen sum and an arboreal pollen sum should be applied. In addition, when expressed as a percentage based on a total pollen sum the variation in *Calluna* is not as obvious as when expressed as percentage based on a tree pollen sum since it is then bound to a maximum of 100%. Therefore, to reflect local variability in herbal vegetation it is best to use an arboreal pollen sum. Since there are only a few *Betula* pollen grains present in the samples it is not possible to judge the exclusion of this species as has been suggested by van Zeist (1967).

Pollen	**% AP-*Betula***					
sum	Alnus	Corylus	Quercus	Fagus	Calluna	Poaceae
Barrow 1 sod1	65.5	14.5	19.1	0.2	246.8	36.6
Barrow 1 sod3	66.3	17.5	12.9	2.6	135.3	52.1
Barrow 1 sod4	58.6	15.9	22.6	1.6	159.9	61.5
Barrow 1 os1	64.7	15.0	19.3	0.7	157.8	46.7
Barrow 1 os2	57.1	15.0	23.7	2.8	174.1	34.3
Barrow 1 os3	74.5	16.1	8.1	1.3	195.2	62.6
Barrow 1 os4	57.5	11.8	28.1	2.2	125.6	63.9
Barrow 2 sod1	44.9	12.0	39.6	1.3	322.2	47.8
Barrow 2 sod2	58.7	19.6	20.8	0.6	140.1	71.5
Barrow 2 sod3	69.2	15.7	12.6	1.3	190.6	101.6
Barrow 2 os1	66.1	14.8	18.4	0.3	261.6	29.4
Barrow 2 os2	63.3	16.9	18.9	0.9	124.3	80.2
Barrow 2 os3	37.7	22.7	33.6	1.8	140.5	75.0
S.D.	9.9	2.9	8.6	0.8	60.4	20.5

Pollen	**% total AP**						**% total pollen sum**					
sum	A	C	Q	F	Ca	P	A	C	Q	F	Ca	P
B1 sod1	65.2	14.4	19.0	0.2	245.8	36.5	16.3	3.6	4.8	0.0	61.6	9.1
B1 sod3	66.3	17.5	12.9	2.6	135.3	52.1	21.5	5.7	4.2	0.8	43.9	16.9
B1 sod4	58.4	15.9	22.5	1.6	159.4	61.3	17.2	4.7	6.6	0.5	47.0	18.1
B1 os1	64.7	15.0	19.3	0.7	157.8	46.7	20.1	4.7	6.0	0.2	49.1	14.5
B1 os2	57.1	15.0	23.7	2.8	174.1	34.3	17.8	4.7	7.4	0.9	54.3	10.7
B1 os3	73.8	16.0	8.0	1.3	193.3	62.0	19.8	4.3	2.1	0.3	52.0	16.7
B1 os4	57.0	11.7	27.8	2.2	124.4	63.3	19.2	3.9	9.4	0.7	41.9	21.3
B2 sod1	44.2	11.8	38.9	1.2	317.1	47.0	9.2	2.5	8.1	0.3	66.2	9.8
B2 sod2	58.5	19.5	20.8	0.6	139.6	71.2	18.0	6.0	6.4	0.2	43.1	22.0
B2 sod3	69.2	15.7	12.6	1.3	190.6	101.6	16.6	3.8	3.0	0.3	45.7	24.3
B2 os1	65.7	14.7	18.3	0.3	259.9	29.2	16.3	3.7	4.5	0.1	64.6	7.3
B2 os2	63.1	16.8	18.9	0.9	123.9	79.9	20.0	5.3	6.0	0.3	39.3	25.3
B2 os3	37.4	22.5	33.3	1.8	139.2	74.3	11.3	6.8	10.1	0.5	42.1	22.5
S.D.	10.0	2.9	8.4	0.8	59.4	20.4	3.5	1.2	2.3	0.3	9.1	6.1

Pollen sum	% total pollen sum-heath						% AP-*Alnus*					
	A	C	Q	F	Ca	P	A	C	Q	F	Ca	P
B1 sod1	42.5	9.4	12.4	0.1	160.2	23.8	187.4	41.5	54.6	0.5	706.6	104.9
B1 sod3	38.4	10.1	7.5	1.5	78.3	30.1	197.1	51.9	38.5	7.7	401.9	154.8
B1 sod4	32.5	8.8	12.5	0.9	88.5	34.0	140.5	38.2	54.2	3.8	383.2	147.3
B1 os1	39.5	9.2	11.8	0.4	96.4	28.5	183.3	42.6	54.6	1.9	447.2	132.4
B1 os2	38.9	10.2	16.1	1.9	118.6	23.3	133.1	35.1	55.2	6.5	405.8	79.9
B1 os3	41.3	8.9	4.5	0.7	108.2	34.7	281.7	61.0	30.5	4.9	737.8	236.6
B1 os4	33.0	6.8	16.1	1.3	72.1	36.7	132.4	27.2	64.7	5.1	289.0	147.1
B2 sod1	27.4	7.3	24.1	0.8	196.1	29.1	79.3	21.2	69.8	2.2	568.7	84.4
B2 sod2	31.7	10.6	11.2	0.3	75.6	38.6	140.8	46.9	50.0	1.5	336.2	171.5
B2 sod3	30.5	6.9	5.5	0.6	84.0	44.8	224.5	51.0	40.8	4.1	618.4	329.6
B2 os1	46.2	10.4	12.8	0.2	182.7	20.5	191.6	43.0	53.3	0.9	757.9	85.0
B2 os2	32.9	8.8	9.8	0.5	64.6	41.7	171.2	45.6	51.2	2.4	336.0	216.8
B2 os3	19.5	11.8	17.4	0.9	72.7	38.8	59.7	36.0	53.2	2.9	222.3	118.7
S.D.	7.1	1.5	5.3	0.5	44.4	7.5	58.8	10.5	10.3	2.2	179.9	71.4

Pollen sum	% AP-*Betula-Alnus*						% AP-*Betula-Corylus*					
	A	C	Q	F	Ca	P	A	C	Q	F	Ca	P
B1 sod1	189.5	42.0	55.2	0.6	714.4	106.1	76.6	17.0	22.3	0.2	288.6	42.9
B1 sod3	197.1	51.9	38.5	7.7	401.9	154.8	80.4	21.2	15.7	3.1	163.9	63.1
B1 sod4	141.5	38.5	54.6	3.8	386.2	148.5	69.7	18.9	26.9	1.9	190.2	73.1
B1 os1	183.3	42.6	54.6	1.9	447.2	132.4	76.2	17.7	22.7	0.8	185.8	55.0
B1 os2	133.1	35.1	55.2	6.5	405.8	79.9	67.2	17.7	27.9	3.3	204.9	40.3
B1 os3	292.4	63.3	31.6	5.1	765.8	245.6	88.8	19.2	9.6	1.5	232.7	74.6
B1 os4	135.3	27.8	66.2	5.3	295.5	150.4	65.2	13.4	31.9	2.5	142.4	72.5
B2 sod1	81.6	21.8	71.8	2.3	585.1	86.8	51.1	13.7	45.0	1.4	366.2	54.3
B2 sod2	141.9	47.3	50.4	1.6	338.8	172.9	72.9	24.3	25.9	0.8	174.1	88.8
B2 sod3	224.5	51.0	40.8	4.1	618.4	329.6	82.1	18.7	14.9	1.5	226.1	120.5
B2 os1	195.2	43.8	54.3	1.0	772.4	86.7	77.7	17.4	21.6	0.4	307.2	34.5
B2 os2	172.6	46.0	51.6	2.4	338.7	218.5	76.2	20.3	22.8	1.1	149.5	96.4
B2 os3	60.6	36.5	54.0	2.9	225.5	120.4	48.8	29.4	43.5	2.4	181.8	97.1
S.D.	60.2	10.7	10.7	2.2	185.3	72.0	11.5	4.2	10.2	1.0	66.9	25.5

Table 6.3. Pollen percentages of the Echoput barrows.

A third case-study that is valuable in the question about the pollen sum is a barrow complex near Oss in the province of North Brabant in the Netherlands (see fig 6.1). Several barrows are situated here, which have been excavated during several campaigns. During these excavations most barrows were sampled for pollen analysis. Two barrows of this barrows complex are similar in age, dating to the Hallstatt C period (Fokkens *et al.* 2009b, Fokkens *et al.* 2012). Hence, pollen spectra should display similar results in at least the regional vegetation pattern. In chapter 12, case study Oss-Zevenbergen, the site will be discussed more in detail, along with an extended overview and discussion of palynological results.

As can be seen in table 6.4 all tested species showed the least variance when a total pollen sum is used. The variance is slightly higher when an arboreal pollen sum is used. This also accounts for the herbal species, probably meaning that there is not much local variability in herbal vegetation. As in the case of the Echoput, an

Pollen sum	% AP-*Betula*					
	Alnus	Corylus	Quercus	Fagus	Calluna	Poaceae
Barrow 3 o.s.	50.8	43.5	3.6	0.0	56.5	3.3
Barrow 3 sod1	55.3	21.9	13.7	3.6	79.3	4.6
Barrow 3 sod2	55.9	24.5	10.6	5.4	75.2	3.6
Barrow 3 sod3	52.8	39.0	3.6	0.5	48.9	41.7
Barrow 7 sod1	56.8	27.8	11.2	0.0	76.4	5.1
Barrow 7 sod2	52.0	28.1	16.3	0.0	65.7	4.9
S.D.	2.4	8.5	5.2	2.4	12.2	15.3

Pollen sum	**% total AP**						**% total pollensum**					
	A	C	Q	F	Ca	P	A	C	Q	F	Ca	P
B3 o.s.	48.8	41.8	3.5	0.0	54.4	3.2	30.7	26.3	2.2	0.0	34.2	2.0
B3 sod1	52.3	20.7	12.9	3.4	75.0	4.3	28.8	11.4	7.1	1.9	41.3	2.4
B3 sod2	53.8	23.5	10.2	5.2	72.4	3.5	30.0	13.1	5.7	2.9	40.4	1.9
B3 sod3	50.6	37.4	3.5	0.5	46.9	40.0	26.4	19.5	1.8	0.2	24.4	20.8
B7 sod1	55.1	27.0	10.9	0.0	74.2	5.0	29.2	14.3	5.7	0.0	39.3	2.6
B7 sod2	49.4	26.7	15.5	0.0	62.4	4.7	29.2	15.8	9.2	0.0	36.9	2.8
S.D.	2.5	8.3	5.0	2.3	11.7	14.6	1.5	5.4	2.8	1.3	6.3	7.5

Pollen sum	**% total sum-heath**						% AP-*Alnus*					
	A	C	Q	F	Ca	P	A	C	Q	F	Ca	P
B3 o.s.	46.6	39.9	3.4	0.0	52.0	3.1	103.1	81.7	6.9	0.0	106.3	6.3
B3 sod1	49.1	19.4	12.1	3.2	70.4	4.0	109.6	43.4	27.1	7.2	157.2	9.0
B3 sod2	50.3	22.0	9.5	4.9	67.7	3.3	116.4	50.9	22.0	11.3	156.6	7.5
B3 sod3	34.9	25.8	2.4	0.3	32.3	27.5	102.3	75.7	7.0	0.9	94.9	80.8
B7 sod1	48.1	23.5	9.5	0.0	64.7	4.3	122.9	60.1	24.2	0.0	165.4	11.1
B7 sod2	46.2	25.0	14.5	0.0	58.4	4.4	97.5	52.8	30.7	0.0	123.3	9.2
S.D.	5.6	7.2	4.8	2.1	14.0	9.7	9.6	15.0	10.3	4.9	29.8	29.5

Pollen sum	% AP-*Betula-Alnus*						% AP-*Betula-Corylus*					
	A	C	Q	F	Ca	P	A	C	Q	F	Ca	P
B3 o.s.	103.1	88.3	7.4	0.0	114.8	6.8	89.8	76.9	6.5	0.0	100.0	5.9
B3 sod1	123.8	49.0	30.6	8.2	1.4	10.2	70.8	28.0	17.5	4.7	101.6	5.8
B3 sod2	126.7	55.5	24.0	12.3	0.0	8.2	74.0	32.4	14.0	7.2	99.6	4.8
B3 sod3	111.7	82.7	7.7	1.0	3.1	88.3	86.6	64.0	5.9	0.8	80.2	68.4
B7 sod1	13.1	64.3	25.9	0.0	176.9	11.9	78.7	38.5	15.5	0.0	105.9	7.1
B7 sod2	10.8	58.5	34.0	0.0	136.7	10.2	72.3	39.1	22.7	0.0	91.4	6.8
S.D.	54.6	15.7	11.4	5.3	79.9	32.2	7.9	19.4	6.5	3.1	9.2	25.4

Table 6.4. Pollen percentages of barrows 3 and 7 of Oss-Zevenbergen.

arboreal pollen sum can be used to show (lack of) variations in both regional and local vegetation. Since *Betula* pollen is rare in these samples it is hard to verify van Zeist's assumption that *Betula* should be excluded from the arboreal pollen sum.

Determining the pollen sum is determining the way to look at the landscape. In the reconstruction of barrow landscapes several approaches are of interest: what did the immediate surroundings of the barrow look like, what was the vegetation character of the open place in which the barrow has been built? Knowing the local vegetation is indispensible. Besides characterising the immediate surroundings, knowing what the further surroundings, the regional vegetation, looked like is necessary to be able to say something about the significance of barrows in the landscape. What did the wider landscape look like? When trying to determine the vegetation composition in a wider area it is best to leave the local vegetation species out of the pollen sum, since they can vary at short distances. An arboreal pollen sum would then be appropriate to answer these questions. Whether to in- or exclude *Betula* from the pollen sum seems to be site dependent. There is no reason to exclude *Betula* from the tree pollen sum according to the case-studies of Echoput and Oss-Zevenbergen. However, not many pollen grains of *Betula* have been found in the samples from these sites. Based on the results of Hijken, *Betula* is indeed very variable and of a probably local origin.

When having several contemporaneous samples from one site, information is provided about the heterogeneity of the herbal vegetation in the immediate surroundings of the site. In the case of Oss-Zevenbergen the variability of all species is least when a total pollen sum is used, but when an arboreal pollen sum is employed the variability is not much higher. Assuming that, besides the regional vegetation, the local herbal vegetation, which is most likely *Calluna*, probably is also very similar, indicates that the area around Oss-Zevenbergen was a quite homogenous heathland. In the case of the Echoput barrows the situation is different. Although also showing least variability of all species when a total pollen sum is used, the variability of especially *Calluna* is much higher when an arboreal pollen sum is used. Arboreal species show also higher variability, but the differences compared with a total pollen sum are small. It is likely that the variability in *Calluna* is caused by local variance of the species at the barrow site, indicating a more heterogeneous heathland.

Conclusions

In conclusion, since herbal vegetation can vary significantly even at short distances, the best pollen sum to use in barrow palynology is an arboreal pollen sum. Whether to in- or exclude *Betula* in this pollen sum seems to be site dependant, but one has to take into account that beside herbs also arboreal species can vary locally.

Although ∑AP seems to be the most useful pollen sum to apply in reconstructing the barrow landscape, percentages based on a total pollen sum do give valuable additional information about the barrow landscape. In barrow landscape reconstructions it is also of interest to estimate the size of the open place where the barrow has been built. The ratio between forest and herbal vegetation is a first indication and a total pollen sum should be applied to get this information. However, one has to take into account that the non-arboreal pollen percentage can fluctuate locally and preferably such an estimate should not be based on one sample. The ratio arboreal versus non arboreal pollen in relation to the size of the open space will be elaborated in the following chapter.

Chapter 7

The size of an open place where a barrow was built

Previous research has indicated that barrows were built in open places (see Chapters 2 and 3), mostly with heath vegetation, surrounded by forest. Knowing the size of these open spaces would give a more detailed vision of what a barrow landscape looked like, giving valuable information about the visibility of barrows in the landscape and about interaction of prehistoric man with the landscape (see section 3.3). As has been pointed out in Chapter 2, not much is known about the dimensions of the heathland area a burial mound was constructed in. In this research it has been attempted to reconstruct the open space the barrows were built in. Not only by determining the vegetation that was present, but also the distance of the open vegetation to the forest edge.

In this investigation three steps were taken to ascertain the size of the open spaces surrounding the barrows. The first step was to determine the minimum size of the open area, by analysing the construction of the barrow itself (section 7.1). The second step involved the comparison of pollen spectra of barrow soil samples with pollen spectra of present Dutch heathland areas (section 7.2). The third step expands on step two by involving palynological models into the reconstruction of the barrow landscapes (section 7.3).

7.1 The size and the number of sods used in a barrow

A first indication about the size of the open space can be obtained from the barrow itself. Barrows were built from sods and these sods were generally taken from treeless vegetation areas. When the original size of the barrow is still preserved or can be reconstructed and the size of the sods can be determined, these data can be used to calculate the treeless area that had been used for sod taking to build the barrow. Barrows were built in an open area. It is generally assumed that sods were taken in the direct surroundings of the place the barrow was going to be built, which can be tested by comparing pollen spectra from the sods and from the old surface beneath the barrow. In addition the sediment of the sods and the barrows should be similar when sods were cut close to the barrow location. When sods were indeed taken in the vicinity of the barrow, the size of the barrow and the sods can be used to reconstruct the minimum size of the open place where the barrow was built in as has been suggested by de Kort (1999). The assumption has to be made that the barrow was a smoothly shaped spherical segment (see figure 7.1). The volume of this spherical segment can be calculated by the following formula:

$$Vss = \frac{1}{6} \cdot \pi \cdot h \cdot (3r^2 + 1h^2)$$

Vss = Volume spherical segment
h = height of the barrow
r = radius of the barrow

Knowing the thickness of the sods, the area that needed to be stripped for 1 m^3 of barrow can be calculated.

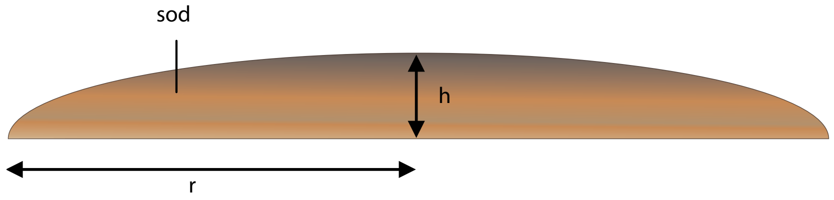


Figure 7.1. A schematic drawing of a barrow. To calculate the minimum area that has been used for sod cutting to build a barrow, a barrow can be seen as a smoothly shaped spherical segment, which has been built with uniform sized sods. Figure after Doorenbosch 2011, figure 5.6 by J. Porck.

7.1.1 An example:

Two barrows are situated at a location called the Echoput near Apeldoorn (see also 8.1). The measurements of the barrows are (van der Linde and Fontijn 2011, 33; Bourgeois and Fontijn 2011, 65):

Barrow 1: r=9.5 m (d=19 m), h=1.08 m
Barrow 2: r=7.25 m (d=14.5 m), h=1.0 m
Sods: average h=0.25 m

These measurements can be used to calculate the area to be stripped for both barrows with the formula discussed above, which represents the minimum size of the open space. For barrow 1 an area of 615 m^2 was stripped and for barrow 2 an area of 332 m^2. These results will be further discussed in section 8.1.

7.2 The size of an open heathland area - examples from present Dutch heathland areas

A second indication about the extent of the open area is provided by the palynological analyses. Palynological analysis gives insight in the type of landscape that has been present at the time the pollen precipitated. The *quality* of the landscape can be determined by the achieved pollen spectra of an area. In addition, the *quantitative* reconstruction of past landscape has been an important goal in many palynological researches. To achieve this goal it is important to understand the relation between pollen and vegetation. A pollen spectrum cannot be directly translated into a vegetation composition, with other words; there is not a simple linear relationship between pollen and vegetation. Since (most) barrows were built in heath vegetation, it is the relation between pollen from a heathland area and its vegetation that is of interest in this study; or, to be more precise, the size of the heathland area and the position of the barrow inside. A comparative study has been conducted in Dutch heathland areas to investigate the relation between the pollen spectra from barrows and the distance from the barrow to the forest. Heath areas have been selected based on a few criteria. Since the purpose is a comparison of barrow landscapes, the vegetation composition from the recent heathland areas should be similar to the heathland of the barrow period. This implies that the main vegetation of the area should be *Calluna vulgaris* and that the heath should be surrounded by forest. Forest in the barrow periods consisted mainly of deciduous trees, coniferous trees were not present in large numbers yet, given that most were planted in the Netherlands from the 19th century onwards (Janssen 1974, 57). At present most forests consist for a significant part of coniferous trees. To make the comparison as realistic as possible heathland areas was selected with a minimal amount of coniferous trees in and around them. Surface samples were taken in the heath area with several distances from the forest edge and analysed for pollen. Pollen spectra and the distance from the sample location to the forest edge were tested for correlation.

Sites and sampling methods

Herikhuizerveld I (HHV1)

Herikhuizerveld is an extensive heathland area in the National Park Veluwezoom in the east of the Netherlands (see figure 7.2). The heath vegetation is dominated by *Calluna vulgaris*. The forest surrounding the open heathland area is a mixture of deciduous and coniferous trees. At the edge of the forest one single common hazel (*Corylus avellana*) was present. *Corylus avellana* was a very common shrub in the barrow periods and pollen of hazel were often found in considerable numbers in barrow pollen spectra. Nowadays, the shrub is much scarcer and finding a heathland area with common hazel in the close surroundings was very difficult. The presence of the species in this heathland area, even if it was just one single shrub, was an important selection criterion for this area. The area is being grazed by sheep, horses and Highland cattle. A transect of twelve moss surface samples was taken (see figure 7.3), or when moss was not present some litter was collected from the surface. Samples were prepared by the method described in section 4.2.

Herikhuizerveld II (HHV2)

Another transect of eleven moss/litter samples was taken in the Herikhuizerveld, about 1 km east from the first transect (see figure 7.3). The vegetation criteria were also applicable here, except for *Corylus avellana*, which was not present close to this transect. Samples were prepared by the method described in section 4.2.

Zuiderheide (ZH)

The *Zuiderheide* is an area in a nature reserve called the *Goois Natuurreservaat* in the middle of the Netherlands (see figure 7.2). It is an area of about 300 ha with forest, heath, drift sand areas and some small lakes. The area is grazed by sheep and cattle (mostly Highland Cattle). Pollen samples were taken along a transect

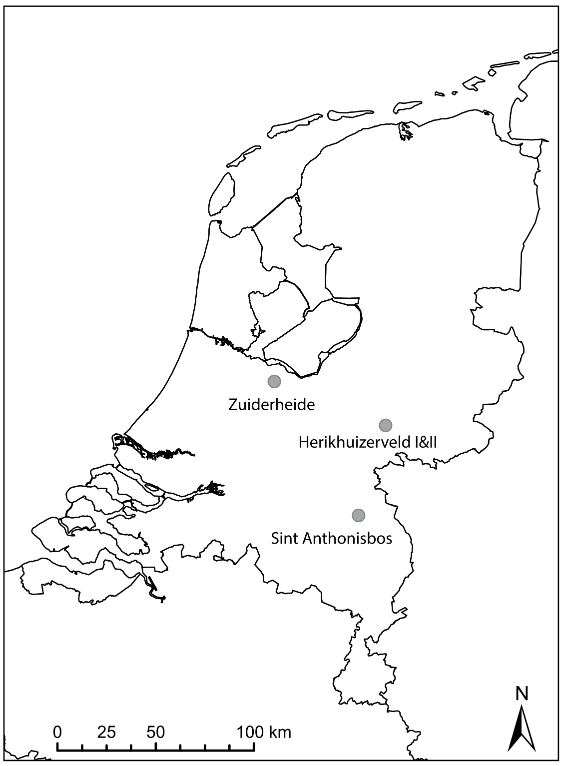


Figure 7.2. The locations of the heath areas at Herikhuizerveld (HHV), Zuiderheide (ZH) and St Anthonisbos (StA).

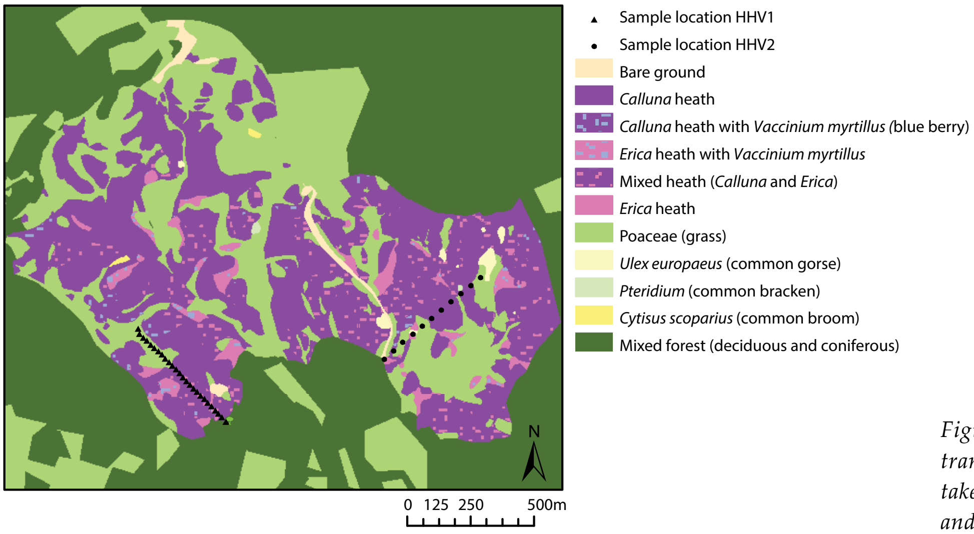


Figure 7.3. Map of the transect of pollen samples taken at Herikhuizerveld I and II.

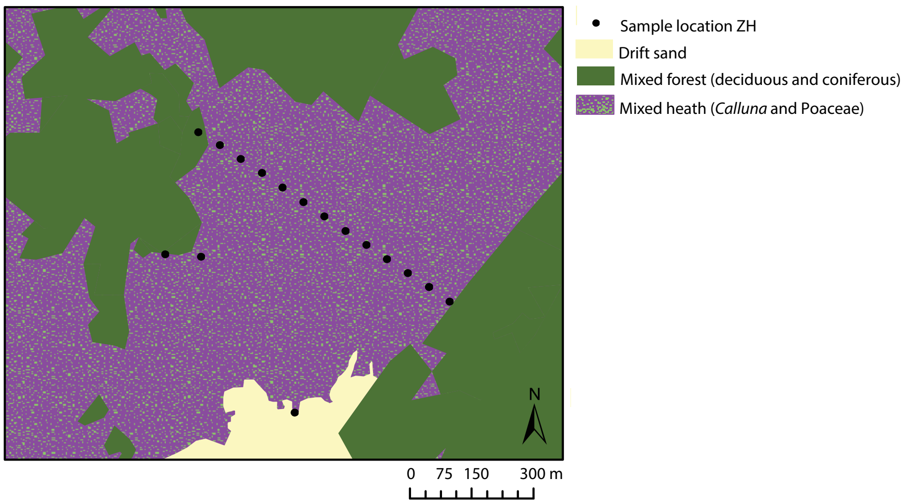


Figure 7.4. Map of the transect of pollen samples taken at Zuiderheide.

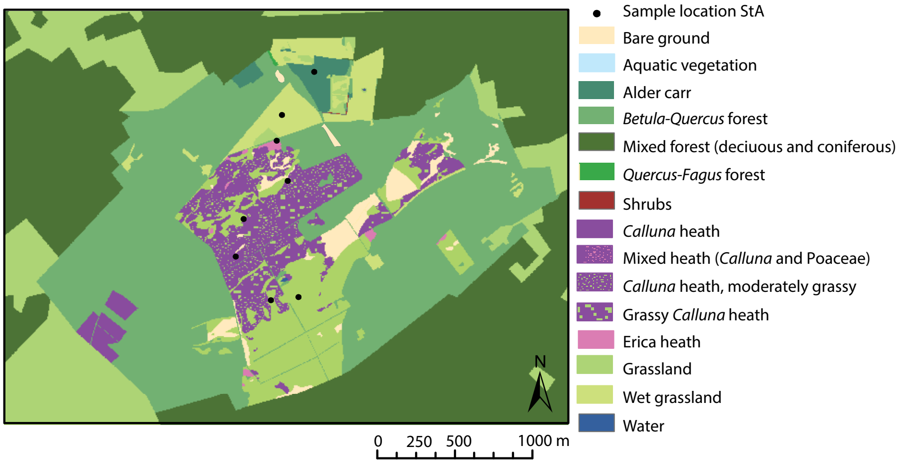


Figure 7.5. Map of the sample locations at St Anthonisbos.

through heath vegetation, from one forest edge to another (see figure 7.4). Heath mainly consists of *Calluna vulgaris*, the forest is a mixture of deciduous (*Fagus sylvatica, Betula pendula, Quercus robur, Amelanchier lamarckii*) and coniferous trees (*Pinus sylvestris*). Sixteen moss surface samples were taken, or when moss was not present some litter was collected from the surface. Samples were prepared according to the method described in section 4.2.

Sint Anthonisbos

In 1999 de Kort analyzed the Sint Anthonisbos (forestry of Sint Anthonis) as part of his MA-thesis. The forestry of Sint Anthonis is a roughly 800 ha nature reserve area in the province of North Brabant in the Netherlands (see figure 7.2). It is a varied landscape of production forest for the most part, coniferous alternating with deciduous trees, and also having heath, fields and pasture areas. In the forest a heath-drift sand area of approximately 150 ha is situated, dominated by *Calluna vulgaris*. The area is currently being grazed by sheep and Highland Cattle. North of this area an alder brook forest is situated. Eight samples were taken in different characteristic parts of this landscape (see figure 7.5). Surface samples were taken from the upper litter layer. Sample preparation and analysis were performed by J.W. de Kort (for methods see de Kort 1999).

Methods of analysis

Pollen samples were analysed as described in section 4.2. A pollen sum of total pollen minus the coniferous trees has been used. Pinaceae have been left out of the pollen sum since they were rarely present at the time the barrows were built. In addition pollen from Pinaceae are known to be transported over long distances and can therefore influence the arboreal pollen percentage, while not coming from within the nearest forest (Pidek *et al.* 2010). The percentages of arboreal (AP) and non-arboreal pollen (NAP) have been calculated based on this total pollen sum. From every sample point the distances to the surrounding forest edges were measured and the average distance to the forest edge (ADF) was determined. Using SPSS 19 Pearson product-moment correlation was carried out to identify significant positive relationships between the percentage of NAP and the ADF (obvious outliers have been removed from the data), which was the case in all of the sites. Then regression analysis was applied to the data to show the correlation between the percentage of NAP and the ADF. It was tested with Graph Pad Prism 5 whether the lines of best fit were significantly different or whether one line could fit all data sets.

Results and discussion

There has been discussion whether pollen percentages can be correlated with vegetation openness. Sugita *et al.* state that pollen percentages are insufficient to quantify the percentage of land cover in open to semi-open land (Sugita *et al.* 1999). Svenning however, found good correlation of NAP percentage with vegetation openness in interglacial sites (Svenning 2002). This was independently confirmed by data from beetle, molluscs and plant macro fossils. In this investigation arboreal percentages and the ADF were significantly positively correlated per site and these data will be used to estimate the size of an open place. In table 7.1 arboreal pollen percentages for each sample per site are presented based on a total pollen sum minus Pinaceae. In addition the ADF per sample is shown. The AP was plotted against ADF and the line of best fit, which is a log-linear function, shows the relationship between the AP and the ADF (see figure 7.6). The lines of best fit of Sint Anthonisbos and Goois Natuurreservaat did not differ significantly from each other ($p=0.26$), the lines that best fit the data of Herikhuizerveld 1 and Herikhuizerveld 2 were significantly different from each other and from the other two data sets. However, the lines of best fit of HHV1 and ZH were almost significantly similar ($p=0.0495$). The differences between the lines become clear when applied to high percentages of non arboreal pollen. Since most barrow pollen spectra show AP percentages between 30% and 60%

HHV 1		HHV2		StA		ZH	
ADF (m)	AP (%)	ADF (m)	AP (%)	ADF (m)	AP (%)	ADF (m)	AP (%)
93.5	58.4	10	64.4	10	81.1	10.0	93.4
146.3	40.1	392.5	42.8	123	38.2	260.0	52.7
142.1	43	391.25	26.4	318.75	25.5	266.7	34
140.4	53.5	372.5	45.5	325	16	258.3	26.7
139.5	57.4	360	15.6	370	11.2	271.7	19.2
144.8	44.9	350	41	313.75	22.7	270.0	18
149.7	62.2	337.5	28.2	316.25	23.5	280.0	19.8
156.0	57.5	320	39.7	318.75	26	285.0	38.6
163.4	42.6					295.0	34.3
270.7	24.4					298.3	27
272.7	18.6					303.3	20.1
						263.3	17.1
						16.7	78.3
						31.7	76.6
						221.7	38.5
						232.3	31.9

Table 7.1. Average distance to the forest (ADF) and arboreal pollen (AP) percentages for each sample per site, based on a pollen sum minus Pinaceae.

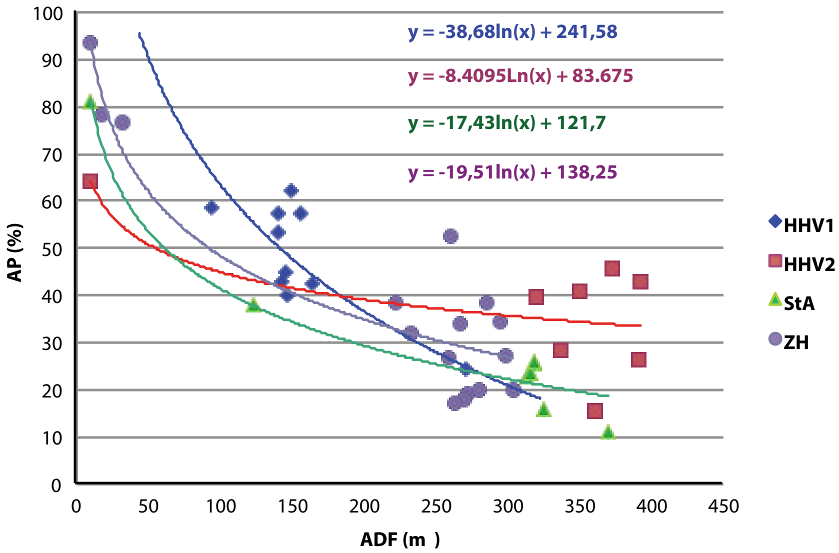


Figure 7.6. AP's plotted against ADF, showing the lines of best-fit. HHV=Herikhuizerveld, StA=St Anthonisbos, ZH=Zuiderheide

(see Chapter 8) these differences do not have great influence on the interpretation of the barrow pollen spectra in relation to the size of the open space which line of best fit will be used.

Hypothetical arboreal percentages from 0 to 100% and the according average distance to the forest edge based on the best fit lines shown in figure 7.6 are presented in table 7.2. Most barrow pollen spectra show AP percentages between 30% and 60%. This corresponds with small open spaces with a radius of 25-100 m for 60% AP and rather large open spaces with a radius up to 500 m for 30% AP.

Other studies have investigated the relation between pollen percentages and land cover. These studies gave comparable results as described above. Contemporary moss polster pollen data indicate that closed canopy forests produce arboreal

Site	AP (%)	ADF (m)	AP (%)	ADF (m)	AP (%)	ADF (m)	AP (%)	ADF (m)
HHV1	0	516	30	237	60	109	90	50
HHV2		118845		552		26		1
StA		1077		193		35		6
ZH		1195		257		55		12
HHV1	10	398	40	183	70	84	100	39
HHV2		4272		198		9		0.4
StA		607		109		19		3.5
ZH		716		154		33		7
HHV1	20	307	50	142	80	65		
HHV2		1536		71		3		
StA		342		61		11		
ZH		429		92		20		

Table 7.2. Hypothetical non arboreal percentages from 0 to 100% and the according average distance to the forest edge (ADF) based on the best fit models (see figure 7.6).

pollen percentages of 60-90%. Completely open sites showed arboreal pollen percentages of less than 50% (Mitchell 2005). Tinsley and Smith took surface samples across a woodland/heath transition in northern England (Nidderdale, Yorkshire; Tinsley and Smith 1974). The results showed that close to the woodland (oak) edge arboreal pollen percentages exceeded 50%. They also showed a rapid decline of arboreal pollen percentage within 100 m from the forest edge. The results in this investigation also show a fast decline of arboreal pollen when the distance to the forest increases, although not as extreme as in Nidderdale. Arboreal pollen percentages of less than 20% have not been found in the Dutch heathland areas. This can be explained by the fact that average distances to the forest edge do not exceed 400 m in the investigated Dutch heathland areas. The woodland may be further away in one direction, but then in another direction other woodland would be nearer. Another research by Tinsley in southwest England again showed a rapid decline in tree pollen with increasing distance from the woodland edge (Tinsley 2001) and also Lanner showed the main decrease of arboreal pollen to lie within 160 m from the woodland (Lanner 1966).

When interpreting a pollen spectrum one has to take into account that individual trees present in an open space have a great influence on the percentage of arboreal pollen. For example HHV2 sample 10 was taken very close to an oak tree (*Quercus*) and the according arboreal pollen percentage is 74.1%. This is a solitary tree in the heathland area, with the closest forest edge at approximately 250 m, so the distance to the forest edge and the size of the open space would be clearly underestimated in this case. This is a problem that is difficult to avoid; in this case study this sample was excluded. In all of the Dutch heathland areas of this investigation solitary trees were present and it is likely that these trees have increased the percentage of arboreal pollen. As a consequence the distance to the forest edge would be overestimated when applying these lines of best fit to data where no individual trees are present. However, when assuming prehistoric heathland areas also contained solitary trees, this effect would be compensated. On the other hand, in the case of an individual tree in close proximity to a barrow, the arboreal pollen percentage would be too high and the distance to the woodland edge would be underestimated.

This investigation has focussed on pollen spectra from heathland areas, since most barrow pollen spectra show considerable percentages of heath pollen. Precaution has to be taken when the non-arboreal component of a pollen spectrum is dominated by grasses (Poaceae) instead of heath in combination with high arboreal percentages. Groenman-van Waateringe has investigated the effect of heavy grazing of sites dominated by Poaceae on the pollen production (Groenman-van Waateringe 1993). Heavy grazing prevents grasses from flowering and as a consequence from dispersing pollen grains. Pollen spectra from these sites can display very high percentage of arboreal pollen, since the percentage of the main herbal vegetation (Poaceae) is kept low by grazing. Consequently, a pollen spectrum with a high arboreal pollen percentage in combination with Poaceae being the main component of the non-arboreal pollen can indicate a site in or close to the forest, but it can also indicate a larger open grassland area that is heavily grazed.

Conclusions

This research has shown a positive correlation between the percentage of arboreal pollen and the distance to the forest edge in Dutch heathland areas. Although the relation seemed to be complicated and precautions must be taken, based on these results it seems that most barrows, showing arboreal percentages between 30% and 60%, have been built in open places varying in size from rather extended to narrow. The larger open spaces used for barrow building would have had a radius of 200-500 m, the smaller open places a radius of 25-100 m. The ratio of AP versus NAP should only be used as a rough approximation of the size of an open place. The pollen spectra from the two barrows at the Echoput (see also 8.1) will serve as an example. In table 7.5, the ratios of AP versus NAP for samples taken from barrow 1 and barrow 2 are shown. The average arboreal percentages for each barrow (30% and 27%) imply an open space of 200-500 m (see table 7.2).

7.3 The distance of a barrow to the forest edge - palynological modelling

Palynological analysis gives insight in the type of landscape that has been present at the time the pollen precipitated. As has also been demonstrated in section 7.2 the relation between pollen and vegetation is quite complicated. The relation is highly dependent on the dispersal of pollen grains from the pollen source into the surroundings. An important factor that determines the dispersal of pollen is the pollen productivity of a taxon. Other factors include pollen-specific characteristics (size, weight, shape), wind speed, height of the vegetation in the surroundings, etc. In the last few decades models of pollen dispersal and deposition have been developed, improving the understanding of this pollen-vegetation relationship. These models could be of great value when reconstructing barrow landscapes, possibly offering the opportunity to show a more detailed view of the vegetation in the surroundings of a barrow and the size of the open space.

Extended R value (ERV) models have been developed to convert pollen percentages into relative plant abundances. These models have been based on the R-value model developed by Davis, $R_i = p_{i,k}/v_{i,k,}$ describing the linear relationship between the pollen percentage ($p_{i,k}$) and the vegetation cover percentage ($v_{i,k}$) of taxon i at site k (Davis 1963). This model has been adjusted in the following decades to account for background pollen. This resulted in the ERV-model. The basic assumption of the ERV-model is that the pollen loading (number of pollen grains) of taxon i at site k ($\gamma_{i,k}$) is linearly related to the distance-weighted plant abundance (in kg/m^2 or m^2/m^2) of taxon i around site k ($x_{i,k}$), $y_{i,k} = a_i x_{i,k} + \omega_i$. The pollen productivity of taxon i (a) and the background pollen loading of taxon i (ω_i) are constant for every taxon (Prentice and Parsons 1983). Since pollen loadings can vary greatly within sites and are often not available (for example in fossil samples) percentage data have to be used. However, interdependence of pollen percentages can cause non-linearity of the relationship between pollen and vegetation percentages (Fagerlind-effect; Fagerlind 1952). The ERV-model has taken the Fagerlind-effect into account by introducing so-called site-factors to be able to relate pollen percentages to vegetation percentages. There are three submodels of the ERV-model that have different assumptions about the background pollen loading. In submodel 1 (Parsons and Prentice 1981), the background pollen loading (ω_i) is assumed a constant proportion of the pollen loading of all pollen taxa γ_k ($\omega_i = z_i \cdot \gamma_k$, where z_i is the background pollen percentage). Submodel 2 (Prentice and Parsons 1983) assumes constant background pollen percentage relative to the total plant abundance of all taxa φ_k ($\omega_i = z_i \cdot \varphi_k$). Submodel 3 (Sugita 1994) relates the pollen percentage to the absolute vegetation abundance, where submodels 1 and 2 used vegetation percentages. This model assumes constant background pollen loading ω_i for each taxon. Distance weighing of the vegetation data is necessary, since plants close to the sampling point contribute more pollen than plants further away. The simplest way to weigh the vegetation is by dividing the plant abundance by the distance *d* between the plant and the sampling point, $\frac{1}{d}$ (Prentice and Webb 1986), or by the square of the distance, $\frac{1}{d^2}$ (Webb *et al.* 1981). Two other models use a weighting method that is based on Sutton's (1953) equations for dispersal of small particles in the atmosphere (Sutton 1953). These models are referred to as the Prentice/Sugita models (Prentice 1985, Sugita 1993). In these models the pollen loading is dependent on the distance, atmospheric conditions and taxon-specific properties.

The parameters *a* and ω can be estimated using maximum likelihood methods (Parsons and Prentice 1981), meaning that the values of these parameters are the most likely of having produced the observed values. The lower the maximum likelihood function score, the better the fit of the observed data to the model estimated data. Because the pollen assemblage is a distance-weighted function of the plant abundance, the maximum likelihood function score should decrease and approach an asymptote as the vegetation area increases. The relevant source area of pollen (RSAP), the area beyond which goodness of fit between pollen and vegetation data does not improve (Sugita 1994), can be determined. The pollen coming from beyond the RSAP can be estimated as the background pollen loading. The pollen productivities should be estimated at or beyond the RSAP (Broström *et al.* 2008). When the vegetation data are properly distance weighted the slope of the ERV-models represents an estimate of the pollen productivity (PPE=pollen productivity estimate), the y-intercept represents the background pollen loading.

Barrow landscape simulation

Software, called HUMPOL (Middleton and Bunting 2004), has been developed in which vegetation cover maps can be used to generate modelled pollen assemblages. This allows for comparing multiple landscape scenarios to fossil pollen spectra (Nielsen 2004, Gaillard *et al.* 2008, Soepboer and Lotter 2009). The openness of the landscape around a barrow based on the ratio NAP versus AP (see section 7.2) can be tested when PPEs are known. PPEs have been calculated for several sites throughout Europe based on the theory described above. An overview has been published by Broström *et al.* (2008). Differences in PPEs between sites are not unusual. Several explanations for these variances are given. Environmental factors such as climate, vegetation structure and vegetation composition have influence on the pollen production. In addition, different vegetation survey methods (visual estimate of cover, modified circle walking [6]and rooted frequency) result in differences in PPEs, so PPEs should only be compared when the vegetation survey method is similar (Bunting and Hjelle 2010). Also the method of pollen collection (moss polsters, lake sediments) can cause differences in PPE (Broström *et al.* 2008). A third factor that can cause differences is the reference taxon. PPEs are calculated relative to a reference taxon (the pollen productivity of the reference taxon is set to 1). Poaceae has become a standard reference taxon (Broström *et al.* 2008), since it is a widespread taxon and present in most vegetation communities. However, it is very likely that the pollen production of Poaceae differs between sites, causing differences in PPEs relative to the PPE of Poaceae. When comparing PPEs between sites, the reference taxon should be similar, but the variability of the reference PPE should be borne in mind. PPEs have not yet been determined in the Netherlands. Detailed vegetation and pollen data are necessary to determine PPEs for a certain region. After intensive search, it would appear that such a combination of data is not possible for Dutch heathland areas at the moment. As an alternative, PPEs from a comparable region should be used for testing the Dutch barrow landscapes. PPEs derived from Southern Sweden and Norway are probably best comparable to Dutch PPEs. Although southern Sweden has longer days in summer and temperatures in western Norway are slightly lower than in the Netherlands, both regions have a moderate maritime climate like the Netherlands. Since in southern Sweden PPEs have been calculated for herbal as well as arboreal taxa, these data will be used to simulate a Dutch heathland area to test whether these PPEs can be applied in simulating barrow landscape scenarios. However, PPEs for tree taxa were originally based on *Juniperus* and later recalculated for Poaceae as reference taxon (Sugita *et al.* 1999, Broström *et al.* 2008). This should be kept in mind when interpreting the results. The software that has been used in this simulation is HUMPOL (Middleton and Bunting 2004).

St Anthonisbos

The St Anthonisbos (see section 7.2) seemed to be appropriate for simulation. A digital vegetation cover map from the area was provided by Staatsbosbeheer. This digital vegetation map was converted into ASCII for the HUMPOL software to process it (see figure 7.7). Vegetation communities have been simplified based on the available PPEs. Fall speeds of the included taxa have been based on Sugita *et al.* (1999) and Broström *et al.* (2004). See for an overview of used PPEs and fall speeds table 7.3. Wind speed was set to 4.05 m s^{-1} according to the daily mean wind speed measured at the Bilt from 1904-2012. The wind rose was set in 16 directions according to the frequency distribution of daily mean wind direction at the Bilt (The Netherlands) from 1904-2012. Both wind speed and wind rose are based on data provided by the Royal Netherlands Meteorological Institute[7]. It is often assumed that the prevailing wind direction in the Netherlands is south-southwest. The mean frequency distribution of the wind direction for the last century shows that this is not entirely correct (see figure 7.8). November, December and January have been excluded for the calculation of the mean wind speed and wind rose, since the majority of plants do not produce pollen during these months[8].

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6 Within a series of concentric rings around the sample point a visual estimate of cover for each taxon within each full ring is recorded.

7 (http://climexp.knmi.nl)

8 Corylus (hazel) is one of the earliest to flower in February, while Ericaceae (heath) can still flower up to October (Weeda *et al.* 1988, 37).

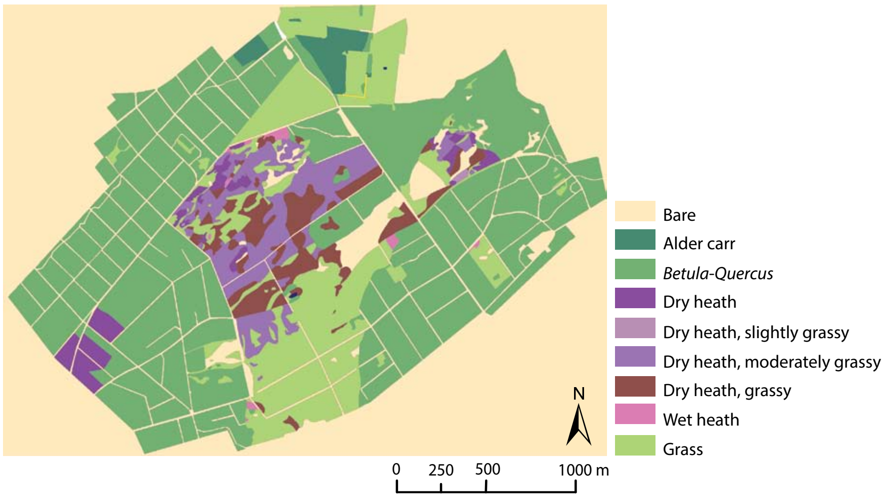


Figure 7.7. Vegetation cover map of St Anthonisbos as used in the simulations. Betula-Quercus=15% Betula, 30% Quercus, 10% Poaceae ; Bare= no vegetation; Alder carr= 70% Alnus, 5% Salix, 10% Poaceae , Dry heath= 90% Calluna; Dry heath, slightly grassy= 70% Calluna, 10% Poaceae ;Dry heath, moderately grassy= 60% Calluna, 30% Poaceae; Dry heath, grassy= 40% Calluna, 30% Poaceae; Wet heath= 30% Calluna, 20% Poaceae ; Grass= 90% Poaceae.

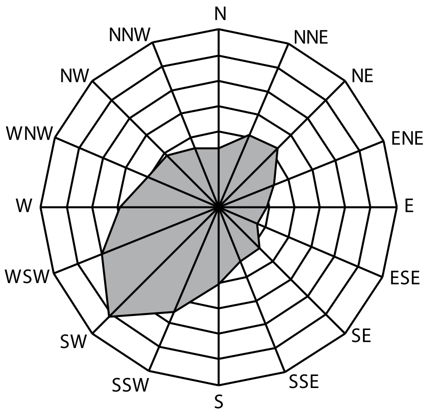


Figure 7.8. Wind rose according to the frequency distribution of daily mean wind direction at the Bilt (The Netherlands) from 1904-2012. November, December and January have been excluded.

Table 7.3. Pollen productivity estimates (PPE) and fall speeds of the pollen from the taxa used in the simulations.

	PPE	**Fall speed (m/s)**
Alnus	4.2	0.021
Betula	8.9	0.024
Corylus	1.4	0.025
Fagus	6.7	0.057
Quercus	7.6	0.035
Salix	1.3	0.022
Tilia	1.3	0.032
Calluna	4.7	0.038
Poaceae	1	0.035

Pollen spectra have been determined from eight sample locations in the area by de Kort (see also 7.2). Simulated pollen percentages of these eight locations have been calculated by the simulation program based on PPEs from south Sweden. The simulated and the percentage data observed in the real samples for the taxa used in the simulation are shown in table 7.4 (simulation 1 versus observed 1). As can be seen the simulated data fit the observed data considerably well. Although the ratio between *Calluna* and Poaceae (see table 7.4) appears to fall short of accurately portraying the situation, the ratio between arboreal and non arboreal pollen percentages seems to be appropriate, with exception of samples 5, 6 and 7. This is probably due to pine trees close to these sample locations (de Kort 1999). When *Pinus* is left out of the simulation, the simulated data fit the observed pollen data very well (see table 7.4). The ratio *Calluna* versus Poaceae not being

	sample 1				sample 2			
	Sim. 1	real 1	sim. 2	real 2	sim. 1	real 1	sim. 2	real 2
Alnus	69.82	77.09	74.73	80	2.85	18.29	3.32	20.04
Betula	5.07	6.48	5.43	6.72	10.80	4.47	12.55	4.90
Pinus	6.60	3.63	0	0	14.10	8.75	0	0
Quercus	8.19	3.48	8.76	3.61	17.44	3.31	20.28	3.62
Salix	1.59	1.42	1.71	1.48	0.08	0.00	0.09	0
Calluna	1.82	0.79	2.06	0.82	6.62	7.98	8.08	8.74
Poaceae	6.91	7.11	7.32	7.38	48.10	57.20	55.68	62.69
AP	91.27	92.10	90.63	91.80	45.27	34.82	36.24	28.57

	sample 3				sample 4			
	sim. 1	real 1	sim. 2	real 2	sim. 1	real 1	sim. 2	real 2
Alnus	1.12	2.57	1.26	2.89	0.38	2.73	0.40	3.11
Betula	8.37	8.28	9.41	9.30	4.68	4.54	4.95	5.18
Pinus	11.11	10.93	0	0	5.90	12.26	0	0
Quercus	13.65	9.32	15.28	10.47	7.38	4.54	7.82	5.18
Salix	0.03	0.42	0.04	0.47	0.01	0.23	0.01	0.26
Calluna	50.81	19.07	57.74	21.41	67.33	52.76	72.26	60.14
Poaceae	14.90	49.41	16.27	55.47	14.31	22.94	14.55	26.14
AP	34.28	31.52	25.99	23.13	18.35	24.30	13.18	13.72

	sample 5				sample 6			
	sim. 1	real 1	sim. 2	real 2	sim. 1	real 1	sim. 2	real 2
Alnus	0.23	1.14	0.23	1.28	0.09	2.46	0.09	3.13
Betula	5.95	2.93	6.12	3.29	5.11	7.58	5.45	9.64
Pinus	7.45	10.78	0	0	6.63	21.31	0	0
Quercus	9.35	4.61	9.62	5.17	8.21	5.74	8.76	7.29
Salix	0.01	0.00	0.01	0.00	0	0.20	0.00	0.26
Calluna	51.40	44.25	65.83	49.60	75.90	53.48	82.07	67.97
Poaceae	25.62	36.29	18.19	40.67	4.05	9.22	3.62	11.72
AP	22.99	19.46	15.98	9.73	20.04	37.30	14.30	20.31

	sample 7				sample 8			
	sim. 1	real 1	sim. 2	real 2	sim. 1	real 1	sim. 2	real 2
Alnus	0.12	2.25	0.13	3.06	0.17	2.68	0.18	3.44
Betula	6.77	6.29	7.36	8.53	7.71	7.79	8.49	9.97
Pinus	8.49	26.33	0	0	9.58	21.88	0	0
Quercus	10.64	7.35	11.58	9.98	12.05	9.26	13.28	11.86
Salix	0	0.47	0.00	0.64	0.01	0.40	0.01	0.52
Calluna	37.20	28.00	41.73	38.00	12.72	2.42	15.12	3.09
Poaceae	36.77	29.30	39.19	39.77	57.77	55.57	62.92	71.13
AP	26.02	42.70	19.07	22.22	29.52	42.01	21.96	25.77

Table 7.4. Simulated and real pollen percentages for St Anthonisbos. Simulation 1 is including Pinus, simulation 2 excluding Pinus.

Table 7.5. Average arboreal percentages (AP) and non arboreal percentages (NAP) for the two Echoput barrows.

	AP (%)	NAP (%)
Barrow 1	31.25	68.75
Barrow 2	28.37	71.63

accurate can be explained by the vegetation data of the vegetation cover map not being detailed enough.

Echoput

As a pilot study the PPEs from south Sweden will be applied to a barrow landscape. The assumption has to be made that PPEs did not change through time. Two barrows are situated near Apeldoorn at a location called the Echoput. These barrows have been excavated and palynologically investigated. The case study will be extensively discussed in chapter 8 (see 8.1; see also 5.3 and 7.2). In MOSAIC (part of the HUMPOL software) a barrow landscape of 1.5 by 1.5 km has been designed based on the palynological results of the Echoput barrows. The taxa considered in this simulation are *Calluna, Poaceae, Alnus, Corylus, Fagus* and *Quercus.* The average percentage of AP in the pollen spectra based on the taxa used in the simulation is 30% (see table 7.5). Based on the results this open space consisting of a mixture of *Calluna* heath and grasses was created with a radius of 300 m (see table 7.2).

The Echoput samples showed rather high percentages of *Corylus*. *Corylus* is a tree that requires light conditions to grow and it will not be able to survive in the reduced light conditions in a closed forest. This indicates that the open space was probably surrounded by a mantle vegetation mainly consisting of *Corylus*, shown by a white ring in the simulation landscape (see figure 9a). Based on the observed pollen percentages in the Echoput samples, the surrounding forest consisted mainly of *Quercus* and some *Fagus*. In the simulation landscape a hypothetical mixture based on an educated guess (*e.g.* observed pollen percentages and fall speed of the taxa) of 75% *Quercus* and 15% *Fagus* was created, surrounding the *Corylus* vegetation mantle. The last species to add to the simulation landscape is *Alnus*. *Alnus* is a tree that requires moist conditions to grow and it is most likely that alder carr was present in the lower and wetter brook valleys in the environment. Since these were located south and west of the Echoput barrows this is where alder carr was placed in the simulation landscape. The simulation landscape with the according vegetation communities is shown in figure 7.9a. Fall speed and PPEs from southern Sweden have been applied to simulate pollen assemblages at the locations of the two Echoput barrows. The wind rose has been set as it was in the St Anthonis simulation.

Table 7.6 shows the simulated (*e.g.* the percentages that were obtained by the simulation) and the observed (*e.g.* in the 'real' Echoput samples) pollen percentages, based on a total pollen sum of taxa used in the simulation. The total arboreal (AP) and non-arboreal pollen (NAP) percentages have been calculated as well. Note how the simulated AP and observed AP are very different from one another. This indicates that the size of the open space was overestimated in the first simulation. To improve the simulation, the open space in the simulation landscape was decreased to a radius of 200 m, all other components being left unchanged (figure 7.9b). In table 7.5 can be seen that the percentage of AP now fits the observed AP percentage. However, the composition of the vegetation communities seems not to be accurate. Several simulation landscapes with varying vegetation compositions were tested to come to a possible landscape scenario where the simulated data fit the observed data. Such a possible landscape scenario is shown in figure 7.10.

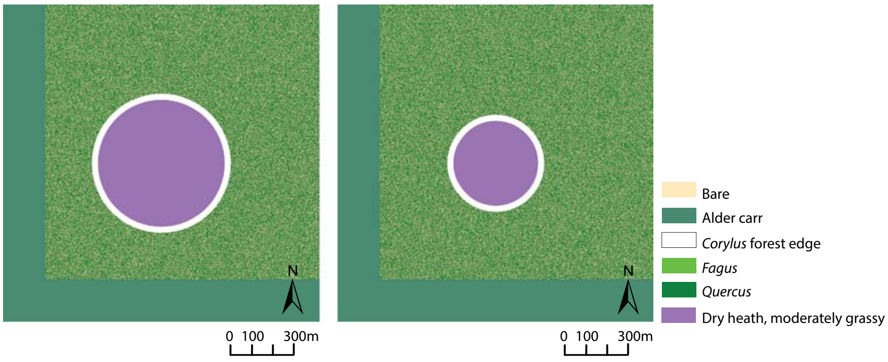


Figure 7.9a-b. Simulated landscape for the Echoput barrows with different sizes of heathland (a=300m and b=200m). Alder carr=90% Alnus; Quercus=100% Quercus; Fagus=100% Fagus; Corylus forest edge= 70% Corylus, 10% Calluna, 10% Poaceae; Dry heath= 50% Calluna, 40% Poaceae.

This landscape shows an open place with a grassy heathland. The alder forest is adjacent to this heathland open space. A wide forest edge consisting of *Corylus* surrounds the open space. The surrounding forest is quite open, with only 50% *Quercus* and 15% *Fagus*. However, this is not a very realistic landscape. The geology of the environment is also of great influence on the landscape. To create a more realistic landscape a digital elevation map of the environment (Dutch: AHN *Actueel Hoogtebestand Nederland*) was combined with the simulation landscape in figure 7.10. The result is shown in figure 7.11. In this scenario the heath area is not circular, but stretched along the top of the plateau the Echoput barrows were built on. This grassy heathland, 40% *Calluna* and 50% Poaceae, is approximately 700 m long and 300 m wide. The barrows are not located in the centre, but in the southwest; the ADF is approximately 250 m. Alder carr is situated in the lowest areas, the brook valleys. The heath is surrounded by a zone of *Corylus* of approximately 150 m in width. This zone gradually shades into the forest, which is very open with 30% *Quercus* and 5% *Fagus*. Simulated pollen percentages show that the alder carr is greatly underestimated and that the abundance of *Quercus* is slightly overestimated. It is however not very likely that the alder carr was situated closer to the barrows. It is possible that the PPE of *Alnus* used in this simulation was too low. A study performed in England has for example calculated a PPE for *Alnus* of 11.4 (Broström *et al.* 2005) and in Estonia an *Alnus* PPE of 13.92 was found (Poska *et al.* 2011). When the PPE of *Alnus* in this simulation is set to 11.4 the simulated pollen percentages are indeed much more similar to the real pollen percentages (see table 7.5).

The investigation gives promising results for the use of models in the reconstruction of past barrow landscapes. Quantitative reconstructions of barrow landscapes would be very useful to enhance our knowledge about the environments that the barrows were built in. These simulations were based on pollen productivity estimates (PPEs) that have been determined in southern Sweden. As has been shown by Broström et al. (2008) PPEs can differ between sites. Although the PPEs from southern Sweden seem to be fairly applicable in Dutch simulations it is very likely that the actual PPEs in the Netherlands were not exactly alike, as has also been been shown in the last simulation. Even within the Netherlands PPEs could show variations between different types of landscapes. Barrows were mainly been built in heath vegetation. It is therefore recommended to have detailed vegetation surveys and collection of pollen data in Dutch heathland areas to be able to achieve PPEs of the major Dutch heathland taxa. The vegetation survey area should be large enough to cover the RSAP of the pollen. Bunting and Hjelle showed that the relevant source area of non-arboreal pollen in heathland areas is less than 4 m (Bunting and Hjelle 2010). This would make the achievement of PPEs of the herbal heathland taxa relatively simple. For the determination of arboreal PPEs

Figure 7.10. Example for an Echoput landscape scenario. Alder carr= 90% Alnus; Quercus= 100% Quercus; Fagus= 100% Fagus, Bare= no vegetation, Corylus heath edge= 70% Corylus, 10% Calluna, 10% Poaceae; Corylus forest edge= 70% Corylus, 5% Quercus, 10% Poaceae; Dry heath= 30% Calluna, 40% Poaceae.

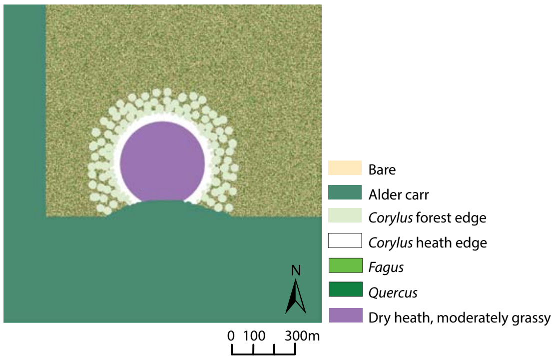


Figure 7.11. Example for an Echoput landscape based on the AHN. Alder carr= 90% Alnus; Background forest= 30% Quercus, 5% Fagus, 20% Poaceae; Corylus heath edge= 70% Corylus, 10% Calluna, 10% Poaceae; Corylus forest edge= 70% Corylus, 5% Quercus, 10% Poaceae; Dry heath= 40% Calluna, 50% Poaceae.

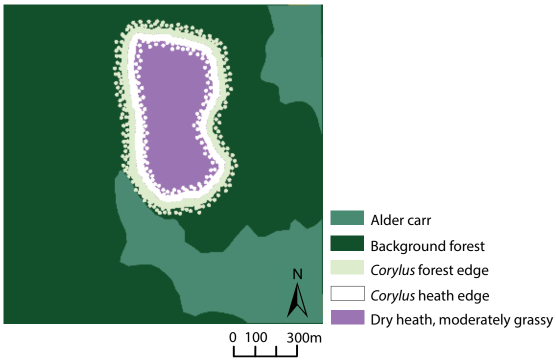


Table 7.6. Simulated and real (average) pollen percentages for the two Echoput barrows. Sim1=landscape shown in fig.7.10a (ADF=300 m); sim2= landscape shown in fig.7.10bx (ADF=200 m); sim3= landscape shown in fig. 7.11; sim4=landscape shown in fig. 7.12 (based on AHN) ; sim5=landscape shown in fig.12, with PPE for Alnus adjusted to 11.4. Wind speed was set to 4.05 and wind rose according to the Dutch growing season for all simulations.

	Alnus					
	real	sim. 1	sim. 2	sim. 3	sim. 4	sim. 5
barrow 1	19.88	3.00	2.86	12.17	6.05	14.87
barrow 2	16.30	2.98	2.84	12.92	5.66	14.01
	Corylus					
barrow 1	4.76	0.39	0.54	2.13	3.93	3.56
barrow 2	4.91	0.39	0.54	2.02	4.35	3.97
	Quercus					
	real	sim. 1	sim. 2	sim. 3	sim. 4	sim. 5
barrow 1	16.59	23.63	11.4	10.89	9.87	16.59
barrow 2	16.56	23.59	11.01	11.37	10.36	16.56
	Poaceae					
	real	sim. 1	sim. 2	sim. 3	sim. 4	sim. 5
barrow 1	16.15	11.30	10.14	19.01	17.08	15.47
barrow 2	19.26	11.31	10.15	18.95	16.99	15.48
	Fagus					
	real	sim. 1	sim. 2	sim. 3	sim. 4	sim. 5
barrow 1	0.53	1.97	2.86	1.94	1.03	0.93
barrow 2	0.31	1.96	2.85	1.87	1.07	0.98
	Calluna					
	real	sim. 1	sim. 2	sim. 3	sim. 4	sim. 5
barrow 1	52.60	66.75	59.98	53.35	61.03	55.3
barrow 2	52.59	66.79	60.03	53.22	60.55	55.2
	AP					
	real	sim. 1	sim. 2	sim. 3	sim. 4	sim. 5
barrow 1	31.25	21.95	29.89	27.64	21.9	29.23
barrow 2	28.15	21.89	29.82	27.82	22.45	29.32

the survey area should be much wider, approximately 1500-2000 metre radius (Broström *et al.* 2008). A relatively simple approach of modelling landscape has been used here as a pilot study to test PPEs on a barrow landscape scenario. When Dutch PPEs are known this approach might be extended by using the 'Landscape Reconstruction Algorithm' (LRA) developed by Sugita (2007a, b). The inverse forms of the ERV-models can be used to reconstruct past vegetation abundance. With an estimate of the pollen productivity and known pollen proportions, vegetation proportions can be calculated. However, the background pollen component is not constant and changes over time. This change in background pollen can be estimated when regional plant abundance and the pollen source area are known. For that reason the LRA has been developed, estimating regional and local vegetation abundance. To obtain a reliable estimate of the regional vegetation it is advisable to use pollen assemblages from large sites (>100-500 ha) or when such large sites are not available, from as many smaller sites as possible. It would be of value to investigate whether this approach can be applied to Dutch barrow landscapes.

7.4 Discussion

In this chapter an attempt was made to give an estimate of the size of the open space barrows were built in. The number of sods that were used to construct a barrow can provide a first indication of the minimum size of this open spot (section 7.1). The ratio between AP and NAP has been used to get a second approximation of the size of the heath area a barrow was built in, by estimating the Average Distance to the Forest (ADF; section7.2). A positive correlation between the size of an open place and the percentage of NAP was found, but there are differences present between the sites and the relation was therefore complicated. Also Broström *et al.* showed the ratio AP versus NAP cannot be simply translated in vegetation openness, and that differences in background pollen appear to play an important role in the relative representation of NAP (Broström *et al.* 1998). Sugita *et al.* too underline the importance of background pollen coming from the regional vegetation (Sugita *et al.* 1999). The landscape simulation models and software that have been developed could give better insight in the relation between Non Arboreal Pollen percentage and landscape openness and enhance our understanding on what a barrow landscape looked like (7.3). To apply these models properly to Dutch barrow landscapes further research is recommended. This study will therefore not test further barrow landscape scenarios with the palynological modelling methods, excepting the Echoput.

The three approaches have been applied to the Echoput case study. The first approach suggested a minimum size of the open space of about 615 m^2 for barrow 1 and 332 m^2 for barrow 2. This could indicate a circular open spot with an ADF of about 14 m and 10 m respectively, which seems rather small. The second approach yielded an ADF of approximately 300 m, which is indeed much greater. The third approach indicated that an ADF of 300 m might be an overestimation. The ADF was corrected to approximately 250 m. The following chapters of this thesis will discuss several case studies and for each case study the size of the open space a barrow was built in will be estimated. Since the palynological modelling approach still needs further research, the second approach (*e.g.* AP:NAP) will be used as a standard in the following chapters. It should be kept in mind though that a slight overestimation of the size of the open space could occur.

Part Three

Case–studies

Part 3 will discuss several case studies, gathering information in answer to the questions that were put forward in the beginning of this thesis (Chapter 3): what did the barrow landscape look like? An answer to this question is needed in order to understand the function of barrows in the landscape and how barrows relate with the natural and cultural landscape surrounding them. What was the original impetus behind the creation of the open space a barrow was built in, and what was that open space used for? Human activity played an important role in the history of an open space. An open space could for example have been used as a grazing area, for the cultivation of crops, or it could have served as settlement location.

In part 2, Chapters 4-7, several methodological aspects of pollen sampling in barrow research have been described and discussed. In addition the uncertainties, assumptions and consequences for the results were discussed as well as how to interpret the results. All have a bearing on part three of this thesis. In Chapter 6 it was concluded that the best pollen sum to use in barrow research is an Arboreal Pollen (AP) sum. Inclusion of *Betula* (birch) should be decided per site.. To be able to compare all sites with one another it has been decided to apply an arboreal pollen sum minus *Betula* to *all* sites. The percentages of arboreal and non arboreal pollen have been calculated based on a total pollen sum (see sections 6.2 and 7.2).

In Chapters 8-12 several case-studies are discussed. Chapters 8-10 consider three research areas that are all situated on the push moraines that were formed during the Early and Middle Pleistocene in the northern half of the Netherlands. Chapters 11 and 12 will study two research areas that are situated in the southern part of the Netherlands, where cover sand was deposited during the Late Pleistocene. Most of the palynological data discussed in Chapters 8-12 were originally obtained by other researchers (for references see the corresponding case-studies). For the case-studies most of the data were re-analysed and pollen spectra and/or pollen diagrams were re-plotted. In some cases pollen percentage data had to be recalculated based on the appropriate pollen sum for the present barrows study (*e.g.* tree pollen sum minus *Betula*, see Chapter 6). Subsequently all (re-analysed) data have been reinterpreted by the author of the present work.

Not all methods described in Chapters 4-7 could be applied to all case-studies. As has been mentioned above, much of the palynological data used in the following chapters were obtained by other researchers many years ago. It is often the case that documentation about the sampling method and the exact sample locations is not available, especially when dealing with older excavations. Many burial mounds were excavated in the 1920s-1940s. Knowledge about barrows has grown enormously since then and excavation methods are much more detailed now. The older excavations sometimes lack proper documentation, and when this is available, is sadly incomplete. Dating of the excavated barrows was usually based on grave goods, but the exact location of these finds was not always well documented. Multi-period barrows were often not recognized, while stratigraphic differences were not distinguished. Hence, it is difficult to relate grave goods to proper dating of the barrow. Many of these barrows were re-excavated during the 1970s. These re-excavations were mostly based on the documentation of the older excavations, which we now know was not always correct or complete. Many samples for pollen analysis were taken during these re-excavations. Since (the original) documentation was not always accurate it is not in all cases clear what the exact sample location was in a barrow. It is therefore hard to establish the relation of the samples to the dating of the barrow. The old surface of the second period of barrow at Stroe (section 8.10), for example, was sampled following the documentation, while with the present knowledge it cannot be confirmed that there was indeed a second period in that barrow. In such a case it is hard to specify the exact sample location and to say more on the dating of the according pollen spectrum. However, since it is not always possible to retrieve the necessary information to clarify this relation, one has to rely on data that are available. As a consequence one has to assume that not all pollen spectra are correctly dated. However, only about 5% of the barrows discussed in this thesis seem to have encountered this problem and this will be accounted for in the discussion of the corresponding case-studies (*e.g.* 8.3 Ermelo, 8.10 Stroe, 8.11 Uddelermeer, 9.1 Warnsborn and 9.1 Wolfheze). For a more extensive discussion about the reliability of older excavations and consequences for interpretation in present research see Bourgeois (2013, p.47-48).

As a final introductory note to the case-study chapters, it should be mentioned that many barrows are known by several names. Barrows were often re-excavated and across several publications the same barrows were assigned different names. For this thesis all the barrows that are discussed have been given a new name. In Appendix I an overview can be found of the other names and numbers a given barrow was assigned in the several publications from which data were extracted for use in the following chapters.

Chapter 8

Northern and central Veluwe

In the northern and central part of the Veluwe (the Netherlands), palynological data was obtained from several barrows that exist in an area of approximately 20 by 20 km (see figure 8.1). In the following sections the palynological results of these barrows will be described and discussed, based on the theory set out in part two of this thesis (Chapter 4–7). This chapter will start with two barrows at the Echoput. All the data from these barrows were collected by the author. Most of the methods described in Chapters 4-7 have been applied to the barrows of the Echoput and therefore these barrows will feature first. The second group of barrows that will be discussed in this chapter is located at Niersen-Vaassen. The data from two barrows of Niersen were collected by the author. The data of all other barrows in this chapter were obtained from other researchers and they will be discussed after the discussion of the Echoput barrows and the barrows of Niersen-Vaassen. At the end of this chapter a pollen diagram derived from a lake sediment (Uddelermeer, see section 8.11) will be presented after all the barrows have been discussed. This pollen diagram will provide more information about the vegetation in the wider surroundings of the barrows.

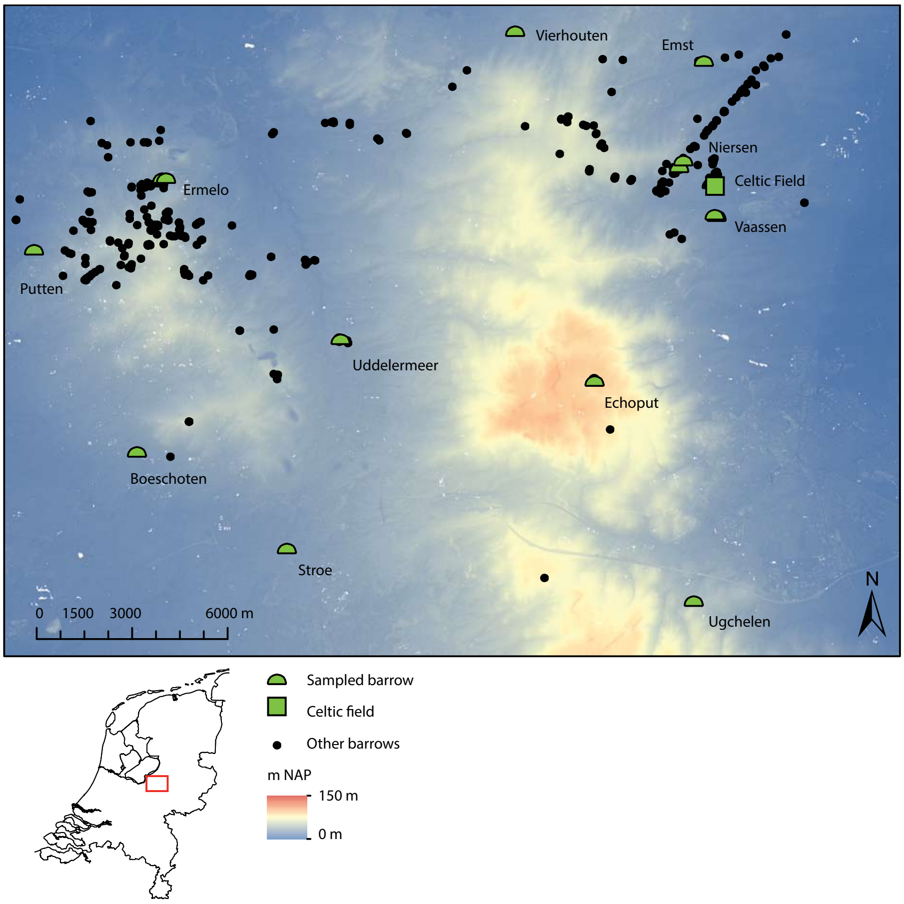


Figure 8.1. Detailed map of the Echoput and surroundings with the location of all discussed barrows. The map is based on digital elevation model of the AHN (copyright www.ahn.nl).

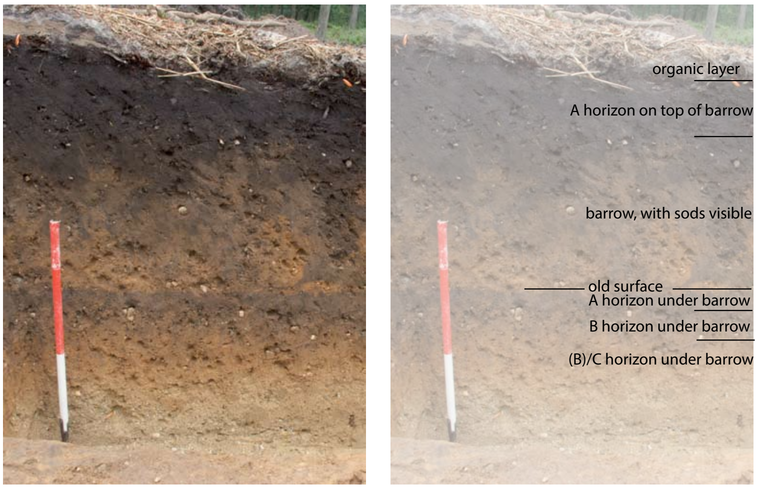


Figure 8.2. The Echoput barrows one year after they were excavated.

Figure 8.3. A section of Echoput barrow 2 (section 2.1 of barrow 2 in trench 2) with the old surface clearly visible. Photograph by Bourgeois 2012, figure 3.2).

8.1 Echoput

Close to Apeldoorn two barrows are situated on a small hilltop. The site that these barrows are located at is known as the Echoput. Excavation of these barrows took place in the summer of 2007 (see figure 8.2). For an extensive description of the excavation results see Fontijn *et al.* (Fontijn *et al.* 2011)

8.1.1 Site description

Both barrows showed similarities in construction and soil properties. They were both built on a surface in which an Umbric Podzol (Dutch soils classification: Holtpodzol gY30 [see *Bodemkaart van Nederland*[9]*])* had developed. The barrows were constructed of sods that were still clearly visible, which were taken from a Holtpodzol identical to the one they were placed on top of. The old surface was well recognizable in the soil profile (see figure 8.3). The barrows were dated to

9 Bodemkaart van Nederland 1:50.000 toelichting kaartblad 33 west Apeldoorn, p. 27, 67-8.

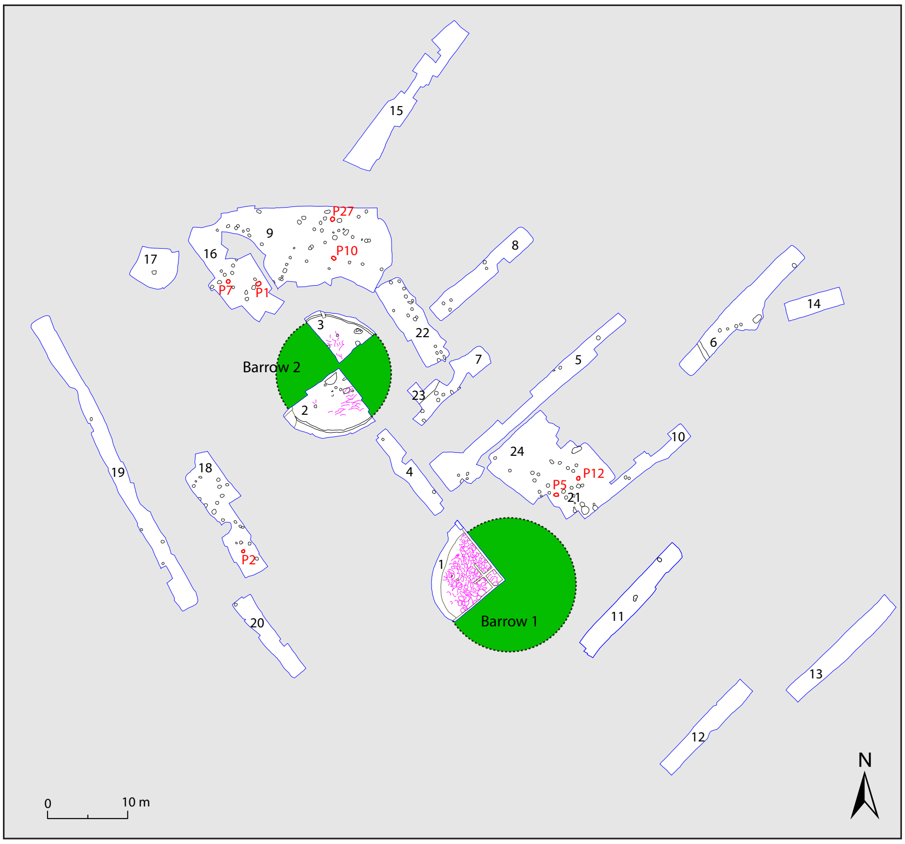


Figure 8.4. Plan of all trenches of the excavation of the Echoput barrows. Trench numbers are indicated. The P-numbers indicate the post features of which the fills have been sampled for pollen analysis. Figure by P. Valentijn/ M. Doorenbosch.

the Middle or Late Iron Age, based on ^{14}C of charcoal from both ring ditches: 2225±30 BP (GrA-44706; 331-203 cal BC, calibrated with Oxcal 4.2; mound 1) and 2240±35 BP (GrA-44879; 326-204 cal BC, calibrated with Oxcal 4.2; mound 2) as *post quem* dates. In addition, a *terminus ante quem* date for mound 1 of 2190±35 BP (GrN-32158; 376-171 cal BC, calibrated with Oxcal 4.2) was derived from charcoal from a pit (S1) that was dug into the mound. The combination of *post* and *ante quem* dates and the similarity of both mounds make it likely that both mounds were constructed in the 4th or 3rd century cal BC (Fontijn 2011, 152-153).

Excavation of the surroundings revealed a large amount of features including a round post structure and two other post structures (see figure 8.4). Traces dating to the Late Mesolithic and the Late Neolithic B period have been found underneath both mounds (van der Linde and Fontijn 2011, 60-61; Bourgeois and Fontijn 2011, 85).

The Echoput is a somewhat aberrant place in the local environment. It is one of the highest places in this part of the Veluwe (95 m above Amsterdam Ordnance Datum). The Veluwe exhibits an average yearly precipitation sum that is considerably higher than in most parts of the Netherlands, since orographic precipitation occurs on the elevated parts, like at the Echoput. The moist air is forced to ascend where the landscape is elevated, causing the air to cool down, form clouds and rain out. The local (loamy) soil conditions prevents the water from draining off immediately, which makes the Echoput hill a rather wet place, with pools of water forming regularly (see for a more detailed description Fontijn 2011a, 29-31). The surrounding area is covered with mixed forest (deciduous and coniferous forest). The modern deciduous forest consists mainly of oak coppice (*Quercus sp.*), with an undergrowth of blueberries (*Vaccinium myrtillus)* and grasses, but also birches (*Betula sp.)* and beeches (*Fagus sylvatica)* are present. The

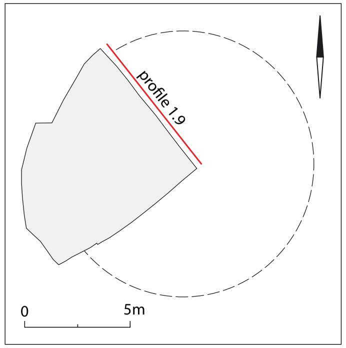
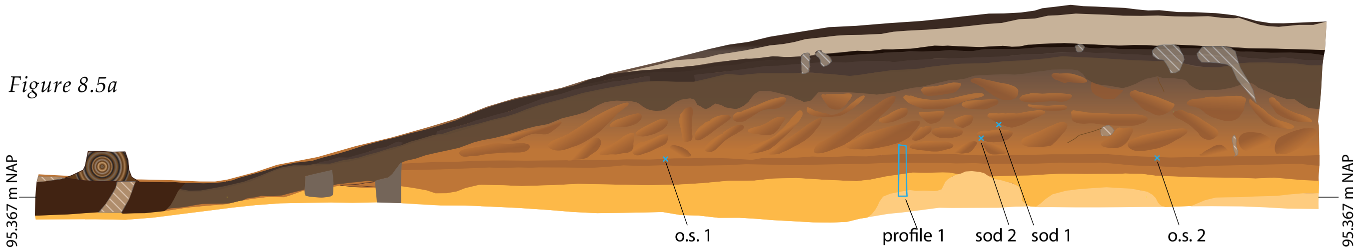
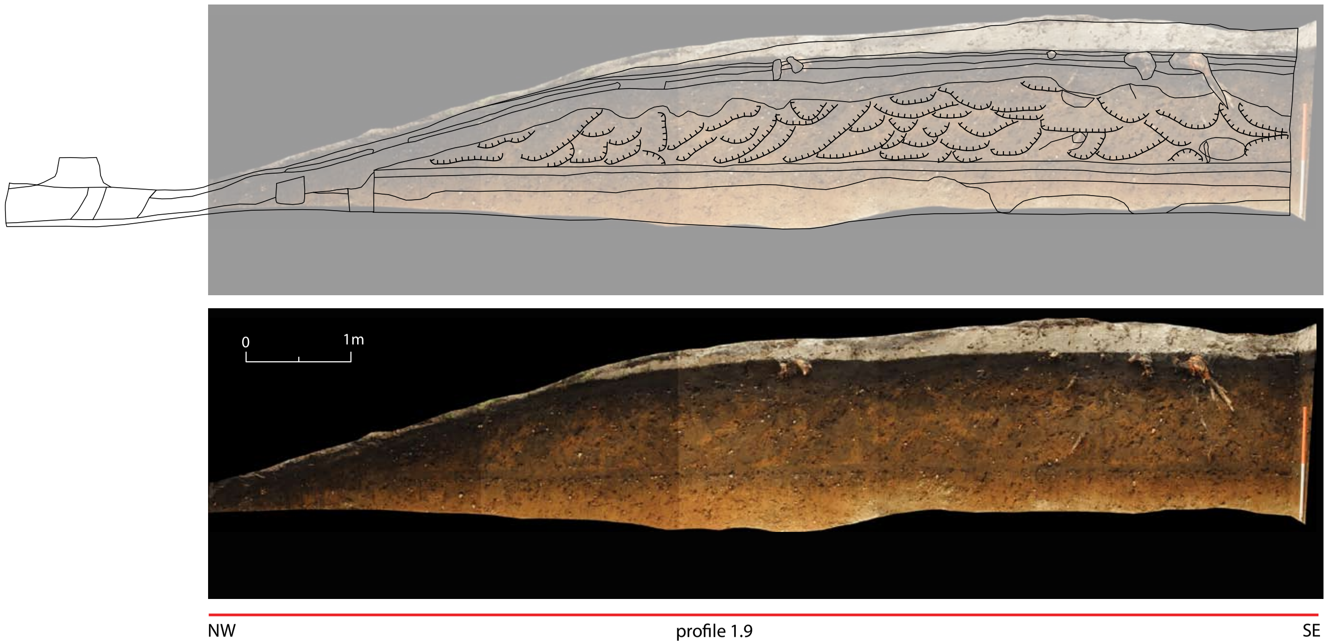


Figure 8.5a-c. Profile sections of Echoput barrow 1 (a-b) and barrow 2 (c) with the location of the pollen samples indicated. Figure 4a-b after van der Linde and Fontijn 2011, figure 2.17 and 2.18 with changes; figure after Bourgeois and Fontijn (2011, figure 3.8 A with changes).

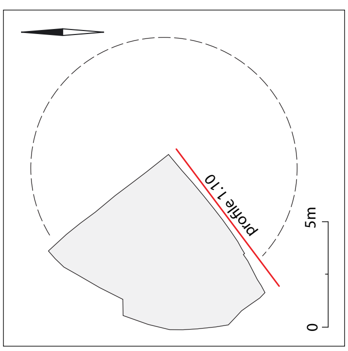
Figure 8.5a






95.366 m NAP
o.s. 4
o.s. 3
sod 4
sod 3
95.366 m NAP
0
1m
SW
profile 1.10
NE

Figure 8.5b


profile 1.10
0
5m

94.821 m NAP
94.779 m NAP
sod 1
sod 2
sod 3
o.s. 1
o.s. 2
o.s. 3
profile 2
1m
0
profile 2.1
profile 3.1
SE
NW
5m

Figure 8.5c

Sample location			Sample name
Echoput1	Profile 1.9	Soil profile series	1-19
			20-35
	Profile 1.9	Sod samples	Echoput1_sod1
			Echoput1_sod2
		Old surface samples	Echoput1_os1
			Echoput1_os2
	Profile 1.10	Ditch samples	Echoput1_ ditch
		Sod samples	Echoput1_sod 3
			Echoput1_sod 4
		Old surface samples	Echput1_os 3
			Echoput1_os 4
	Level 10	Structure 17	Pit 1
Echoput 2	Profile 2.1	Soil profile series	1-24
	Profile 2.1	Soil profile series	25-29
	Profile 2.1	Sod samples	Echoput2_ sod 1
			Echoput2_ sod 2
			Echoput2_ sod 3
		Old surface samples	Echoput2_ os 1
			Echoput2_ os 2
			Echoput2_ os 3
Trench 9	Level 1		Post 10
			Post 27
Trench 16	Level 1		Post 1
Trench 18	Level 1		Post 2
Trench 21	Level 1		Post 5
			Post 12

Table 8.1. Overview of the samples taken from the Echoput barrows and their surroundings. The samples that have been analysed are indicated by a shade. Those with a darker shade did not contain any or not enough pollen. For the exact location of the analysed samples, see figure 8.4 and 8.5. os = old surface underneath mound.

coniferous forest consists mostly of pines (*Pinus sp.*), together with some Douglas-firs (*Pseudotsuga menziesii*) and Larches (*Larix sp.*). The barrows were located in the forest, overgrown with trees and other vegetation, making them difficult to spot. In 1999 both barrows were consolidated. The above ground parts of the trees found on and around the barrows were removed, and the barrows were covered with white sand to regain their presumed original shape.

8.1.2 Pollen sampling and analysis

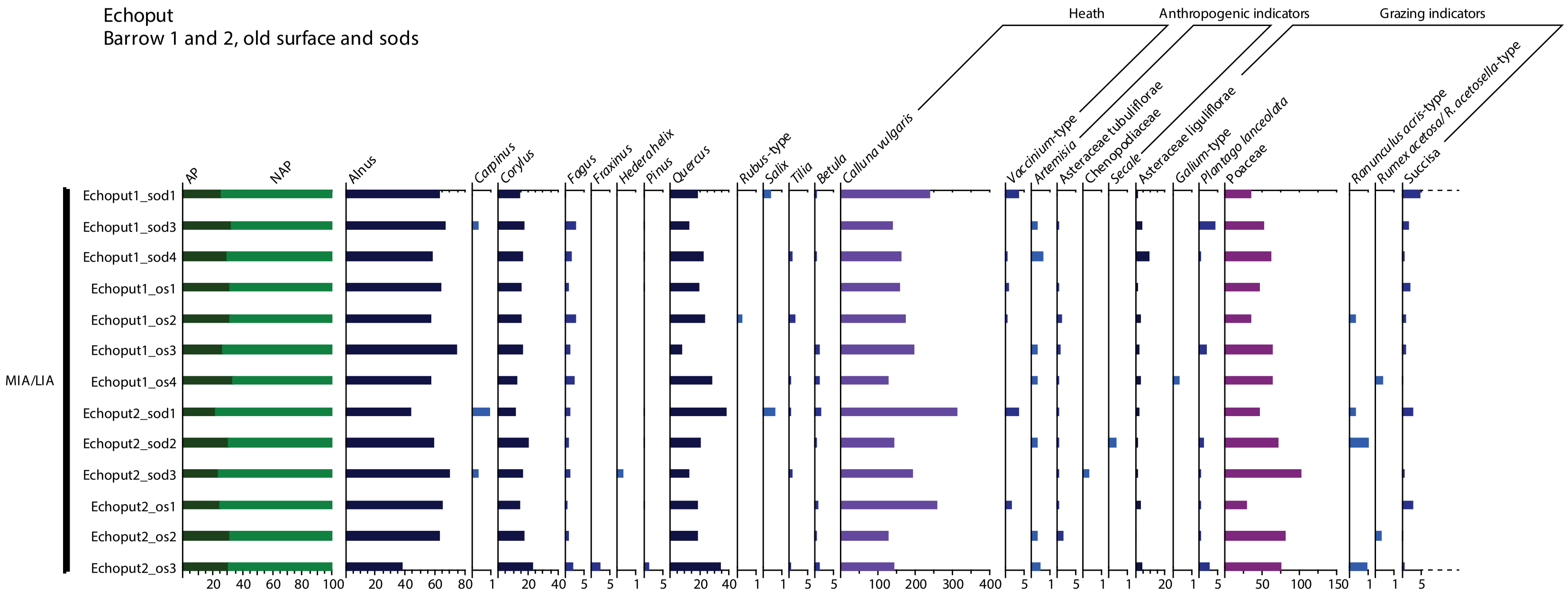
During the excavation samples were collected for pollen analysis. For each mound, individual samples were taken from different locations in and under the barrows by Bakels and Achterkamp (University of Leiden, the Netherlands). From each mound several samples were taken from the old surface underneath the mounds, where the old surface was clearly visible. In addition several samples from the top (*e.g.* the old surface) of different good recognizable sods of both mounds were taken. The bottom of the ditch around mound 1 and the fill of a small pit (structure 17) that was found underneath mound 1 were also sampled. Sampling was done using methods described in Chapter 4. From these samples a selection was made for analysis, based on the quality (colour and texture) of the soil. An overview of the samples that were taken and analysed is shown in table 8.1. The location of the analysed samples in the mounds is given in figure 8.5. In addition samples were taken from the soil profile underneath both mounds. Samples were collected as has been described in 4.1.3 over a length of 30 cm, containing the A and most of the B horizon (see figure 8.5). In addition many samples were taken from the fill of post features that were found in the surroundings of which four were analysed. These four post features belonged to four different structures (see figure 8.4). A description of the sampling method and discussion can be found in 4.1.5. Chemical treatment and analysis of the samples took place as described in 4.2. For all pollen spectra a pollen sum of ∑AP–*Betula* (chapter 6) has been used, except for the AP and NAP. These percentages have been based on a total pollen sum. A minimum of 300 arboreal pollen grains (excluding *Betula*) per sample have been counted by the author of the present work.

8.1.3 Results

For mound 1 four samples of the old surface, four sod samples, a sample taken from the ditch (profile 1.10) and a sample from a small pit (level 10, structure 17) underneath mound 1 have been analysed (see table 8.1). Sample 2 from the old surface did not contain enough pollen to count, as did the ditch sample and the sample from the pit. The remaining samples contained sufficiently preserved pollen. In addition the soil profile underneath mound 1 was sampled, from which pollen could be obtained from 1 to 19 cm below the old surface. From mound 2 the three samples from the old surface and the three sod samples gave good results, although pollen preservation was relatively poor. From the pollen series that was taken the soil profile underneath mound 2 results could be obtained from 1 until 25 cm below the old surface. The samples derived from 25-29 cm were very poor in pollen numbers. Below the results will be described.

Pollen from the old surface underneath the mounds and from the sods

The pollen spectra from the two barrows show no clear differences and therefore they will be discussed together. In addition, no differences could be noted between the pollen spectra from the old surface and the sods of both mounds, so the result description below counts for both the old surface and the sod spectra. The percentage of non arboreal pollen (NAP) exceeds the percentage of arboreal pollen (AP) in all samples (see figure 8.6). Especially heather (*Calluna vulgaris)* and less but still in considerable amounts Poaceae (grasses) show high percentages. The most abundant tree pollen types are *Alnus* (alder, 35-70%)*, Quercus* (oak, 15-40%) and *Corylus* (hazel, 15-25%). The presence of *Carpinus* (hornbeam) in some of the spectra should be noted. Some *Pinus* (pine) pollen is present, but it is unlikely that this tree was present in the surrounding forest. *Pinus* is not a common native tree in the Netherlands in the time period after the Boreal but before the large scale *Pinus* plantation starting in the 19th century AD (Janssen 1974, 57) and therefore the *Pinus* pollen in the pollen spectra most likely came from long-distance. This accounts for all pollen spectra that will be discussed. Anthropogenic indicators (*cf.* Behre 1986) and grazing indicators (*cf.* Hjelle 1999) are present in all the samples. One pollen grain of *Secale* (rye) was found in one of the sods (2) of mound 2. Non-pollen palynomorphs were mostly represented by *Sphagnum* (peat moss) and moss spores, but also algae like *Debarya glyptosperma* and *Zygnema* type 314 (van Geel in: van Hoeve and Hendrikse 1998) are notable.



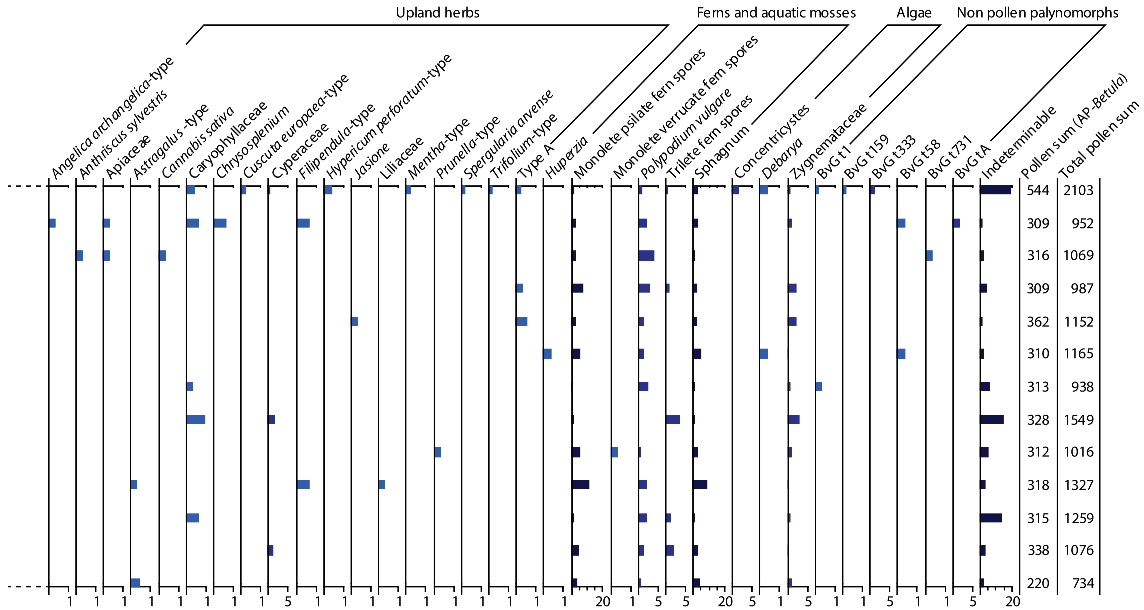


Figure 8.6. Pollen spectra from the sod and old surface samples taken from Echoput barrow 1 and 2. Spectra are given in % based on a tree pollen sum minus Betula pollen. In the total AP (=arboreal pollen) Betula is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours. MIA= Middle Iron Age, LIA= Late Iron Age.

Pollen from the soil profile underneath mound 1

The zones described below are biostratigraphical units, based on palynological changes in the diagram (see figure 8.7). This means they are not automatically equivalent to geochronological zones.

Zone 1

A slight decrease in the arboreal pollen component from approximately 40 to 25% can be seen. This is mainly due to a decrease in *Tilia* pollen, which starts at 20% and decreases to around 2%. The forest cover in the surroundings of the Echoput was dominated by *Alnus*. In addition the forest consisted mainly of *Quercus* and *Corylus*. A high percentage of heather is present which even starts to expand further at the end of this zone. Besides *Calluna vulgaris* grasses (Poaceae) were present in considerable amounts as well as *Polypodium vulgare* (common polypody). Pollen of anthropogenic and grazing indicators such as *Artemisia* (mugwort) and *Plantago lanceolata* (ribwort plantain) are present in low amounts.

Zone 2

The expansion of *Calluna vulgaris*, which started in Zone 1, continues followed by an expansion of Poaceae. The forest cover does not appear to be subject to extreme changes in total, there is however an increase in *Quercus* and a decrease in *Corylus* pollen percentage. In addition an increase in *Fagus* pollen is shown. The anthropogenic and grazing indicators have expanded to some extent.

Zone 3

In zone 3 an increase in *Tilia* pollen percentage can be seen, together with a decrease in *Calluna vulgaris*. Poaceae shows an increase as well as most other herbs and ferns.

Pollen from the soil profile underneath mound 2

The zones described below are biostratigraphical zones, based on palynological changes in the diagram (see figure 8.8). This means they are not automatically equivalent to geochronological zones.

Zone 1

In this oldest part of the diagram, a decrease in AP can be seen, from 40% to 20%. The forest at the beginning of this period consisted mainly of *Tilia* (lime), *Quercus* and *Alnus.* A decline of *Tilia* pollen is notable in this zone, as well as the appearance of *Fagus* (beech) pollen. The percentage of *Alnus* pollen shows an increase as well. Heather shows an expansion, as well as Poaceae. Anthropogenic indicators, like *Artemisia* and Asteraceae tubuliflorae are present in low amounts, grazing indicators like Poaceae, Asteraceae liguliflorae and *Plantago lanceolata* are present in higher amounts.

Zone 2

In Zone 2 *Tilia* decreases further until almost no *Tilia* pollen is found. *Corylus* shows an increase and the other tree species remain quite stable. *Calluna vulgaris* fluctuates between 100 and 200%, Poaceae between 50 and 100%. Anthropogenic and grazing indicators are present in higher amounts than in Zone 1. The percentages of ferns and mosses have decreased, as well as *Sphagnum*.

Zone 3

Zone 3 shows a peak in *Tilia* pollen numbers and a decrease of *Calluna vulgaris*. This is also shown in Zone 3 of Diagram 1. Zone 3 of Diagrams 1 and 2 is based on the top samples taken from the soil profile and it is very well possible that part of the sod above the old surface has been included in these samples. This sod also contains a soil profile, similar to the soil profile underneath the barrow. As a consequence it is likely that these samples do not represent the youngest vegetation composition in this diagram, but older, comparable to part of Zone 2 in the diagram.

In all samples from both soil profiles particles of charcoal have been found.

Pollen from the post features

Trench 9

A very low percentage of arboreal pollen grains, 15-20%, can be seen (see figure 8.9). The absence of *Tilia* is notable in comparison to the pollen spectra obtained from the barrows, as well as fairly high percentages of *Fagus* pollen and the presence of *Carpinus*. The herb pollen types are dominated by *Calluna vulgaris*, with percentages over 500%. Grasses show high percentages as well, around 70%. Anthropogenic indicators are present in low amounts; however, the percentage of *Secale* is relatively high.

Trench 16

This spectrum also shows a low percentage of arboreal pollen, around 15%. *Tilia* is absent, *Fagus* and *Carpinus* are present in considerable amounts. *Calluna vulgaris* is the dominating species, together with a high percentage of Poaceae. The presence of *Fagopyrum* and *Centaurea cyanus* (cornflower) should be noted.

Trench 18

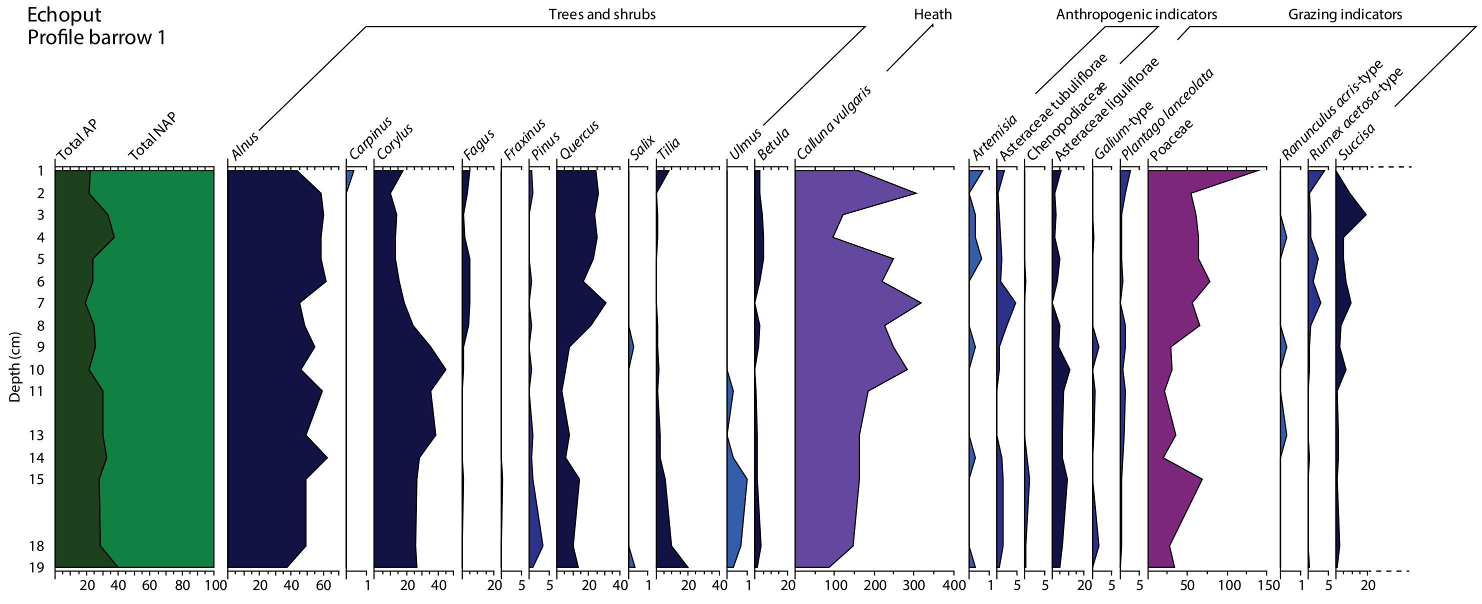
This spectrum is similar to the spectrum from Trench 16, except for a lower percentage of Poaceae.

Trench 21

These spectra looks very much like the spectrum of Trenches 16 and 18 as well, including the presence of *Fagopyrum* and *Centaurea cyanus*. Remarkable is the very high percentage of *Calluna vulgaris* found in one of the spectra.

The size of the open space

The minimum size of the open space can be estimated by the amount of sods that was used to build the barrows as has been explained in section 7.1. Knowing the height and the diameter of the mounds and the thickness of the sods the minimum size of the open area that was stripped can be calculated (see also table 8.2).



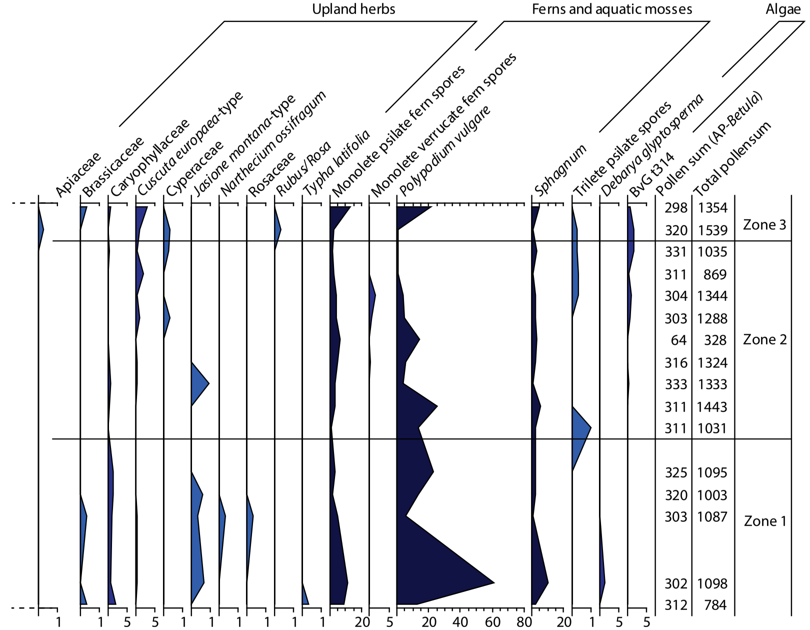
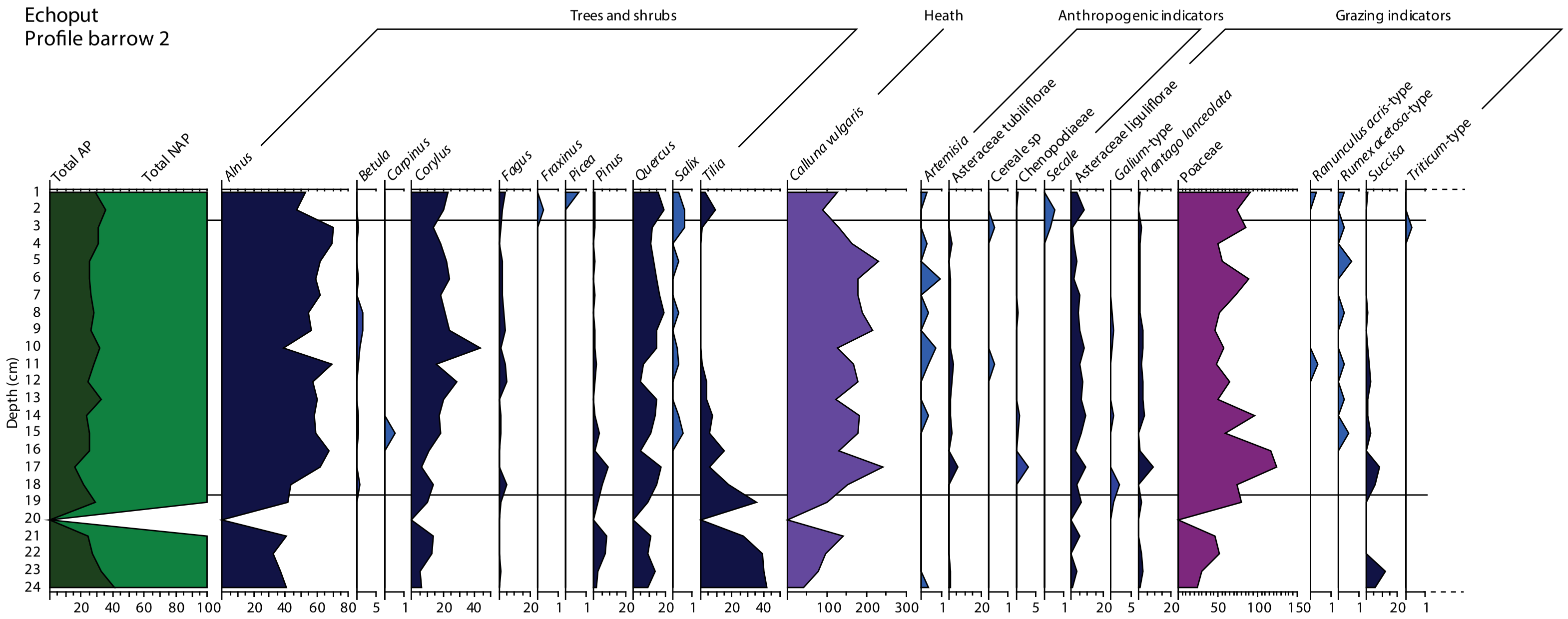


Figure 8.7. Pollen diagram derived from the series of samples taken from underneath Echoput barrow 1. A percentage diagram is shown, with % based on a tree pollen sum minus Betula. In the AP (= arboreal pollen) Betula is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.



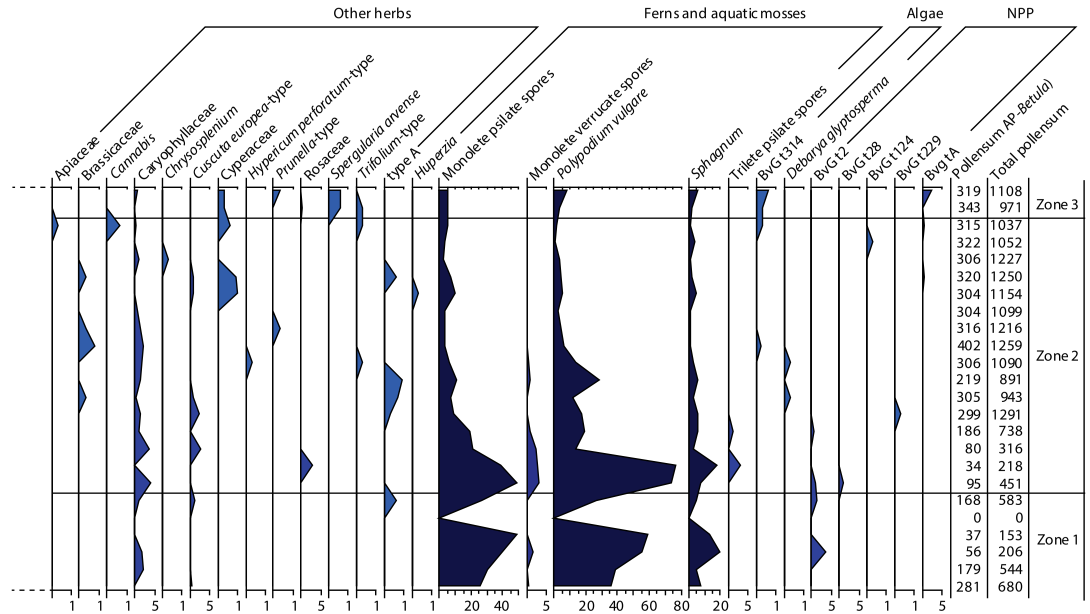
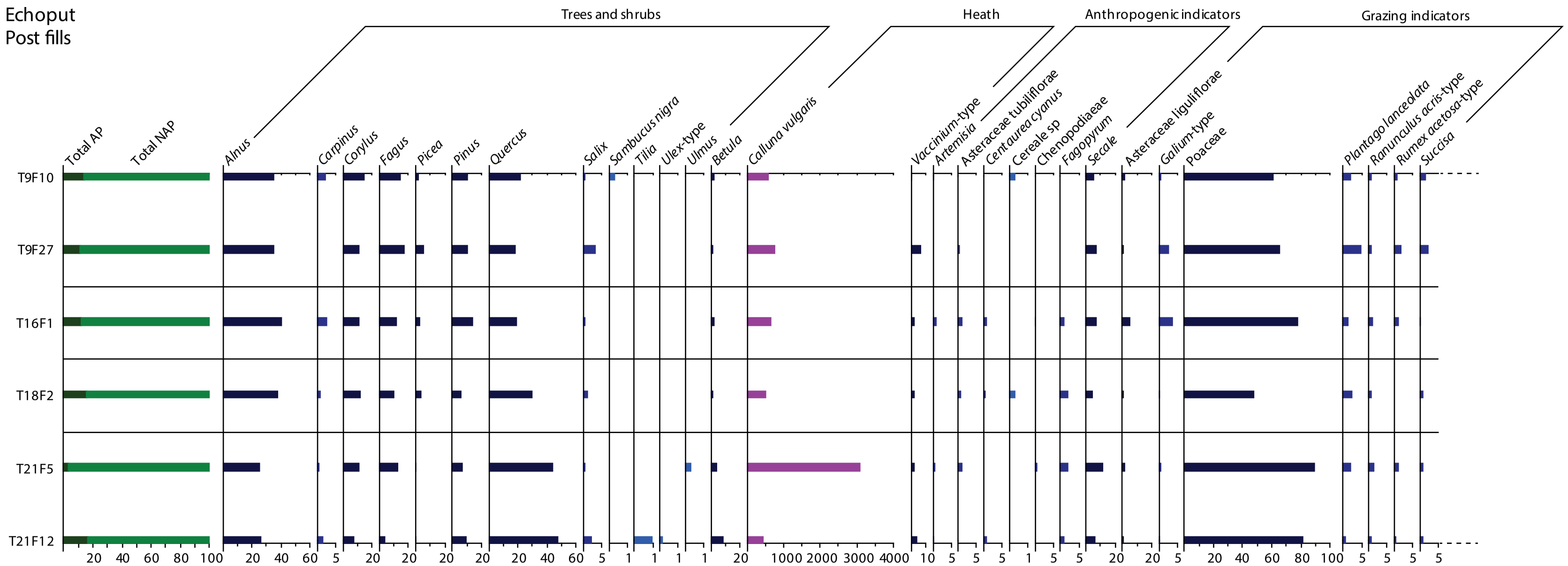


Figure 8.8. Pollen diagram derived from the series of samples taken from underneath Echoput barrow 2. A percentage diagram is shown, with % based on a tree pollen sum minus Betula. *In the AP (= arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*



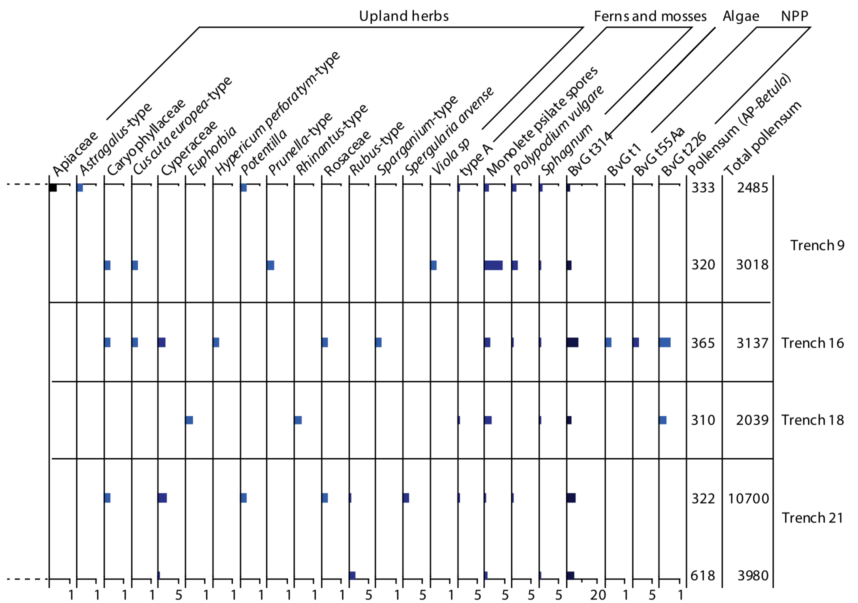


Figure 8.9. Pollen spectra derived from the post hole fill samples. A percentage diagram is shown, with % based on a tree pollen sum minus Betula. *In the AP (= arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

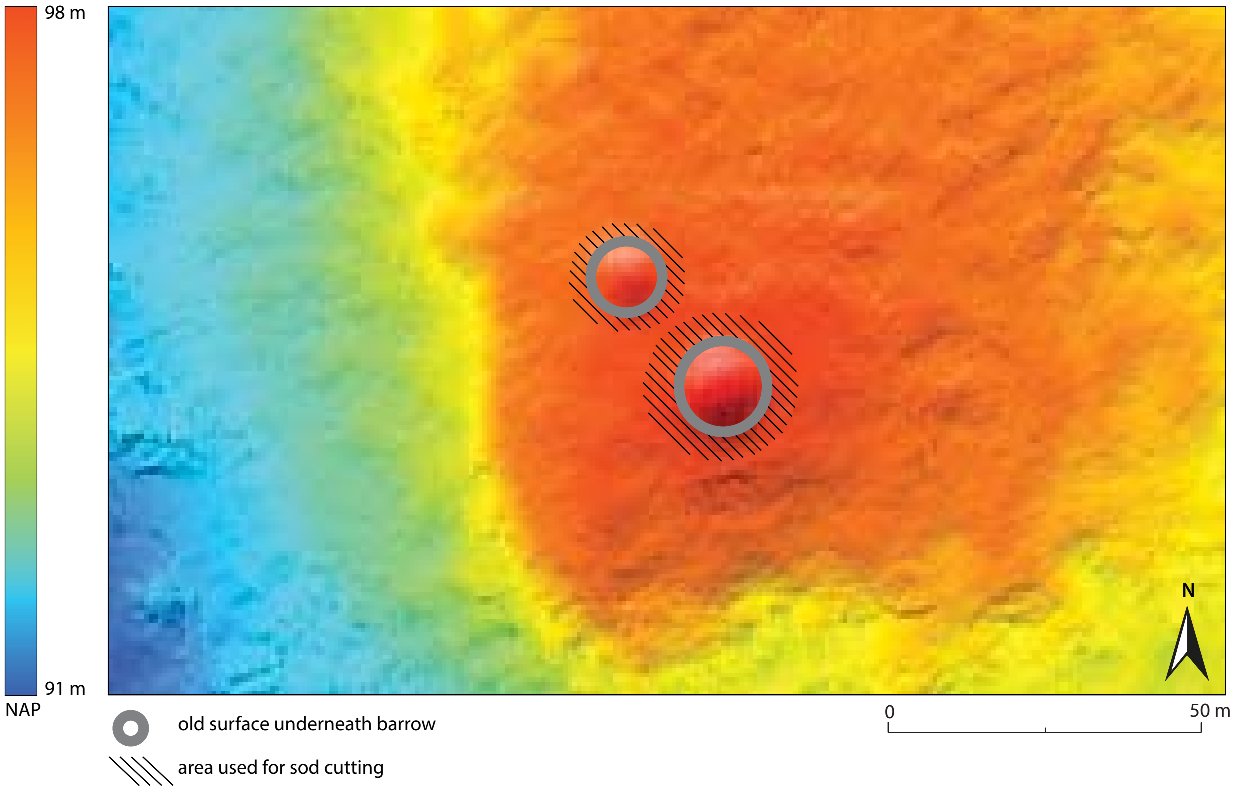


Figure 8.10. View of the Echoput hill with the two excavated barrows, based on digital elevation model of the AHN (copyright www.ahn.nl), with around each barrow an indication of the area that had to be used for sod cutting.

The measurements of the barrows are (van der Linde and Fontijn 2011, 33; Bourgeois and Fontijn 2011, 65):

Barrow 1: r=9.5 m (d=19 m), h=1.08 m
Barrow 2: r=7.25 m (d=14.5 m), h=1.0 m
Sods: average h=0.25 m

The calculated area to be stripped for Mound 2 is 332 m^2. For Mound 1 a correction should be made, because this barrow was not completely spherical, but had a flattened top. Taking this into account, the stripped area for Mound 1 was 902 m^2. A total area of 1234 m^2 was used for sod cutting (see figure 8.10).

The size of the open space can also be estimated by the percentage of arboreal pollen as has been described and discussed in section 7.2. The arboreal pollen percentage of the Echoput barrows is on average only 29%. This implies an open space with an average distance to the forest (ADF) of approximately 300 m.

8.1.4 Discussion

Dating the barrows

The first thing to point to in the palynological results is the resemblance between the two barrows. Pollen spectra from the old surfaces indicate a similar vegetation pattern at the time the barrows were built, which makes it likely that they were built in the same period. This is in line with what was expected on the basis of the ^{14}C-datings and the general similarities between the mounds. The occurrence of *Carpinus* suggests that this period can be placed in the Iron Age (Janssen 1974). Both their contemporaneity as well as their Iron Age dating are in agreement with the excavation results, on the basis of which the dating could be further specified to the late Middle or earlier Late Iron Age (van der Linde and Fontijn 2011, 62; Bourgeois and Fontijn 2011, 87).

The barrow landscape

The similarity of the pollen composition of the old surface and the sods indicates that the sods were cut in the close surroundings of the barrows, where vegetation composition was similar to the spot where the barrows were built. The following discussion about the barrow landscape is based on the results of the samples of both the old surface and the sods of the two mounds, which represent the vegetation composition at the time just before the barrows were built.

Figure 8.6 shows the pollen spectra of the mentioned samples. They indicate that herbs are much more abundant than trees. Especially heather (*e.g. Calluna vulgaris)* and less, but still in considerable amounts, grasses (*e.g.* Poaceae*)* dominate the herb species. Heather pollen tends not to spread outside the heathland where the pollen is produced (de Kort 2002). This implies that the Echoput barrows were built in an open spot, where heather was the most dominant species. Non-pollen palynomorphs such as *Debarya glyptosperma* and *Zygnema* type 314 (van Hoeve and Hendrikse 1998) suggest the presence of some water at the site, at least part of the year, conditions which nowadays still exist (the pools of water that remain after rain for some time). Anthropogenic indicators are present amongst the herbal pollen. These are dominated by *Plantago lanceolata* and Asteraceae tubuliflorae. Remarkable is the find of one pollen grain of *Secale* in the pollen spectrum from sod 2 of Mound 2. This cereal species (rye) had not been commonly introduced in the Netherlands during the Iron Age yet, however, some early Iron Age finds in northern and western Europe have been reported (van Zeist 1976, Behre 1992). The anthropogenic indicators suggest the presence of human activity at the site, which is consistent with the find of pottery sherds and flint fragments in the sods and the old surface (van der Linde and Fontijn 2011, 59-60; Bourgeois and Fontijn 2011, 87). However, the pollen percentages of anthropogenic indicators are too low to conclude the site was a settlement area or with (former) arable fields nearby. This is consistent with the data from the excavations in the close surroundings of the barrows (Valentijn and Fontijn 2011).

The tree pollen that is present in the pollen spectra is mainly *Alnus, Quercus* and *Corylus. Alnus* is likely to have grown on the lower sites in the surroundings of the heathland, where hydromorphic soils occurred like Gleyic Podzols, Umbric and Histic Gleysols. This indicates that alder carr was probably present in the stream valleys in the surroundings of the Echoput hill. The dominance of *Alnus* pollen within the total arboreal pollen content could imply an open landscape where the alder pollen was free to travel in from out of the alder carr, since no other sizeable forest blocked their way. In addition, *Alnus* blooms before *Quercus* and *Corylus* get their leaves, making it easier for *Alnus* pollen to travel freely. *Corylus* is a tree that requires light conditions to grow; it will not be able to survive in the reduced light conditions in a closed forest. The tree requires moist soil, but not wet conditions. It is very likely that *Corylus* grew on the slopes around the Echoput hill, together with *Quercus*, a tree that has also has a preference for soil that is not very wet (Weeda *et al.* 1985, 113). The presence of alder carr in the valleys and the more open vegetation in the surroundings of the barrows indicates that forest clearing had only taken place in the higher and drier places around the *Echoput* hill. The forest was not cleared recently before the barrows were built, indicated by the presence and the diversity of the herb vegetation. The herb vegetation had already had some time to establish and to develop and the open place must have existed some time before the mounds were constructed. Heath vegetation is not a natural vegetation type in the Netherlands (with exception of the coastal area). This implies that the barrow landscape was already managed to maintain the heathland. The amount of grasses (Poaceae) together with *Plantago lanceolata*, Asteraceae liguliflorae, *Succisa* (and *Galium*-type could be an indication that the heathland was kept open by grazing (Hjelle 1999) and as such was part of the economic zone of settlements.

The size of the open space

It has already been mentioned that the barrows were built at the same time, or one relatively quickly after the other. The similarity of the pollen spectra from the old surface and the sods indicates that the sods were taken in the near surroundings of the place where the barrows were built. In addition, the similarities between pollen from sods and the old surface underneath the mound and in lithology of sods and the Echoput hilltop all imply that the sods were cut from the Echoput hilltop and not from the hill flanks. Regeneration of heath after sod-cutting takes a period of 5-40 years, depending on the thickness of the sods. Thin sods, preferably containing only the F horizon of the soil, were traditionally used as fuel or as bedding in stables. Regeneration after cutting thin sods takes only 5-8 years (Pape 1970). When thicker sods were cut, containing the A- and E-horizon, regeneration takes up to 40 years. Such sods were for example used as construction material (Stoutjesdijk 1953, *cf.* Bakels and Achterkamp 2013). Assuming that the period between the construction of the first and the second burial mound had been too short for the heath vegetation to regenerate the open place had to be large enough to cut sods for building two barrows. The soil profile shows that the surface beneath both barrows was not used for sod cutting (Fontijn 2011b, 154), which also implies that the barrows were built at the same time or that at least part of the area had already been kept free from sod-cutting as a reservation for the construction of the second burial mound.

As has been shown in the results, the area to be stripped for Barrow 1 is 902 m^2 and for barrow 2 332 m^2, so a total area of 1234 m^2 was used for sod-cutting. This implies that a minimum area of 1683 m^2, the surface beneath the barrows included, consisted of open vegetation. Based on the arboreal percentage the open space had an ADF of approximately 300 metre, implying an open area of about 28 ha ($\pi r^2 = \pi \cdot 300^2 = 282743$ m^2). Although this size could have been overestimated (see section 7.3, according to palynological modelling the ADF was probably about 200 m) the open space is considerably larger than based on the amount of sods that had been used to construct the burial mounds. The combination of these two methods builds an image of how the burial mounds were situated in the landscape. The barrows were located in an area that was dominated by a heath and grass vegetation. Trees could probably not be found in the first 200 to 300 metre around the mounds. The barrows, already located on a relatively high place in the environment, were probably even more prominent in the landscape, knowing that the direct surroundings were cleared from both vegetation and the topsoil, creating a bare environment (see figure 8.10). This will have increased their visibility in the surrounding landscape.

The pre-barrow landscape

Based on the theory presented in Chapter 5, the pollen diagrams derived from the soil under Barrows 1 and 2 represent the vegetation development of a certain period before the barrows were built. Since the soil profiles have not been dated the duration of the period represented is not clear (see Chapter 5). The pollen diagrams show that heath was already present at the place where later on the barrows were built since at least the time span that is represented by the diagrams. The presence of an Umbric Podzol (Dutch classification: Moderpodzol) suggests that heath vegetation could not have been present for a very long time, since underneath heath vegetation a Carbic Podzol (Dutch classification: Humuspodzol) soil would develop. This could however take several centuries (Andersen 1979). During the oldest zone represented in the diagram the AP is higher than at the time the barrows were built, 40% compared to 20%. The forest was mainly dominated by *Tilia* and *Quercus* at the drier sites and *Alnus* at the wetter sites. Despite the low pollen counts in some of the lower samples of diagram 2 clear trends can be seen in both diagrams. A decline of *Tilia* is indicated by decreasing *Tilia* pollen percentages. Such developments in forest cover is presumed to have taken place generally in the Netherlands as has been shown by several pollen analyses of lake and peat sediments (Janssen 1974, van Geel 1978). At the same time an increase of *Fagus* is visible in the diagram, comparable to the general increase of *Fagus* in several parts of the Netherlands, since its arrival between ca. 3700 cal BC and ca. 500 cal BC (Fanta 1995). An increase of *Alnus* pollen that can be noticed might be primarily related to the decrease of *Tilia* or could indicate an expansion of the wet forest. The decrease of forest cover seems to go hand in hand with an expansion of the heath vegetation.

At the time the barrows were built vegetation was dominated by heather, at least locally. It is not entirely clear how the open place was created nor what it was used for in the period before the barrows were built. Indications of the presence of human activities at the site in several periods before the barrows were built are evidenced by finds from below and beyond the mounds, although they certainly do not indicate a very intensive use of this site in the Bronze Age or early Iron Age (Louwen *et al.* 2011, 141). The absence of cereal pollen grains and low amounts of arable weeds like *Artemisia vulgaris* in the diagram demonstrate that the location had not been used for crop cultivation. The size of the heathland can be estimated. Based on the ratio of arboreal pollen versus non arboreal pollen, the size of the open space is estimated to have been from approximately 200 metre ADF to approximately 300 metre ADF at the moment the barrows were built. To maintain the heath, the landscape must have been managed. Methods of heath management can involve sod-cutting, grazing, mowing and burning (Stortelder *et al.* 1996, 287).

Sods were cut in the area, at least with the purpose of building barrows. With sod cutting the soil is stripped from all vegetation. For heath to recover it is dependent on re-establishment by seeds that were present in the deeper soil layers or by expansion of surrounding heath vegetation. Recovering of the heath vegetation after sod cutting will take 5-40 years, depending on the thickness of the sods that were removed (see above). The area needed for building the barrows was most likely much smaller than the total heath area in which the barrows were built (see above, r=200 to 300 m). Consequently, sod cutting for the purpose of building the barrows would not be sufficient to maintain the entire heath area. Large scale sod cutting in heathland areas is mainly known from the Medieval Period into the 19th century, when the sods were laid in stables to catch animal dung and subsequently were used on arable fields as fertilizer. Small scale practise of this way of farming may have taken place at the time the *Echoput* barrows were built. There are however no indications of such arable fields in the environment. In addition, manual sod cutting is quite labour-intensive and it is not likely that this heath area was managed by sod cutting alone.

The amount of grasses (Poaceae) together with *Plantago lanceolata*, Asteraceae liguliflorae, *Succisa* and *Galium* type could be an indication that the heathland has been grazed (Hjelle 1999). Mowing and grazing are comparable since they both keep the plants down. Grazing is more selective than mowing, with animals having a preference for certain species. Sheep prefer young *Calluna* heath and grass and herb vegetation in between the heath vegetation. They are not very fond of older *Calluna* plants (Elbersen *et al.* 2003). Cattle eat mainly grasses, although some landraces also eat young *Calluna* plants (*cf.* Lake *et al.* 2001, 31). Archaeozoological evidence from several excavations suggests that prehistoric farming communities kept mainly sheep and cattle (Brinkkemper and van Wijngaarden-Bakker 2005, 493). Both sheep and cows are used in present times to maintain heathland areas by grazing. Historical data show that in Medieval Period grazing using only sheep was sufficient to maintain heathland vegetation. A stocking rate of 1 sheep/ha is assumed (Piek 2000). Also in present heathlands several studies mention that an average of 1 sheep/ha/yr should be sufficient to manage the heathland (Elbersen *et al.* 2003, Verbeek *et al.* 2006). The size of the stocking rate of cattle in the past is not clear, although it is clear that cattle grazing in Dutch heathlands occurred on large scale before the 18th century (Bieleman 1987). Bokdam en Gleichman investigated the influence of grazing cattle on the development of *Calluna* heath (Bokdam and Gleichman 2000). A stocking rate of 0.2 livestock unit per hectare per year appeared not to be adequate against invasion by grasses and tree growth. *Natuurmonumenten*, a Dutch organization that protects and manages nature reserves in the Netherlands, has over 30 years of experience with grazing in heathland areas. They experienced that in dry heathland areas 1 head of cattle per 5-6 ha is sufficient to prevent grasses from getting dominant in heathland areas (Siebel and Piek 2001). This is however in the present environmental circumstances with higher deposition of nutrients, and it is likely that in the past less cattle would have been adequate enough for maintaining heathland vegetation. When an indication of the minimum size of livestock from a prehistoric farming community should be calculated that was responsible for managing the heathland area where the barrows are being built in, an average of 1 sheep per hectare and/or 1 head of cattle per 6 hectare will be used. At the Echoput, based on the ratio of arboreal versus non arboreal pollen grains the area that was covered with heath vegetation at the time the barrows were built is estimated to have been 28 hectare ($\pi \cdot 300^2$), implying a livestock size of approximately 28 sheep and/or 4-5 head of cattle. Mowing can be seen as a kind of grazing, although grazing is more selective.

Regular burning is also a traditional way of heath management. When the heath is being burnt every 10-20 years the heath vegetation can be maintained by rejuvenating the heath (Mallik and FitzPatrick 1996, Yallop *et al.* 2006). A combination of burning and grazing is nowadays often applied, which seems to be very effective. Small scale burning provides young vegetation, which is more nutritious to the grazing stock. The remains of charcoal found in all the pollen samples from the Echoput barrows may be an indication that human burnt the heath vegetation. Particles of charcoal have been found elsewhere as well during excavations of barrows and in soil samples that were taken for palynological analyses (Karg 2008). A combination of grazing and burning and perhaps some sod cutting seems a plausible explanation of how the heath was managed at the Echoput.

Posts at the barrow site

The pollen spectra from the four possible structures that have been sampled have a different composition than the barrow spectra. As was discussed in section 4.1.5 the posts might be dated based on their pollen spectra. The pollen spectra from the four posthole structures (see figure 8.4) show a vegetation composition that can be dated to a much younger period than the period the barrows were mainly built in. This is implied by the presence of *Secale*, which is known as a common crop in the Netherlands only after being introduced during the Roman Period (Behre 1992, RADAR 2006). In addition, the relatively high percentages of *Carpinus* and *Fagus* indicate a rather young pollen composition. Both species show an increase during the Holocene vegetation development in the Netherlands since the Subatlantic period up to the Medieval Period (Janssen 1974). In addition, all posthole fillings, with exception of the postholes from Trench 9, contained pollen from *Fagopyrum* and *Centaurea cyanus*, which are only present in the Dutch pollen spectra from the Late Medieval period (Bakels 2000, 2012). However, can the dating of the pollen spectra be coupled to the dating of the posts? In other words, can the posts also be dated in the Late Medieval Period? As has been discussed in section 4.1.5, the Medieval pollen could have come from the vegetation that was present at the Echoput hill at the time the posts were placed or they could have infiltrated in the soil from some time after the posts were placed. The posts could then be dated in the Late Medieval Period or later (as a *terminus ante quem* date). The pollen spectrum from the posthole from Trench 9 lacked pollen that indicates the Late Medieval Period and consequently the Roman Period can be assessed as a terminus *post quem* date for this posthole filling.

What did the landscape look like at the time the posts were placed? The posthole fill pollen spectra indicate a landscape that was more open than during the time the barrows were built. The amount of *Alnus* had decreased. This implies deforestation of the lower sites as well, or a change in soil water content. The barrow site was at this time an open spot as well, but the character of the place had slightly changed compared to the barrow landscape. *Calluna* had expanded at the cost of the forest. The diversity and quantity of other herbs increased. At Trench 21 a very high percentage of *Calluna* pollen can be seen, which is not visible in any of the other samples. This could indicate a local abundance of heather, for example the covering of the roof of the structure could have been made of it.

8.1.5 In conclusion: the history of the Echoput barrow landscape

It is generally assumed that most barrows were built in open spaces in a forest area. However, the origin of these open spaces is little known. The pollen analyses of two barrows at the Echoput show the vegetation history of the open space from a period before the barrows were built. This showed that the clearing in the forest was indeed much older than the barrow, as has been suggested in section 2.3. When and how the open space was created is not known.

From the beginning of the period that our data represent, the open spot was mainly covered by heath vegetation mixed with grasses and several other herbs. The open space, surrounded by a forest of *Tilia* and *Quercus*, had been used for at least a few centuries by prehistoric man. This is indicated by several features dating to the Middle Bronze Age period. The presence of anthropogenic indicators confirms the influence of prehistoric man in the environment. Mesolithic and Bell Beaker features were also present (Louwen *et al.* 2011), though it is not known if the forest was already cleared by then. Although we did not uncover any evidence for a settlement near the mounds, it is clear that the area has been used by prehistoric man. However, what did they use the open place for since the Bronze Age? It is very likely that it was included in the economic zone of farming communities as grazing grounds, keeping the vegetation open. Based on the high percentage of pollen from Poaceae, in combination with the presence of *Plantago lanceolata*, Asteraceae liguliflorae, *Succisa* and *Galium* type, the use of this open spot as pasture is very plausible (following Hjelle 1999). Furthermore, regular burning of heath could have occurred, indicating that a form of heath management was used to keep the area open. The use of fire is indicated by the amounts of charcoal found in the pollen records.

Before the barrows were built the open area seems to have been used solely as a place for the living, since no indications have been found that people were buried there. This changed when the burial mounds were constructed in the later Middle Iron Age or early Late Iron Age. At this time the vegetation surrounding the Echoput hill had changed. The *Tilia* dominated forest had shrunk and forest with a more open character mainly consisting of *Quercus* and *Corylus* had taken its place. The heath vegetation at the open place at the top of the Echoput hill had expanded. This change in vegetation was probably due to human activities, such as burning and cattle grazing. The upper surface of a large part of the heathland at the Echoput hill was stripped in order to get sods for the construction of the barrows. The surface where the barrows were going to be located was left untouched. Whether the barrows were built at exactly the same time or with a short period in between does not change the fact that both places had already been designated as barrow location, based on the observation that the surface underneath both barrows were not used for sod-cutting. The two barrows must have been quite pronounced features in the landscape; placed on one of the highest locations in the area, cleared from surrounding vegetation. It is unknown whether the surrounding landscape was kept open after the barrows were built. However, one of the mounds had been re-used as a burial location (van der Linde and Fontijn 2011, 64). In addition, during the Roman Period and the Late Medieval period (based on palynological dating of the post hole fillings) there was a very large open spot covered with heath vegetation. It is likely that the place had been kept open all this time.

8.2 Niersen-Vaassen

In the north-eastern part of the Veluwe several barrow alignments are situated. Several of these barrows were excavated over a series of campaigns. An extensive description and analysis of the barrow alignments have been made by Bourgeois (2013). Barrows not part of alignments are also present in this area. Dating and palynological data are available for five barrows in the area, of which two were part of a larger alignment. In addition palynological data are available from samples taken from a Celtic field present in the same area (see figure 8.11). Combining these data makes it possible to reconstruct the vegetation development in this area from the Neolithic until the Iron Age.

8.2.1 Site description and sample locations

Niersen, barrow 4 and 6

The two investigated barrows of Niersen form part of a 6 km long alignment containing at least 46 barrows (Bourgeois 2013). The original excavation of Niersen 4 and 6 took place in 1907 by Holwerda (Holwerda 1908). Holwerda described Niersen 4 as a Bell Beaker tumulus with a height of 1.65 m and a diameter of 36 m. He noticed that this barrow was situated approximately 2.25 m higher than the other barrows in this area. In the barrow a grave was found in which skeletal remains of more than one individual were present. Holwerda decided to take out the entire grave-area after plastering to be able to examine the remains later. This plaster box has recently been rediscovered in the collection of the National Museum of Antiquities in Leiden and has been subject of research by the museum in cooperation with the University of Leiden (Bourgeois *et al.* 2009). They dated the grave, on the basis of stylistic parallels, to the late Neolithic period (2600-2200 cal BC). Samples for pollen analysis were taken from the sediment in between

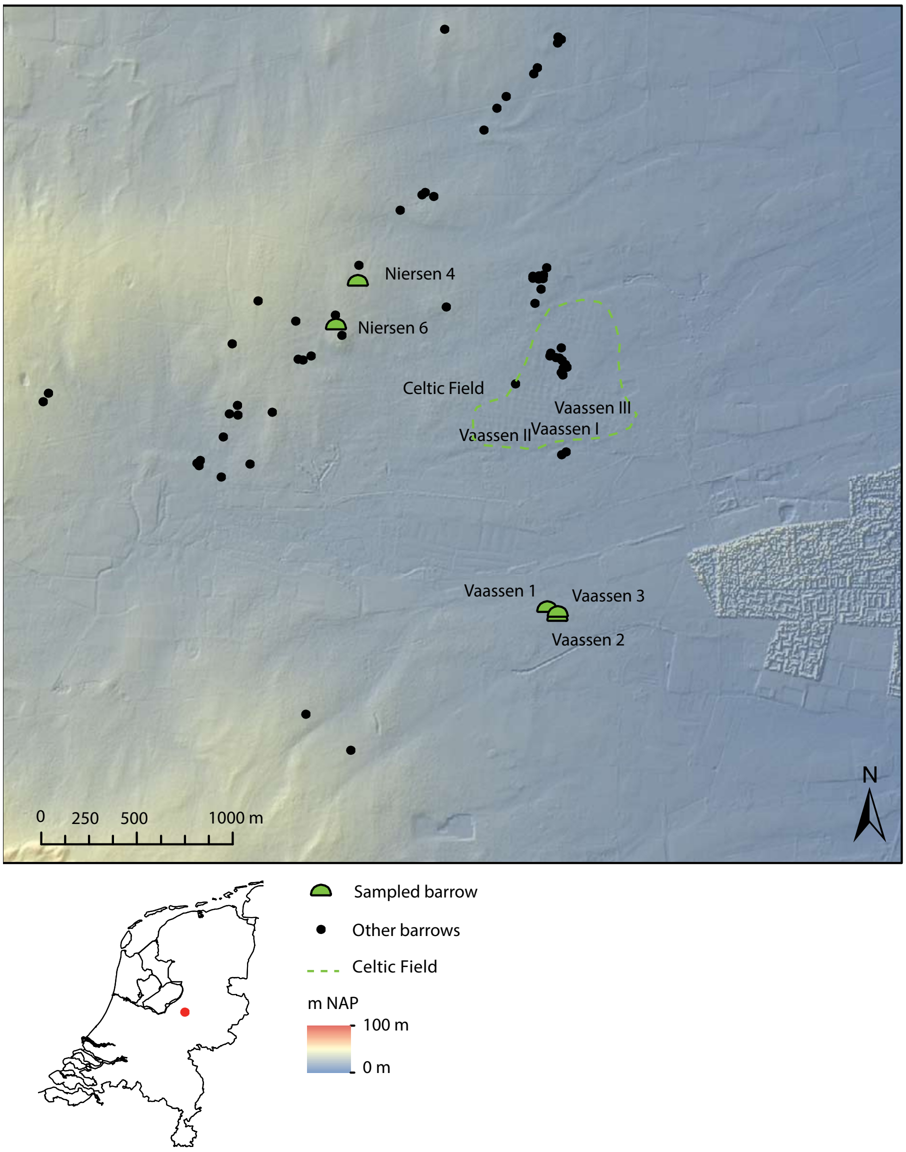


Figure 8.11. Detailed map of the Niersen-Vaassen area with the locations of the barrows of Vaassen and Niersen and the Celtic Field of Vaassen. The map is based on digital elevation model of the AHN (copyright www.ahn.nl).

the skeletal remains, but unfortunately pollen could not be obtained from these samples. In 1984 the Niersen 4 barrow was consolidated by the ROB (presently known as the Cultural Heritage Agency of the Netherlands). They described the tumulus as a bank-and-ditch barrow with a diameter of 28 m. Niersen 6 was a barrow with a height of 1.50 m and a diameter of 16 m. The tumulus probably dates to the early Bronze Age (Bourgeois 2013). The ROB report corrects the size of the barrow to a diameter of 19 m. During the conservation carried out on the barrow, pollen samples were taken from the old surface underneath both mounds and from the mounds themselves by Groenman-van Waateringe[10]. One sample of the old surface per mound was prepared and analysed by the author. Methods of sample preparation have been described in Chapter 4.

10 Due to poor documentation it is not completely certain that during reconstruction of the barrows by the ROB the barrows were identified correctly as barrow 4 and 6 (Bourgeois et al. 2009). Samples for pollen analysis were taken during this reconstruction.

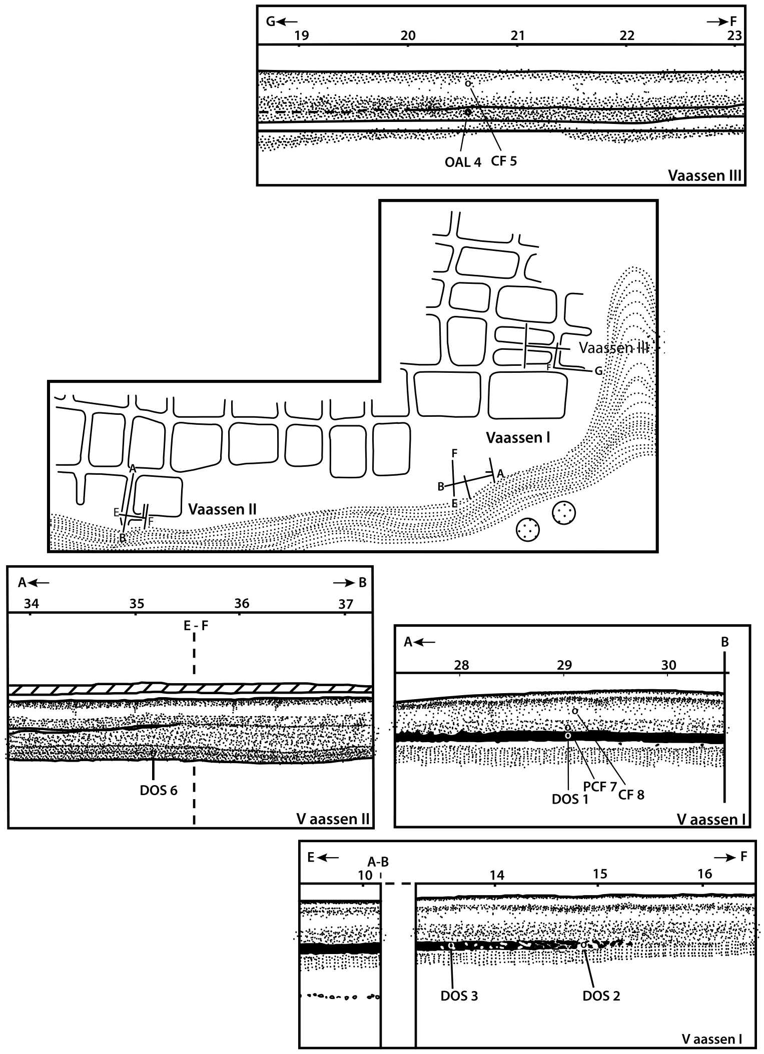


Figure 8.12. Sample locations in the sections Vaassen I, II and III at the Celtic Field at Vaassen. Figure redrawn after Brongers (1976), plate 13.

Vaassen, barrows 1-3

Three barrows at Vaassen were excavated by Bursch and Tromp in 1941; re-excavation took place in 1970-1971 by Lanting and van der Waals (1971). During that last excavation samples were taken and analysed for pollen by Casparie and Groenman- van Waateringe (1980, 28, 35).

Vaassen 1 (V1) is a single period barrow radiocarbon dated to 2850-2600 cal BC (Bourgeois 2013, 53). Underneath V1 a sherd of a PF beaker and some flint was found. The original dimensions of the barrow were probably a diameter of 13 meter with a height of approximately 1 metre. Samples for pollen analysis were taken from the old surface. Vaassen 2 (V2) is a two-period barrow of which the first period can be dated to the Bell Beaker Period based on the find of a Veluvian Bell Beaker (Lanting and van der Waals 1971a). The second period is dated to the Middle Bronze Age. The primary barrow was approximately 8 m in diameter and approximately 30 cm high. For the secondary period the barrow was expanded to a diameter of approximately 15 m and a height of 1.40 m. The thickness of the sods used for the second period is approximately 25 cm. Samples were taken from the old surface of the primary mound and from sods belonging to the second period. Vaassen 3 (V3) is also a two-period barrow of which the first period has been radiocarbon dated to 2885-2625 cal BC (Bourgeois 2013, 53). The second period has been dated to the Bell Beaker period. The diameter of the barrow is not known; its surrounding feature measured approximately 7.5 m across. The height of the barrow was about 0.3 m. Samples for pollen analysis have been taken from the first period from the intermediate ditch and the outermost palisaded ditch (Casparie and Groenman-van Waateringe 1980, 28).

Vaassen, Celtic Field

In the woods west of Vaassen (municipality of Epe), a Celtic field is situated on a 15 hectare heathland and continuing over a surface of almost 100ha. Three parts of the Celtic field were excavated: Vaassen I, II and III (Brongers 1976). Vaassen I was situated at the south boundary of the Celtic field, Vaassen II was situated west of Vaassen I and Vaassen III could be found at the east side of the heathland (see figure 8.12). Sections were made at these locations, revealing a sequence of several layers. These layers, an old surface and three agricultural layers, represent several phases. Local agricultural activities started on an old surface that became partly denuded. Part of the A-horizon of the podzol belonging to this old surface was homogenized and changed into an arable layer. The remaining part of the A-horizon of this podzol is called the *denuded old surface* (*DOS*). The arable layer, which does not belong to the bank system of the Celtic field (CF), is called the *pre-Celtic field (PCF) layer*. On top of the PCF-layer a bank system was constructed, forming a Celtic Field. At Vaassen III an older arable layer was present (OAL) on top of the DOS and underneath the PCF layer. This OAL layer was not present at the other two locations. Underneath the banks the DOS and/or OAL, PCF and CF layers were clearly visible. In between the banks the DOS was seriously disturbed and the PCF and CF layer could not be differentiated from each other. Soil samples were taken for pollen analysis from all layers (see figure 8.12). At Vaassen I samples were taken from or underneath a bank. Three samples were taken from the DOS, one sample from the PCF and one sample from the CF. At Vaassen II a sample was taken from the DOS, underneath a PCF layer that was covered by a bank. At Vaassen III two samples were taken. One sample was derived from the OAL layer that was overlain by the PCF layer. The second sample was taken from the CF layer in the bank that covered this PCF layer. The samples were analysed by Casparie. The pollen data that were published in 1976 (Casparie 1976) were re-used in this research, in addition to the barrow data in the Epe area.

Dating the Celtic Field

Several locations in the Celtic field and the layers underneath were sampled for ^{14}C. Remains of a farmhouse (Haps type) were discovered at Vaassen I. The house plan was covered by the CF-layer and possibly also the PCF layer (CF and PCF could not be differentiated here). The house was dated by fragments of charcoal to 2420 ± 65 BP (GrN-5498; 671-396 cal BC, calibrated with Oxcal 4.2), dating the part of the Celtic field that was situated on top of the house to 671-396 cal BC *terminus post quem*. Such farming houses were often found associated with Celtic fields and it well is possible that part of the Celtic field had already been developed when the farmhouse was still in use (Brongers 1976). The DOS is difficult to date and the dating of the samples from the DOS depends on the depth at which they are taken. At Vaassen I the dating of the house plan can be interpreted as a *terminus ante quem* date for the DOS layer (*e.g.* 671-396 cal BC); samples were taken approximately 25m west of the house. The pollen spectra, which will be discussed in more detail below, show the presence of *Fagus* and *Carpinus*. *Carpinus* appears in the Netherlands around 1500 cal BC and both

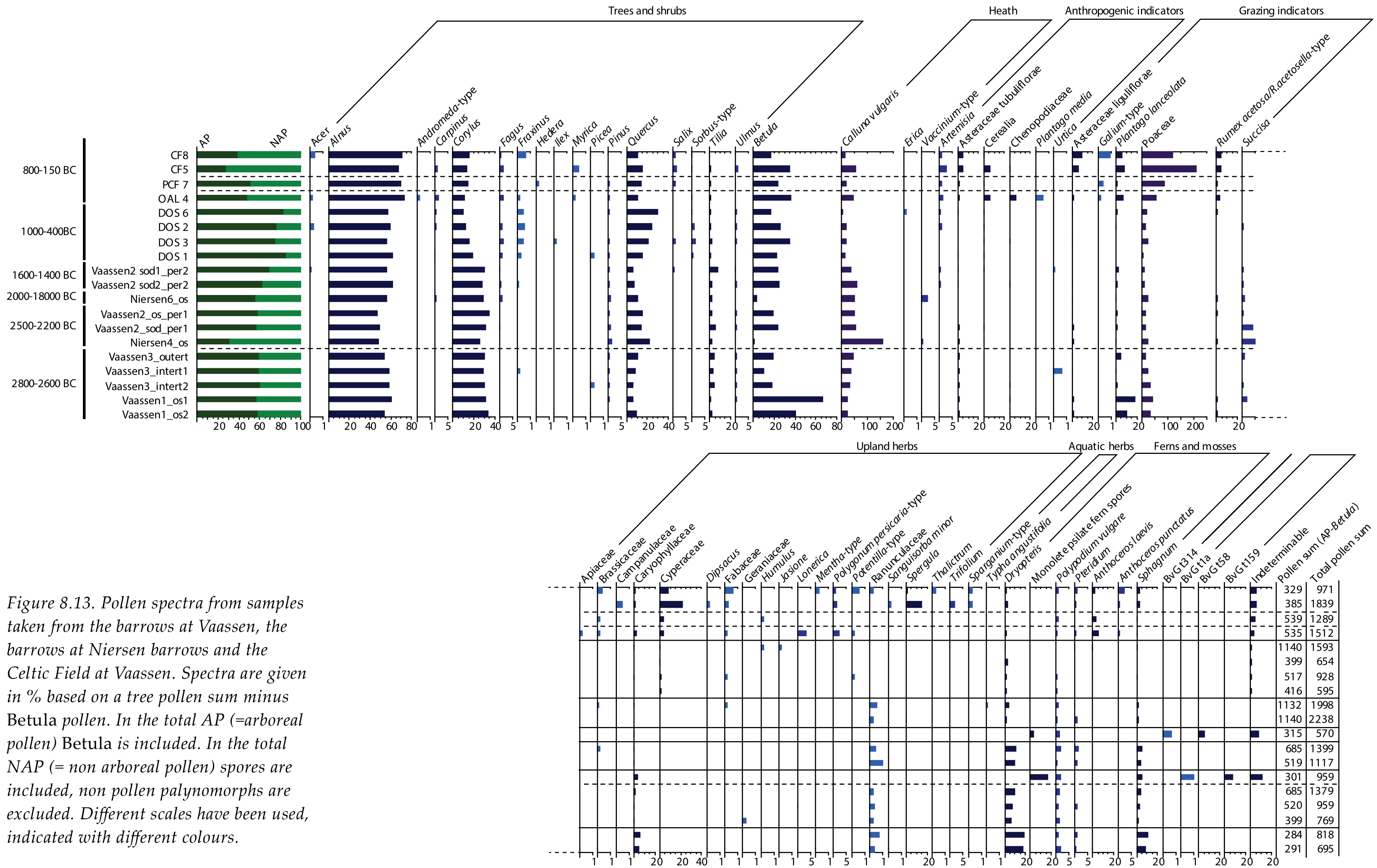


Figure 8.13. Pollen spectra from samples taken from the barrows at Vaassen, the barrows at Niersen barrows and the Celtic Field at Vaassen. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

species are known to expand in the Netherlands since the Iron Age (Janssen 1974). Since the percentages of *Fagus* and *Carpinus* are still low (<1.5%) a dating of around 1000 – 400 cal BC is suggested.

Traces of post holes have also been found at Vaassen III, covered by the OAL-layer. Charcoal from one of the post holes was dated to 3020 ± 55 BP (GrN-5895, 1418-1114 cal BC, calibrated with Oxcal 4.2). This implies that the first agricultural activities started after 1418-1114 cal BC. The presence of *Fagus* and *Carpinus* (respectively 1.5 and 1.3%) suggests a date around 1000 cal BC.

The third date is provided by charcoal found in a pit underneath the CF layer. The pit was dug into the CF layer, since part of the arable layer (PCF and/or CF) had sunk down into the pit. The ^{14}C-date of 1800 ± 55 BP (GrN-5495, 82-352 cal AD, calibrated with Oxcal 4.2) can be considered as a *terminus post quem* date for the end of the agricultural activities at the Celtic Field. Brongers (1976, 64) argued that this date coincides with the period the Celtic Field came to an end, since this disturbance of the arable layer is probably the result of unstable times during the Roman occupation.

8.2.2 Results

Figure 8.13 shows the results of the pollen analyses of all barrows and the Celtic field. The pollen spectra were placed in chronological order to see the vegetation development in the area. It should be noted that the different phases show some gaps or overlap in time, so the spectra do not show a continuous vegetation development. Secondly, the spectra belonging to the Celtic field could only very roughly be dated (see above). Although the spectra have been derived from different types of samples (barrow versus agricultural layers) it has been decided by the author to all compare them with each other. All Celtic Field spectra probably represent a longer period of time, since the soil has been mixed up due to agricultural activities. The herbal vegetation composition shown by the spectra is very local and cannot be expanded to the barrow sites nearby, but the extra-local and regional forest vegetation probably can.

Phase 1: 2800-2600 cal BC

Vaassen 1

The amount of forest pollen represents approximately 57% of all pollen (including spores). The herbal vegetation consisted mainly of grasses and *Calluna* heath. The surrounding forest mainly consisted of *Betula* with some *Quercus* and *Tilia*, although *Betula* might also have been present locally on the heathland. *Corylus* was present in high amounts. In the wetter areas *Alnus* was the dominating tree.

Vaassen 3, period 1

The ratio between arboreal and non-arboreal pollen is the same as that of barrow of Vaassen I. There seem to be some differences in the forest composition: *Quercus* decreased, while *Tilia* increased. There is a considerable decrease in *Betula* pollen. Grasses have decreased, while heather was able to expand a little. Together with the decline of *Betula* this could indicate some heath management, for example by grazing activity. This prevented new *Betula* trees from establishing and grasses from flowering.

Phase 2: 2500-2200 cal BC

Niersen 4

Compared to the barrows at Vaassen, which are at almost 2 km of distance apart, there is a great difference in the vegetation composition at Niersen. At Niersen there seems to have been a larger open space, dominated by heather (*Calluna vulgaris)*, in which the barrow has been built (AP=32%). There were hardly any *Betula* trees present and the amount of grass was considerable, indicated by pollen percentages of 25-50%. This species-poor heathland could have been maintained by heath management, preventing *Betula* to re-establish and *Calluna* to expand. The surrounding forest consisted mainly of *Quercus, Tilia* and *Corylus.* In addition, some peaks can be seen in *Succisa* pollen and fern spores, indicating moist conditions. The *Alnus* forest in the stream valleys seems not to show any differences with that of Vaassen.

Vaassen 2, period 1

The vegetation character derived from the pollen analysis of Vaassen 2 is comparable to Vaassen 1 and 3. The percentage of *Betula* pollen is comparable to Vaassen 3. This means that the percentage of *Betula* is higher than in Niersen, but considerably lower than at Vaassen 1. There seems to be a slight increase in *Quercus* pollen compared to the other barrows of Vaassen.

Phase 3: 2000-1800 cal BC

Niersen 6

Compared to the other barrow at Niersen, Niersen 4, there has been an increase in trees (AP=57%). The percentage of tree pollen is comparable to Vaassen II. This increase of trees is probably mainly caused by a decrease in heather pollen. An increase of *Betula* can be seen, although the amount of *Betula* pollen is still very low compared to Vaassen. Re-establishment of *Betula* might have been possible because heath management has been less intensive, also causing the heathland to decrease in size.

Phase 4: 1600-1400 cal BC

Vaassen 2, period 2

There has been an increase of tree pollen, compared to all previous phases (both Niersen and Vaassen). All arboreal pollen has increased, except *Quercus* and *Corylus.* Heath seems to remain unchanged. Some Cerealia pollen is present, but only in very low amounts and other anthropogenic indicators are also not very numerous.

Phase 5: 1000-400 cal BC

DOS, Celtic field

The percentage of tree pollen is high, accompanied by a low percentage of herbal pollen. The percentage of anthropogenic indicators is very low as well. This suggests that forest was present at this site before the start of agricultural activities. This forest, with mainly *Quercus* and *Corylus,* might have been present when the barrows were constructed, although at that time *Carpinus* and *Fagus* were not part of it. *Tilia* pollen is present in very low amounts and might have been replaced by *Fagus* and *Carpinus*, confirming a younger dating than the barrows. Alder carr is present in the stream valleys, as in the barrow period.

Phase 6: 1000 cal BC- 150 cal AD

OAL, Celtic field

The pollen spectrum of the OAL might represent a period that is older than the period represented by the DOS samples, since this arable layer was present at another location. However, the higher percentage of *Carpinus* and *Fagus* suggests that this spectrum represents a slightly younger period (see also 2.1 and 8.1.4). The percentage of arboreal pollen is considerably lower than in the DOS-spectra, while the amount of cereal pollen and other anthropogenic indicators is much higher. *Calluna* is also present in considerable amounts.

PCF, Celtic Field

The sample from the Pre Celtic Field layer is taken from the layer above one of the DOS-samples at Vaassen I described above (DOS1). Compared to this spectrum the percentage of arboreal pollen has decreased, while the percentage of anthropogenic indicators and Poaceae has increased. The amount of cereal pollen is in contrast to the OAL-spectrum very low.

CF, Celtic Field

One CF-sample is taken from the layer above the PCF-layer, the spectrum of which is described in the previous paragraph; the other sample is coming from Vaassen III, from the layer covering the PCF layer above the OAL. At both locations the amount of tree pollen has further declined. The *Alnus* forest had not changed or increased some, but the dry forest had decreased in size. Cerealia and other anthropogenic indicators are present, but there is a difference between the CF at Vaassen I and the CF at Vaassen 3: at Vaassen 3 the percentage of cereals is much higher than at Vaassen 2.

The size of the open spaces

The minimum size of the open spaces can be estimated by the measurements of the barrows and the height of the sods that had been used in the construction of the mounds (see 7.1).

The height of the sods is only known for the second period of the Vaassen 2 barrow (0.25 m). Fontijn *et al.* (2013, 99-100, figure 4.25) have measured the length and thickness of many sods at a barrow site called Oss-Zevenbergen (see also 12.1) and concluded that the average thickness of sods used at that site was on average 20-35 cm. In addition, the thickness of the sods of the Echoput was approximately 0.25 m as well and apparently this is a suitable thickness to build barrows. For the calculations of the other barrows a height of 0.25 m will be assumed as well. This leads to the following minimum areas to be stripped per barrow (see also table 8.2):

Niersen4: 2041 m^2, $r_{openarea} \approx 25.5$ m, based on a circular open spot
Niersen6: 858 m^2, $r_{openarea} \approx 16.5$ m
V1 540 m^2, $r_{openarea} \approx 13$ m
V2 period 1: 30 m^2, $r_{openarea} \approx 3$ m
V2, period 2: 268 m^2, $r_{openarea} \approx 9$ m
V3: 30m^2, $r_{openarea} \approx 3$ m

These numbers indicate minimum areas. The dating of the barrows is not detailed enough to determine whether some of the barrows were built at the same time as was probably the case with the Echoput barrows (see 8.1). Hence, the calculated areas of the Vaassen 1 and Vaassen 3 barrows cannot be added together. Based on the ratio of arboreal versus non arboreal pollen percentages (see 7.2) the open spaces were larger than the stripped area. The ADF of the Vaassen open spot is estimated at 25-100 m. The ADF of the open area at Niersen was at the oldest phase (Niersen 4) 100- 200 m and was somewhat smaller (around 50-100m) when Niersen 6 was built.

8.2.3 Discussion

The pollen spectra show that the barrows at both Vaassen and Niersen were built in open places with heath vegetation. The barrows of Vaassen were built in an open spot with an ADF of approximately 100 m based on the ratio AP versus NAP. The open place in which the Niersen barrows were built was larger with an ADF of more than 100 m. Both open spaces were dominated by *Calluna* heath and grasses. The arboreal pollen percentage is dominated by *Alnus*, which is probably the result of an alder carr in the lower and wetter parts of the area. The forest of the drier area consisted mainly of *Quercus* and *Corylus*, the latter likely to be found at the forest rim. The vegetation of the open space seems stable, since the barrow spectra from all represented periods show similar vegetation patterns: an open place with species-poor grassy heathland surrounded by oak forest with an alder carr nearby. Some Neolithic finds underneath barrow V1, together with the relatively high percentage of anthropogenic indicators in the samples from V1 might indicate that the open space of the Vaassen barrows was used as a settlement area prior to the barrow building. After the barrow was built archeologically visible human activity decreased, leading to the decreased amount of anthropogenic indicators present at the when time barrow V2 was built. This could be an indication of change in function: a place for the living changed into a place for the dead with only the necessary management activities being maintained. The continued maintenance of the heath vegetation from when the oldest barrows (V1, V3) were built continuing to when the younger barrow (V2) was constructed strongly indicates conscious management. This also accounts for the Niersen barrow area in an even more pronounced way. The Niersen barrows formed a long alignment of barrows[11] (Bourgeois 2013, 51-66). From this alignment only two barrows were analysed for pollen. However, based on the results of barrows that formed part of other alignments (see Chapter 9) and on the palynological data of all other barrows in the southern and central Netherlands (see the remaining of this chapter and Chapters 9-12), it can be assumed that all barrows belonging to the Niersen alignment were built amongst heath vegetation. During the earliest phase (late Neolithic A) the alignment was at least 1.6 km long containing 6 barrows. With an ADF of 100-200 m it is very likely that the heath areas the barrows were built in were connected to each other, forming a long-stretched heath area. The alignment was extended in the Bell Beaker phase implying an even more extended heath area; Heath that had to be managed to remain in existence. Comparable to the *Echoput,* barrow management could have taken place by grazing, burning and/or sod cutting. It is not clear from the results whether there are indications of burning the heath. Grazing is indicated by the presence of Poaceae in combination with *Plantago lanceolata*, Asteraceae liguliflorae and *Succisa* (Hjelle 1999). A notable difference between the Vaassen

11 The alignment might even have been more extended while part of it might have been destroyed by modern land use

and the Niersen barrows are the high amounts of *Betula* pollen at Vaassen and the almost absence of this taxon at Niersen. *Betula* is a pioneer tree, meaning that it is one of the first to appear when no management is applied to prevent the tree from establishing. Young *Betula* trees are easily removed by grazers. This could indicate a difference in grazing intensity or management method (grazing versus not grazing) between the two barrow locations. Either this could mean that the barrows of Niersen belonged to another community with different management regimes or perhaps this could mean a difference in importance between Niersen and Vaassen is indicated. Niersen being part of a barrow alignment, while the Vaassen barrows might not be related to this.

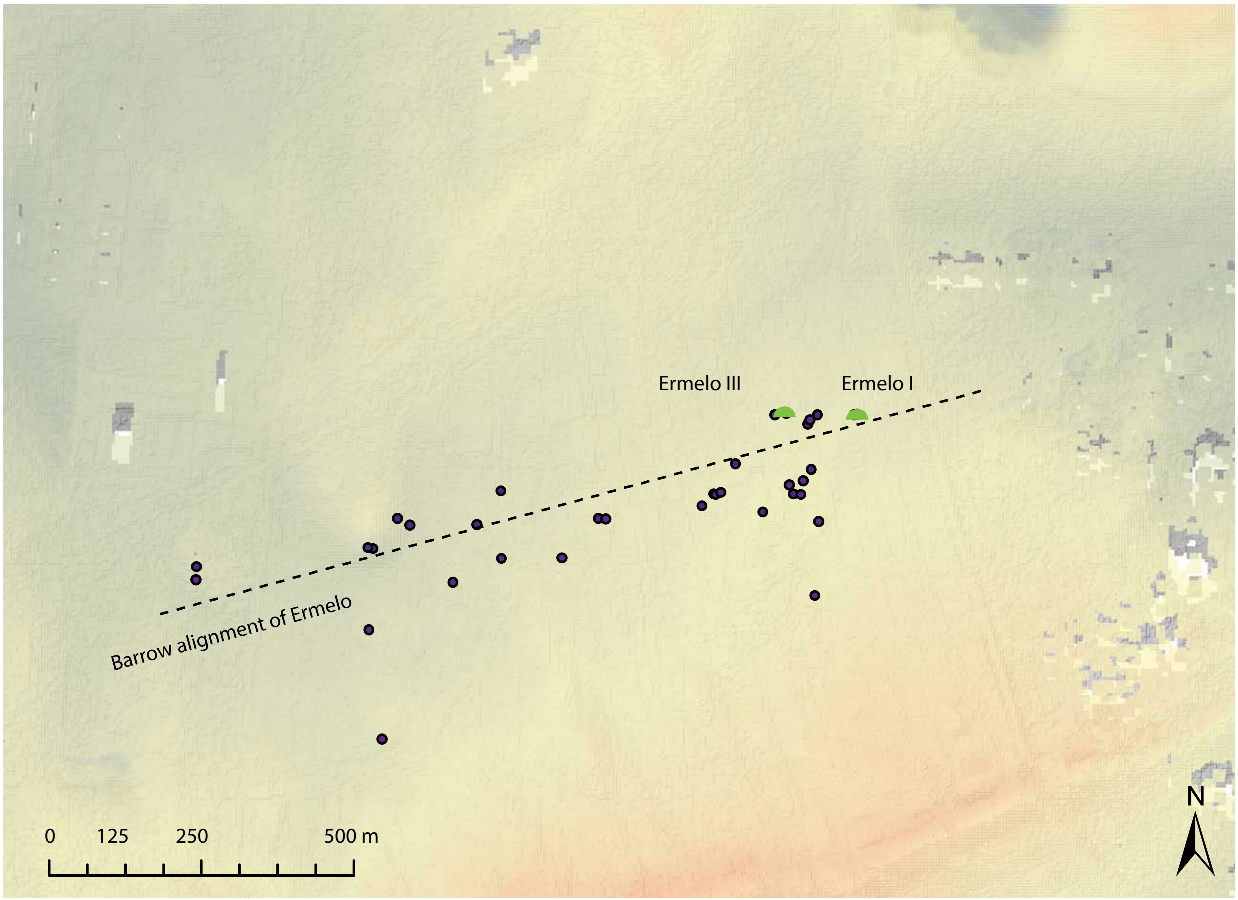
The next phase is represented by the DOS (denuded old surface) layer, the surface at which the first cultivation of crops started. This phase shows a higher percentage of arboreal pollen compared to the barrow phases. Although the dating of this layer is very coarse it is likely that this pollen spectrum represents the phase prior to the arable activities, since the amount of cereals and arable weeds is still very low. Probably forest was present at this site, which might very well be the forest that has been recorded in the barrow pollen spectra. The amount of anthropogenic indicators is very low. This could indicate that there was not a lot a human activity in the area. The absence of human influence in the area is also indicated by the sparseness of archaeological finds in the area. From the Middle Bronze Age period onwards there is hardly any evidence for the building of new barrows (Bourgeois 2013). However, older barrows have been frequently used for secondary graves indicating not a total absence of humans in the area. In addition urnfields have been found in the area, including one in the Celtic field of Vaassen.

At the Celtic field sections of Vaassen III the first agricultural activities have been recorded (OAL). The forest had probably decreased in size and at least this site was cleared of trees. The amount of anthropogenic indicators, including Cerealia, and arable weeds like *Artemisia,* is a clear indication for crop cultivation and more specifically the cultivation of cereals. Heather is well represented in the pollen spectrum. Since this spectrum probably represents a longer period, it is likely that heath vegetation was present at the site before agricultural activities started or perhaps during times when the arable fields were abandoned. Another possibility is the presence of heath very close to the agricultural field.

At the Pre-Celtic Field phase the forest that was first present (Vaassen I, DOS) was cleared and agricultural activities were started. The amount of cereals is not very high, but considering that prehistoric cereal pollen do not spread (Diot 1992) it is likely that this spot was used for crop cultivation. The agricultural activities were probably expanded during the next phase, when the Celtic Field system was created. The forest clearance had been furthered at this stage. At Vaassen III cereal cultivation was continued (started at the OAL) and at Vaassen I other crops might have been cultivated.

8.3 Ermelo

In the area of Ermelo over a hundred barrows are known to be located, of which 55 have been excavated. During a great campaign in 1952, Modderman excavated 34 of these barrows (Modderman 1954) providing high-quality information on the mounds (Bourgeois 2013). In 1971 a re-excavation took place by Lanting and van der Waals during which two barrows (Ermelo I and III) were sampled and analysed for pollen (Casparie and Groenman-van Waateringe 1980, 29-30, 31).



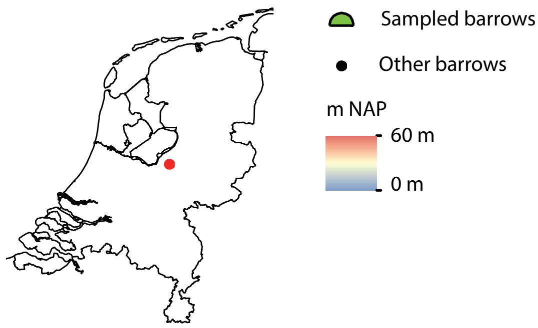
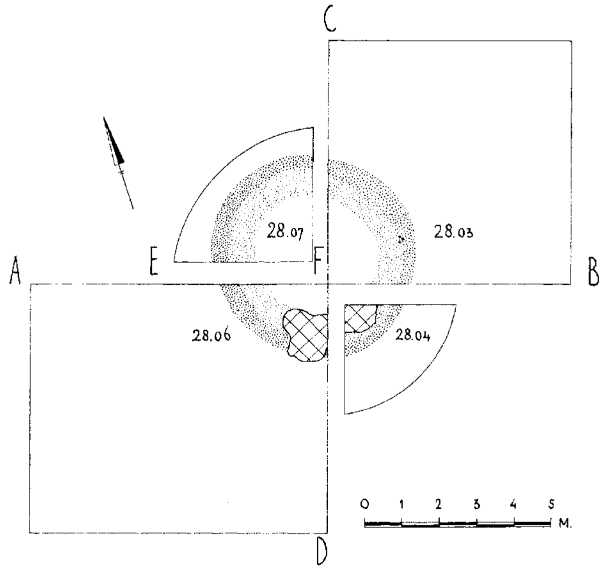


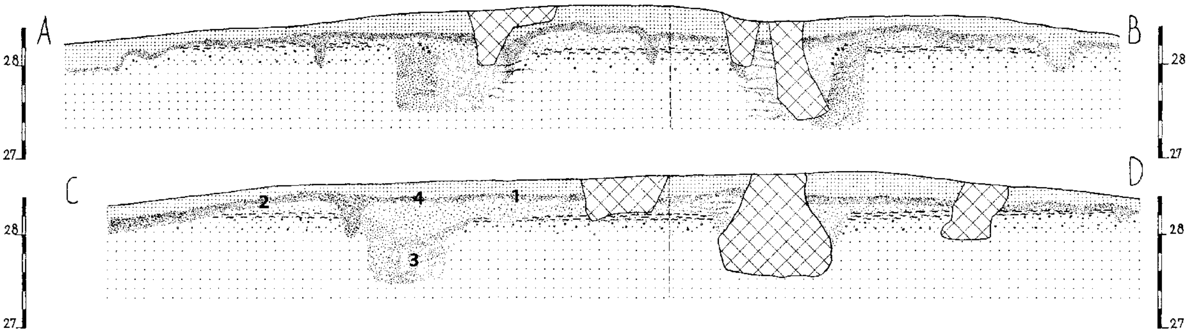
Figure 8.14. Detailed map of the Ermelo area with the locations of the barrows from the Ermelo barrow alignment that were sampled for pollen analysis. The map is based on digital elevation model of the AHN (copyright www.ahn.nl).

8.3.1 Site description and sample locations

Several barrow alignments were recognized in this region. The two investigated barrows formed part of one of these alignments and are situated about 125 m from each other (Bourgeois 2013, 78-88; figure 8.14). This barrow alignment is situated at the bottom of a valley on the northern slope of the ice-pushed ridge of Garderen. Ermelo I is a single period barrow, originally excavated by Modderman (1954). The mound probably was surrounded by a palisaded ditch (diameter=5.5 m), that consisted of a broad trench which was filled up after posts were placed. Part of an AOO-beaker was found in the upper part of the ditch fill (see figure 8.15), dating the barrow to the late Neolithic A. The barrow was re-excavated by Lanting and van der Waals in 1971 (Lanting and van der Waals 1971b, 1976). Samples for pollen analysis were taken from the old surface in and outside the encircling ditch, from the ditch fill (referred to as turfs by Casparie and Groenman-van Waateringe 1980) and from upper part of the ditch fill (referred to as the old surface by Casparie and Groenman-van Waateringe 1980, 31; see figure 8.15). Ermelo III

Figure 8.15. Ermelo barrow I with the probable sample locations. 1= old surface inside encircling ditch, 2= old surface outside encircling ditch, 3= ditch fill, 4= upper part ditch fill. Figure redrawn after Modderman (1954, plate XXXIV).





is a single period barrow. The barrow was originally excavated by Modderman (1954). Two PF-beakers and a flint blade have been found, dating the barrow to the Neolithic A. This barrow is like Ermelo I approximately 0.5 m of height and has a diameter of about 6.5 m. The barrow was re-excavated by Lanting and van der Waals in 1971 (Lanting and van der Waals 1971b). Samples for pollen analysis were taken from the old surface underneath the mound (Casparie and Groenman-van Waateringe 1980, 29-30).

8.3.2 Results

Results will be described per barrow in chronological order. See figure 8.16.

Ermelo III (2900-2500 cal BC)

The pollen spectra from the old surface of Ermelo III show an arboreal percentage of approximately 50%. This arboreal pollen percentage consists mainly of *Alnus*. Corylus is present in considerable amounts of approximately 35%. Other trees are *Quercus* (5-10%), *Tilia* (10-15%) and *Betula* (5%). The herbal vegetation is dominated by *Calluna vulgaris* and Poaceae. Some anthropogenic indicators are present in the form of Chenopodiaceae and Asteraceae tubuliflorae. A few pollen grains of Cerealia were also noticed. Grazing indicators are mainly represented by Poaceae and *Plantago lanceolata*.

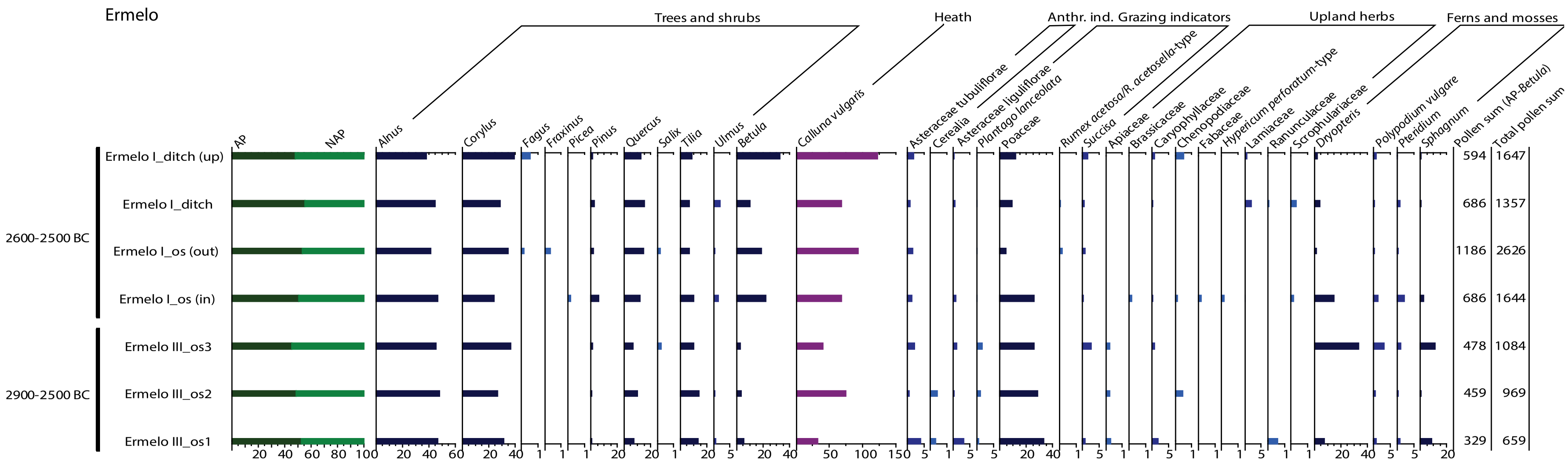


Figure 8.16. Pollen spectra from samples taken from the Ermelo barrows. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

Ermelo I (2600-2500 cal BC)

Compared to Ermelo III the arboreal pollen percentage seems to have slightly increased to 55%. The main tree is still *Alnus*. *Corylus* is also still present in high amounts (35%). The amount of *Tilia* seems to have decreased to 5-10%; the amount of *Quercus* seems to have slightly increased to 10-15%. *Fagus* has appeared, although still in very low numbers. *Betula* expanded from 5% at Ermelo III to 20% at Ermelo I. The heather seems to have expanded with percentages up to 125% at cost of Poaceae. No indications of Cerealia have been found. Other anthropogenic indicators such as Asteraceae tubuliflorae and Chenopodiaceae are present in low amounts.

The size of the open space

Based on the measurements of the barrows the minimum size of the open area has been calculated (see also table 8.2). Since the height of the sods is not known a standard height (known from the Echoput and Vaassen barrows) of 0.25 m has been applied. This gives the following estimates of open area:

Ermelo I: 33.4 m^2, $r_{openarea} \approx 3.3$ m, based on a circular open spot
Ermelo III: 24 m^2, $r_{openarea} \approx 2.7$ m

Based on the ratio AP:NAP, the open space had an ADF of approximately 50-100 m. The open spot might have decreased a little at the time Ermelo I was built (AP=55% for Ermelo I and AP=50% for Ermelo III). The relation found between arboreal pollen percentage and size of the open space (see 7.2) is not detailed enough to explain this difference in percentage by a difference in distance to the forest.

8.3.3 Discussion

The vegetation composition in the area of the Ermelo barrows in the late Neolithic seems to be quite similar to the late Neolithic phase of Vaassen (8.1.2). The barrows were built in an open space with an ADF of 50-100 m with a vegetation cover of mainly heather and grasses. When the first barrow (Ermelo III) was built the heath seemed to more grassy than when Ermelo I was built. The two investigated barrows were part of a barrow alignment implying that they were built in a long-stretched heath area (see also 8.2.3 and chapter 9). Management is required to maintain such areas of heath. The increased amount of *Betula* could indicate a change in management regime making it possible for *Betula* to expand. This is also indicated by a slight decrease in anthropogenic and grazing indicators. An extensive alder carr must have been present in the stream valleys close to the barrows indicated by *Alnus* pollen percentages of approximately 45%. The dry forest was most likely quite open with mainly *Corylus* and some *Quercus* and *Tilia*.

8.4 Putten

8.4.1 Site description and sample locations

Close to the village of Putten, approximately 5 km to the southwest of the Ermelo barrows, a burial mound is situated (see figure 8.1). This barrow was excavated by van Giffen in 1947 and a sample from the old surface was analysed for pollen by Waterbolk (1954, 93-94). During this excavation a PF-beaker was found together with a battle axe, a Grand Pressigny dagger, a flint axe and four flint flakes. Three secondary interment Bell Beakers were buried in the mound

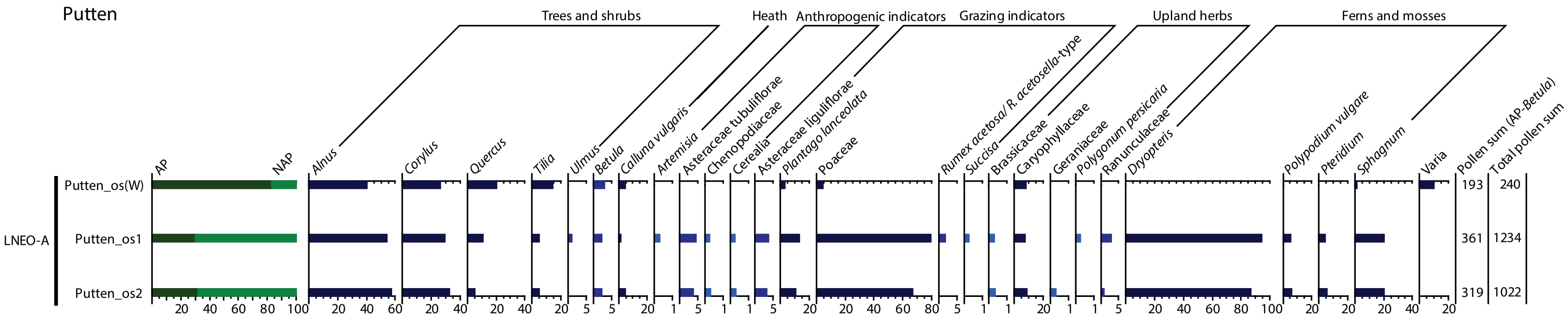


Figure 8.17. Pollen spectra from the samples taken from the Putten barrow. Spectra are given in % based on a tree pollen sum minus Betula pollen. In the total AP (=arboreal pollen) Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours. LNEO-A= Late Neolithicum A.*

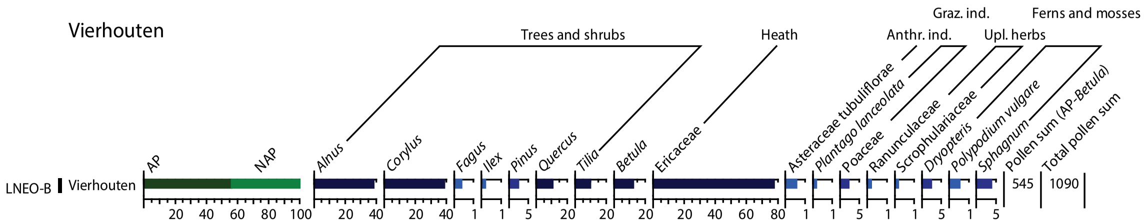


Figure 8.18. Pollen spectra from the samples taken from the Vierhouten barrow. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

(Waterbolk 1954, 93). The old surface contained fragments of PF-Beakers that might indicate a former settlement site (Casparie and Groenman-van Waateringe 1980, 30). Re-excavation of the barrow took place in 1971 for pollen sampling. Samples were taken from the old surface. Results have been published by Casparie and Groenman-van Waateringe (1980, 30). Measurements of the mound are not known.

8.4.2 Results and discussion

See figure 8.17

The first thing to notice is the difference in pollen spectra from the sample published by Waterbolk and those published by Casparie and Groenman-van Waateringe. The Waterbolk spectrum shows an arboreal pollen percentage of approximately 75%, while the arboreal pollen percentage in the spectrum published by Casparie and Groenman-van Waateringe is only 30%. The differences seem mainly to have been caused by high percentages of Poaceae and ferns in the Casparie and Groenman-van Waateringe spectra, which are very low or absent in the Waterbolk spectrum. Waterbolk mentioned the bad conservation of pollen in his sample. He did not reach a pollen sum of 300 arboreal pollen grains and as a consequence this spectrum might not be representative. However, it is difficult to conclude this being the cause of the dissimilarities. Yet, it is difficult to interpret these results. Some similarities can be seen. All pollen spectra show very low percentages of *Calluna vulgaris*, indicating that the open space did not contain a lot of heather. This could be the result of a small open space (as in the Waterbolk spectrum) or a larger open space that was dominated by grasses (as in the Casparie and Groenman-van Waateringe spectra).

8.5 Vierhouten

8.5.1 Site description and sample locations

Close to Vierhouten (see figure 8.1) a single period barrow was excavated in 1939 by A.E. van Giffen. Two Veluvian Bell Beakers and a wrist guard were found dating the barrow to the late Neolithic B period (2500-2000 cal BC, see table 2.1). Measurements of the mound are not known. In 1972 a re-excavation took place by Lanting and van der Waals (1972c). At that time samples for pollen analysis were taken from the old surface. One sample was analysed and published by Casparie and Groenman-van Waateringe (1980, 36).

8.5.2 Results and discussion

The pollen spectrum (see figure 8.18) shows an arboreal pollen percentage of approximately 56%, which indicates an open place with an ADF of approximately 50-100m. Trees in the surroundings are dominated by *Alnus* and *Corylus*, which both occur with pollen percentages of approximately 40%. *Quercus*, *Tilia* and *Betula* are present in less but still considerable amounts of circa 10%. The open spot was mainly covered with Ericaceae, most likely *Calluna vulgaris*. Other herbs were almost absent. The situation is comparable to the late Neolithic B-phase of Niersen-Vaassen.

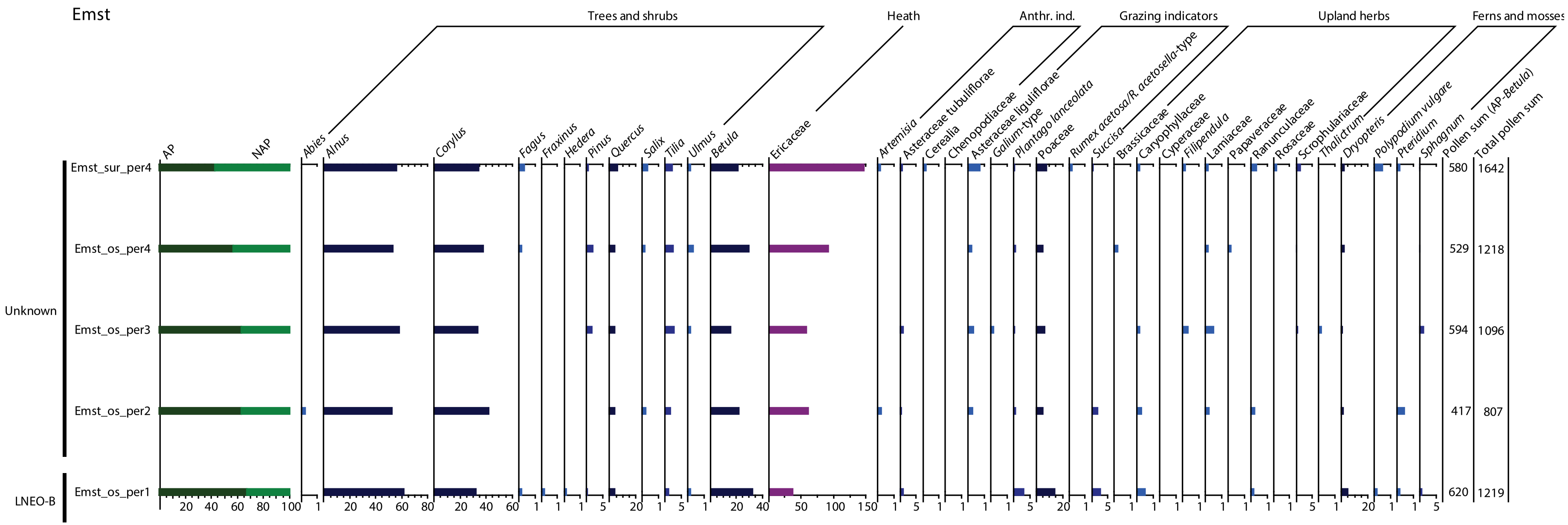


Figure 8.19. Pollen spectra from the samples taken from the Emst barrow. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

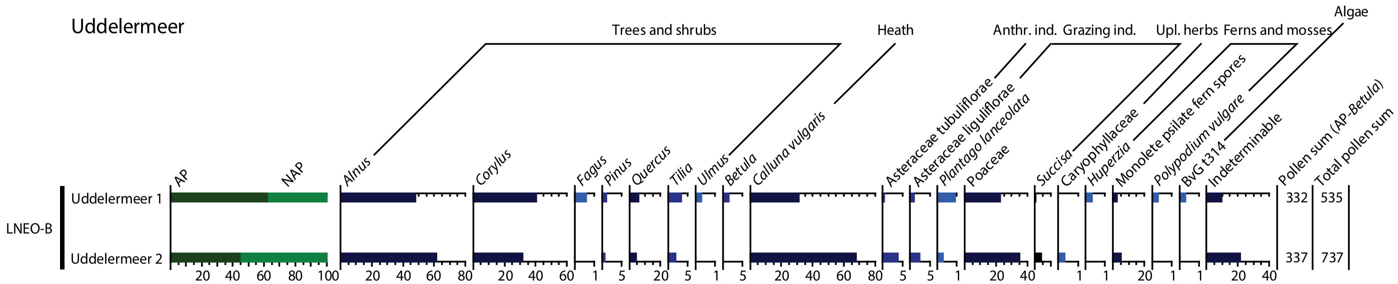


Figure 8.20. Pollen spectra from the samples taken from the Uddelermeer barrows. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

8.6 Emst

8.6.1 Site description and sample locations

Near Emst a barrow of probably four periods is situated. The barrow was first excavated in 1932 by J. Butter. The first period was dated to the late Neolithic B period based on the bodies being buried semi-flexed (Hulst 1972). The original measurements of the barrow are not known. Samples for pollen analysis were taken from the old surface of all periods. The results were published in Casparie and Groenman-van Waateringe (1980, 36-37).

8.6.1 Results and discussion

See figure 8.19

The pollen spectrum of the late Neolithic B period shows an arboreal pollen percentage of approximately 65% dominated by *Alnus* (60%) and *Corylus* (30%). This indicates an open space with an ADF of approximately 50 m at the oldest phase, which is very small compared to most of the other barrows in this region. This open spot is mainly covered with heath vegetation and grasses and most likely some *Betula* trees. In the next periods (which are not dated) the amount of arboreal pollen decreases, accompanied by an increase of heath. This indicates an increase of the open spot to an ADF of approximately 150m.

8.7 Uddelermeer

8.7.1 Site description and sample locations

Two barrows at the edge of the Uddelermeer (see figure 8.1) were excavated in 1911 by Holwerda. Uddelermeer 1 measured approximately 20 m in diameter and 1.0 m in height. Uddelermeer 2 was approximately 18 m in diameter and 1.5 m high. Both barrows were dated to the late Neolithic B period based on sherds from Bell Beaker pottery (Holwerda 1912), however, since these finds were small this dating could be questioned (Q. Bourgeois pers. comm., October 2012). In 1989 both mounds were the focus of conservation by the ROB (presently known as Cultural Heritage Agency of the Netherlands). Samples for pollen analysis have been taken from the profile in trenches during consolidation. The soil samples were taken in small glass tubes, which were sealed and sent to the University of Amsterdam, to Prof. Groenman-van Waateringe. The samples were stored until July 2009 and then taken to Leiden University for analysis. From both mounds a sample from the old surface was prepared and analysed by the method described in Chapter 4. It should be noted that samples were derived from trenches. This makes it is difficult to relate these samples exactly to the barrow, since only a small part of the barrow was exposed. Therefore properly dating of the pollen spectra is difficult as well, what with the dates of the barrows themselves being already in doubt.

8.7.2 Results and discussion

The preservation of pollen was poor in both samples resulting in a high amount of indeterminable pollen grains. The ratio arboreal versus non arboreal pollen is approximately 65-35% for Uddelermeer 1 and approximately 45-55% for Uddelermeer 2 (see figure 8.20). When an average thickness of 0.25m for the sods is assumed (see 8.2.2) the area that needed to be stripped to build Uddelermeer 1 is approximately 630 m^2 indicating an open space with a radius of approximately 14 m. To build Uddelermeer 2 approximately 770 m^2 (radius ≈ 15.5 m) was necessary. Based on the arboreal pollen percentage the size of the open area had an ADF of approximately 50 m for Uddelermeer 1 and approximately 150 m for Uddelermeer 1. This might indicate that Uddelermeer 1 was built first in a small open space and that Uddelermeer 2 was constructed later when the open space had expanded. Both barrows were built in heath and grass vegetation. The forest in the surroundings was probably quite open and consisted mainly of *Corylus.* Alder carr was present in the wetter areas.

8.8 Boeschoten

8.8.1 Site description and sample locations

In de area of Boeschoten (see figure 8.1) a barrow was excavated by Glasbergen and van der Waals in 1952. The old surface contained lots of charcoal particles. The excavators dated the barrow to the Early Bronze Age or the late Neolithic B period, based on sherds of ceramics found in the old surface. Measurements of the barrow are not known. Samples for pollen analysis were taken from the old surface underneath the mound and from the fill of the ditch surrounding the barrow. The results of the pollen analysis were published by Waterbolk (1954, 93-95).

8.8.1 Results and discussion

The pollen spectra from both samples show rather similar results (see figure 8.21). The arboreal pollen percentage is approximately 65%. This indicates a small open space with an estimated ADF of approximately 50 m. The surrounding forest consisted mainly of *Quercus* and *Corylus* with nearby an alder carr in the wetter parts of the area. The amount of herbal pollen is low and consists of 13-28% *Calluna* and approximately 15% Poaceae. The pollen spectra show very poor variety of species. Some anthropogenic indicators are present, however, in such low amounts that they cannot be linked to the activity of man.

8.9 Ugchelen

8.9.1 Site description and sample locations

Near Ugchelen four barrows were excavated in 1947. All barrows were heavily damaged prior to the excavation and the original measurements of the barrows could not be reconstructed. Two of the barrows (Ugchelen 1 and 4) could be sampled for pollen analysis. These barrows could not be dated. The obtained pollen spectra from the old surfaces of both barrows have been published by Waterbolk (1954, 94-95).

8.9.1 Results and discussion

See figure 8.22

Like the barrow of Boeschoten, the barrows of Ugchelen were built in a small open space with an ADF of approximately 50 m covered with heather and grasses surrounded by a forest of mainly *Quercus* and *Corylus*. Alder carr in the wetter surroundings was probably responsible for the high percentage of *Alnus* pollen in the spectra. A remarkable difference in *Tilia* pollen between the two barrows (approximately 20% for Ugchelen 1 and approximately 2% for Ugchelen 4) makes

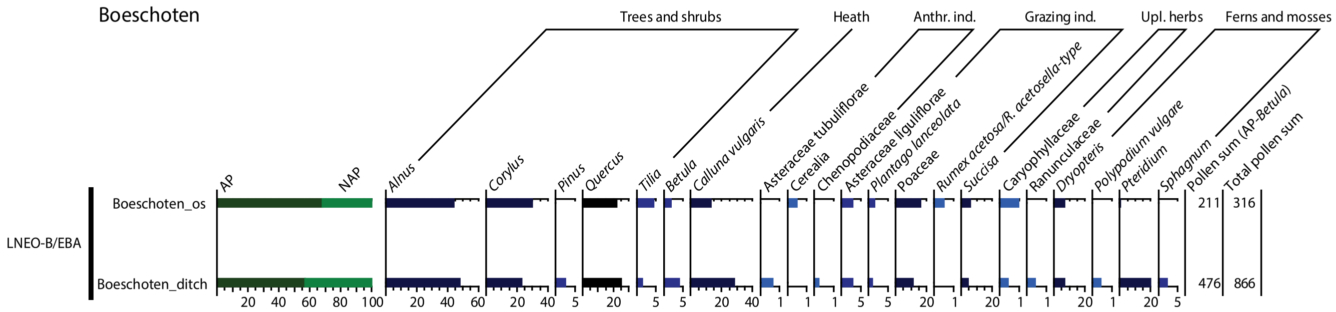


Figure 8.21. *Pollen spectra from the samples taken from the Boeschoten barrow. Spectra are given in % based on a tree pollen sum minus* Betula *pollen. In the total AP (=arboreal pollen) Betula is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

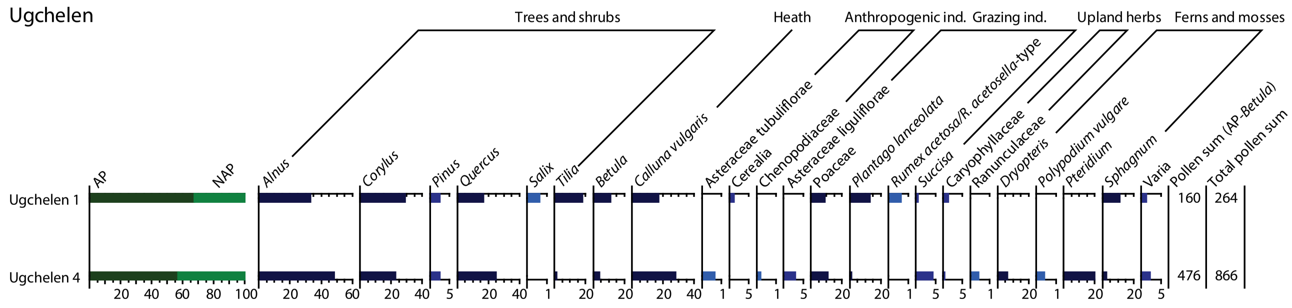


Figure 8.22. *Pollen spectra from the samples taken from the Ugchelen barrows. Spectra are given in % based on a tree pollen sum minus* Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

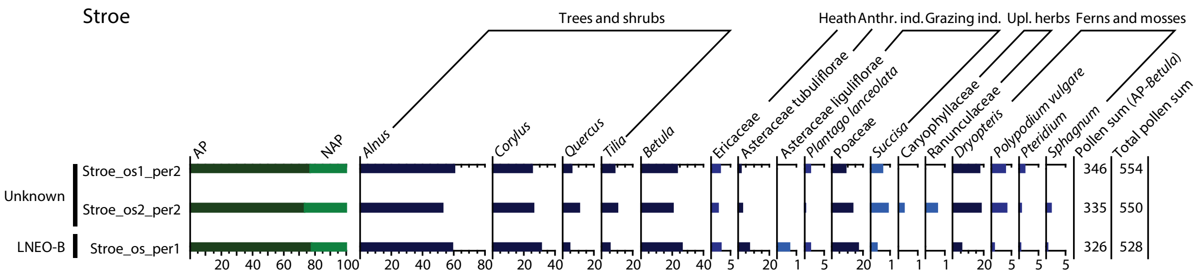


Figure 8.23. Pollen spectra from the samples taken from the Stroe barrow. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

it unlikely that they were built in the same period. Although the barrows have not been dated, Barrow 1 can be assumed the older of the two based on the rather high percentage of *Tilia* pollen. However, based on only one sample this cannot be concluded with certainty. Also remarkable are the high percentage of *Plantago lanceolata* in the spectrum from Barrow 1 and the presence of Cerealia. This may indicate an increase in human activity in the area around the period Barrow 1 was constructed than when Barrow 4 was built.

8.10 Stroe

Near Stroe (see figure 8.1) a barrow is located that was excavated several times (by Pleyte and Nairac in 1877, by Westendorp in 1926-1929 and by Lanting and van der Waals in 1971). The barrow might contain two periods, although this cannot be confirmed with certainty based on the excavation data. The first (?) period of the barrow was dated to the Late Neolithic B, based on the find of a copper tanged dagger, a wrist guard and a Veluvian Bell Beaker. Below the mound some PFB sherds were found. Some fragments of charcoal that were scattered on the old surface were ^{14}C-dated to 3955 ± 55 BP (GrN-6350; 2600-2287 cal BC, calibrated with Oxcal 4.2) and might be associated to the PFB material. The barrow was re-excavated by Lanting and van der Waals in 1971 (Lanting and van der Waals 1971c, 1976). Samples for pollen analysis were taken from the old surface of the primary mound and from the old surface of the presumably secondary mound in 1971. The results of the pollen analysis were published by Casparie and Groenman- van Waateringe (1980, 34).

8.10.1 Results and discussion

The barrow was built in a very small open place with an ADF of less than 50 m. In contrast to all other analysed barrows this mound was not built in heath vegetation (see figure 8.23). Instead, the vegetation at the open spot was probably covered with grass, indicated by the relatively high percentages of Poaceae found in the pollen spectra (ca. 15%). The forest in the surrounding area mainly consisted of *Corylus*, *Quercus* and probably also *Betula*. Alder carr was present in the wetter parts of the area. The barrow was possibly built on a former settlement, given the finds of PFB material. The presence of heath and grazing indicators suggests that the site was used as pasture before the barrow was built and after abandonment of the settlement.

	diameter (m)	height (m)	sod thickness (m)	diameter 2nd period (m)	height 2nd period (m)	Sod area (m2)	Radius (m)	Sod area 2nd period (m2)	Radius 2nd period (m)
Echoput 1	19	10.8	0.25			615.06	13.99		
Echoput 2	14.5	1	0.25			332.35	10.29		
Niersen 4	28	1.65	0.25			2041.39	25.49		
Niersen 6	19	1.5	0.25			857.65	16.52		
Vaassen I	13	1	0.25			267.56	9.23		
Vaassen II	8	0.3	0.25	15	1.4	30.22	3.10	470.33	12.24
Vaassen III	7.5	0.3	0.25			26.56	2.91		
Ermelo I	6.5	0.5	0.25			33.44	3.26	1422.91	21.28
Ermelo III	5.5	0.5	0.25			24.02	2.77		
Putten	unknown								
Vierhouten	unknown								
Emst	unknown								
Uddelermeer 1	20	1	0.25			630.41	14.17		
Uddelermeer 2	18	1.5	0.25			770..48	15.66		
Ugchelen	unknown								
Boeschoten	unknown								

Table 8.2. The minimum size of the open space per barrow based on the sods used to build the barrows.

8.11 Palynological results from peat and lake sediments

8.11.1 Site description and sample locations

The Uddelermeer is one of the largest pingo ruins in the Netherlands created in the Last Glacial period of the Pleistocene. It is very deep, around 17 m, and has slowly been filled up with organic mud. Pollen was caught in every layer of organic mud and an archive of vegetation development was formed. Polak took samples for pollen analysis at four places, the results of which were published in Polak (1959).

8.11.2 Results and discussion

Polak (1959) made several pollen diagrams that show the regional vegetation development of the area. In figure 8.24 a summarized pollen diagram of the Polak diagrams is shown. The diagram is based on the results of two different sample locations: a deeper location with the older organic layers, the results of which are shown in the part below the dashed line. The part above the dashed line shows the more recent vegetation development, derived from the upper organic layers. The pollen sum used in this diagram is based on the arboreal pollen sum minus *Betula* to be able to compare it to the barrow pollen spectra. The total arboreal and non arboreal percentages are based on a total pollen sum of which the aquatic vegetation has been left out (Poaceae are included although the marsh plant reed belongs to this family and could have been locally present). Although the diagrams have not been ^{14}C-dated, pollen zones according to Jessen and Iversen have been applied to the lake samples, based on the stratigraphy of the lake sediments and the palynological results. The results from the Preboreal (zone IV) until the Subatlantic (zone IX) will be discussed here. The pollen diagram shows the regional vegetation development of the area where the barrows described above are situated in. Although not directly linked in time to the barrows due to the lack of exact dating, the pollen diagram shows the general development of the environment of the barrows.

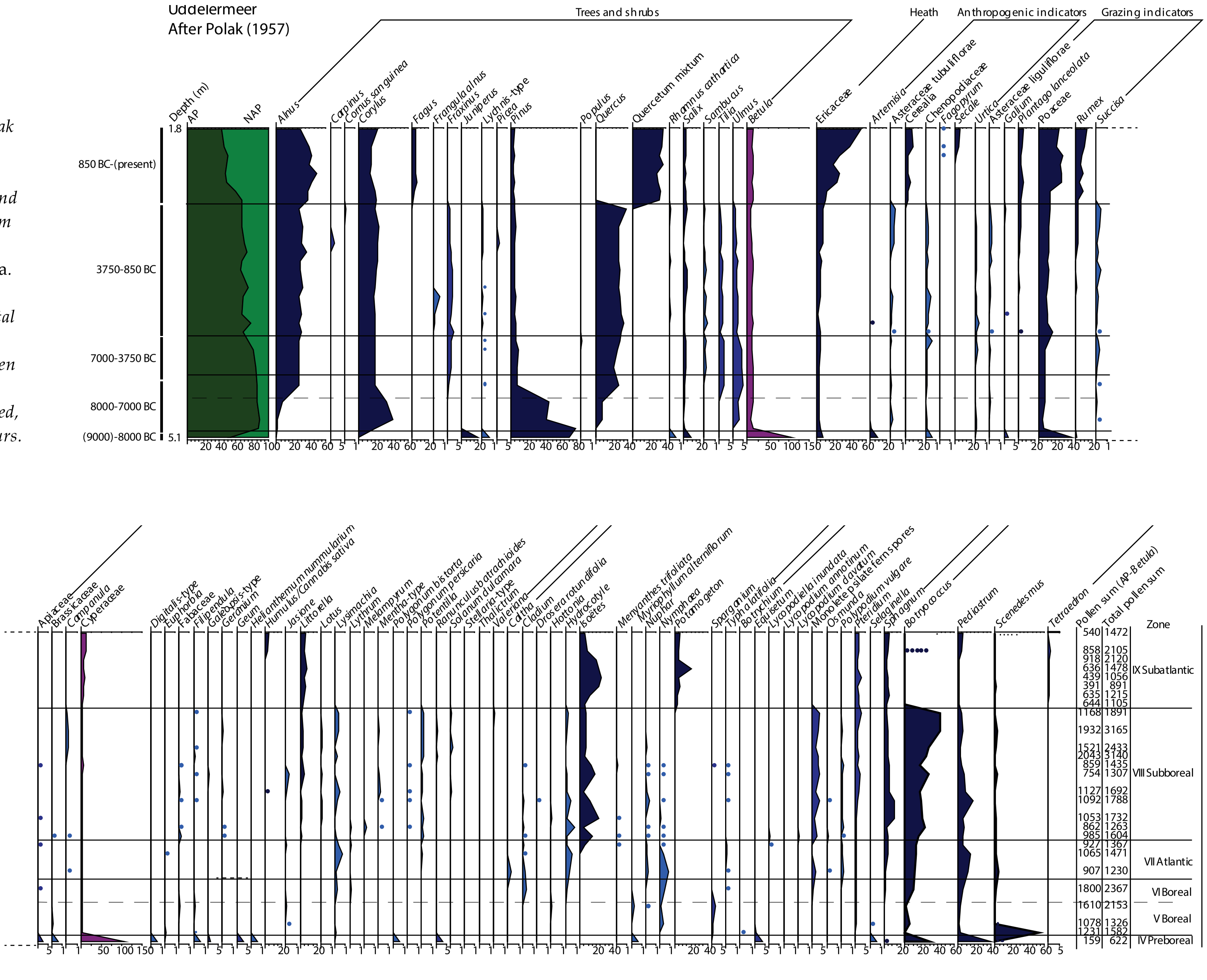


Figure 8.24. Pollen diagram from the Uddelermeer, composed and redrawn from three pollen diagrams by Polak (1959, diagrams I, VI and VII). Pollen zones have been applied according to Jessen and Iversen. A percentage diagram is shown, with % based on a tree pollen sum minus Betula*. In the AP (= arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

In the Preboreal (IV) the percentage of arboreal pollen increased due to a decrease of herbs like Poaceae, Cyperaceae and *Artemisia*. The arboreal pollen percentage consisted mainly of *Pinus* and *Corylus,* of which the latter appeared in the preceding period. In the Boreal (V&VI) period percentages around 80% of total pollen (minus aquatic plants) were reached. During this period *Alnus* and *Quercetum*-mixtum (*e.g.* tall deciduous dryland trees) appeared. *Alnus* reached percentages of around 25-30% and *Quercetum*-mixtum increased even further until 35-40%. At the same time *Pinus,* probably a long distance element at this time, decreased to around 5% (of ∑AP-*Betula*). *Corylus* decreased as well, although less dramatically until around 20%. *Tilia, Ulmus* and *Fraxinus* appeared in this period. Ericaceae were present with percentages of approximately 2-4%. This situation remained quite stable until the last part of the Subboreal period, although the amount of herbs gradually increased. This is mainly due to the increase of Poaceae until percentages of around 10-15%. The amount of Ericaceae increased slightly too up to 10%. Anthropogenic indicators like *Plantago lanceolata* and *Rumex* rose up to around 3%. Cereal pollen grains increased until 3-4%.

Towards the end of the Subboreal period (which ends at 800 cal BC, see table 2.1) the arboreal-non arboreal ratio changed in favour of the non-arboreal pollen. The percentage of non-arboreal pollen increased until around 45%. This is mainly caused by the further increase of grasses (until around 30%) and Ericaceae (around 25%). A slight decrease in *Quercetum*-mixtum pollen can be seen, while the percentage of *Alnus* pollen seemed to increase slightly. This change in vegetation composition could be indicative for the influence of humans in the area.

The Subatlantic (zone IX, from 800 cal BC, see table 2.1) started with a further decrease of total arboreal pollen and an expansion of Ericaceae and Poaceae. Cereal pollen grains continued to increase slowly as well. Halfway through this zone *Secale* appears in the diagram, which probably coincides with the Roman Iron Period (Behre 1992). At this time there seems to be a slight regeneration of the forest (mainly *Quercetum*-mixtum) and some decrease of heath. Then the non arboreal vegetation expanded again at cost of the forest, with further increase of heath and cereal pollen, including *Secale.* The end of the diagram probably represents the early Middle Ages (according to Polak 1959).

8.12 Summary: the barrow landscape of northern and central Veluwe

In this chapter the palynological results of barrows at the northern and central part of the Veluwe have been discussed in order to answer the question: What did a barrow landscape look like before and after the barrows were built? And, what was the role of prehistoric human?

Barrows from the late Neolithic A period until the Iron Age were built in open spaces that generally had an average distance to the forest (ADF) of approximately 50-100m, shown by arboreal pollen percentages of 55-60%. Most herb pollen is coming from local vegetation. All barrows except one (Stroe; 8.10) were built in a heath vegetation type, according to the percentages of *Calluna vulgaris* found in all pollen spectra. These percentages are on average lowest in the oldest barrow spectra (around 20%) and highest in the youngest, with percentages up to 100%. However, percentages over 100% did also occur during the late Neolithic, shown by the pollen spectra from Ermelo (8.3). This implies that heath was present in the whole area during the entire period. These heath areas varied from small to rather large, and in general the heath areas expanded over time. Besides *Calluna vulgaris*, the heath vegetation consisted for a considerable part of grasses. Anthropogenic indicators are present in all barrow spectra, although in low percentages. The most dominant anthropogenic indicator is *Plantago lanceolata*, indicating that the area had been significantly disturbed by human hands. The open places with heath vegetation where the barrows were built in were not recorded as such in the Uddelermeer diagram, indicating the local spread of pollen of heath species. The Uddelermeer diagram suggests that the vegetation consisted of mainly forest and human activity was slight. The barrow pollen spectra however, indicate otherwise. Open places with heath vegetation must have been present in considerable numbers from the Neolithic onwards.

In all pollen spectra *Alnus* was the dominant arboreal pollen type. It is very likely that alder carr forests were present in the wetter parts of the area, probably the stream valleys. The drier forest in the surroundings consisted mainly of *Tilia*, with pollen percentages of 5-20%, *Quercus*, with pollen percentages of approximately 10% and *Corylus* at the forest edge, with pollen percentages of 30-40%. The remaining tree species occur with somewhat fluctuating but low percentages during the entire period. This general view on forest composition in the area is also shown by the pollen diagram from the Uddelermeer, where zone VI-VIII probably represent the situation that has also been registered in the barrow pollen spectra: the high percentages of *Alnus* in the wetter parts of the area; the drier forest consisting mainly of *Quercus* and *Corylus*.

In the Middle/Late Iron Age the barrow landscape seems to have changed, according to the palynological data of the Echoput barrows (8.1). These barrows were built in much larger open spaces, with an ADF of approximately 200-300 m (arboreal pollen percentage is around 20%). *Calluna vulgaris* and Poaceae are, as at the older barrow locations, the dominating species at the open space. Percentages of *Calluna vulgaris* now substantially exceed 100%, while grasses (Poaceae) fluctuate around 60%.

The forest composition in the Middle/Late Iron Age period at the Echoput was slightly different from the forest composition shown by the older barrows in the area. The amount of *Tilia* (pollen percentages of 1-2%) and *Corylus* (pollen percentages of less than 20%) seem to have decreased, while *Quercus* (pollen percentages until 40%) and Fagus (pollen percentages until 5%) seem to have increased. In addition, *Carpinus* has appeared in the pollen spectra. Alder carr is still present in the wetter areas.

As mentioned above, at the time the Echoput barrows were built, heath vegetation had expanded in the area. This spreading out of heath vegetation most likely continued. At the time posts were placed close to the Echoput barrows, probably in the Medieval period (see 8.1.4), arboreal pollen percentages were only around 15%. These low percentages indicate an ADF over 600 m (see table 7.2). This large scale expansion of heath in the Medieval Period is also recorded in the Uddelermeer diagram (when *Fagopyrum* and *Secale* have appeared as well). This is most likely due to the large scale opening up of the landscape caused by intensified human activities.

In this chapter it has been shown that the barrows from the Late Neolithic A period until the Late Iron Age were built in heath vegetation. It was also shown that during the late Neolithic A period long alignments of barrows were present (8.2 Niersen-Vaassen and 8.3 Ermelo). These barrows alignments were probably built in long stretched heathland areas, where visibility from one barrow to the next is likely (Bourgeois 2013, 154-155). The fact that heath and herb vegetation had already developed at the barrow places, suggests that these long stretched heath areas were already present some time *before* the barrows were built. Moreover, these open spaces must have been kept open until the barrows were built. This also accounts for the smaller heath areas where barrows were built in that not formed such alignments. It is important to realise that management was required to maintain these heath areas. This indicates the activity of humans in the area, at least and perhaps specifically at the places where the barrows were going to be built. Some open spaces might have been used as settlement area prior to the barrow building (8.2 Vaassen I and 8.4 Putten). These sites must have been abandoned for some time before the mounds were raised. For the other barrows in this region no such indications have been found, nor for the cultivation of crops. As has been discussed extensively in paragraph 8.1.4 (Echoput) it is likely that most of these open spaces have been kept open by grazing.

Chapter 9

The Renkum stream valley

In Chapter 8 palynological analyses of barrows at the northern and central part of the Veluwe have shown a barrow landscape that was dominated by heath vegetation that must have been managed for several millennia (from the late Neolithic A period until the Late Iron Age). In this chapter another group of barrows will be discussed. These barrows are located in a region further to the south that is very much comparable to the northern and central Veluwe. This region is also situated on the Pleistocene push moraine complexes. In Chapter 8 two alignments of barrows have been discussed and in Chapter 9 another example of a barrow alignment will be shown.

This alignment with a length of at least 4.5 km[12] is situated in a stream valley near Renkum (Bourgeois 2013, 67-77), in the southern part of the Veluwe (see figure 9.1). Several of the barrows of the alignment have been excavated and sampled for pollen analysis as well as three barrows in the same region outside this alignment. The barrows were all analysed by Casparie and Groenman-van Waateringe (1980, 24-36), with the exception of Bennekom 1. Bennekom 1 was published by van Giffen (1954). Section 9.2 presents a new interpretation of the data retrieved by the above mentioned researchers.

9.1 Site description and sample locations

Burial mounds belonging to the barrow alignment

Renkum 1: A single-period barrow that was excavated in 1929 by Bellen. The barrow was dated to the late Neolithic A based on the find of a PF Beaker. Originally the barrow measured approximately 9 m in diameter and 0.80 m in height. Lanting and van der Waals re-excavated the barrow. Samples were then taken from the old surface for pollen analysis (Lanting and van der Waals 1972b, Casparie and Groenman-van Waateringe 1980, 28).

Renkum 2: A single-period barrow in which a PF Beaker was found when it was excavated in 1929 by Bellen. Based on this PF Beaker the barrow was dated to the late Neolithic A. During a re-excavation in 1972 by Lanting and van der Waals samples were taken for pollen analysis (Lanting and van der Waals 1972b). Samples from the old surface have been analysed (Casparie and Groenman-van Waateringe 1980, 29).

Renkum 3: A two-period barrow that has been excavated in 1975 by Bakker and Groenman-van Waateringe (1980, 29). A PF Beaker has been found in the primary mound, dating it to the late Neolithic A. The barrow measured 15 m in diameter and 1.8 m in height. Samples that have been analysed were taken from the old surface of the primary mound and from a sod of the secondary mound.

12 According to Bourgeois (2013, 74), two alignments are situated in the stream valley of Renkum, that possibly formed one long alignment of at least 4.5 km in length.

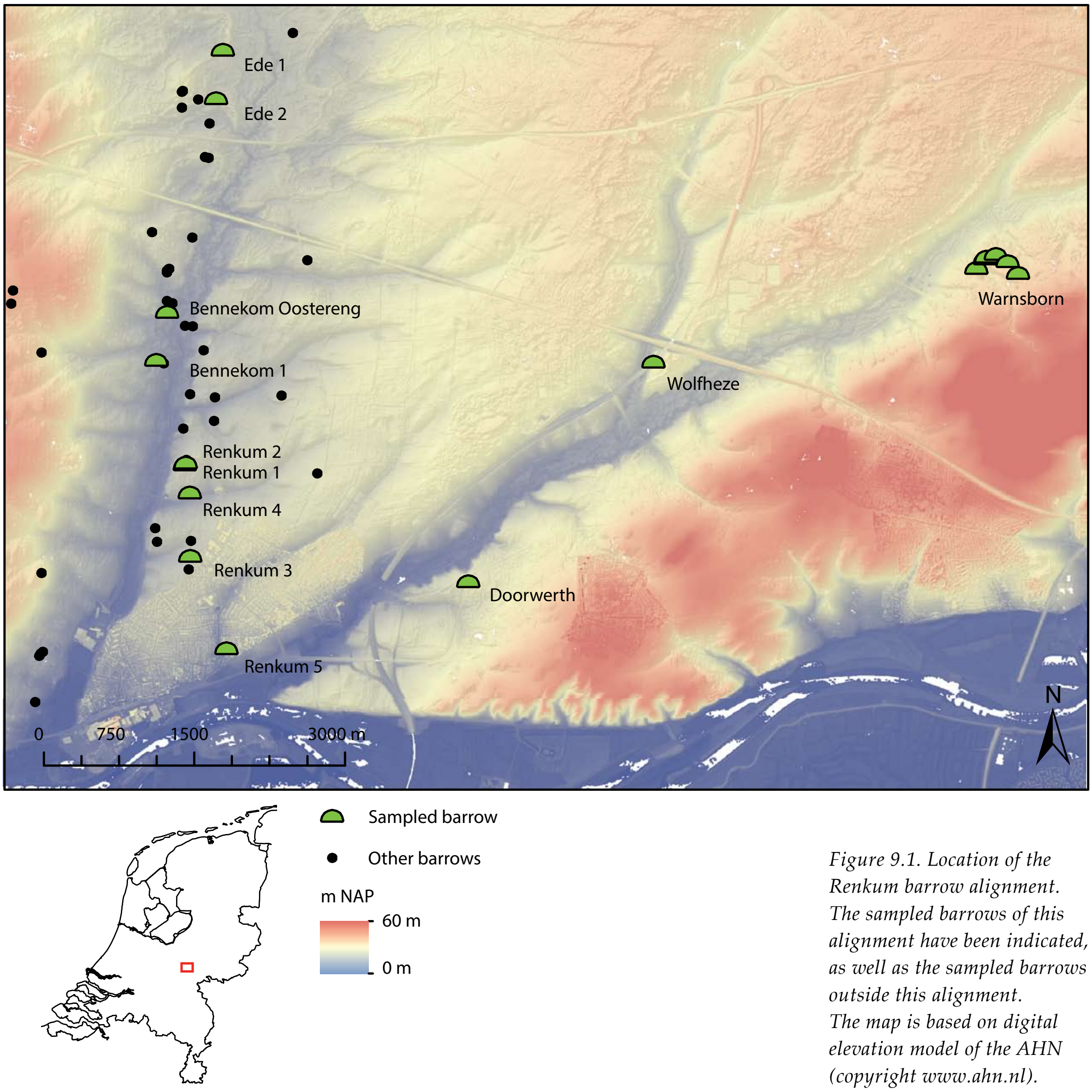


Figure 9.1. Location of the Renkum barrow alignment. The sampled barrows of this alignment have been indicated, as well as the sampled barrows outside this alignment. The map is based on digital elevation model of the AHN (copyright www.ahn.nl).

Renkum 4: A single-period barrow that has been excavated in 1929 by Bellen. Lanting and van der Waals have re-excavated the barrow in 1972 and at that time samples from the old surface were taken for pollen analysis (Lanting and van der Waals 1972b, Casparie and Groenman-van Waateringe 1980, 29). The barrow was dated to the late Neolithic A based on the find of a PF Beaker. A ^{14}C-date of charcoal derived from sods, 2866-2472 cal BC (4065 ± 55 BP, GrN-6712C, calibrated with Oxcal 4.2), can be used as a *terminus post quem* date. The barrow was 15 m in diameter and 1.0 m high.

Renkum 5: A two-period barrow that was excavated in 1958 by van Giffen. A Veluvian Bell Beaker was found dating the barrow to the Late Neolithic B period. Measurements of the barrow are unknown. A sample for pollen analysis was taken from the old surface (Casparie and Groenman-van Waateringe 1980, 36).

Ede 1: A single-period barrow in which a Veluvian Bell Beaker was found and twelve amber beads during its excavation in 1927 by Bellen. The barrow was dated to the late Neolithic B. The barrow measured 11 m in diameter and approximately

0.70 m in height. The mound was re-excavated by Lanting and van der Waals (1971a). At that time samples were taken for pollen analysis from the old surface (Casparie and Groenman-van Waateringe 1980, 36).

Ede 2: A barrow that was originally excavated by Bellen in 1927 and re-excavated by Lanting and van der Waals (1976). The barrow was dated to the late Neolithic B based on the find of a Maritime Bell Beaker and a ^{14}C-date of 2890-2580 cal BC (4155 ± 60 BP, GrN-6688C, calibrated with Oxcal 4.2) as a *terminus post quem* date for the grave. The diameter of the barrow was approximately 12 m and the height approximately 0.60 m. Two samples were taken from the old surface, which were analysed for pollen (Casparie and Groenman-van Waateringe 1980, 34).

Bennekom 1: A multi-period barrow of which the first period most probably dates to the late Neolithic B. Measurements of the barrow's size after the fourth period have been determined to have been approximately 23 m in diameter and 1.70 m in height. Samples for pollen analysis were taken from the old surface of period 1-5, from a sod of period 1 and from the ditch belonging to period 4 (van Giffen 1954).

Bennekom Oostereng: A three-period barrow that was excavated in 1929 by Bursch. The primary mound contained a Veluvian Bell Beaker, a wrist guard and several flint artefacts, dating the barrow to the Late Neolithic B period. Samples for pollen analysis were taken during re-excavation in 1972 by Lanting and van der Waals (1972a). Samples that were analysed originated from the old surface and a sod of period I, the old surface of the second period and the old surface of period III (Casparie and Groenman-van Waateringe 1980, 35).

Burial mounds outside the barrow alignment

Warnsborn (Warnsborn 1-6): Six barrows that were situated near Arnhem were excavated in 1947 and 1948 by Glasbergen and Waterbolk (Waterbolk 1954, 95-99; Glazema 1951). Barrow 1 was dated to the Late Neolithic A period, based on the find of a PF Beaker, a flint axe and a flint blade. Barrow 2 could not be dated, but Waterbolk mentions that this barrow was similar in structure to barrow 1 and possibly also originated from the Late Neolithic A period. Both barrows were small and the old surface was barely recognisable. Barrows 3-6 were all dated to the Early Bronze Age, based on burial typology. This dating, however, is questionable, given that secure dating is not possible based on burial typology. The barrows were built of recognisable sods on a Carbic Podzol (Dutch classification: Humuspodzol). Samples for pollen analysis were taken from the old surface of Barrows 1-4. Barrow 5, which was a two-period barrow, was sampled at the old surface and two sods (one sod from each period). From Barrow 6, a three-period barrow, samples were taken from the old surface of all three periods. All samples were analysed and published by Waterbolk (1954, 95-99). In 1972 Lanting and van der Waals re-excavated barrow 1. Charcoal from the primary grave was ^{14}C dated 3822-2290 cal BC (4435 ± 320 BP, GrN-318, calibrated with Oxcal 4.2). Samples for pollen analysis were taken by W. Groenman-van Waateringe from the old surface and from a Bronze Age interment (Casparie and Groenman-van Waateringe 1980, 24).

Doorwerth: A two- or possibly a multi-period barrow excavated by Hulst in 1972 (Hulst *et al.* 1973). Grave-goods of the first period included an AOO Beaker, dating the mound to the late Neolithic B period. Samples for pollen analysis were taken from the old surface and from a sod from the primary mound (Casparie and Groenman-van Waateringe 1980, 31).

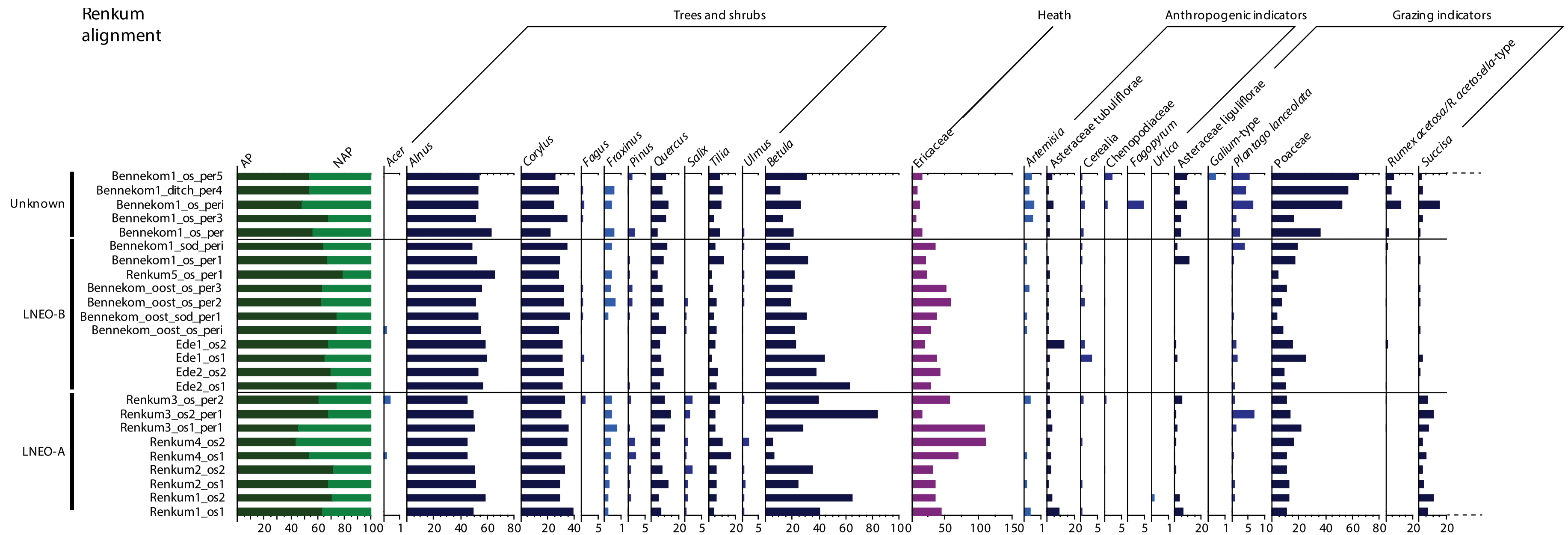
Wolfheze: A two-period barrow at Wolfheze. The barrow was excavated in 1971 by Hulst (Hulst 1971). The first period of the mound was dated to the Bronze Age based on the find of a Drakenstein urn. Samples for pollen analysis were taken from the old surface and a sod of period 1, the old surface of period 2 and the old surface of the secondary mound (Casparie and Groenman-van Waateringe 1980, 37).

9.2 Results and discussion

The analysed barrows belonging to the alignment are all from late Neolithic origin and they all indicate being surrounded by a rather similar vegetation pattern. All barrows were built in an open space with heath and grasses. For the Neolithic A period the ratio AP versus NAP is different between barrows (see figure 9.2 and 9.3), indicating a difference in size of the open space the barrows were built in. Arboreal percentages fluctuate from around 45% to around 75% suggesting very small open spaces of approximately 30 m in diameter to larger open spaces with a diameter of approximately 250 m. A barrow also dating to the late Neolithic A period that is situated approximately 6 km to the east of the alignment (Warnsborn 1) shows an arboreal pollen percentage in the spectrum derived by Casparie and Groenman-van Waateringe of approximately 75%. This high percentage suggests a very small open space of approximately 30 m in diameter. The spectra of barrow 1 and 2 obtained by Waterbolk (Warnsborn 1 and Warnsborn 2) show even higher numbers of AP, but Waterbolk (1954, 98) mentions that herbal pollen from these barrows were not investigated with enough care. The AP might have been lower. As expected, the composition of the forest in the surroundings is similar for all barrows. *Alnus* pollen, probably coming from an alder carr in the wetter parts of the area, dominates the arboreal pollen spectra with 45-50%. The drier forest consists mainly of *Corylus* (30%), *Quercus* (10%) and *Tilia* (5%). *Betula* was present in fluctuating amounts, indicating that solitary *Betula* trees were probably present in the heathland area. Barrow 1 of Warnsborn (Warnsborn 1) shows a slightly lower percentage of *Alnus*. This could indicate that the barrows belonging to the alignment were situated closer to an alder carr than the Warnsborn barrow. The open space this barrow was built in differs also from the alignment barrows while grasses are the dominating herbs instead of Ericaceae.

In the next phase (late Neolithic B period) the vegetation composition seems not to have changed in the alignment. Apparently the forest composition remained unaltered and the open spaces the barrows were built in consisted of mainly heath and grasses. The size of the open spaces seems in general to be smaller than during the preceding period with an ADF of approximately 25-50 m. The late Neolithic B barrow of Doorwerth, situated east of the barrow alignment shows a similar vegetation composition as Warnsborn 1 with low percentages of Ericaceae.

The vegetation development in the following periods is hard to reconstruct. Barrows belonging to the Bronze Age period were not investigated in the alignment. The Bronze Age barrows at Warnsborn (Warnsborn 3-6) show an expansion of heath at cost of mainly Poaceae compared to the Late Neolithic A period of Warnsborn 1. The BA barrows of Warnsborn show a similar vegetation composition as the Neolithic barrows in the barrow alignment discussed above. Secondary and tertiary periods (undated) of the Warnsborn mounds show a slight decrease in AP and a slight increase in Ericaceae pollen. A two-period barrow that is situated approximately 3 km to the east of the alignment (Wolfheze) was dated to the Bronze Age period as well (the primary mound). This barrow also shows a similar pollen spectrum. The secondary mound has not been dated. The pollen spectrum of this period suggests a slight decrease of forest cover and an



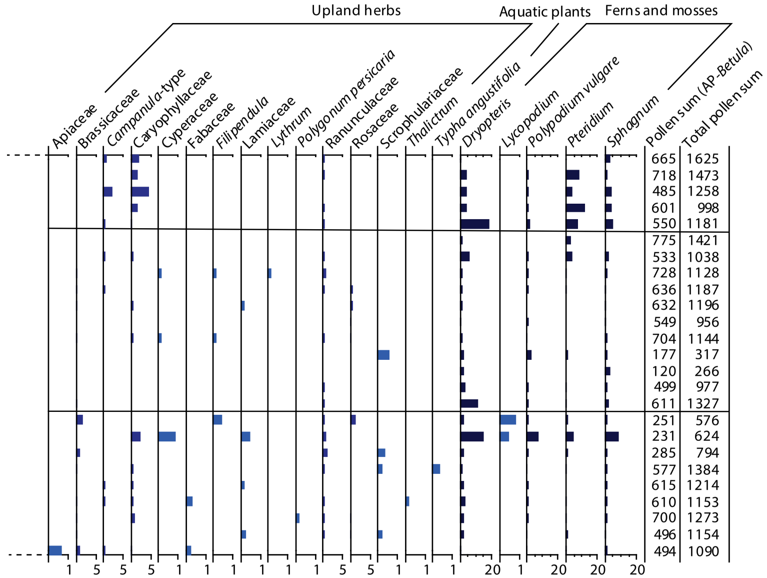


Figure 9.2. Pollen spectra from the samples taken from the barrows of the Renkum alignment. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

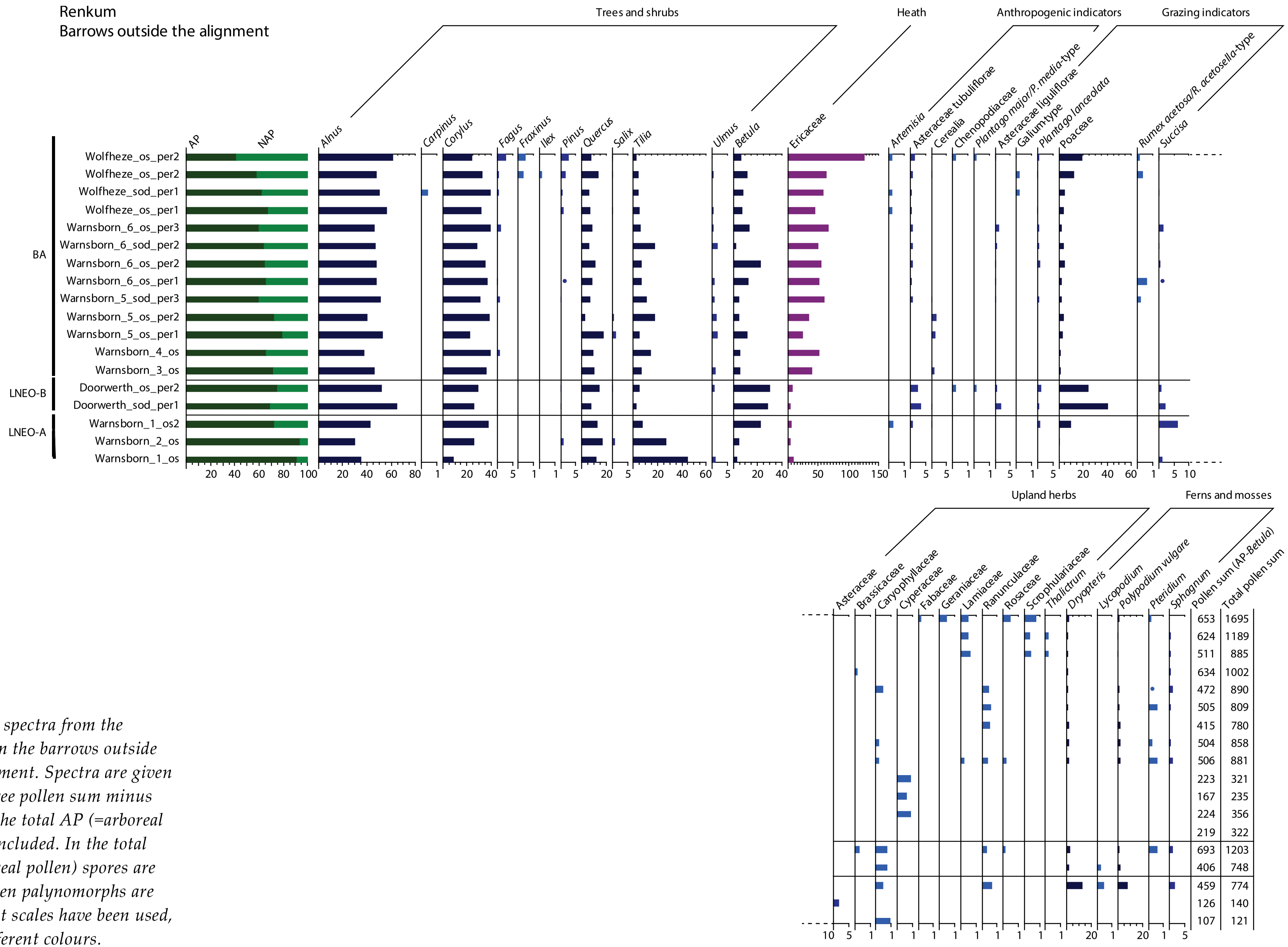


Figure 9.3. Pollen spectra from the samples taken from the barrows outside the Renkum alignment. Spectra are given in % based on a tree pollen sum minus Betula pollen. In the total AP (=arboreal pollen) Betula is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.

expansion of heath. Another multi-period barrow in the alignment (Bennekom 1) of which the first period was dated to the late Neolithic B, shows in the fourth period (which was not dated) a similar decrease of arboreal pollen. In this case it is not the heath that increases, but the grasses and other grazing indicators (*e.g. Rumex*, Asteraceae liguliflorae). While this indicates a change in grazing regime, the development cannot be placed in time.

Most of the barrows discussed above are part of a long alignment of many barrows. In Chapter 8 it was shown that it is likely that all barrows of a barrow alignment were built in heath vegetation. The Renkum alignment confirms this conclusion. Nine out of about 20 barrows of this alignment (Bourgeois 2013, 71-74) were analysed for pollen and the results have shown they were all built in heath vegetation as well. In addition, all barrows that do not form part of an alignment, both in the area of Renkum as well as the barrows discussed in the previous chapter, were built in open spaces that were covered with heath vegetation. This leads to the conclusion that all other barrows of the Renkum alignment were built in similar heathland open spaces with an ADF up to 250 m. The barrows of the Renkum alignment were built quite close together with distances varying between 1030 m to 500 m (Bourgeois 2013, 74) and it is likely that the open spaces were connected to each other. If this holds true, there would have been a long and narrow stretched area of heath vegetation with a length of at least 4.5 km. This type of landscape existed for hundreds or perhaps thousands of years (spanning the period the barrows were built) and during this long period the heath must have been maintained by human interference, in spite of the pollen spectra under discussion, which have not all been dated properly. As has been explained in section 8.1.4, management is likely to have taken place by grazing, sod cutting and/or burning. Based on the pollen spectra, grazing seems probable, as indicated by the presence of Poaceae, *Plantago lanceolata* and *Succisa* in the barrows belonging to the alignment (Hjelle 1999). Assuming an area of 4.5 km long (Bourgeois 2013), with a width of approximately 60 m (≈27 ha), a live-stock herd of 27 sheep and/or 4-5 head of cattle is indicated (see section 8.1.4). Indicators of heath burning have not been recorded. Sod cutting is indicated at

Table 9.1. The minimum size of the open space per barrow based on the sods used to build the barrows.

	Diameter (m)	Height (m)	Sod thick-ness (m)	Diameter 4th period (m)	Height 4th period (m)	Sod area (m2)	Radius (m)	Sod area 4th period (m2)	Radius (m)
Renkum 1	9	0.8	0.25			102.86	5.72		
Renkum 2	unknown								
Renkum 3	15	1.8	0.25			648.39	14.37		
Renkum 4	15	1	0.25			355.52	10.64		
Renkum 5	unknown								
Ede 1	11	0.7	0.25			133.76	6.53		
Ede 2	12	0.6	0.25			136.17	6.58		
Bennekom 1			0.25	23	1.7			1422.91	21.28
Bennekom Oostereng	unknown								
Warnsborn 1	unknown								
Warnsborn 2	unknown								
Warnsborn 3	unknown								
Warnsborn 4	unknown								
Warnsborn 5	unknown								
Warnsborn 6	unknown								
Doorwerth	unknown								
Wolfheze	unknown								

least for the purpose of barrow building. Based on the measurement of the barrows, 100-1500 m^2 areas were stripped by sod taking to build these barrows (see table 9.1). The method aside, management of such vast heath areas must have involved a long lasting special interest of prehistoric man at least for the period the barrows were built. What about the period prior to the barrow building? Heathland was already present when the oldest mounds were constructed. Heathland vegetation with *Calluna vulgaris* and other herbs had developed, indicating that the area must have been open for some time before. It is not clear when and how this open area had been created, neither what it had been used for until the barrows were built. Traces of a settlement have not been found close to the barrow sites and there are no indications that crop cultivation had taken place prior to the barrow building. The activity of man is required however, to manage the heath and it is likely that grazing took place before the mounds were constructed. As has been discussed for the Echoput and surroundings in Chapter 8, this area too was most likely part of the economic zone of a farming community, keeping the area open before, and after, the barrows became part of the landscape.

To recapitulate, in addition to Chapter 8, in this chapter another example of a barrow alignment has been shown that was built in heath vegetation, possibly forming a long stretched heathland area that already was in place in the Late Neolithic A period, an area where grazing might have been important for the maintenance of the heath.

Chapter 10

Gooi

The previous two chapters have shown many examples of barrows, including several barrow alignments, on the push moraine complexes of the Veluwe that were all built in heath vegetation. In the following chapter another three groups of barrows (and one solitary barrow) will be discussed. These barrows are situated in a region in the centre of the Netherlands called Het Gooi (see figure 10.1). These barrows were also built on a push moraine complex. A more regional vegetation development covering most of the Holocene could be reconstructed based on a recently investigated sequence of podzols that was discovered in a nature reserve area, called the Laarder Wasmeren area (Sevink *et al.* in press). This area is situated very close to one of the barrow groups (Hilversum, see figure 10.1).

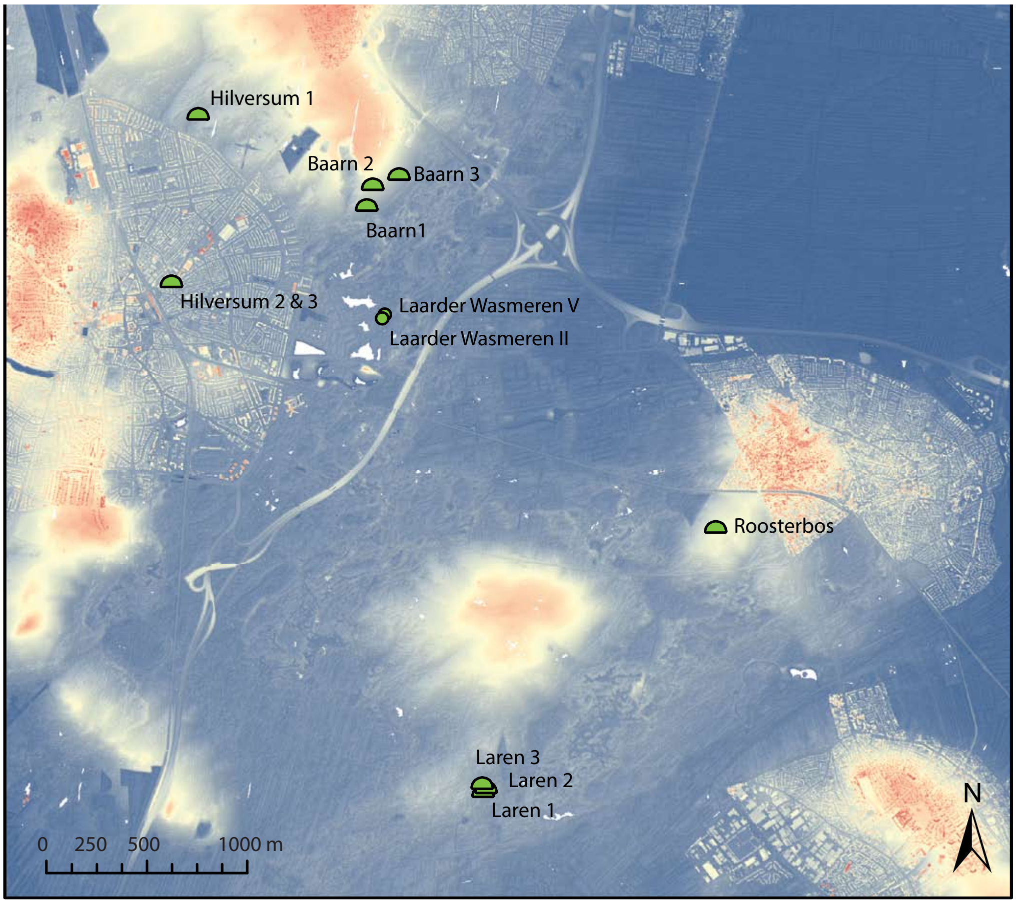
10.1 Site description and sample locations

Baarn Group

Close to the Lage Vuursche, a small village in the municipality of Baarn, 6 barrows are situated of which three have been sampled and analysed for pollen (Baarn 1-3). The results of these analyses have been published by Casparie and Groenman-van Waateringe (1980, 30-31, 36). Baarn 1-3 were originally excavated in 1927 by van Giffen (van Giffen 1930) and re-excavated and sampled for pollen in 1965 by Addink-Samplonius and Glasbergen. Two barrows (Baarn 1 and 2) are single-period barrows that were dated to the Late Neolithic A period. From Baarn 1 two samples were taken from the old surface. From Baarn 2 one sample from the old surface and two sod samples were taken. The third (Baarn 3) barrow is according to Casparie and Groenman-van Waateringe a two-period barrow, although this could not be confirmed by excavation data. This barrow could not be dated since no grave goods were found. Samples were taken from the old surfaces of each period, a sod and a later interment.

Hilversum Group

The second group of barrows is situated in Hilversum. The barrows have been excavated in 1934 by Bursch (Bursch 1935). Samples for pollen analysis have been taken from the old surface and sods of three single-period barrows (Hilversum 1-3) during a re-excavation that has taken place in 1965 by van Giffen and Bakker (Bakker and van Giffen 1965). Pollen spectra have been published in 1980 by Casparie and Groenman-van Waateringe (1980, 31-32, 37). Hilversum 1 was dated to the Late Neolithic B period based on the find of a copper tanged dagger. Hilversum 2 was dated to the Late Neolithic A or B period based on the type of burial (northeast-southwest orientated crouched inhumation burial; pers. comm. Bourgeois). It should be noted that according to Casparie and Groenman-van Waateringe (1980, 37) this barrow was dated to the Bronze Age, which is now known to be incorrect. The third barrow (Hilversum 3) was dated to the Bronze Age, based on a ^{14}C-date of 1609-1436 cal BC (3240 ± 35 BP, GrN-4885, calibrated with Oxcal 4.2). Measurements of the barrow could not be reconstructed.



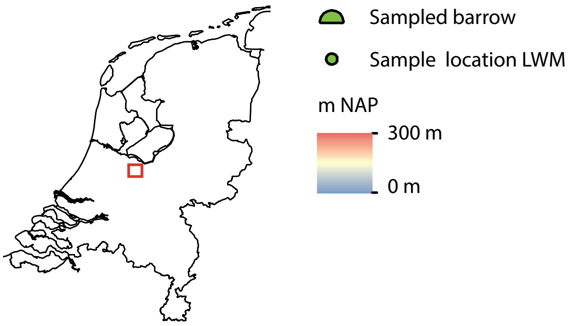


Figure 10.1. Locations of the barrows in the Gooi area that were sampled for pollen analysis and the location of the Laarder Wasmeren. The map is based on digital elevation model of the AHN (copyright www.ahn.nl).

Laren Group

The third group consists of 10 barrows and is located near Laren. Three of these barrows (Laren 1-3) were sampled and analysed for pollen (Casparie and Groenman-van Waateringe 1980, 30, 31, 34). The barrows were originally excavated in 1925/1926 by Remouchamps (1928). The oldest barrow (Laren 1) is a two-period barrow of which the first period was dated to the Late Neolithic A period based on the find of PF Beaker and a *terminus post quem* ^{14}C date of 3139-2890 cal BC (4385 ± 75 BP, GrN-6683C, calibrated with Oxcal 4.2). During re-excavation by Lanting and van der Waals in 1971 pollen samples were taken from the old surface and sods belonging to the first period and from the old surface beneath the secondary mound. Laren 2 is also a two-period barrow. The old surface and a sod belonging to the first period were dated to the Late Neolithic B period (based on a copper tanged dagger), and were sampled for pollen analysis in 1958 (Lanting and van der Waals 1976). The third barrow (Laren 3) is represented by a pollen spectrum from the old surface underneath the mound. This is a single-period barrow that was dated to the Late Neolithic B period (based on V-perforated amber buttons). Sampling took place in 1958 by Bakker and Casparie (Lanting and van der Waals 1976).

Roosterbos

Approximately 4 km to the northeast of the Lage Vuursche barrows a single-period barrow is situated in a forest called the Roosterbos. This barrow was excavated in 1926 by van Giffen. A PF Beaker and a flint scraper were found dating this barrow to the Late Neolithic A period. The barrow was re-excavated in 1970 for the collection of palynological samples only. Samples were taken from the old surface and from a sod. The pollen spectrum of one old surface sample (other samples were too poor in pollen for pollen analysis) was published by Casparie and Groenman-van Waateringe (1980, 30).

The Laarder Wasmeren area

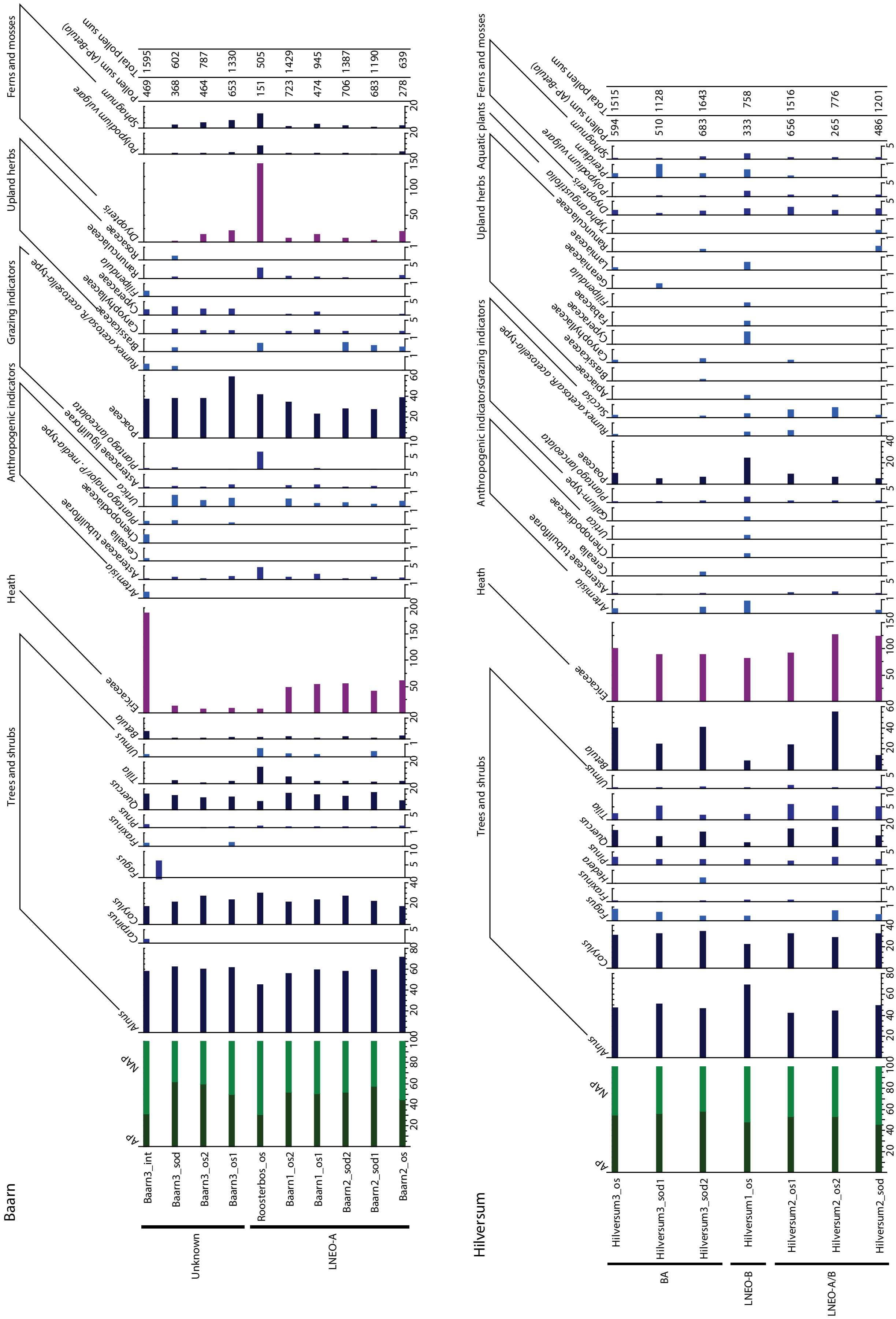
In the same region in which the above described barrows were situated, very close to the barrows of Laren, a nature reserve called the Laarder Wasmeren is situated. The soil in this area shows three or four podzols on top of each other developed in layers of drift sand, which were discovered and studied by Sevink *et al.* (in press). The Laarder Wasmeren data on soil and sand drifting used in the following are derived from this study. Based on OSL dates (see table 5.1) a reconstruction of soil formation and drift sand phases in time could be made. Profile II consisted of four podzols (S1-S4). S1 has developed in Pleistocene cover sand that was deposited around 11500 years BP. Around 8800-6500 years BP this soil was covered by drift sand. In this sand layer another podzol was formed (S2) until it was also covered by a new layer of drift sand around 6400-5800 years BP. A distinct podzol (S3) could develop in this layer, which was marked by bioturbation in the form of presumed beetle burrows. Around 5300-4800 years BP a third layer of drift sand was deposited on S3. S4 developed in this layer. Profile V consists of three layers; S1 and S2 probably have merged together at this location (Sevink *et al.* in press). Both profiles were sampled for pollen analysis by van Geel (Sevink *et al.* in press). The prepared samples were kindly provided to the author of the present work who (re-)analysed the samples. The results of these analyses are shown in figure 10.3. The theory and discussion of pollen diagrams derived from mineral soils have been extensively described in Chapter 5. The site and methods of sampling have been described more in detail in section 5.2.

10.2 Results and discussion

What now follows is first a reinterpretation of all barrow pollen data, followed by a presentation of pollen data from the Laarder Wasmeren area analysed by the author. Following this, all data is combined with the results of the study by Sevink *et al.* (in press) and discussed.

Gooi area

The barrow pollen spectra (see figure 10.2a-c) represent three periods: the late Neolithic-A period, the late Neolithic-B period and the Bronze Age period. The oldest barrows show an arboreal pollen percentage of 30% (Roosterbos) – 55% (Baarn 1 and 2 and Laren 1). This indicates open spaces with an ADF of approximately 100 m for the barrows of Baarn and Laren (see table 7.1). The barrow of Roosterbos possibly was built in a large open space with an ADF that could reach up to 500 m. However, there seems to be an overrepresentation of



Baarn
Baarn3_int
Baarn3_sod
Baarn3_os2
Baarn3_os1
Roosterbos_os
Baarn1_os2
Baarn1_os1
Baarn2_sod2
Baarn2_sod1
Baarn2_os
Unknown
LNEO-A
Trees and shrubs
Heath
Anthropogenic indicators
Grazing indicators
Upland herbs
Ferns and mosses
AP
NAP
Alnus
Carpinus
Corylus
Fagus
Fraxinus
Pinus
Quercus
Tilia
Ulmus
Betula
Ericaceae
Artemisia
Asteraceae tubuliflorae
Cerealia
Chenopodiaceae
Plantago major/P. media-type
Urtica
Asteraceae liguliflorae
Plantago lanceolata
Poaceae
Rumex acetosa/R. acetosella-type
Brassicaceae
Caryophyllaceae
Cyperaceae
Filipendula
Ranunculaceae
Rosaceae
Dryopteris
Polypodium vulgare
Sphagnum
Pollen sum (AP-Betula)
Total pollen sum
Hilversum
Hilversum3_os
Hilversum3_sod1
Hilversum3_sod2
Hilversum1_os
Hilversum2_os1
Hilversum2_os2
Hilversum2_sod
BA
LNEO-B
LNEO-A/B
Aquatic plants
Hedera
Galium-type
Succisa
Apiaceae
Fabaceae
Geraniaceae
Lamiaceae
Typha angustifolia
Pteridium

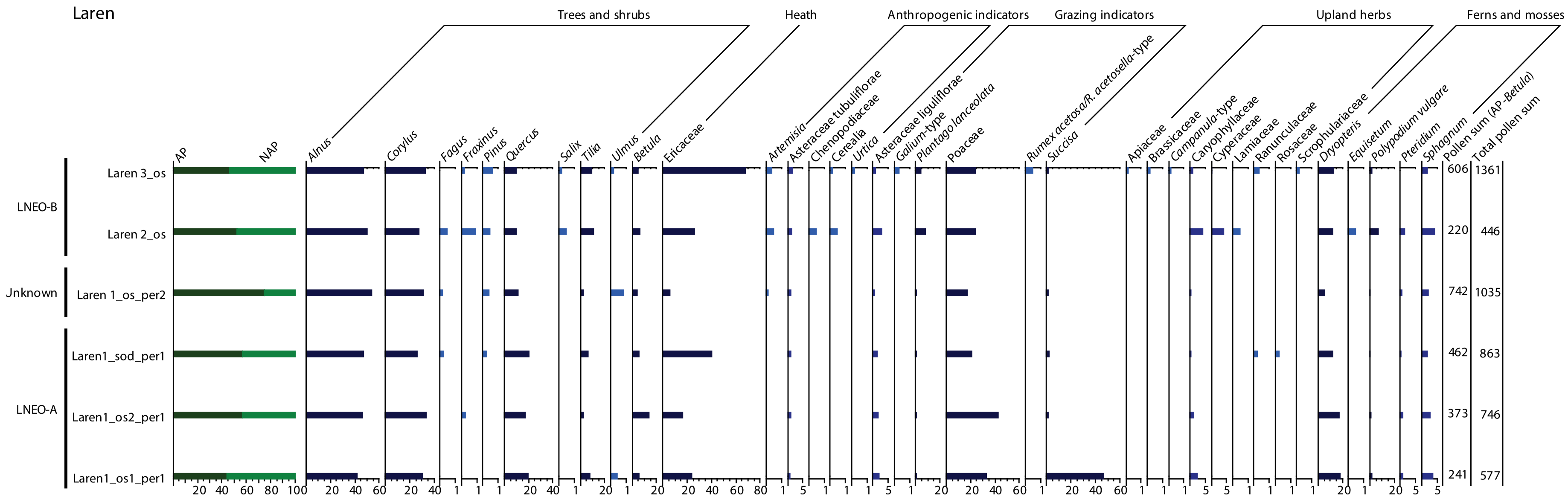


Figure 10.2a-c. Pollen spectra from the samples taken from the barrows in the Gooi area. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

Dryopteris spores, since the percentage is extremely high compared to all other pollen spectra. When *Dryopteris* spores are left out of the pollen sum the arboreal percentage is 57%. This indicates an open spot with an ADF of approximately 100 m, which is comparable to the barrows of Baarn and Laren. In the Neolithic A period the forest consisted of mainly *Corylus* (with a pollen percentage of 20-30%), *Quercus* (pollen percentage = 15-20%) and *Tilia* (pollen percentage = 2-5%), with an alder carr (*Alnus*) nearby. The pollen spectra from Baarn show a higher pollen percentage of *Alnus* (55-70%) than Laren and Roosterbos (45%). It is possible that the Baarn barrows were situated close to an alder carr. The open spaces the barrows were built in were covered with mixed heath-grass vegetation at Laren and Baarn, while grasses and ferns are dominant at Roosterbos. In the following period (late NEO-B) some changes are visible. Two barrows were built in the area of Laren (Laren 2 and 3). The open spots were probably larger than around the older Laren barrows, with an ADF of approximately 100-150 m. Two late Neolithic-B barrows were built in the group of Hilversum (Hilversum 1 and 2) in an open place with an ADF of approximately 100-150 m. The heath vegetation was still a mixture of *Calluna vulgaris* and grasses, their ratio more in favour of *Calluna*. *Betula* trees were probably present as solitary trees in the heathland, indicated by the fluctuating amounts of *Betula* in the pollen spectra from Hilversum (10-60%). The composition of the dry forest was comparable to the late Neolithic A period with mainly *Corylus*, *Quercus* and *Tilia*. Remarkable is the high percentage of *Alnus* in one of the Hilversum barrows (Hilversum 1). Perhaps an alder carr was situated very close to this barrow, which had then retreated when Hilversum 2 was built. This barrow shows similar percentages of *Alnus* as the Bronze Age barrow of Hilversum (Hilversum 3). This barrow was built in an open space with an ADF of approximately 50-100 m in heath vegetation that was dominated by *Calluna vulgaris*. Baarn 3 could not be dated, but it shows in general a similar vegetation pattern as the dated barrows of Baarn. A difference can be noticed in the composition of the herbal vegetation. At the time Baarn 3 was constructed it was dominated by grasses and contained very little *Calluna vulgaris.* Since the barrows of Baarn are located quite close together (about 100 m apart from each other, see figure 10.1b) it can be assumed that they were all built in the same open space covered with heath vegetation. This would indicate that Baarn 3 was not built contemporary with the other two barrows, since the herbal vegetation composition seems to have been fairly different when barrow 3 was built. Another possibility is that the open space Baarn 3 was built in was situated separate from Baarn 1 and 2. In that case nothing can be said about the simultaneity of the barrows. A sample taken from the grave pit of the barrow shows an increase in non arboreal pollen and *Calluna vulgaris*. However, it is not very clear where exactly this sample came from, yet it is difficult to draw any conclusions on this pollen spectrum. It could indicate an expansion of the open space, with an expansion of *Calluna vulgaris*. However, it is also possible that the deceased was buried on top of a layer of heather twigs.

Clearly open spaces with heath vegetation were present in this area since the late Neolithic A period. From this period onwards to the Bronze Age not much changed in vegetation composition. The open spaces varied from approximately 50 to 150 m ADF and consisted mostly of heath and grasses. The surrounding forest was dominated by *Corylus*, *Quercus* and *Tilia* and alder carr(s) were present in the environment. Comparable to the Echoput and surroundings (Chapter 8) and Renkum and surroundings (Chapter 9) this was a landscape that was managed to maintain its heath vegetation. The method of management could not be deduced from the pollen spectra. Some anthropogenic indicators were present, but only

	Diameter (m)	Height (m)	Sod thickness (m)	Sod area (m2)	Radius (m)
Baarn 1	unknown				
Baarn 2	unknown				
Baarn 3	unknown				
Hilversum 1	unknown				
Hilversum 2	unknown				
Hilversum 3	unknown				
Laren 1	unknown				
Laren 2	unknown				
Laren 3	unknown				
Roosterbos	unknown				

Table 10.1. The minimum size of the open space per barrow could not be determined for the barrows of the Gooi case-study, since measurements of the barrows were unknown.

in very low amounts. Grazing could be indicated by the presence of Poaceae and, although in low amounts, *Plantago lanceolata* and *Succisa*.

Laarder Wasmeren area

The pollen diagrams from the Laarder Wasmeren (LWM) area (figure 10.3) show the vegetation development from approximately 8700 BP onwards, long before the first barrows were built in the area. The vegetation development per soil phase, consisting of a phase of deposition and a phase of soil development, can be reconstructed. The soil phases have been plotted continuously after each other. It should be noted however that each soil phase ended with a sand drifting period, probably resulting in a gap in vegetation development between each soil phase.

LWM II – S1 (before 8700 years BP, ca. 6700 cal BC)

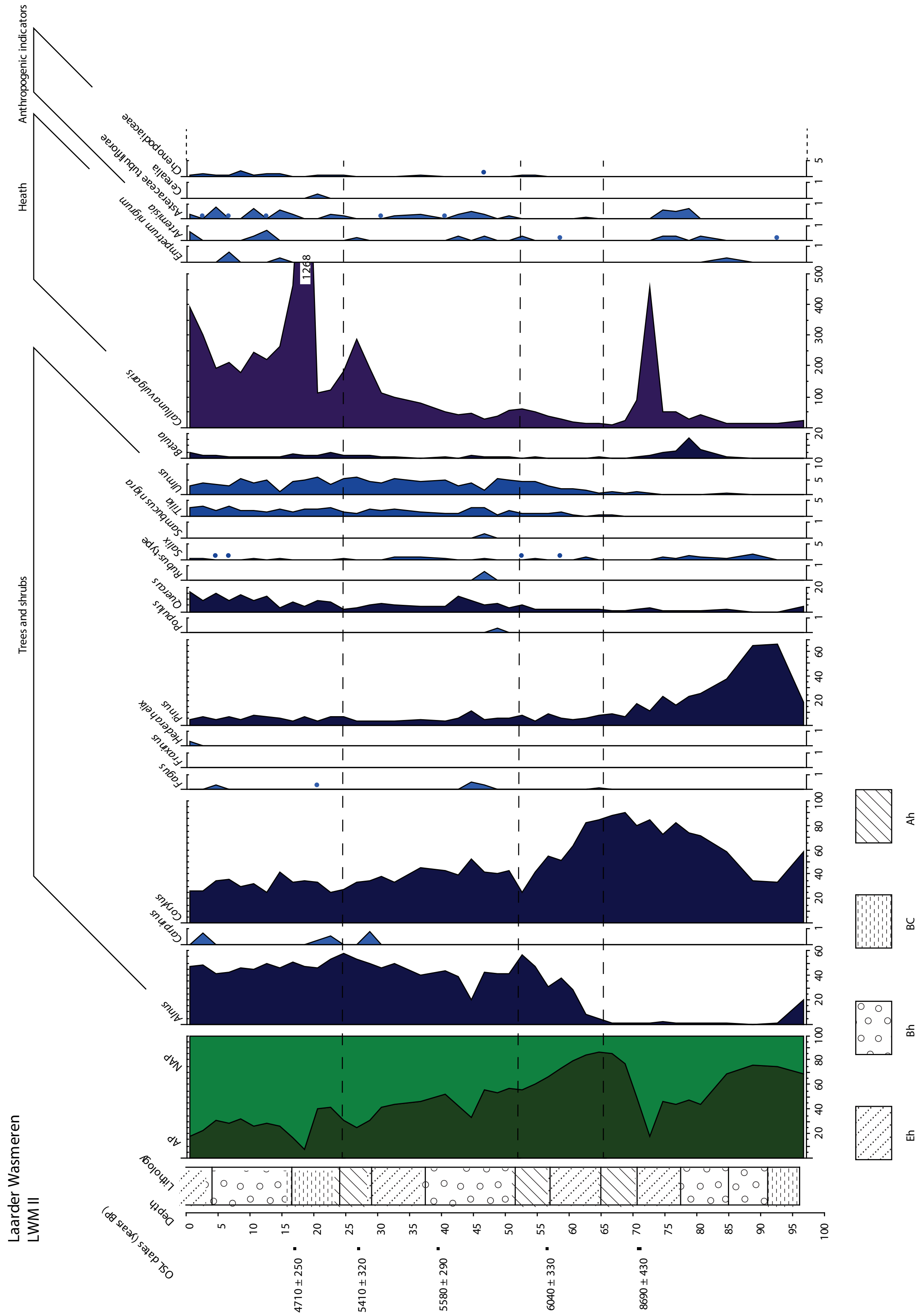
The first phase in profile II shows a period in which *Pinus* was the dominant species. The presence of large amounts of *Botryococcus* and ferns suggest the presence of shallow water at the site. When *Pinus* and *Botryococcus* decreased, *Corylus* increased. More open vegetation developed with first an expansion of Poaceae, followed by an expansion of *Calluna vulgaris*.

LWM II – S2

Arboreal species are dominant in the pollen diagram, with total AP percentages around 80%. An alder carr developed, as shown by the increasing percentages of *Alnus*. A dry forest was present in the surroundings, which consisted mainly of *Quercus*, *Tilia* and *Ulmus*, with *Corylus* at the forest edge. Heath vegetation was present, starting with low amounts (pollen percentages around 10%) and gradually increasing to pollen percentages around 50%. At the end of this phase AP had decreased to approximately 50%.

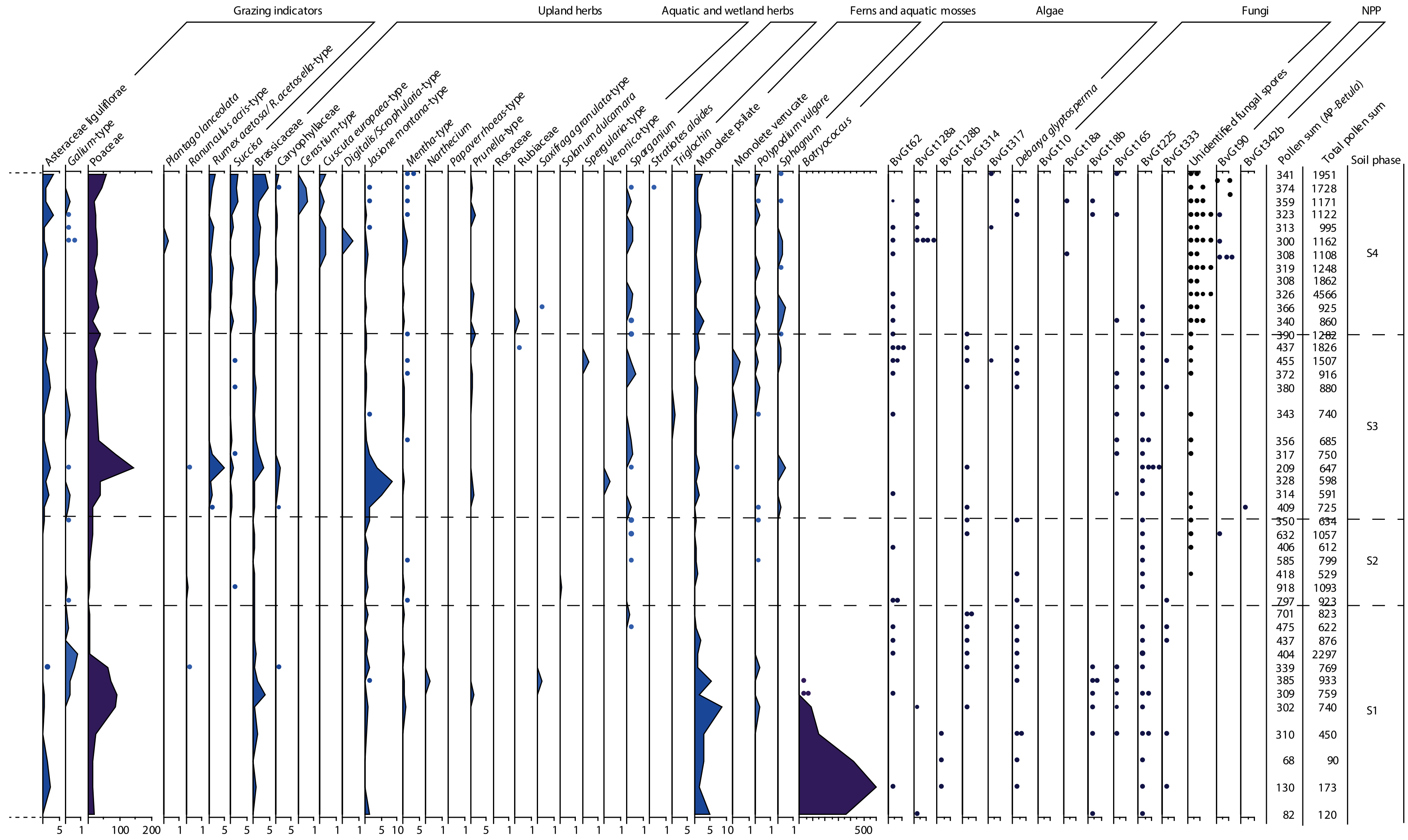
LWM II – S3

AP decreased further until percentages around 40%; the composition of the forest remained unchanged with mainly *Corylus*, *Quercus*, *Tilia* and *Ulmus* in the drier part of the area and alder carr in the wetter surroundings. Heath expanded together with Poaceae. At the end of this phase *Calluna vulgaris* is represented with percentages of more than 100% in the pollen diagram, Poaceae fluctuates around 30%. Other anthropogenic indicators were present in the area, but only in small amounts (pollen percentages <1%). Grazing indicators were present as well, in slightly higher amounts (pollen percentages <5%). This part of the soil



Laarder Wasmeren
LWM II
Anthropogenic indicators
Heath
Trees and shrubs
Chenopodiaceae
Cerealia
Asteraceae tubuliflorae
Artemisia
Empetrum nigrum
Calluna vulgaris
1268
Betula
Ulmus
Tilia
Sambucus nigra
Salix
Rubus-type
Quercus
Populus
Pinus
Hedera helix
Fraxinus
Fagus
Corylus
Carpinus
Alnus
AP
NAP
Lithology
Depth
OSL dates (years BP)
4710 ± 250
5410 ± 320
5580 ± 290
6040 ± 330
8690 ± 430
Ah
BC
Bh
Eh

Figure 10.3a. Pollen diagram from the Laarder Wasmeren area: LWM II. Percentage diagrams are shown, with % based on a tree pollen sum minus Betula. *In the AP (= arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*



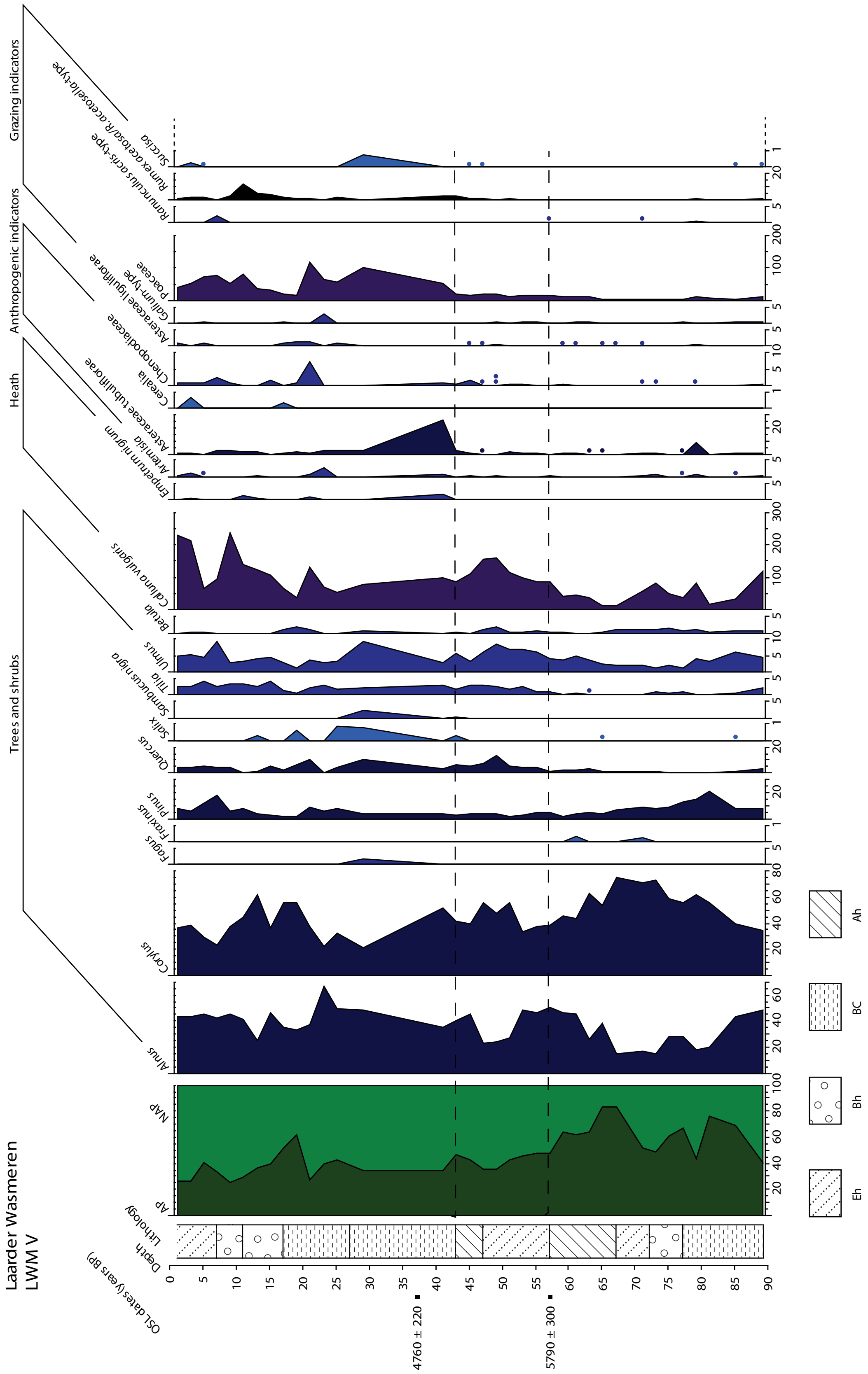
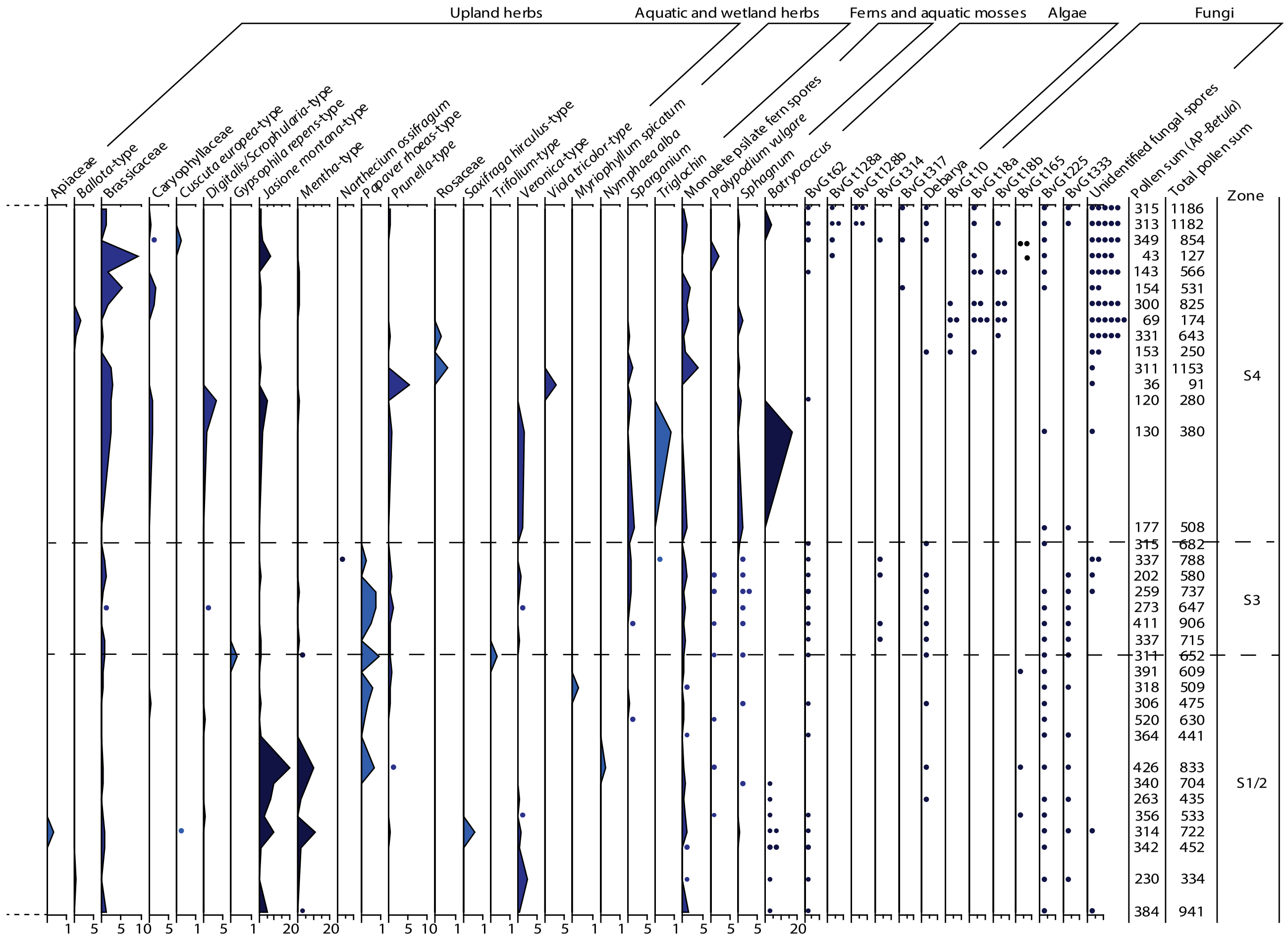

Laarder Wasmeren
LWM V
OSL dates (years BP)
Depth
Lithology
AP
NAP
Alnus
Corylus
Fagus
Fraxinus
Pinus
Quercus
Salix
Sambucus nigra
Tilia
Ulmus
Betula
Calluna vulgaris
Empetrum nigrum
Artemisia
Asteraceae tubuliflorae
Cerealia
Chenopodiaceae
Asteraceae liguliflorae
Galium-type
Poaceae
Ranunculus acris-type
Rumex acetosa/R. acetosella-type
Succisa
Trees and shrubs
Heath
Anthropogenic indicators
Grazing indicators
4760 ± 220
5790 ± 300
Eh
Bh
BC
Ah

Figure 10.3b. Pollen diagram from the Laarder Wasmeren area: LWM V. Percentage diagrams are shown, with % based on a tree pollen sum minus Betula. *In the AP (= arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*



profile showed bioturbation. Consequently this part of the pollen diagram could be showing a mixture of the original vegetation development during this phase. S3 of profile LWM V, however, shows similar vegetation development and in this profile bioturbation was not recorded.

LWM II – S4

This phase started 5400 years BP and during it barrows were built in the Netherlands, including in the surroundings of the Laarder Wasmeren (see above). In this phase an open landscape existed with non arboreal pollen percentages of approximately 70%. Heath expanded further with pollen percentages around 200-300% and even a peak of over 1000%. The forest in the surroundings consisted mainly of *Corylus*, *Quercus, Ulmus* and *Tilia*, with alder carr in the wetter areas, as also shown by the barrow pollen spectra. The levels of anthropogenic and grazing indicators had increased slightly.

LWM V

In profile V the soil phases S1 and S2 probably have merged together. The oldest period, with a dominant *Pinus* presence, appears to be missing in this diagram. Alder carr in the surrounding area had already developed, as well as the deciduous forest with *Corylus*, *Quercus*, *Tilia* and *Ulmus*. The heathland is represented by pollen of *Calluna vulgaris* with percentages fluctuating around 50%. The soil phases S3 and S4 show, as expected, similar vegetation development as LWM II.

The (pre)barrow landscape of the Gooi

The pollen diagrams of the Laarder Wasmeren show a 'normal' Holocene forest development as has been described in section 2.1, starting with high percentages of *Pinus*, which decreased at the beginning of the Holocene. When *Pinus* decreased *Corylus* expanded and a deciduous forest developed with mainly *Quercus*, *Tilia* and *Ulmus* (see Chapter 2). Striking is the relatively open landscape with relatively high percentages of *Calluna vulgaris* already before the first sand drift phase around 6500-8800 years BP (4500-6800 cal BC), since the landscape in the Netherlands was assumed not to have been opened up before the Late Neolithic period (see also section 2.3.1).

The previous chapters have mentioned the presence of considerable heathland areas in the Late Neolithic, since the first barrows were built. This investigation places the occurrence of heath much earlier, to the Mesolithic (Boreal). In addition, periods of sand drifting as early as 8800-6500, 6400-5800 and 5300-4800 years BP (based on OSL, Sevink *et al.* in press; see table 5.1) are remarkable. Sand drifting could only occur when conditions are unstable. Due to unstable conditions vegetation becomes scarce and is not able to stabilize the soil. Under the influence of wind the topsoil is blown away. Periods of sand drifting are generally linked to human activities. For example due to extensive exploitation of the soil for crop cultivation, intensive grazing by cattle or sod cutting activities vegetation disappears, giving wind free play.

The first man-induced sand drifts in the Netherlands are known to have occurred since the Early Middle Ages (Castel *et al.* 1989, Riksen *et al.* 2006), but perhaps prehistoric man was inducing sand drifts long before then. This has also been suggested by Willemse and Groenewoudt (2012), who recorded prehistoric sand drifts along Dutch river valleys. They concluded that these sand drifts were mainly anthropogenic in the area north of the LWM area (the Wester- and Bussumerheide) some Mesolithic artefacts and flint fragments have been found, indicating the use of the area by prehistoric man. For the Early and Middle Neolithic no archaeological finds have been reported (Wimmers *et al.* 1993) and also in the LWM area itself no Meso- or Neolithic archaeological artefacts were found (Sevink *et al.* in press). The third sand drifting period (5300-4800 years BP) occurred around the time the first barrows were built a few hundred metres from the LWM area. Prehistoric man's activities probably intensified, indicated by the slightly increased percentages of anthropogenic indicators. It cannot be determined whether the recorded human activities could induce sand drifting. The pollen diagrams and barrow pollen spectra only show few anthropogenic indicators and there are no indications that the area was used for crop cultivation. Therefore, it is not likely that the area was intensively used. However, given the constant presence of *Calluna vulgaris*, the maintenance of the heath by humans is indicated. This might have been accomplished by grazing, burning or sod cutting, as has been explained in Chapter 8. Grazing is slightly indicated in the LWM pollen diagrams and the barrow pollen spectra and it is not unlikely that the heath area was grazed. Perhaps overexploitation of the heathland was the cause of the sand drifting. However, Jungerius and Riksen state that these agricultural activities alone were probably not sufficient to cause large scale sand drifts (Jungerius and Riksen 2010). They emphasize the role that climate played. A dramatic shift in climate could bring with it adverse conditions for vegetation establishment and maintenance, such as in the case of drought. However, in general the Holocene climate was relatively stable and fluctuations in temperature and precipitation were probably not sufficient to destroy the vegetation cover (Jungerius and Riksen 2010). Therefore, it is not likely that severe climate change was the cause of the sand drifts in the LWM area. Jungerius and Riksen (2010) stress that climatic events such as violent storms were of great importance for the origin of sand drifts. However, this theory is purely hypothetical (Sevink *et al.* in press). At this moment the origin of the sand drifts in the LWM area, anthropogenic or natural or a combination of both, cannot be determined, although anthropogenic seems the most plausible explanation (in accordance with Sevink *et al.* in press).

In the preceding chapters it has been shown that from the Late Neolithic period onwards, barrows, including long alignments of barrows, were built in heath vegetation that must have been kept and maintained by human activities. In general it is assumed that before the Neolithic vegetation was dominated by forest, with man adjusting their way of life to the landscape. In this chapter it has been shown that the landscape was already open long before the first barrows were built, and that *Calluna vulgaris* was the prevalent species in the investigated area. This implies a landscape that was managed. The study in this chapter has also shown that very early periods of sand drifting have occurred in this area of which the cause may have been anthropogenic. Possibly overexploitation of the landscape resulted in sand drifting. If Late Neolithic barrow landscape management in itself was already a remarkable conclusion, it is even more surprising that heath management probably took place long before. This topic will be returned to in Chapter 13.

Chapter 11

Toterfout-Halve Mijl and surroundings

In Chapters 8-10 a number of barrows in three research areas in the northern half of the Netherlands have been discussed. In the following two chapters the discussion on the barrows landscape will be continued by investigating several barrows that are situated in two regions in the southern half of the Netherlands.

Chapter 11 is on the barrows of Toterfout-Halve Mijl and numerous other barrows situated in an area of about 30 by 20 km (see figure 11.1). A large number of these mounds have been visited by several researchers performing palynological analyses (for references see the corresponding sections). In this chapter the palynological data will be described and discussed to determine the barrow landscape in the area.

11.1 Toterfout-Halve Mijl

In an area southwest of Eindhoven, close to the two villages of Toterfout and Halve Mijl, 34 barrows are situated on high cover-sand ridges along a large lake (the now-drained Postelse Weijer, which still existed up to the 19th century, Glasbergen 1954, 17; see figure 11.1 and 11.2). These barrows were excavated and all dated to the Bronze Age (Bourgeois 2013, 91-92). More than half of the barrows in this area have been sampled and analysed for pollen analysis by Waterbolk (Glasbergen 1954, 105-122; Waterbolk 1954, 101-104).

11.1.1 Site description and sample locations

The barrows of Toterfout-Halve Mijl are situated on cover-sand ridges. The old surface underneath all barrows was the top of a Carbic Podzol (Dutch classification: Humuspodzol). Samples were taken by Waterbolk from the old surface underneath the barrows, the sods the mound was constructed of and from the fill of surrounding ditches. Besides determining the surrounding landscape, the barrows were sampled with the purpose of dating them (Glasbergen 1954, 28). The relative chronology based on the palynological results was for a great deal rejected by radiocarbon dates[13] and the surrounding features. Following the well substantiated chronology proposed by Bourgeois (2013, 93-96), three groups can be distinguished based on ^{14}C-dating. The first group represents the oldest barrows. In contrary to several barrows that form part of barrow alignments, described in chapters 8 and 9, these barrows are extensively dispersed (Bourgeois 2013, 102). Based on ^{14}C dates these barrows (14, 4 and 1B) were built roughly between 1850 and 1600 cal BC. The second group represents the youngest barrows (8, 17, 15, 12), which were built between 1500 and 1250 cal BC. The third group consists of 9 barrows that were dated in between the first two groups. However, overlap with both occurs. Then

13 Theunissen suggested a relative chronological order based upon radiocarbon dates (Theunissen 1993). These radiocarbon dates have been further calibrated by Bourgeois (2013) based on the detailed dating program developed by Lanting and van der Plicht (2001/2002).

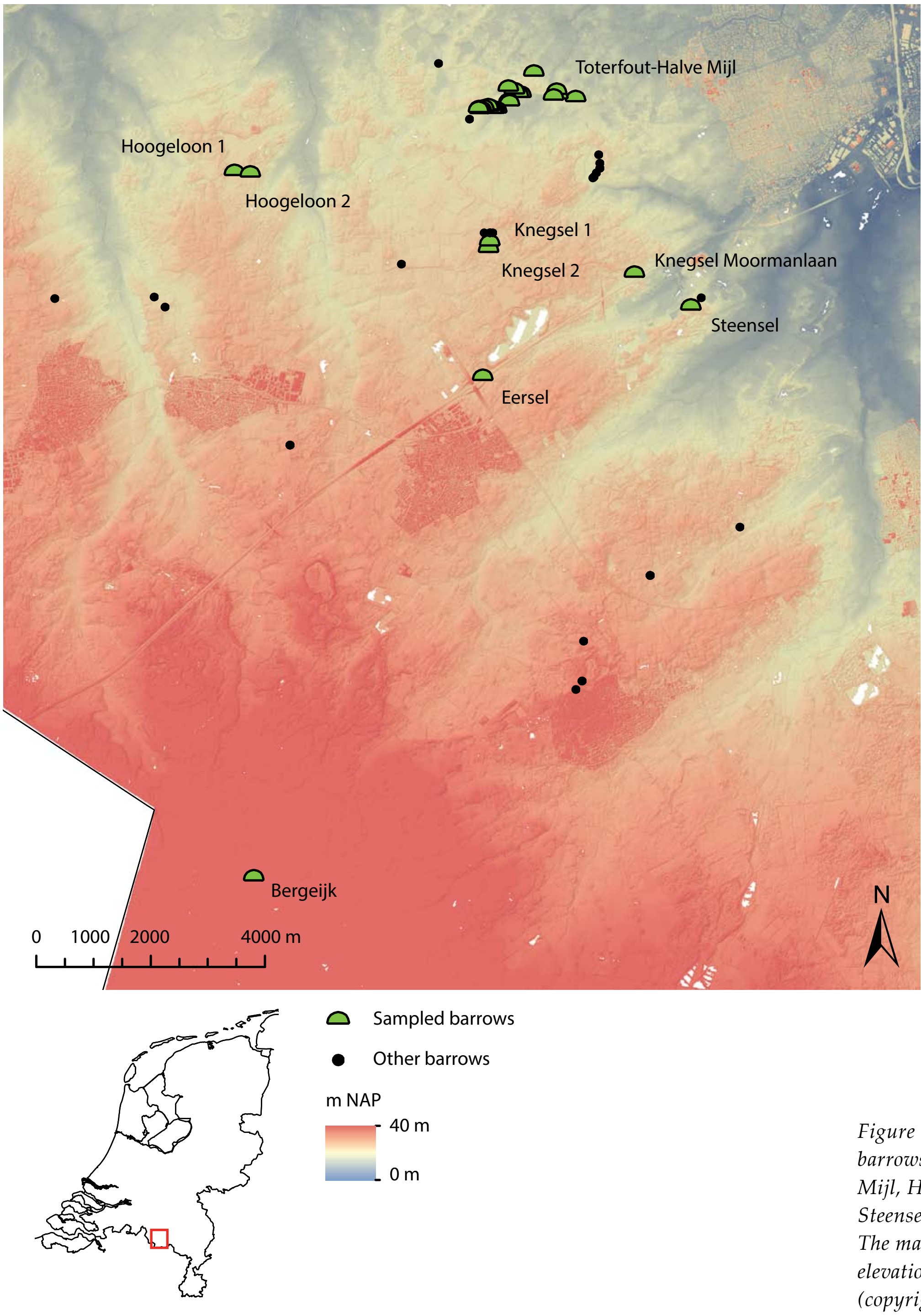
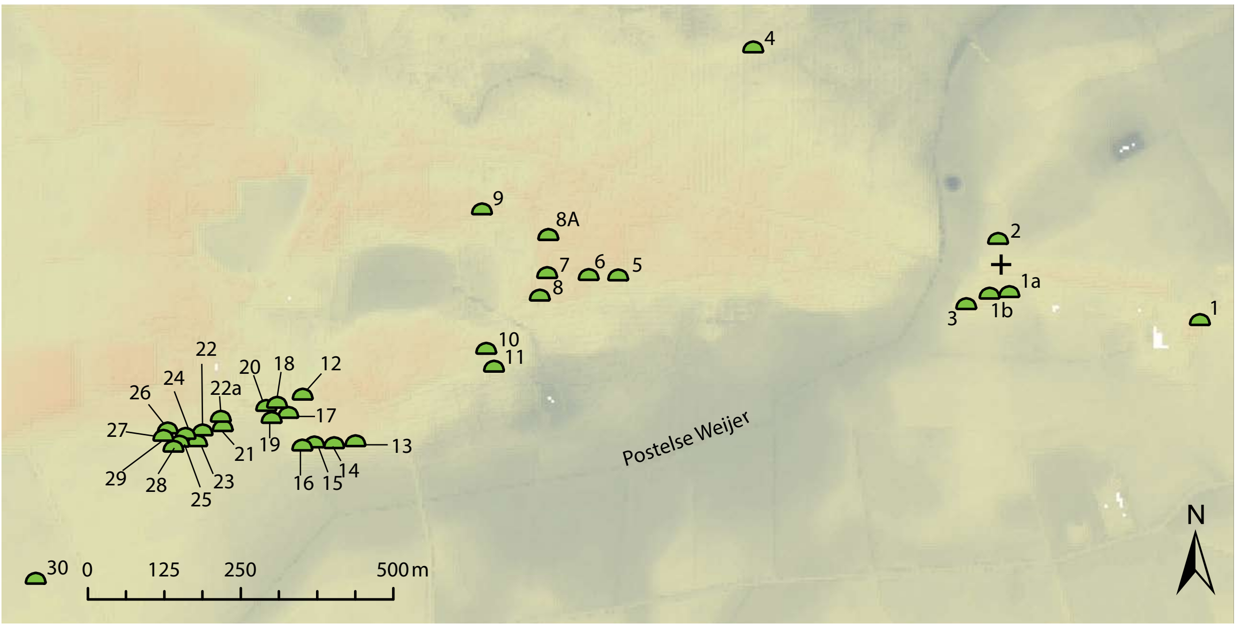


Figure 11.1. Location of the barrows at Toterfout-Halve Mijl, Hoogeloon, Knegsel, Steensel, Eersel and Bergeijk. The map is based on digital elevation model of the AHN (copyright www.ahn.nl).

there are 18 barrows that have not been dated by ^{14}C. They have been dated based upon the surrounding features resulting in a broad spectrum of dates. Some of these barrows may belong to the group of the oldest barrows, while others might be relatively young. Not included in the barrow group of Toterfout Halve Mijl by Bourgeois, but situated in this area and sampled for pollen analysis (Glasbergen 1954, 95-97), is an urnfield. The pollen spectrum of this sample is considered to represent the youngest period (approximately 800-500 cal BC). An overview of barrows that have been sampled and the location of the samples in the barrows (*e.g.* the old surface, sod and ring ditch) is given in table 11.1. The barrows are placed



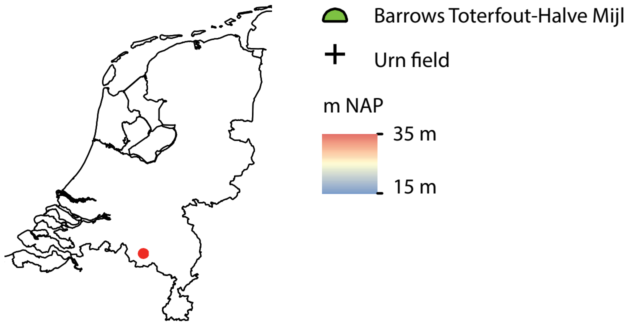


Figure 11.2. Locations of the barrows belonging to the Toterfout-Halve Mijl group in detail. The map is based on digital elevation model of the AHN (copyright www.ahn.nl).

in chronological order as determined by Bourgeois. Based on their geographical location the barrows can roughly be divided into three groups (see figure 11.1c). An easterly group consists of barrows 1-3 (including 1A and 1B), a central group of barrow 5-11 (including 8A) and a western group of barrow 12-30 (including 22A). All barrows have been extensively described by Glasbergen and Waterbolk (Glasbergen 1954), some findings should be noted. Glasbergen mentions that two barrows (12 and 18) were built on and of former arable soil:

> *"No podsolized surface was found under it (barrow 12) anywhere; like tumulus 18 to be described hereafter it was apparently situated on a plot of prehistoric arable. No plough markings were found in the subsoil."*

> *"The barrow (18) was not built on a naturally podsolized subsoil but as a stratum of made soil, of a dirty grey colour (thickness 0.10-0.14 cm), probably old arable. (Glasbergen 1954, 62, 72)."*

It is however uncertain that such disturbed soil indeed can be interpreted as old arable, since no plough marks are present. The second finding to be noticed is the traces of fences that have been found underneath three barrows (14, 20 and 21).

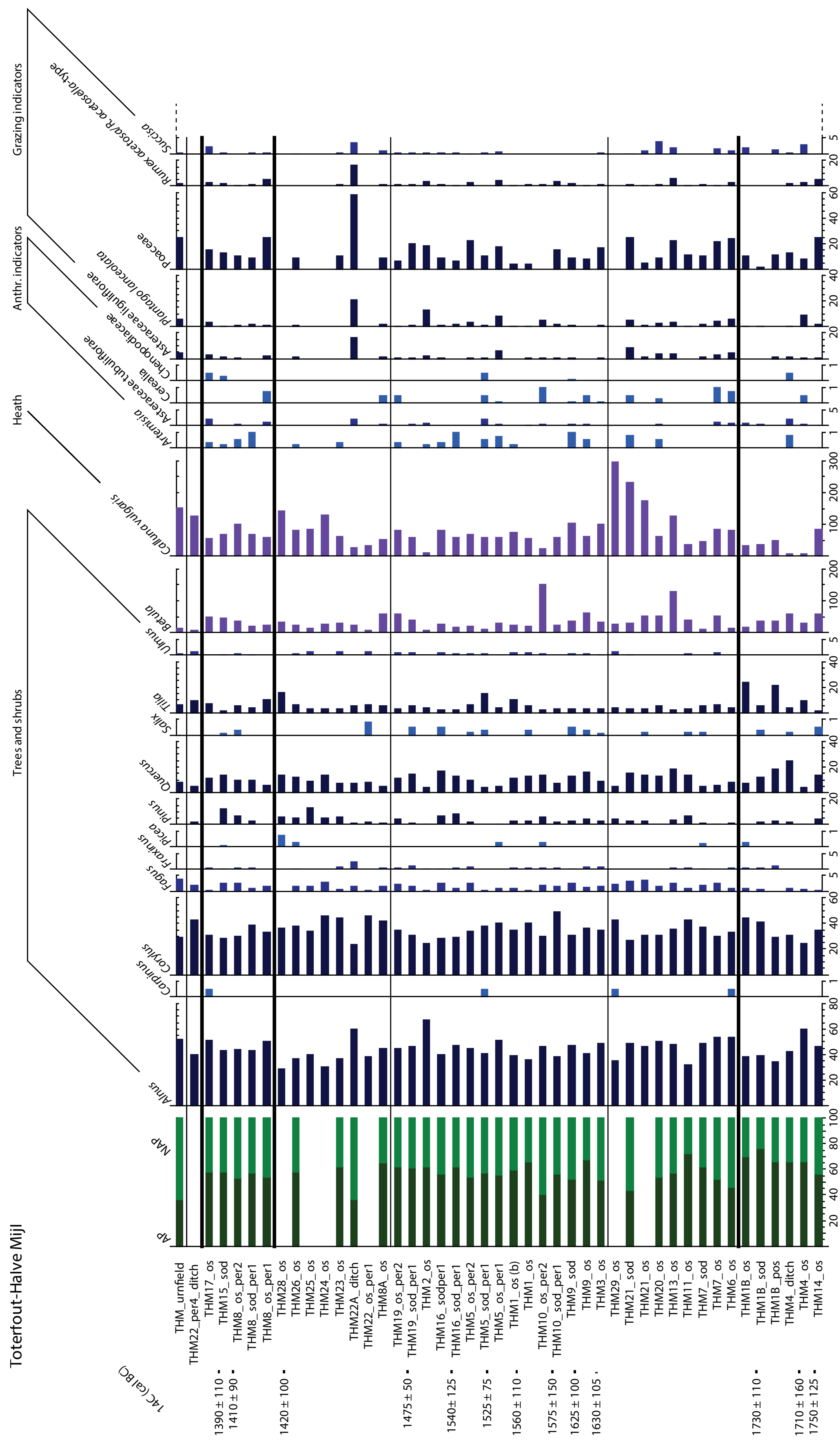

Toterfout-Halve Mijl
Trees and shrubs
Heath
Anthr. indicators
Grazing indicators
AP
NAP
Alnus
Carpinus
Corylus
Fagus
Fraxinus
Picea
Pinus
Quercus
Salix
Tilia
Ulmus
Betula
Calluna vulgaris
Artemisia
Asteraceae tubuliflorae
Cerealia
Chenopodiaceae
Asteraceae liguliflorae
Plantago lanceolata
Poaceae
Rumex acetosa/R. acetosella-type
Succisa
14C (cal BC)
THM_urnfield
THM22_per4_ditch
THM17_os
THM15_sod
THM8_os_per2
THM8_sod_per1
THM8_os_per1
THM28_os
THM26_os
THM25_os
THM24_os
THM23_os
THM22A_ditch
THM22_os_per1
THM8A_os
THM19_os_per2
THM19_sod_per1
THM2_os
THM16_sodper1
THM16_sod_per1
THM5_os_per2
THM5_sod_per1
THM5_os_per1
THM1_os (b)
THM1_os
THM10_os_per2
THM10_sod_per1
THM9_sod
THM9_os
THM3_os
THM29_os
THM21_sod
THM21_os
THM20_os
THM13_os
THM11_os
THM7_sod
THM7_os
THM6_os
THM18_os
THM18_sod
THM18_pos
THM4_ditch
THM4_os
THM14_os
1390 ± 110
1410 ± 90
1420 ± 100
1475 ± 50
1540± 125
1525 ± 75
1560 ± 110
1575 ± 150
1625 ± 100
1630 ± 105
1730 ± 110
1710 ± 160
1750 ± 125

Figure 11.3a

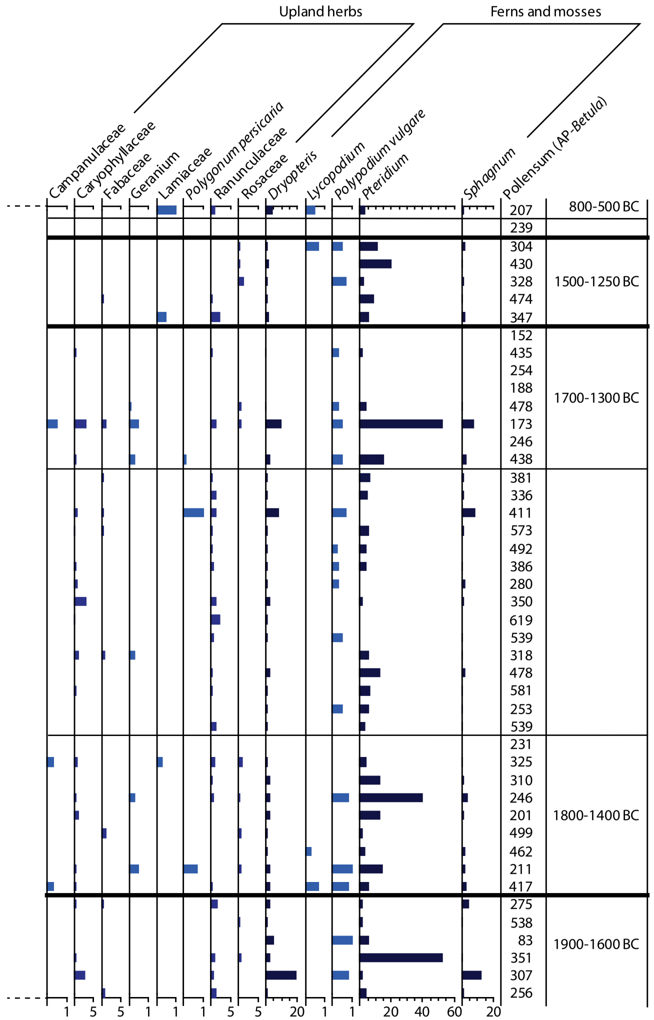
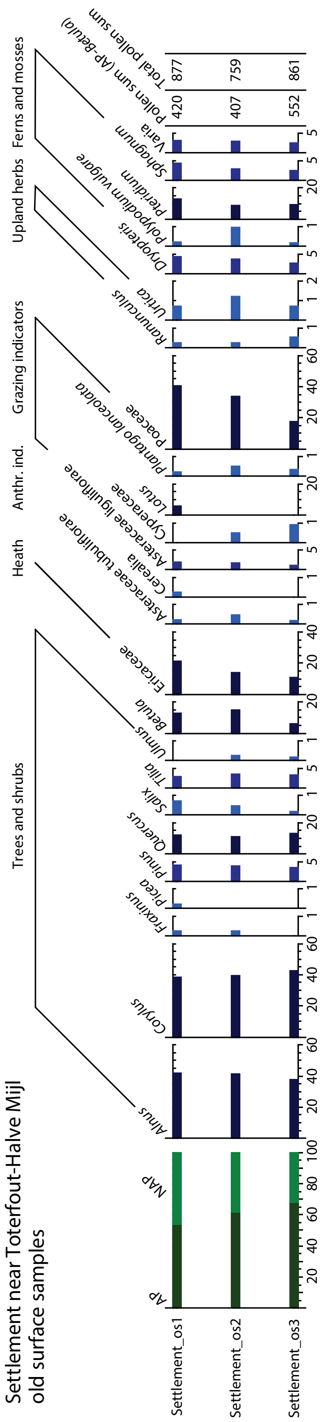


Figure 11.3a

Figure 11.3a-b. Pollen spectra from the samples taken from the Toterfout-Halve Mijk barrows (11.3a) and the Neolithic settlement (11.3b). Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*



Settlement near Toterfout-Halve Mijl
old surface samples
Trees and shrubs
Heath
Anthr. ind.
Grazing indicators
Upland herbs
Ferns and mosses
Settlement_os1
Settlement_os2
Settlement_os3
AP
NAP
Alnus
Corylus
Fraxinus
Picea
Pinus
Quercus
Salix
Tilia
Ulmus
Betula
Ericaceae
Asteraceae tubuliflorae
Cerealia
Asteraceae liguliflorae
Cyperaceae
Lotus
Plantago lanceolata
Poaceae
Ranunculus
Urtica
Dryopteris
Polypodium vulgare
Pteridium
Sphagnum
Varia
Pollen sum (AP-Betula)
Total pollen sum
420
877
407
759
552
861

Figure 11.3b

Sitename		Sample location
Toterfout Tumulus 14		old surface
Toterfout Tumulus 4		old surface, ditch
Toterfout Tumulus 1b		old surface, sod, present podsolized surface
Toterfout Tumulus 6		old surface
Toterfout Tumulus 7		old surface, sod
Toterfout Tumulus 11		old surface
Toterfout Tumulus 13		old surface
Toterfout Tumulus 20		old surface
Toterfout Tumulus 21		old surface, sod
Toterfout Tumulus 29		old surface
Toterfout Tumulus 3		old surface
Toterfout Tumulus 9		old surface, sod
Toterfout Tumulus 10	period 1	sod
	period 2	old surface
Toterfout Tumulus 1		old surface 2x
Toterfout Tumulus 5	period 1	old surface
	period 2	sod
Toterfout Tumulus 16	period 1	sod
	period 2	sod
Toterfout Tumulus 2		ditch
Toterfout Tumulus 19	period 1	sod
	period 2	old surface
Toterfout Tumulus 8A		old surface
Toterfout Tumulus 22	period 1	old surface
	period 4	ditch
Toterfout Tumulus 22A		ditch
Toterfout Tumulus 23		old surface
Toterfout Tumulus 24		old surface
Toterfout Tumulus 25		old surface
Toterfout Tumulus 26		old surface
Toterfout Tumulus 28		old surface
Toterfout Tumulus 8	period 1	old surface
	period 2	old surface
Toterfout Tumulus 17		old surface
Toterfout Tumulus 15		old surface

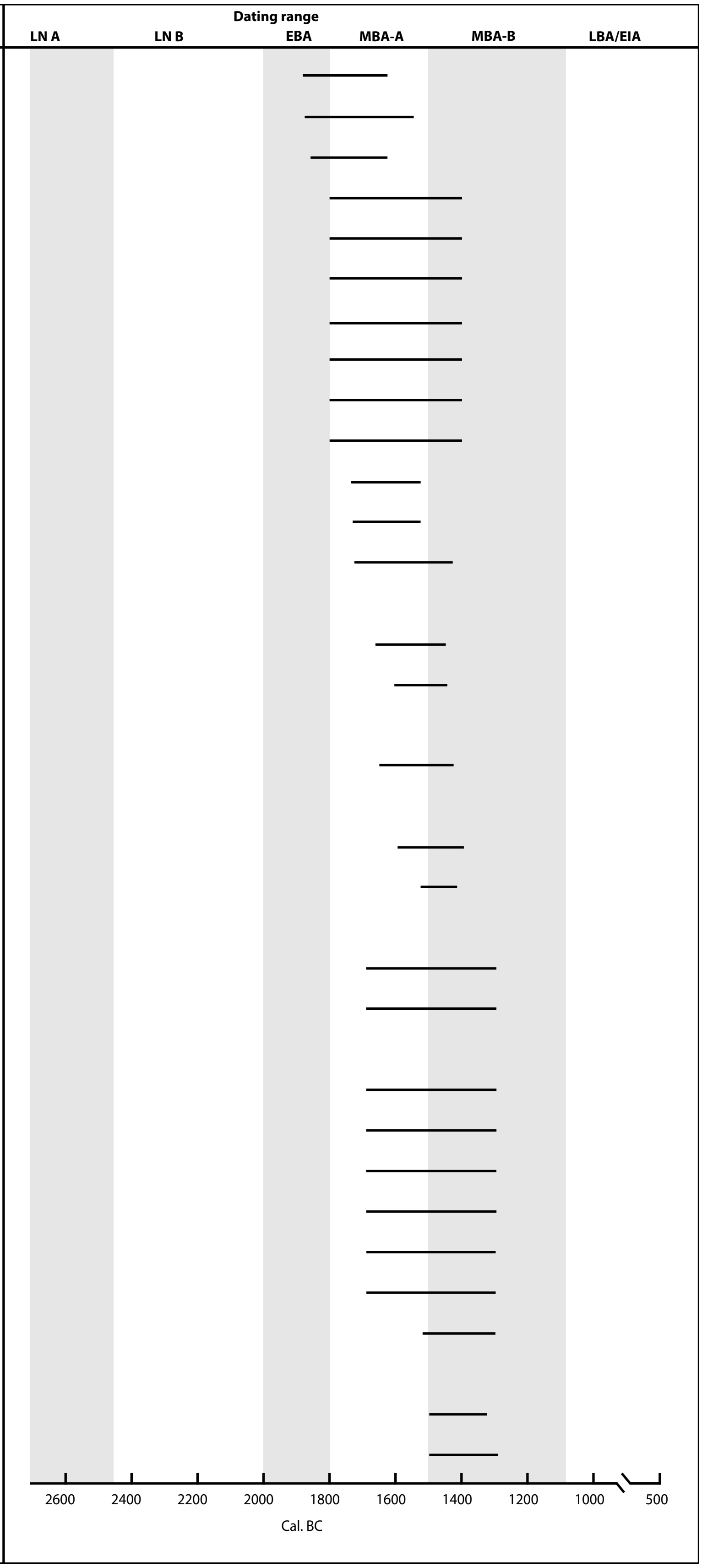


Table 11.1. Overview of samples taken at the Toterfout-Halve Mijl barrows. Dating ranges for each barrow have been indicated. Figure after Bourgeois (2013, table 5.5).

11.1.2 Results and discussion

Figure 11.3a shows the pollen spectra of the sampled mounds in the relative chronological order proposed by Bourgeois.

The oldest group shows the highest arboreal percentages from 55% to almost 80%. The open spaces these barrows were built in had an ADF that varied from 25 to 100 m. The herbal vegetation at these open spots consisted mainly of *Calluna vulgaris* and grasses. An exception is barrow 4, which is actually not part of one of the (geographical) barrow groups, but situated approximately 300 m north of the central group. Here the vegetation in the open space is a mixture of some *Calluna*, grasses and ferns. The youngest barrows show an AP of approximately 55%, so the open spaces seem to be slightly larger in this period (ADF=50-100 m), indicating an expansion of the heath in the area. The sample of the urnfield shows that the heath at the location of one of the oldest barrows (1B) indeed expanded (AP=35%) with a *Calluna* percentage of more than 100%. Not many changes in landscape seem to have occurred in the period in between. The barrows that were roughly dated to this period show a similar vegetation pattern. Only tumulus 4 shows a different vegetation composition of the open space with a low percentage of heath. This barrow might have been constructed at the edge of the open space where the heath was grassier. This pollen spectrum was derived from a ditch sample and the spectrum shows a remarkable high percentage of *Pteridium* (bracken) spores. This is also the case for another ditch sample of Toterfout-Halve Mijl (barrow 22A). Possibly *Pteridium* was one of the first species to grow on the barrow after it was built. The ferns might already have shed spores before the ditches of barrow 4 and 22A were filled up. Close to the barrows alder carr must have been present, represented in the pollen spectra by high percentages of *Alnus*. Surrounding forest consisted of mainly *Corylus*, *Quercus*, *Tilia* and *Fagus*. *Betula* is present in all the pollen spectra in fluctuating percentages. Probably birch trees were present in the surrounding forest. In addition they were probably also present in the heathland area close to some of the barrows, causing percentages of over 100% in for example the pollen spectrum of barrow 13.

Open spaces fluctuated between approximately 25 m and 250 m in ADF. Barrows 1A, 1B, 2 and 3 were built very close together. So were barrows 5–8, 10 and 11. They were most likely built in one open place with heath vegetation. Barrow 13-16, 17-20 and 21-29 were also built close together and perhaps these three groups were built in one large area with heath vegetation. It is not unlikely that all barrows in the Toterfout-Halve Mijl group (except for barrow 4) were constructed in one and the same heathland: in a long stretched open space with a minimum length of approximately 1.5 km. Whether one large heath area or several smaller heath areas, the heath must have been managed throughout the barrow building period, as has been discussed for the more northern areas (Chapter 8-10). Grazing being part of the heath management is likely. This is indicated by the presence of herbal species such as *Plantago lanceolata*, *Succisa* and *Asteraceae liguliflorae*, although only represented in low amounts. No evidence for burning of the heath was found. Charcoal that was found at the site was probably related to funeral activities, since charcoal was mostly found together with bone material (Glasbergen 1954, Theunissen 1993). Sod-cutting could have been a heath-management activity, while sods were cut to build the barrows (see table 11.2). Since the amount of barrows is enormous, and that a large number of them were built in a relatively short time period, sod-cutting must have been a regular activity.

	Diameter (m)	Height (m)	Sod thickness (m)	Sod area (m2)	Radius (m)
THM 1	15/22	1.46	0.25	20018	25.4
THM 1A	10.4	unknown	0.25		
THM 1B	12.2	0.86	0.25	202	8
THM 2	15.8	1.2	0.25	474	12.3
THM 4	16	0.7	0.25	282	9.5
THM 5	110.2	1.15	0.25	191	7.8
THM 7	10.8	0.9	0.25	166	7.2
THM 8	11.2 (after 4th period)	0.86	0.25	170	7.3
THM 8A	7.4	unknown	0.25		
THM 9	7.5	0.8	0.25		
THM 10	9	0.6	0.25	72	4.8
THM 11	7.5	0.66	0.25	59	4.3
THM 13	69.3	0.48	0.25	65	4.6
THM 14	12.4	0.72	0.25	175	7.5
THM 16	9.2 (2nd period)	0.68	0.25	91 (2nd period)	5.4
THM 18	6.2	0.45	0.25	27	3.05
THM 19	7	0.62	0.25	48	3.9
THM 20	8	unknown	0.25		
THM 21	11.3	0.6	0.25	121	6.2
THM 22	8	1.0	0.25	268	9.2
THM 22A	6.2	unknown	0.25		
THM 23	7.4	0.25	0.25	22	2.6
THM 24	6.1	0.25	0.25	15	2.2
THM 25	9	0.3	0.25	38	3.5
THM 26	4.4	0.45	0.25	14	2.1
THM 28	8	0.3	0.25	30	3.1
THM 29	11.5	0.22	0.25	46	3.8

Table 11.2. The minimum size of the open space per barrow based on the sods used to build the barrows.

Not much is known about the open spaces for the period prior to the barrow building. The open spaces were not created just before the mounds were constructed, since the herbal vegetation had already had some time to develop. Some of the barrows (12 and 18) were possibly built on of former arable land, indicating that at least part of the area had been used for crop cultivation prior to the barrow building. Unfortunately samples taken from these barrows were unsuitable for palynological analysis. In some of the barrows some cereal pollen grains and arable weeds like *Rumex* were found, although in such low amounts that it cannot be concluded that they were linked to crop cultivation at or close to the barrow spots. Traces of fences have been found underneath barrow 14, 20 and 21 and could be associated with crop cultivation as well, indicating the boundaries of a field. Pollen analyses of these barrows show that heath vegetation was present at the time the barrows were raised and no crops were cultivated close before the building. Yet, another possibility is that the fences indicate grazing within enclosures. In all cases it is clear that the area was heavily influenced by human activities and the area was most likely part of the economic zone of a farming community. The presence of prehistoric man in the area long before the barrows were built is also indicated by traces of a late Neolithic B settlement that were found approximately 60 m northeast of barrow 5 (Glasbergen 1954, van Beek 1977). A small part of the original soil was preserved. At this location the old surface, which was overblown by sand shortly after abandonment of the settlement (for argumentation see van Beek 1977, 48-49), was still recognizable. The old surface was sampled for pollen analysis by Groenman-van Waateringe. The pollen spectra are likely reflection of the vegetation composition that was present shortly after abandonment of the settlement. These pollen spectra show that heath was already present at that time, although the herbal vegetation was dominated by grasses (see figure 11.3b). Grazing may have already taken place by then. It is not clear whether the presumed arable field and the fence traces underneath some of the barrows, which were found approximately 0.5 km to the southwest, belonged to Neolithic settlement. It is also not clear where the community moved to after abandonment of this settlement. Evidence for a Bronze Age settlement that might belong to the builders of the barrows was not found. Although the function of the area changed from settlement to burial site it stayed part of the economic zone of the community living in the area, while the heath was probably grazed.

11.2 Hoogeloon

Approximately 6 km southwest of the Toterfout-Halve Mijl barrow group two barrows are situated close to Hoogeloon (Hoogeloon 1 and 2; see figure 11.1).

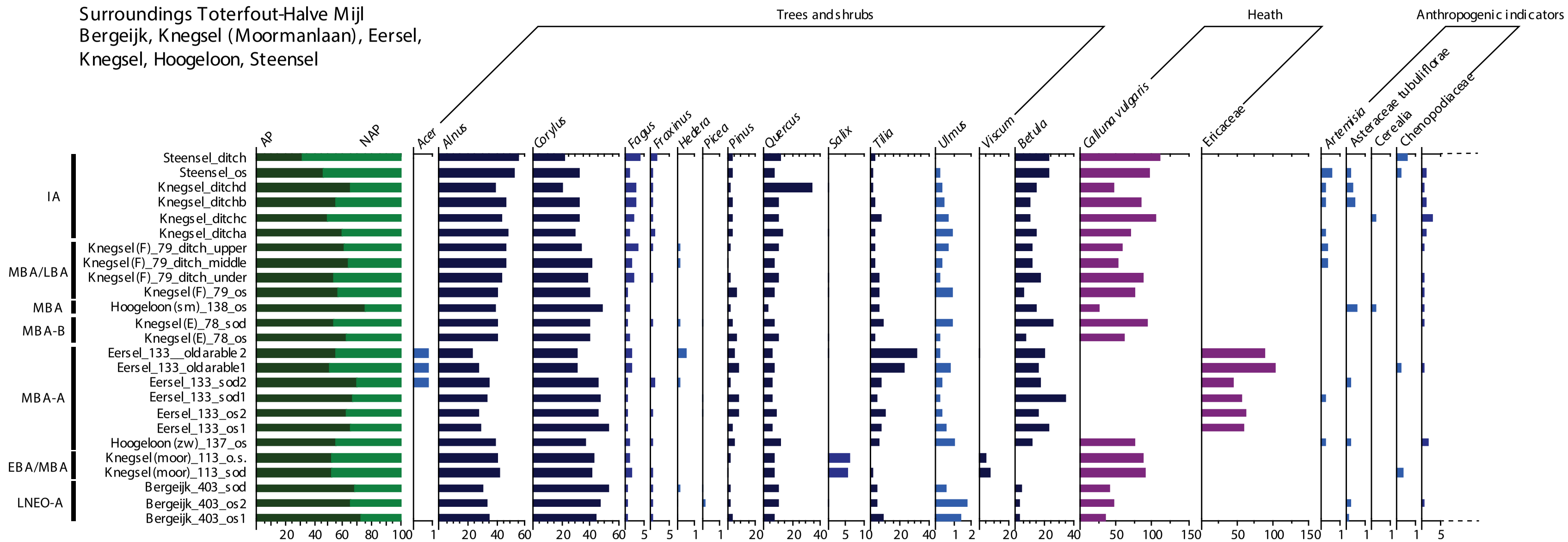
11.2.1 Site description and sample locations

A barrow near Hoogeloon, approximately 4 km from Toterfout-Halve Mijl, called the 'Zwartenberg' (Hoogeloon 1) was excavated in 1950 by Brunsting on behalf of the ROB (presently known as Cultural Heritage Agency of the Netherlands, RCE). The mound was dated to the Middle Bronze Age A, based on the find of a bronze axe in 1846 by Panken. The barrow was constructed of sods that were still clearly visible during the excavation. Measurements were 18 m in diameter and 1.4 m in height (Waterbolk 1954, 108; Beex 1964a). A sample from the old surface was analysed by Waterbolk and published in his thesis (Waterbolk 1954, 103).

Approximately 150-200 m to the west of Hoogeloon 1 a small barrow was located called the 'Smousenberg' (Hoogeloon 2). This barrow was a two-period barrow of which the first period was dated to the Middle Bronze Age. Its diameter was approximately 4 m. The barrow was excavated by Beex and a pollen sample from the old surface was analysed by Waterbolk (Beex 1954).

11.2.2 Results and discussion

Hoogeloon 1 was built in an open space with the forest at an average distance of approximately 50-100 m. The open space was covered with heath vegetation that was dominated by *Calluna vulgaris* (see figure 11.4). The heath was very poor in other herbal vegetation, including anthropogenic indicators. The area that was used for sod cutting had a radius of approximately 15 m (based on an average sod thickness of 0.25 m, see also 8.2.2). Hoogeloon 2, which was probably younger than Hoogeloon 1, was built in a much smaller open space with an ADF of approximately 25 m. *Calluna vulgaris* was also the dominant species in this small open space. The surrounding forest consisted mainly of *Quercus* and *Tilia*. *Fagus* was also present in low amounts. *Corylus* was most likely present at the edge of the forest. Some *Betula* trees were probably present as solitary trees in the heathland or were perhaps part of the forest. In the lower and wetter parts of the area alder carr was present, represented by high percentages of Alnus in the pollen spectra from both mounds.



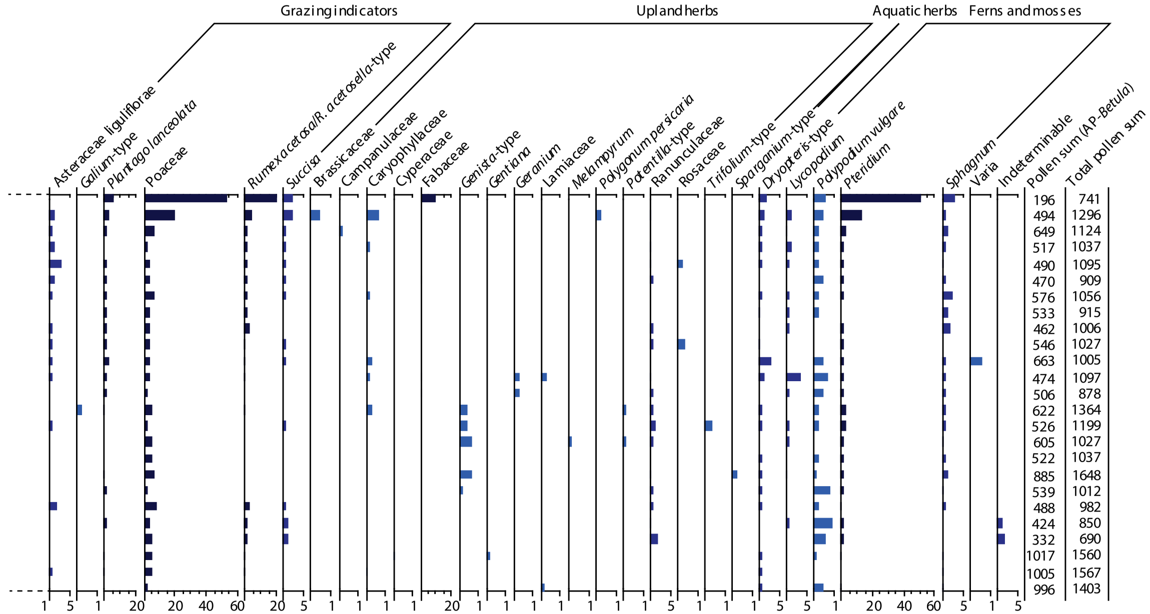


Figure 11.4. Pollen spectra from the samples taken from the barrows at Hoogeloon, Knegsel, Steensel, Eersel and Bergeijk. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

11.3 Knegsel-Urnenweg

Circa 2 km south of Toterfout-Halve Mijl a cemetery complex is located. An urnfield was constructed around and partially on top of several older barrows. The cemetery complex is situated around a small pool, which was drained around 1930. Over several excavations the urnfield was excavated including five of the older barrows (Braat 1936, Glasbergen 1954). Two of these barrows (Knegsel 1 and 2) and four ring ditches belonging to the urnfield (Knegsel ditch a-d) had been sampled and analysed for pollen by Waterbolk, with results being published in his thesis (Waterbolk 1954, 104-108; see figure 11.1).

11.3.1 Site description and sample locations

Knegsel 1 is a three-period barrow of which the first and the second period are dated to the Middle Bronze Age B. The third period dates to the Early Iron Age. The diameter of the first period is 7.5 m, of the second 10 m and of the third 8 m. The height of the barrow is unknown, which makes it impossible to calculate the sod-area. Samples were taken from the old surface of the primary mound and from a sod originating from the grave pit, belonging to the first period.

Knegsel 2 is a two-period barrow. The first period dates to the Middle Bronze Age, the second period to the Late Bronze Age/Early Iron Age. The diameter of the first period barrow is 8 m and of the second 5.4 m. The barrow was 0.28 m high. Samples were taken from the old surface of the primary mound and from three consecutive humic layers in the ring ditch.

In addition samples were taken from the fills of four ring ditches that belonged to the urnfield. Ditch (a) was a circular ring ditch, ditch (b) and (c) belonged to two long beds (oblong barrows, belonging to an urnfield) and ditch (d) was a rounded rectangular ring ditch with posts.

11.3.2 Results and discussion

Knegsel 1 and 2 show similar pollen spectra (see figure 11.4). They were both dated to the Middle Bronze Age-A and it is possible they were built (almost) at the same time. They were built in an open space with an ADF of approximately 50-100 m. About 28 m^2 of heath area needed to be stripped to build the primary Knegsel 2 barrow (based on an average sod thickness of 0.25 m, see also 8.2.2). The secondary mound required about 13 m^2. The vegetation of the open space was dominated by *Calluna vulgaris* with most likely some *Betula* trees nearby. Other herbs were almost absent, also Poaceae were only present in low amounts. Alder carr was present in the river valleys in the environment. *Corylus, Quercus* and *Tilia* were the main trees in the forest that could be found in the drier areas. Other samples that were taken from this site came from urnfield ditches. Three of them (a-c) show almost similar AP as Knegsel 1 and 2 indicating an ADF of approximately 50-100 m. The fourth ditch showed a higher arboreal pollen percentage of 65%, indicating an open space of approximately 30-50 m. The forest composition seemed slightly different with a relatively high percentage of *Quercus* (30%) at cost of *Corylus*.

11.4 Knegsel-Moormanlaan

Approximately 3 km southeast of the Toterfout-Halve Mijl barrow group and approximately 2 km east of the Knegsel barrows a tumulus is located at the Moormanlaan, a sandy road close to Knegsel (see figure 11.1).

11.4.1 Site description and sample locations

The barrow at the Moormanlaan is a 2 or 3 period barrow of which the first period was dated to the Early Bronze Age/Middle Bronze Age-A (diameter=6 m). The second (and third) period was dated to the Middle Bronze Age (diameter=5.4 m/6 m). The barrow was excavated by Modderman, Verwers and Boogerd in 1967. Samples for pollen analysis were taken from a sod and from the original surface in the north-west quadrant by Bakels (Modderman and Bakels 1971).

11.4.2 Results and discussion

The pollen spectra (see figure 11.4) show an arboreal pollen percentage of approximately 50%, indicating that the barrow was built in an open spot with an ADF of approximately 100 m. This open spot was mainly covered with heath vegetation (*Calluna vulgaris*). Other herbal species are present in very low amounts, including Poaceae. The surrounding forest consisted of *Quercus*, *Tilia* and *Fagus* with *Corylus* and possibly *Salix* at the forest edge. Alder carr was present in the wetter parts of the area.

11.5 Steensel

Circa 4 km southeast of Toterfout-Halve Mijl, close to Steensel, an urnfield with over 100 (urnfield) barrows is situated at a locality called the 'Heibloem'. This cemetery has been the subject of several excavations since the first in 1844 by Panken. In 1948 van Giffen decided to undertake there a trial-excavation to rescue the cemetery (Modderman and Louwe Kooijmans 1966). At that time samples for pollen analysis were taken by Waterbolk from one of the 'long beds' in the cemetery, the results of which were published in his thesis (Waterbolk 1954, 103, 109-110; see figure 11.1).

11.5.1 Site description and sample locations

The cemetery is situated on the northern half of a ridge consisting of loamy, fine sand deposited by wind (Modderman and Louwe Kooijmans 1966). Samples for pollen analysis were taken by Waterbolk from the old surface and the fill of a ditch belonging to one of the long beds (Waterbolk 1954, 103, 109-110). No dating is known for this barrow, but in general long beds are dated to the Late Bronze Age/Early Iron Age.

11.5.2 Results and discussion

The barrow was built in an open place with an ADF of approximately 125 m, based on the percentage of arboreal pollen observed in a sample from the old surface. The pollen spectrum of the ditch seems to represent a slightly younger period with a higher percentage of herbal pollen, like Poaceae, *Rumex* and *Plantago lanceolata* (see figure 11.4). A high percentage of *Pteridium* in the ditch spectrum possibly is the result of a *Pteridium* being present on top of the barrow, as a pioneer species, after construction of the barrow and shedding spores before the ditch was filled up (see also 11.1, p.46-47). *Calluna vulgaris* was the dominating species at the open place, indicated by the high percentages of this species in both samples. Compared to the other barrows in the region the heath was grassier, indicated by percentages of Poaceae of 20-50%. *Betula* trees were probably present in or close to the heathland.

11.6 Eersel

Approximately 5 km to the south of Toterfout-Halve Mijl, close to Eersel a ring and ditch barrow called 'De Gloeiende Engelsman' is situated (Beex 1964b; see figure 11.1).

11.6.1 Site description and sample locations

The barrow was dated to the Middle Bronze Age-A, based on ^{14}C-dating (3460 ± 35 BP, GrN-5350; 1777-1603 cal BC, calibrated with Oxcal 4.2) and the find of a Drakenstein urn. The barrow measured 20.2 m in diameter and approximately 1 m in height. It was built partially on an undisturbed Carbic Podzol (Dutch classification: Humuspodzol) and partially on grey, fairly homogenous soil, interpreted by van Zeist (1967) as former arable land. This interpretation can be questioned, given the absence of ploughing marks (see also section 11.1.1) The tumulus was excavated in 1966 by the ROB and sampled for pollen analysis by van Zeist (van Zeist 1967b). Samples were taken from the old arable land, from the old surface underneath the mound (the Carbic Podzol) and from sods with which the mound was constructed.

11.6.2 Results and discussion

The pollen spectra show that the barrow was built in an open space that was covered in heath vegetation (see fig 11.4). If the open space had been used for agricultural activities as was suggested by van Zeist (see 11.6.1), the old arable was at the time the barrow was built no longer in use as such, indicated by the high percentage of *Calluna vulgaris* and the absence of cereal pollen and other indicators of crop cultivation. Based on the arboreal pollen percentage the average distance to the forest was approximately 150-300 m. The minimum area that was used for sod cutting to build the barrow could be calculated. This was an area of circa 643 m^2, indicating a radius of approximately 14 m. Alder carr must have been present in the neighbourhood of the barrow shown by percentages of approximately 30% *Alnus*. Forest in the drier regions mainly consisted of *Quercus* and *Tilia* with *Corylus* present at the forest edge. The pollen spectra of the old arable land show higher percentages of *Tilia* than the other pollen spectra and also *Fagus* is present in both samples. Since these samples came from disturbed soil, the relatively high number of *Tilia* pollen can be attributed to an older sediment that was mixed with younger sediment.

11.7 Bergeijk

Approximately 15 km south of Toterfout-Halve Mijl a barrow, close to Bergeijk is located (see figure 11.1).

11.7.1 Site description and sample locations

The barrow is situated on a high sandy ridge. The barrow was dated to the late Neolithic-A period based on ^{14}C-dating (3950 ± 150 BP, GRO 381; 2707-2460 cal BC, calibrated with Oxcal 4.2). This is the oldest barrow that will be discussed in this chapter. The centre of the barrow was sandy and had a diameter of approximately 3-4 m. Around the centre of the barrow a small ditch was dug from which the sand was accumulated, forming a small bank encircling the barrow. On top of this bank a second bank was constructed with sods expanding the diameter of the monument to approximately 8 m. On top of this bank and barrow a layer of sand was deposited, enlarging the total tumulus to a diameter of approximately

20 m and a height of 0.70 m. Samples for pollen analysis were taken by Beex from the old surface underneath the barrow, from the old surface outside the secondary bank and from a sod belonging to this bank. The samples were analysed by Waterbolk (Beex 1957, Waterbolk 1957).

11.7.2 Results and discussion

The mound was probably built in a small open space with an ADF of approximately 25-50 m, based on the high percentage of arboreal pollen (70%; see figure 11.4)). Part of this open place was probably used for sod cutting. A minimum area of approximately 630 m^2 was required to build the barrow, indicating a radius of approximately 14 m. The small open place was covered with species-poor heath vegetation that was dominated by *Calluna vulgaris*. *Quercus* and *Tilia* were the main species of the surrounding forest, with *Corylus* dominating at the forest edge. Alder carr was present in the wetter parts in the surroundings.

11.8 Alphen

A barrow called 'Op de Kiek' (Alphen 1) is located approximately 30 km west of the Toterfout-Halve Mijl barrow group. The barrow was excavated in 1955 by Modderman (Modderman 1955; see figure 11.5).

Circa 3.5 km to the southwest of Alphen 1 another barrow is present called 'The Kwaalburg (Alphen 2). It was excavated in 1964 by Beex (1964c; see figure 11.5).

11.8.1 Site description and sample locations

Alphen 1 is a multi-period barrow that was dated to the Middle Bronze Age-A period based on ^{14}C-dating of the primary cremation (3450 ± 60 BP, GrA-15479; 1922-1618 cal BC, calibrated with Oxcal 4.2). The inner diameter of the encircling ditch was approximately 6 m and the original barrow was approximately 1 m of height. Samples for pollen analysis were taken by Modderman from the old surface underneath the primary mound, outside the primary mound, from the ring ditch and from the old surface underneath the secondary mound. Results were published by Casparie and Groenman-van Waateringe (1980, 37, 40).

Alphen 2 was dated to the Middle Bronze Age-A period based on a bronze flanged axe. This barrow was a so-called bank-and-ditch barrow, meaning that the original barrow was surrounded by a circular bank and ditch. Alphen 2 was built of sods and had a diameter of approximately 15 m. At a distance of approximately 1 m a circular bank with sods of approximately 4 m wide was placed. At approximately 1.5 m from this bank another surrounding bank of approximately 3.5 m wide was made. The complete monument had a diameter of approximately 41 m. Samples for pollen analysis were taken during the excavation from the old surface, a sod and from the encircling ditch and primary bank (Casparie and Groenman-van Waateringe 1980, 38).

11.8.2 Results and discussion

The pollen spectrum of Alphen 1 and 2 both showed an arboreal pollen percentage of approximately 70% (see fig 11.6). This indicates that the barrows were built in a small open space with an ADF of approximately 25-50 m. The vegetation at the open space was dominated by *Calluna vulgaris* with most likely some solitary trees of *Betula*. Other herbs are, including Poaceae, are only present in very low amounts. The samples from the ditch and the bank of Alphen 2 show a slightly different (younger?) vegetation composition, with an expansion of the heath.

Comparable to Toterfout-Halve Mijl and surroundings, the forest in the environment consisted of mainly *Quercus* and *Tilia*. *Corylus* was present in considerable amounts at the forest edge. In the lower and wetter parts of the area *Alnus* was the dominating tree.

11.9 Goirle

Approximately 2 km to the east of the barrow 'Op de Kiek' an alignment of barrows on a cover sand ridge close to a river valley is situated in an area called 'Rechte Heide'. Along approximately 1.5 km of this barrow alignment a barrow is situated that was excavated in 1949 by Glasbergen and Waterbolk (Glasbergen 1954; see figure 11.5).

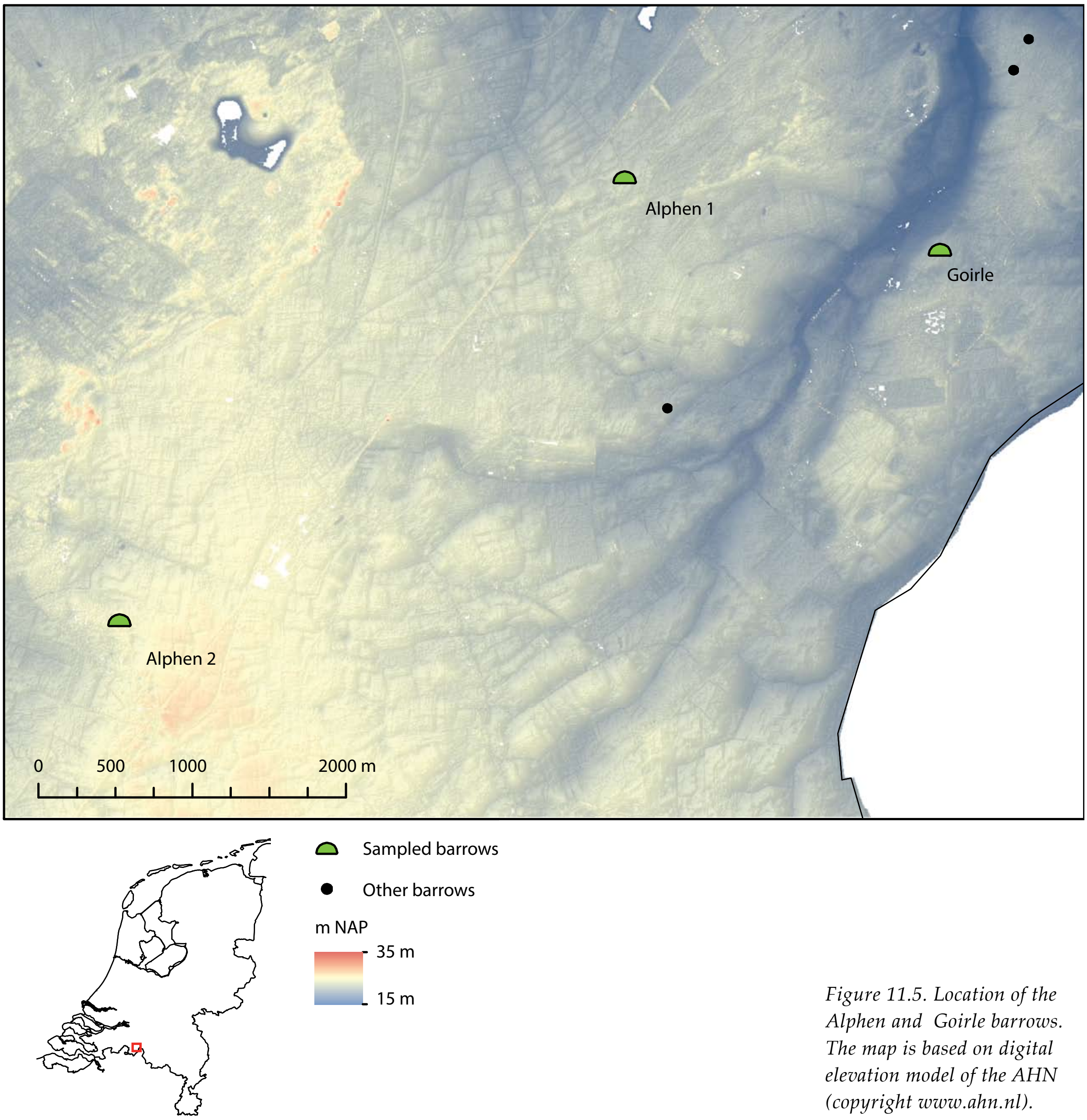


Figure 11.5. Location of the Alphen and Goirle barrows. The map is based on digital elevation model of the AHN (copyright www.ahn.nl).

11.9.1 Site description and sample locations

A two-period barrow (h=0.90 m, d=15 m) of which the primary mound was dated to the Middle Bronze Age. The secondary mound was probably almost similar in age (Bourgeois 2013). From the mound a number of large wall and rim fragments of a Drakenstein urn were recovered. The monument was heavily damaged by deep ploughing. The old surface underneath the barrow was strongly affected by rabbits and intrusion of tree roots. A sample for pollen analysis was taken from one of the clearly recognizable sods (Waterbolk 1954, 103, 111).

11.9.2 Results and discussion

This barrow was constructed in an open space with an ADF of approximately 100 m. The open space was covered with heath vegetation that was, when compared to the other barrows discussed in this chapter, quite grassy with a percentage of Poaceae of 30% (see figure 11.6). *Calluna vulgaris* is the dominating species with 75%. This barrow was probably situated close to an alder carr, indicated by the high percentage of *Alnus* (60%). Sods were cut to build the barrow; a minimum area of approximately 320 m^2 was required to obtain the sods.

11.10 Summary: the barrow landscape of Toterfout-Halve Mijl and surroundings

From the area around Toterfout-Halve Mijl pollen data are available from the late Neolithic-A to the Iron Age. The vegetation in the surroundings of the discussed barrows seems not to have differed greatly from each other during this entire period. Barrows were built in open spaces with heath vegetation which was dominated by *Calluna vulgaris* with in most cases probably some solitary *Betula* trees. All other herbal vegetation, including Poaceae, was very low in number. These heath areas formed, in the case of the Toterfout-Halve Mijl group, most likely long stretched areas in which groups of barrows were built in the Bronze Age period. The forest in this area could be divided into two components. In the lower and wetter parts alder carr was present, indicated by the high percentage of *Alnus* in all of the pollen spectra. The forest at the drier parts in the area consisted mainly of *Quercus* and *Tilia* and in the Bronze Age also of some *Fagus*. As has been discussed in the previous chapters as well, the activity of man is required to manage the heath. The method of management in this area is not easy to deduce from the pollen spectra. Anthropogenic indicators are very low in amount. Some grazing indicators have been found in the barrows from Toterfout-Halve Mijl. There is no evidence for burning. Sod cutting is indicated by the barrows, while they were built of sods. Especially for the amount of barrows being built at Toterfout-Halve Mijl sod-cutting could certainly been part of the heath maintenance.

One of the research questions concerns the origin of the open spaces the mounds were raised in. For the Toterfout-Halve Mijl group the history of its open spaces is available. Some of the barrows were built on possibly former arable land (although questionable, see sections 11.1.1 and 11.6.1) and traces of a Neolithic settlement have been found nearby. After abandonment of the settlement an open area covered with grasses and some heath was left behind. Possibly the area was grazed at that time, causing an expansion of the heath in which later the barrows were built. The construction of the mounds in the area did not stop prehistoric man from using the area as pastoral grounds, because the heath could only be maintained by human interference. The destination of the area changed through time from settlement area with agriculture, to pastoral area, to burial site combined with pastoral area. On the other barrows discussed in this region no

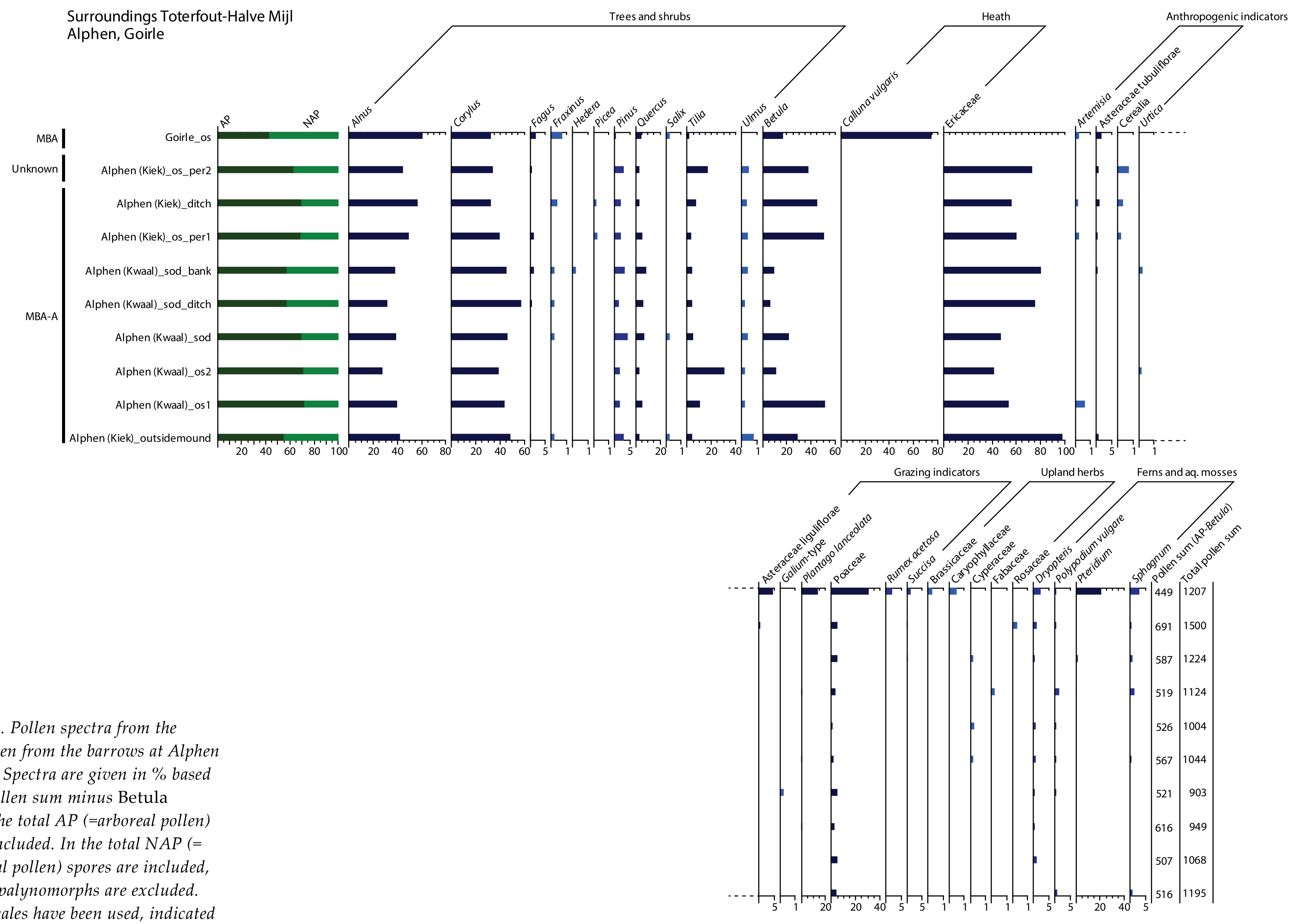


Figure 11.6. Pollen spectra from the samples taken from the barrows at Alphen and Goirle. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

data are available that can reveal the origin of the open places these barrows were built in. It is clear that the open spaces were already present some time before the barrows were built, since heath vegetation had already developed, a process that in general takes approximately 40 years (Stoutjesdijk 1953). It is likely that grazing was involved in the maintenance of the heath vegetation already before the barrows were constructed.

Table 11.3 The minimum size of the open space per barrow based on the sods used to build the barrows.

	Diameter (m)	Height (m)	Sod thickness (m)	Sod area (m2)	Radius (m)
Hoogeloon 1	18	1.4	0.25	718.26	15.12
Hoogeloon 2	4	unknown			
Knegsel 1	7.5	unknown			
Knegsel 2	8	0.28	0.25	28.19	3.00
Knegsel - Moormanlaan	6	unknown			
Steensel	unknown				
Eersel	20.2	1	0.25	643.04	14.31
Bergeijk	20	1	0.25	630.41	14.17
Alphen 1	6	1	0.25	58.64	4.32
Alphen 2	15	unknown			
Goirle	15	0.9	0.25	319.61	10.09

Chapter 12

Oss-Zevenbergen and surroundings

Near the town of Oss, encompassing an area of approximately 7.5 km², several burial complexes are situated from which palynological data have been obtained (see figure 12.1). The palynological results of these barrows will be described and discussed to reconstruct the barrow landscape in this area. At the end of this chapter three pollen diagrams derived from a palaeosoil and peat sediments (Schaijksche heide, Sint Annabos and Venloop, see section 12.5) will be discussed. These pollen diagrams will provide more information about the vegetation in the wider surroundings of the barrows.

12.1 Oss-Vorstengraf area and Oss-Zevenbergen

Close to the town of Oss two burial complexes are situated, Oss-Zevenbergen and the grave field of the Chieftain's Grave of Oss (Dutch: Oss-Vorstengraf). These two sites have been the subject of various excavations since 1933 when the Chieftain's Grave of Oss was discovered. Especially in the last 15 years detailed research has taken place, revealing that these two sites might actually form one large burial complex. This will be further discussed in section 12.1.3.

The sites of Oss-Vorstengraf and Oss-Zevenbergen have a long and rather complex research history, the results of which have been published in several publications (Verwers 1966, Fokkens and Jansen 2004, Jansen and Fokkens 2007, Fokkens *et al.* 2009b, Fontijn and van der Vaart 2013). For a detailed report of all the research on the two sites the reader is referred to those publications. A short overview of the several research campaigns and a summary of their findings will be given in table 12.1. Then a more detailed description per barrow will be given.

12.1.1 Site description and sample locations

Oss-Zevenbergen and the Oss-Vorstengraf area are situated on the northwest edge of the Peel Blok, a by tectonics elevated (uplifted) area. The grave fields in this area are for the most part located on a ridge of cover sands. Along the side of the Peel Block area groundwater seepage wetland occur, causing locally very wet conditions west, north and east of the cemetery area (Dutch: *wijstgronden*; see figure 12.2). The higher parts of the terrain consist of a Carbic Podzol (Dutch classification: Haarpodzol, while the lower and wetter areas consist of Gleyic Podzols (Dutch classification: Veldpodzol). Thin layers of wind-blown sand can be found all over the terrain, especially at the flanks of the barrows. Along the southeast-side of the terrain an extended drift-sand layer is located (van der Linde and Fokkens 2009, Jansen and van der Linde 2013)

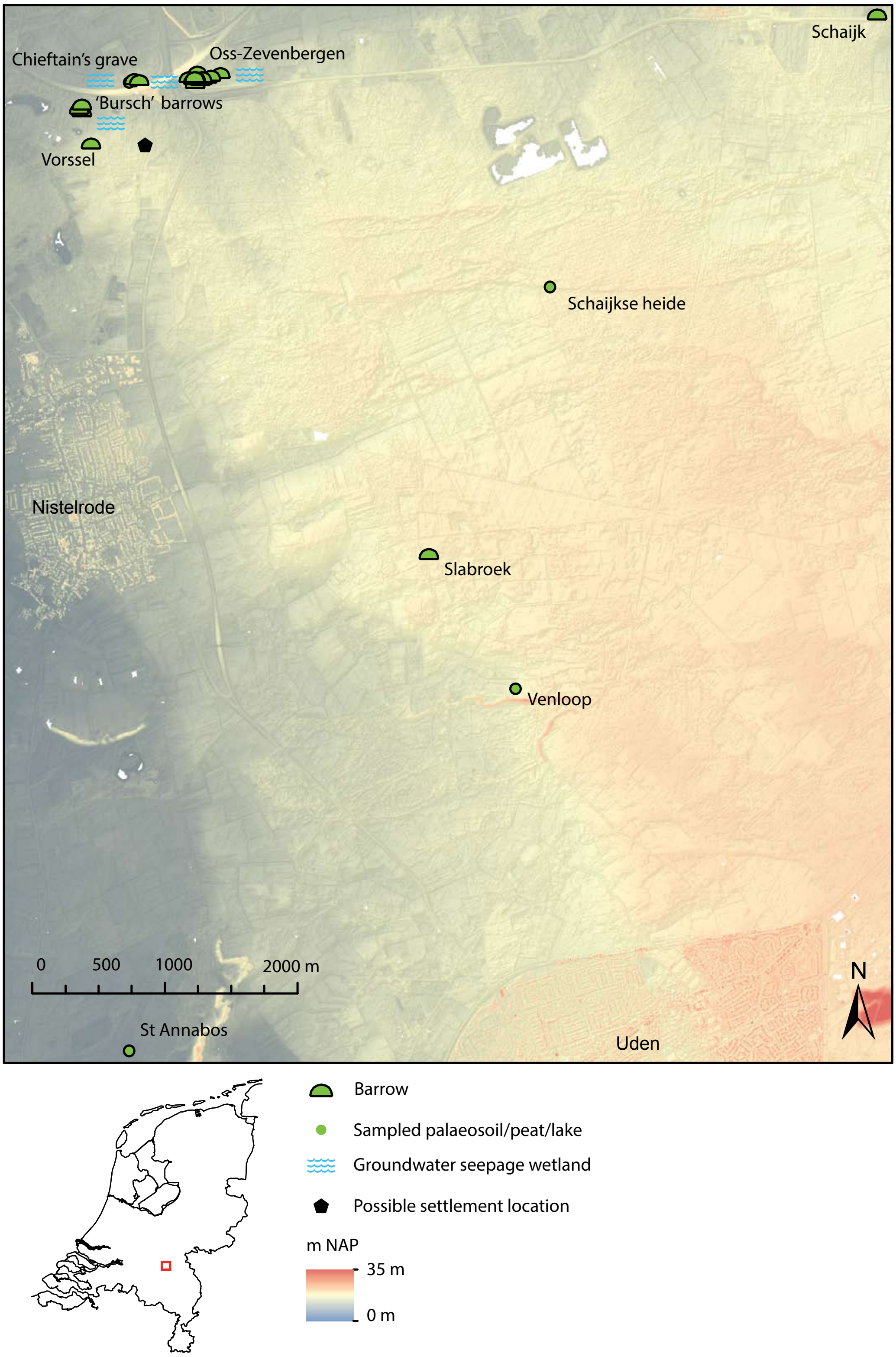


Figure 12.1. Locations of the barrows in the case-study area of Oss-Zevenbergen and surroundings. In addition the location of a possible Middle Bronze Age settlement has been indicated, as well as the locations where groundwater seepage wetlands occur. The map is based on digital elevation model of the AHN (copyright www.ahn.nl).

Year of excavation	Excavator	Results Oss-Vorstengraf area	Results Oss-Zevenbergen
1933	Bursch	Discovery of the rich Oss-Vorstengraf	
1935	Bursch	Excavations of 3 other mounds at Oss-VG complex, one dating to the Late Neolithic and two to the Middle Bronze Age	
1964-1965	Modderman & Verwers	Analysis of the cremation remains of Oss-VG: a disabled, older individual	Research into Oss-Zevenbergen mounds: at least 2 of the 7 mounds are barrows (mound 3 and 7), 5 other mounds were not excavated.
1969	Beex		10 barrows at Oss-Zevenbergen, of which 6 were shown to be built of sods and 4 appeared to be built of drift sand. 5 mounds are barrows, 5 belong to an urnfield.
1972		Urns were found in the area. 4 ring ditches were observed, of which one was rectangular.	
1978	Van Alphen		Discovery of post alignments just north of Oss-Z (part of a Medieval 'landweer': a defence wall)
1994 – 1997		ROB decided that re-excavation would be best to preserve the archaeological information	
1997	Leiden University	A survey of the VG area with test trenches: • Rediscovery of the VG: a Hallstatt C grave dug into a Bronze Age barrow, covered with a new mound. • Six-post structure • Urnfield (2 ring ditches) Re-analysis of cremation remains: male, disabled, 40-60 years.	
2002	Leiden University	Discovery 3rd ring ditch, 4 urns and a post alignment underneath the Hallstatt C burial. 4th (rectangular) ditch was probably too recent to be part of the urnfield.	
1998-2005	Leiden University	A survey with test trenches north and northwest of the VG complex was carried out: a Bronze axe deposition was found in 2003	
2004-2007	ARCHOL BV/ Leiden University		A survey of the Oss-Z area: all barrows were (re-) investigated: 3 MBA barrows (4, 2, 6), 2 LBA/EIA barrows (8,1), 1 Hallstatt C barrow (mound 3). Barrow 7 could not be excavated yet. Remains of 5 additional small monuments (ring ditches) and 4 secondary burials in older barrows were discovered. Discovery of 5 post alignments.
2007	University of Leiden		Re-excavation of barrow 6 Excavation of barrow 7: Hallstatt C barrow. Double post alignment underneath barrow 7
2012		Re-analysis of cremation remains VG: possibly younger and less disabled than previously thought	
1933-2012	Several	Several restorations of the grave goods, new discoveries were made each time.	

Table 12.1. Overview of the research history of the Chieftain's grave of Oss and the Oss-Zevenbergen area.

Oss-Vorstengraf area

Chieftain's grave of Oss

In 1933 a large barrow with a diameter of approximately 53 m, surrounded by a circular ditch, was discovered in which a rich Hallstatt C (Early Iron Age) grave was found: a bronze situla containing amongst others cremation remains, a Mindelheim sword (an iron sword with a hilt inlaid with gold) and many small bronze objects. Because of the grave good's richness the grave was named the Chieftain's Grave (Dutch: *Vorstengraf*) (Bursch 1937). Later research revealed that the cremation remains were of an older, disabled man, although recent research showed that he

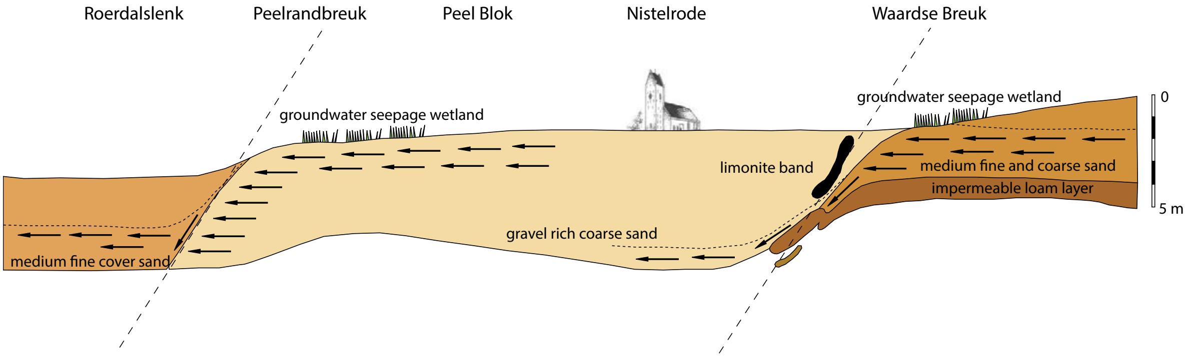


Figure 12.2. Groundwater seepage wetlands at the Peel blok. Figure after van der Laan et al. (2011).

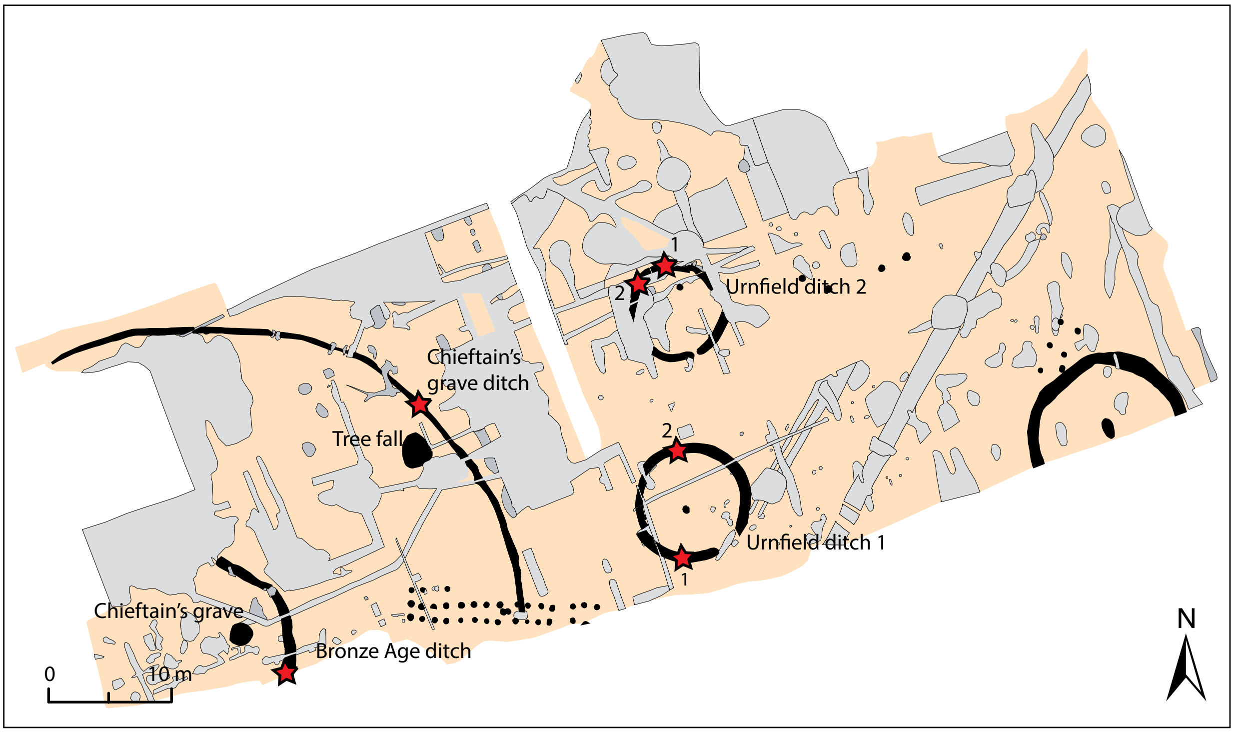
might have been much younger and healthier than previously thought (Lemmers *et al.* in prep). The bronze objects were probably the remains of bronze horse gear (Fokkens and Jansen 2004, Jansen and Fokkens 2007, Fokkens *et al.* 2012). The Chieftain's Grave was rediscovered in 1997, although it was heavily disturbed at this time. The mound itself had disappeared and only the remains of ditches and posts were preserved. The re-excavation nevertheless revealed that the grave was a secondary burial into a smaller Bronze Age barrow, which had an original diameter of 16 m and was surrounded by a ditch. A new barrow was built on top with the Chieftain's Grave positioned off-centre in relation to the Bronze Age barrow, possibly to respect the older grave. The Hallstatt C barrow had a diameter of 53 m. It was probably 1 m in height above the older mound and flattened at the top. During the 1997 excavation a fallen tree that had grown on top of the barrow was investigated. It was discovered that in its fall, the tree had retained a small intact part of the barrow in between its roots (see figure 12.3 and 12.4). Although the original mound was levelled in the past, the part of the barrow that was captured by the tree roots contained a fraction of the old surface, the soil below and some sods. Samples for pollen analysis were taken from here by de Kort (1999): three samples from the old surface and four samples from the sods. In addition two monolith tins were hammered into the section of which samples could be taken from the old surface downwards to provide a pollen diagram as has been described in chapter 5. Samples were also taken from the ditch belonging to the original Bronze Age barrow and from the ditch belonging to the Chieftain's Grave. All samples were analysed and published by de Kort as part of his MA thesis (de Kort 1999).

Three barrows

In 1935 Bursch excavated three other barrows that were situated close to the Chieftain's Grave (see figure 12.1). Just south of it a barrow was located that was dated to the Late Neolithic, based on the find of a Veluvian Bell Beaker. Two other barrows were surrounded by multiple post circles, which date them to the Middle Bronze Age. In addition an undecorated Middle Bronze Age urn was discovered in one of the mounds (Bursch 1937, Fokkens *et al.* 2012). No samples for pollen analysis were taken from these barrows.

Urnfield

Some urns were found in 1972 and the discovery of three small circular ring ditches and four urns without monumental structures in 1997 and 2002 indicated the presence of a small urnfield southeast of the Middle Bronze Age barrows. Two ring ditches were found in 1997 just east of the Chieftain's Grave and had a diameter of respectively 10 and 7 m. The largest ditch was located about 15 m east



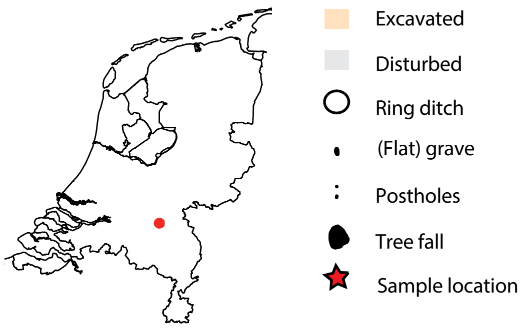
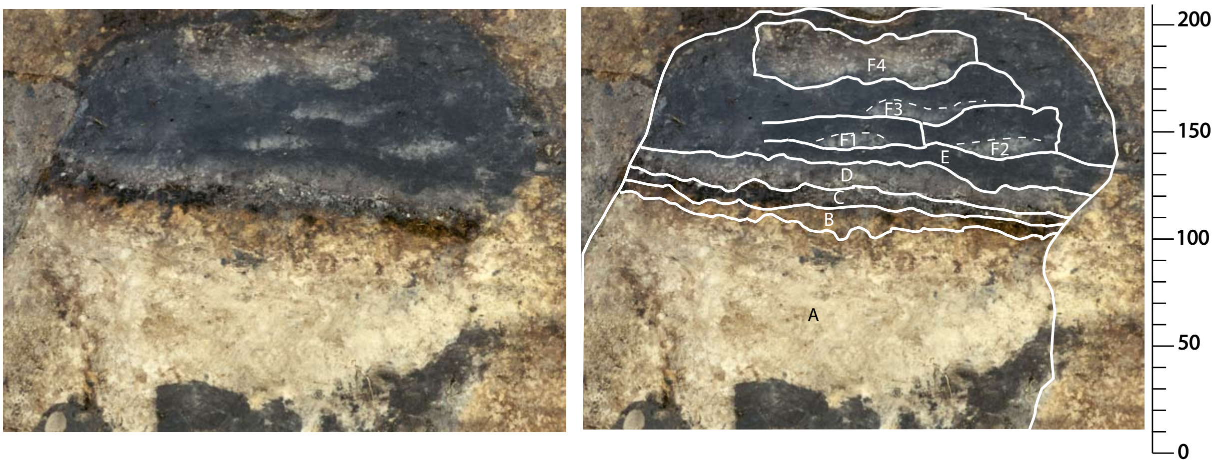


Figure 12.3. Location of the barrows in the Chieftain's grave of Oss area. Figure after Fokkens and Jansen (2004, figure 4.5).

Figure 12.4. Tree fall at the Chieftain's grave of Oss that had captured a small intact section of the barrow. A fraction of the old surface, the soil below and some sods were remained in this section. A indicates the uprooted subsoil from underneath the tree. B, C, D and E together form the original podsolic soil, with the original topsoil (E), a leached horizon (D) and the zone with iron pan formation (C). F1, F2, F3 and F4 are sods from the barrow, laid down with the turf upwards. Figure by H. Fokkens.



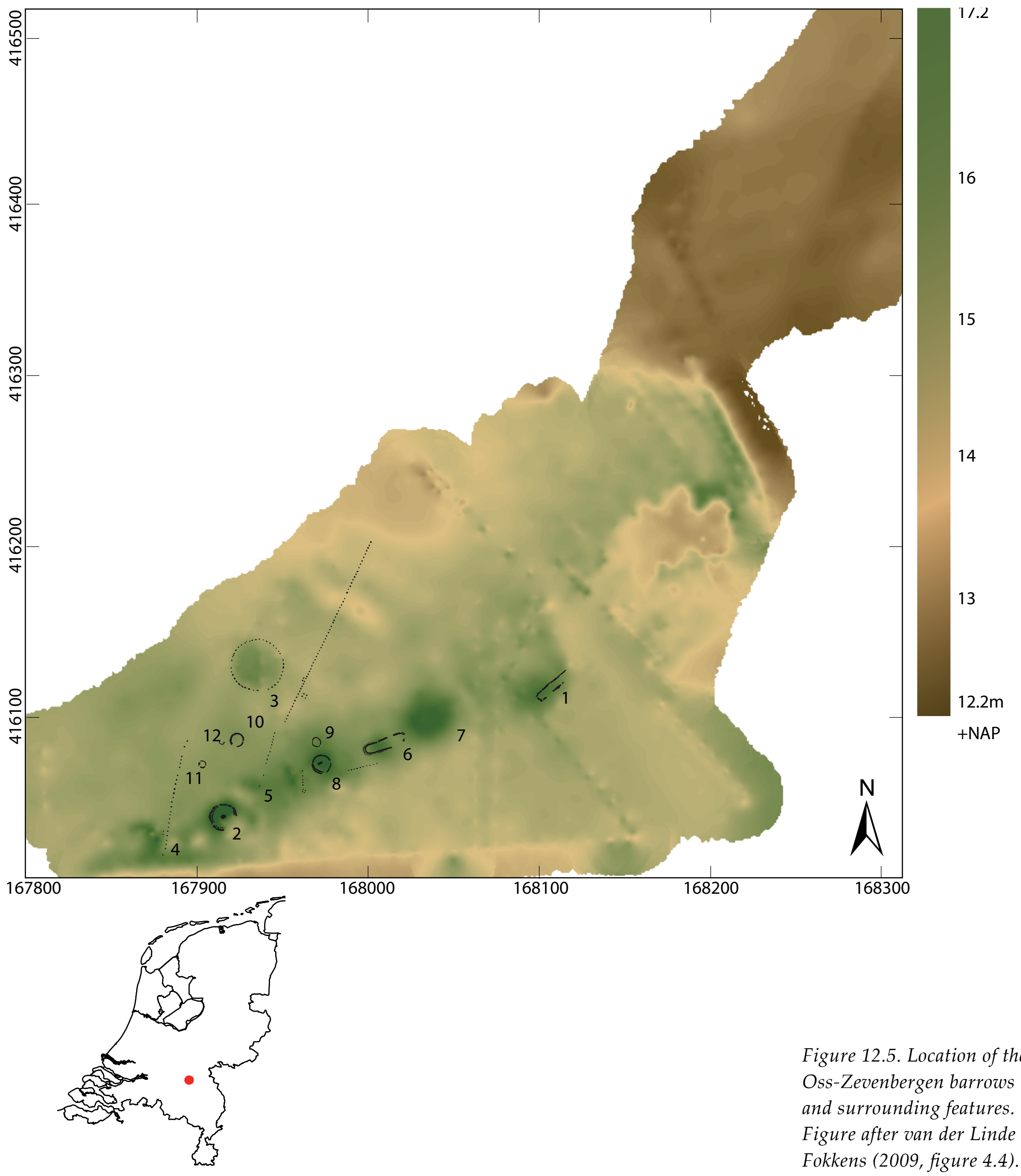


Figure 12.5. Location of the Oss-Zevenbergen barrows and surrounding features. Figure after van der Linde and Fokkens (2009, figure 4.4).

of the Chieftain's Grave and had a maximum depth of 25 cm. A cremation was found in the centre of the (now disappeared) barrow. The other ditch was located about 25 m east of the Chieftain's Grave. A cremation was not found in the centre, but eccentric at only about 1 m from the ditch. This was probably a secondary burial, dating the ditch to the Late Bronze Age/Early Iron Age. The northern part of a third ring ditch was discovered in 2002. In addition the remains of 4 urns without monumental structures were found (Fokkens and Jansen 2004, Jansen and Fokkens 2007, Fokkens *et al.* 2012). Samples for pollen analysis were taken from the two ring ditches that were found in 1997 (see figure 12.3). One of the samples from the northern ditch (urnfield ditch sample 2) was useless for pollen analysis (de Kort 1999).

Posts

In 1997 a double and partly triple post alignment was found. This post alignment was located partially underneath the eastern part of the Chieftain's Grave, dating the post alignment before the Hallstatt C period. The alignment is probably related to the Bronze Age burial underneath the Chieftain's Grave (Fokkens and Jansen 2004, Jansen and Fokkens 2007, Fokkens *et al.* 2012).

A six-post structure was found directly north of one of the ring ditches, which was interpreted as a mortuary house. It was not possible to date this post structure (Fokkens *et al.* 2012). None of the posts were sampled for pollen analysis.

Oss-Zevenbergen

Approximately 350 m east of the Chieftain's Grave a barrow complex including at least seven burial mounds and several post structures is located (see figure 12.5), called Oss-Zevenbergen. The barrows date from the Middle Bronze Age to the Early Iron Age. They are situated on a ridge of cover sands in a southwest to northeast alignment. Below follows a description per barrow. All information about these barrows is based on the publication of van Wijk *et al.* (2009), unless stated otherwise.

Oss-Zevenbergen 1

In 2004 Barrow 1 was the first to be excavated. The mound itself had mostly disappeared, but the ditches were for the greater part still recognizable. Barrow 1 is a long bed that measured 4.7 m by at least[14] 23.5 m. Its height was probably between 30 and 50 cm. It probably dated to the Late Bronze Age/Early Iron Age (van Wijk *et al.* 2009, 73-74). The soil underneath the barrow was a Carbic Podzol (Dutch classification: Haarpodzol). De Kort took five samples for pollen analysis, of which three were analysed: two pollen samples of the old surface and a sample from the fill of the lower part of the surrounding ditch (de Kort 2009, 158).

Oss-Zevenbergen 2

Barrow 2 was recognized as a burial mound in 1964/1965, but not excavated until 2004. It was situated on the highest part of the cover sand ridge. The barrow appeared to be a two-period barrow. The primary mound was built on top of a pit that was filled with thin (5-10 cm) sods. No skeletal remains have been found in this pit. The mound was constructed of sods with a thickness of 10-15 cm and an average length of 34 cm. The diameter of the first period was approximately 12.5 m. Its height was probably approximately 60 cm. The mound was surrounded by a closed spaced single post circle, probably dating the mound to 1700-1300 cal BC (*cf.* Bourgeois 2013, 34). The old surface belonging to period 1 was, different from what was underneath the other barrows, an Umbric Podzol (Dutch classification: Moderpodzol). The secondary mound was also constructed of sods of which the thickness is unknown. The mound was increased to a height of approximately 1.2 m and a diameter of approximately 17.5 m. No grave was found. A closely spaced double post circle was placed around the mound probably preceding the sod placing (the mound seemed to cover the post holes), dating the second phase of mound building also to the Middle Bronze Age (1700-1300 cal BC, *cf.* Bourgeois 2013, 34). The barrow was re-used in the Iron Age, when an Iron Age urn with cremation remains was placed in the mound. In the Medieval

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14 The barrow was heavily damaged and exact measurements could not be reconstructed (Fokkens *et al.* 2009).

Period another three graves were dug at the base of the mound. Barrow 2 has been sampled for pollen analysis by de Kort (2009). Samples were taken from the E- and B-horizon underneath the primary mound, from 2 sods belonging to the first period, from the old surface underneath the secondary mound and from a sod belonging to the second period. Another sample was taken from underneath a grey layer that covered the sods of period 1, but since it is not very clear what this sample represents it will not be discussed.

Oss-Zevenbergen 3

Barrow 3 is located approximately 40 north of the barrow alignment and situated in a lower part of the area. It was first discovered in 1964/1965 and excavated in 2004. It is a single-period barrow with a diameter of approximately 30 m. Its original height is not exactly known but is conservatively estimated to have been approximately 90 cm. The mound was constructed of sods with an average thickness of 8-18 cm and an average length of 50 cm. The central grave consisted of a large burnt oak plank, some smaller pieces of charcoal, a piece of burned bone, a small fragment of a bronze sword and fragments of one bronze and two iron objects; probably a *pars pro toto* deposition (only parts of an object and/or the deceased have been buried representing a whole object and/or person). The barrow was dated to the Hallstatt C period (Early Iron Age), based on ^{14}C dating of the oak plank and might be contemporary to the Chieftain's Grave. The soil underneath the barrow was a Gleyic Podzol (Dutch classification: Veldpodzol). Samples for pollen analysis have been taken from the old surface and from three sods by de Kort (2009).

Oss-Zevenbergen 4

Barrow 4 was heavily disturbed and not recognized as a barrow before the excavation in 2004. Barrow 4 concerns a barrow that was built in four phases. The first phase consists of a sod layer with a thickness of approximately 15 cm. Before adding a new layer of sods (phase 2) burning seems to have taken place, indicated by a high concentration of charcoal fragments in the old surface underneath phase 2. Phase 2 consists of another layer of 10-15 cm thick sods (length about 80 cm). After phase 2 the mound measured approximately 14.5 m in diameter and approximately 50 cm in height. Another burning event seems to have taken place after phase 2 as indicated by fragments of charcoal. Charcoal fragments ^{14}C date this layer to phase 2 to the Middle Bronze Age A (1530-1390 cal BC). The barrow was increased to a height of approximately 60 cm in phase 3, while the diameter of the mound was not enlarged. No sods have been recognized in this layer. In the fourth phase the mound was probably enlarged to a diameter of about 16 m, while the mound was not heightened. After the last period the mound was covered with a layer of drift sand. Underneath the barrow a disturbed brown layer was found on top of which the old surface belonging to the primary mound was situated. This layer was probably anthropogenic and was interpreted as an old arable layer. Five samples have been analysed for pollen by de Kort (2009). One sample was taken from the old surface underneath the drift sand layer at the southern part of the barrow. Four samples were taken from the old surface belonging to phases 2, 3 and 4. A fifth sample was taken from the disturbed brown layer underneath the old surface.

Mound 5

Mound 5 was recorded as a barrow in 1964/1965. During the excavation in 2004 it appeared not to be a barrow but a natural hill formed of drift sand. Two samples for pollen analyses were taken from the old surface underneath the hill (de Kort 2009).

Oss-Zevenbergen 6

Barrow 6 was first excavated in 1964/1965 by Verwers. The data from this excavation were reinterpreted by Valentijn (2013). It was discovered that a round mound was built on top of an oblong monument. Next to the ditch a closely spaced multiple post setting was found. Pottery sherds together with cremation remains were found. In 2004 the eastern part of the barrow was re-excavated. The western part of the monument could not be excavated yet since this part was situated in a protected zone due to a badger sett in barrow 7 (see next section). It was concluded that barrow 6 was constructed in two or three phases, but possibly these construction phases occurred in the same period (the Late Bronze Age/Early Iron Age). The first (and possibly second) phase consisted of an oblong ditch and a double ring of posts with a length of 27 m and width of 7.5 m. In the next phase a round barrow was erected within the eastern part of the oval monument (van Wijk *et al.* 2009).

In 2007 the remaining part of the monument could be excavated, revealing that the oldest peripheral structure is the double post setting, which measures 28.5 by 8.5 m. The post setting probably dates to the Middle Bronze Age B or Late Bronze Age. During the second phase an oval ditch was dug that cut the inner post-setting. It was also shown that the round mound probably was the remains of a disturbed long mound. The long mound was extended on the southern side, covering the oblong ditch (Valentijn 2013). In 2007 one single sample for pollen analysis was taken from the ditch, which was analysed by Bakels (Bakels and Achterkamp 2013).

Oss-Zevenbergen 7

Barrow 7, a large mound with a diameter of about 36 m and a height of 1.5 mm, was first discovered in 1964/1965. During the excavation campaign of 2004, when most of the other barrows at Oss-Zevenbergen were investigated, this barrow had to be left alone. A badger family made the barrow their home and since badgers are a protected species in the Netherlands Barrow 7 (and part of Barrow 6) could not be excavated before the badgers had been relocated. Finally, in 2007 the barrow could be thoroughly investigated. It appeared to be built of sods on a naturally formed small hill of cover sand and the actual barrow did not measure 36 m in diameter, but 22.8 m, and was 80 cm high[15]. On the northern side of this hill wind-blown sand was deposited in the Middle Neolithic[16]. Underneath the burial mound a Carbic Podzol (Dutch classification: Humuspodzol) had developed in the cover sand. An Early Iron Age urn (Schräghals type) was excavated near the centre of the mound. The urn was half-filled with cremation remains that appeared to be from a male in the age of 23-40 years. The bone was ^{14}C dated to the Hallstatt C period (794-538 cal BC) (Fontijn *et al.* 2013a, 96; Smits 2013). Very close to the urn more than 1000 small, bronze studs and large amounts of scattered charcoal

15 The original height of the mound could not be exactly reconstructed, but it was presumed that at least 30 cm of the original top was absent (Fontijn *et al.* 2013a, 70).

16 Based on OSL dating by Wallinga and Lemmers, reported in an unpublished thesis (Lemmers 2008), the deposition took place around 5000 BC.

were found. Since the bronze and wood items appeared to be very fragile it was decided to lift the area with its finds, covering an area of approximately 10 m^2, in blocks to allow for further treatment, preservation and excavation in a laboratory [17](*cf.* Fontijn *et al.* 2013a , 80-81).

The charred wood consisted of oak (94%), ash (5%) and willow (<1%). In the centre of the mound three charcoal pieces were recovered from the find assemblage. These charcoal fragments were ^{14}C dated to the Hallstatt C period (Fontijn *et al.* 2013a, 115-116). Several fragments of burned bone were found in between the pyre remains as well as two pieces of decorated (animal) bone and an undefined iron object. The burned bone most likely belonged to the same individual as the remains in the urn that was buried next to the pyre debris, although this cannot be confirmed with absolute certainty (van der Vaart *et al.* 2013, 138-139). The bronze items probably were the remains of a wagon/horse-gear (yoke decoration) that was dismantled and then partly burned with the deceased. The burned remains were partly deposited a little to the east of the pyre and partly left behind (Fontijn and van der Vaart 2013, 191, 193). The A-horizon was missing under the centre of the barrow, indicating that the surface was stripped before the pyre was built (Fontijn *et al.* 2013a, 114). Altogether, Barrow 7 appeared to be a rich Hallstatt C burial mound, broadly contemporaneous with the Chieftain's Grave and Barrow 3.

In the corner of the southwest quadrant traces of an oval pit containing a large amount of charcoal were discovered underneath the barrow. The pit was dated to the Middle Bronze Age A based on ^{14}C dating of a piece of charcoal that was retrieved from the pit fill (Fontijn *et al.* 2013a, 111-112). Close to this pit, traces of an (pre-barrow) eight-post structure were found. This feature was interpreted as an allée, a corridor related to funerary activities, comparable to the post alignment that was found underneath the Chieftain's Grave (see 12.1). The allée might have been related to the funeral activities of Mound 6 (Fontijn *et al.* 2013a, 110-111).

Samples for pollen analysis were taken from several locations in the barrow. As a large part of the top surface of the hill was stripped before the barrow was erected on top of it, sampling of the old surface was difficult, but on top of the wind-blown sand dune part of the old surface was preserved. A monolith tin that was driven in this section contained two soils on top of each other of which the lowest probably contained the old surface underneath the dune and the upper the old surface underneath the actual barrow. The lower soil did not reveal pollen. From the results of the upper soil a pollen diagram was derived, based on the theory described in Chapter 5. In addition eight samples that were taken from sods were analysed for pollen. Sampling and analysis of these samples was done by Achterkamp as part of her research master's thesis (Achterkamp 2009, Bakels and Achterkamp 2013). In 2009 a bulk sample was taken from the central grave assemblage by Restaura, the laboratory at which the lifted blocks were investigated. This sample was analysed for pollen by the author of the present work.

Oss-Zevenbergen 8

Barrow 8 was for a great part excavated in 1964/1965 by Modderman and Verwers. The last part (northwest quadrant) was excavated in 2004. The results of both excavations show that Barrow 8 is a single period barrow that measured approximately 12 m in diameter and 0.6 m in height. It was built of sods, covering an inhumation grave. The barrow was dated to the Early or Middle Bronze Age, based on the stretched position of the deceased. The barrow contained two

17 Laboratory of Restaura.

secondary interments (urns) of which the oldest dates to the Middle Bronze Age and the youngest to the Early Iron Age. An encircling ditch with a diameter of 9.5 m was dug into the barrow probably when the youngest urn was buried. The ditch was most likely part of the urnfield that was located northwest of Barrow 8 (see next section; van Wijk *et al*. 2009, 121-126). Samples were taken for pollen analysis: two samples from the old surface, one from the ditch fill and one from a sod[18]. In addition a monolith tin was driven into the soil underneath the barrow of which three samples have been analysed (de Kort 2009).

Urnfield, Oss-Zevenbergen 9-12

North of the barrow alignment the remains of a small urnfield were found (see figure 12.5). In addition to the Early Iron Age ditch at Barrow 8 (the remains of) four ring ditches were found, called Barrow 9 (d=5 m), 10 (d=7.5 m), 11 (d=4 m) and 12 (d=2.5-2.8 m). Fragments of urns were found in Barrows 10 and 11, which were dated to the Early Iron Age (van Wijk *et al*. 2009, 126-131). Samples for pollen analysis were taken from the ditch belonging to Barrow 10, 11 and 12. One sample from the ditch of Barrow 12 has been analysed by de Kort (2009). The samples of the ditch of Barrow 10 have not been analysed and the samples from the ditch of Barrow 11 did not contain enough pollen for analysis.

Post alignments and post structures

Five post alignments and four post structures were revealed during the excavation in 2004 (see figure 12.5). Post alignment 1 is situated east of Barrow 3 and about 116 m long. At the southern part of the alignment (close to Barrow 3) some additional posts were found, belonging to post structures 1 and 2 (see figure 12.5). Post alignment 2 is situated in extension of alignment 1, but with different orientation. Its length is unknown, but at least 18 m and probably 32 m. Post alignment 3 was found east of barrow 4 and has a length of 58 m. Two extra posts were placed parallel to the alignment, forming post structure 3. A 17 m long alignment of posts is situated between Barrows 6 and 8. The fifth post alignment is located between Barrow 8 and Mound 5. At the end of this 8 m long alignment post structure 4 is situated, consisting of 4 posts. The dating of the post alignments and structures is unknown, but van Wijk *et al*. argue that they belong to the urnfield and that they date to the Early Iron Age (van Wijk *et al*. 2009). The fill of one of the post features of alignment 1 was sampled and analysed for pollen by de Kort (2009).

Drift sand layer

Thin layers of drift sand were present throughout the entire Oss-Zevenbergen area, probably the result of (post) Medieval small scale sand drifting due to the intensive use of roads. An older layer of drift sand was found in the southeast of the area. A sample from the old surface underneath this sand layer was analysed for pollen by de Kort (2009).

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18 At the time the samples were taken it was not entirely clear yet whether the barrow was built in one phase or in two phases. In between the sods a layer with grey-yellow sand was present. It was not clear whether this layer represented a second building period or that sods were taken from less developed podzol or that the barrow was built of sods and sand. It was later concluded that the barrow was built in one phase. The pollen sample was taken from one of the sods taken from less developed soil/sand layer.

One barrow complex or not?

The Oss-Vorstengraf area was at first believed to be separate from the Oss-Zevenbergen barrows. However, it has also been assumed that they formed one large barrow complex (Fokkens *et al.* 2009a, 223-224). The area was probably first used for barrow building in the Late Neolithic, when a barrow was built in the Oss-Vorstengraf area. In the Middle Bronze Age (A) the burial complex got its shape, with probably six barrows dating to this period: the Bronze Age mound underneath the Chieftain's Grave, two additional barrows nearby and Barrow 2, 4 and 8 in the Oss-Zevenbergen area. In the following period several barrows were enlarged and/or used for secondary burials. In the Late Bronze Age/Early Iron Age two additional mounds were constructed (Barrows 1 and 6) and in the Hallstatt C period (Early Iron Age) three more barrows were added to the now already extensive burial complex (Barrow 3, 7 and the Chieftain's Grave). Two small urnfields were probably contemporaneous to the Hallstatt barrows.

The barrow complex of the Oss-Vorstengraf area and the Oss-Zevenbergen area might certainly have formed one barrow complex, since they are similar in time depth. It is however not likely that they physically formed one complex. West, east and south of the Oss-Zevenbergen area seepage of groundwater occurs, causing these areas to be very wet. The occurrence of seepage water west of the Oss-Zevenbergen area creates a natural boundary between the barrow complex of Oss-Zevenbergen and the Vorstengraf area (R. Jansen pers.comm., March 2013; see also the introduction of section 12.1.1 and figure 12.1).

12.1.2 Results

Now follows a description of the results per barrow/sampled feature of which the data have been produced by several researchers mentioned in the previous section. The data have been reprocessed and reinterpreted by the author. After this section this reinterpretation will be discussed in section 12.1.3.

Oss-Vorstengraf area

Chieftain's Grave, old surface and sods (see figure 12.6a)

The pollen spectra from the old surface and sods are very similar, indicating that sods belong to the same environment as the barrow. They show arboreal pollen percentages of approximately 55% (ADF= 100 m), except for sod 1 that shows an arboreal pollen percentage of almost 70%. The arboreal pollen component is very much dominated by *Alnus* pollen with percentages of over 65%, indicating an alder carr was present in the near surroundings. *Corylus* is well represented with percentages of 10-20%, being present in the drier parts of the surrounding forest. *Quercus* (ca. 5%), *Tilia* (1-2%) and *Fagus* (1-3%) pollen, also representing components of the dry forest, are present in low percentages. Herbal pollen consists of almost only Ericales, showing that a species-poor heathland was present at the site.

Chieftain's Grave, tree fall section (see figure 12.6b)

The pollen diagram shows a vegetation development from the period before the construction of the Chieftain's Grave. Arboreal pollen percentages fluctuated through time between 40% and 80%, indicating a fluctuating ADF between 25 and 150 m. This is mainly caused by fluctuating percentages of Ericales pollen. Other herbs are almost absent. *Alnus* shows an increase from about 40% to 60%, *Corylus* decreases from 45% to 25%. *Tilia* decreases while *Fagus* appears. The

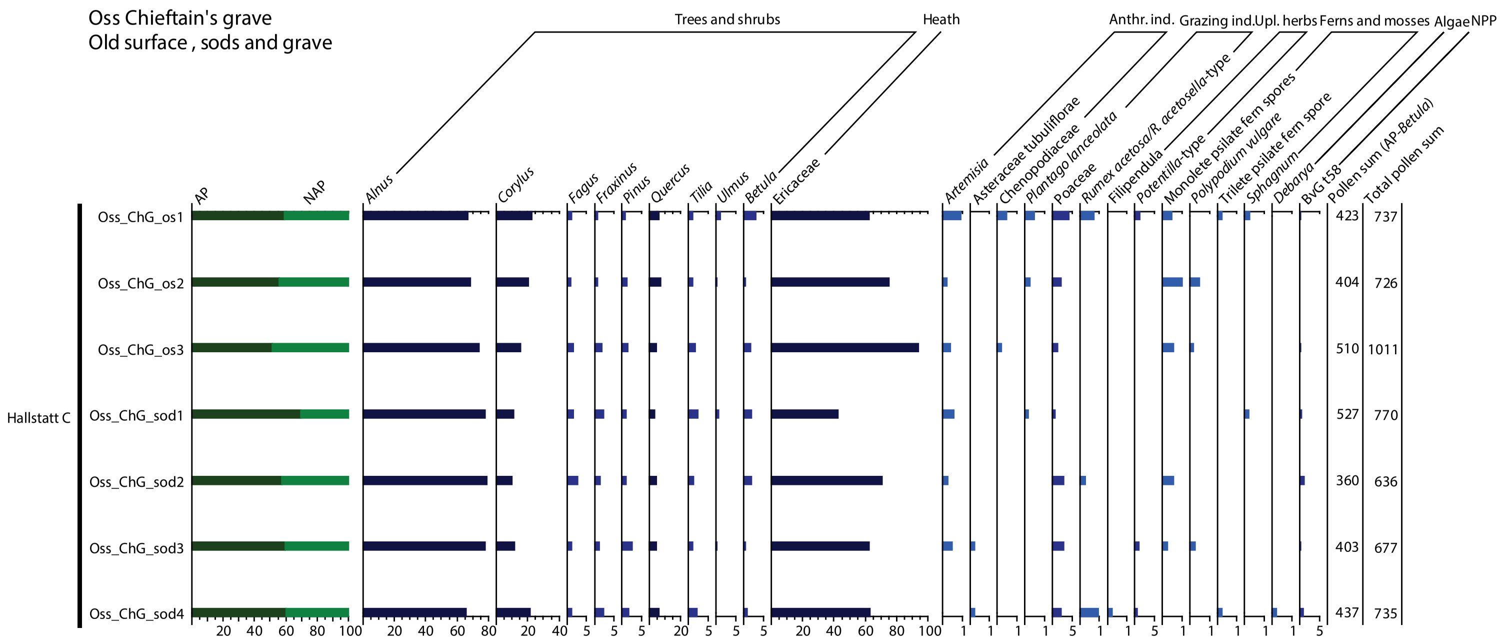
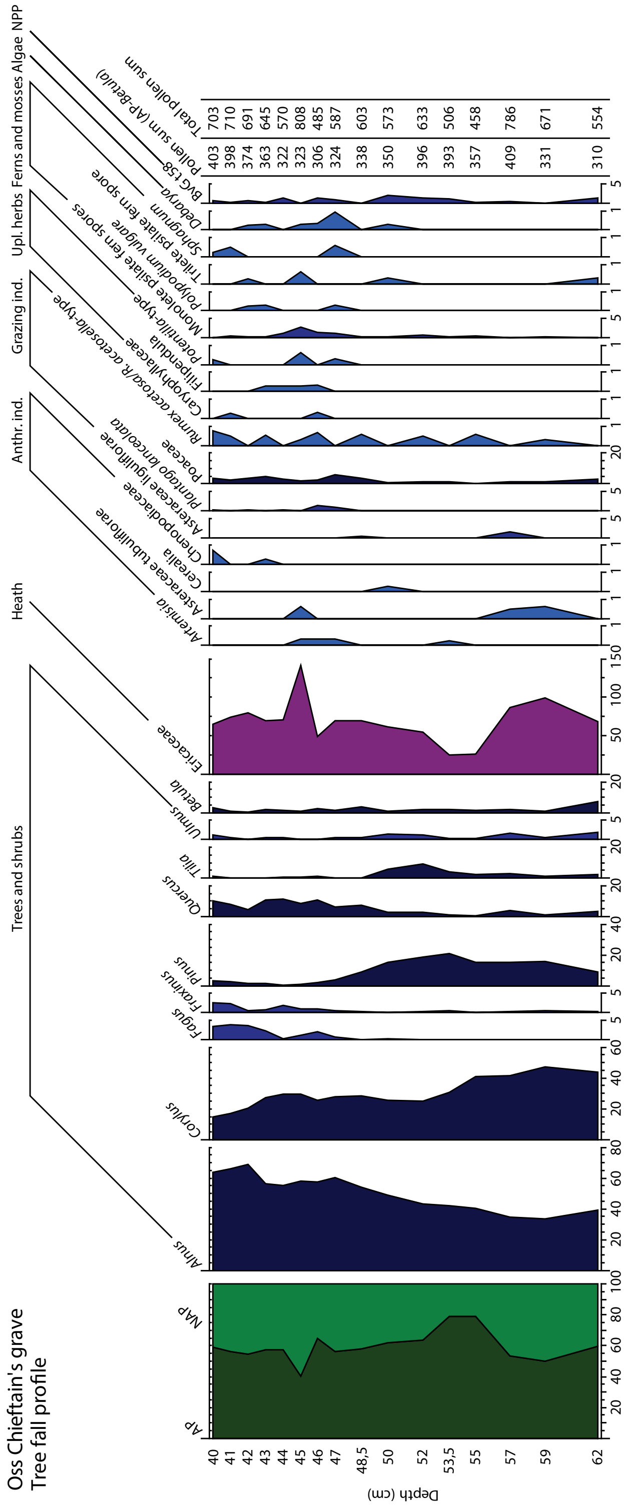


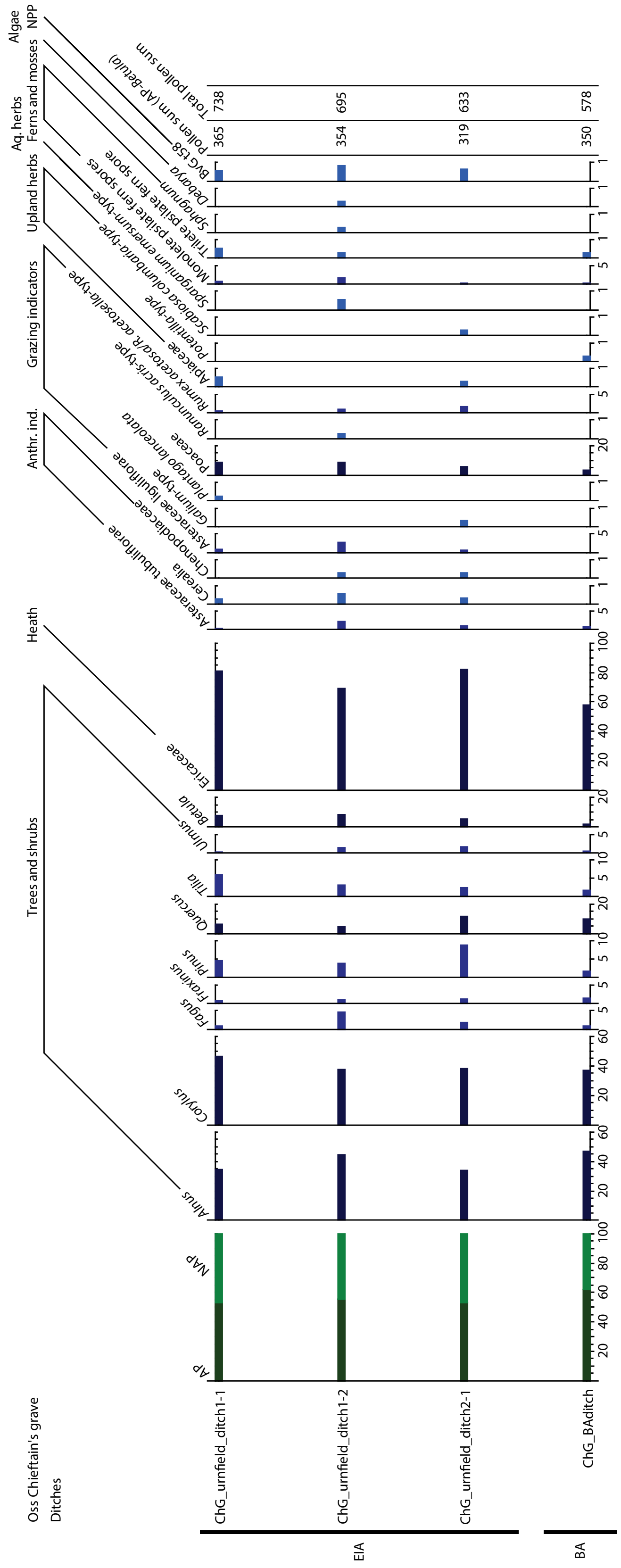
Figure 12.6a

Figure 12.6a-c. Pollen spectra from the samples taken from the Chieftain's grave of Oss area. 12.6a: pollen spectra from the samples taken from the old surface and sods; 12.6b: pollen diagram from the samples taken from section captured by the roots of the fallen tree; 12.6c: pollen spectra from the samples taken from the ditches in the Chieftain's grave of Oss area. BA= Bronze Age, EIA= Early Iron Age.
Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*



Oss Chieftain's grave
Tree fall profile
Trees and shrubs
Heath
Anthr. ind.
Grazing ind.
Upl. herbs
Ferns and mosses
Algae
NPP
AP
NAP
Alnus
Corylus
Fagus
Fraxinus
Pinus
Quercus
Tilia
Ulmus
Betula
Ericaceae
Artemisia
Asteraceae tubuliflorae
Cerealia
Chenopodiaceae
Asteraceae liguliflorae
Plantago lanceolata
Poaceae
Rumex acetosa/R. acetosella-type
Caryophyllaceae
Filipendula
Potentilla-type
Monolete psilate fern spores
Polypodium vulgare
Trilete psilate fern spore
Sphagnum
Debarya
BvG t58
Pollen sum (AP-Betula)
Total pollen sum
Depth (cm)

Figure 12.6b



Oss Chieftain's grave
Ditches
ChG_urnfield_ditch1-1
ChG_urnfield_ditch1-2
ChG_urnfield_ditch2-1
ChG_BAditch
EIA
BA
AP
NAP
Trees and shrubs
Alnus
Corylus
Fagus
Fraxinus
Pinus
Quercus
Tilia
Ulmus
Betula
Heath
Ericaceae
Anthr. ind.
Asteraceae tubuliflorae
Cerealia
Chenopodiaceae
Asteraceae liguliflorae
Galium-type
Plantago lanceolata
Grazing indicators
Poaceae
Ranunculus acris-type
Rumex acetosa/R. acetosella-type
Apiaceae
Upland herbs
Potentilla-type
Scabiosa columbaria-type
Aq. herbs
Sparganium emersum-type
Ferns and mosses
Monolete psilate fern spores
Trilete psilate fern spore
Sphagnum
Algae
Debarya
NPP
BVG 158
Pollen sum (AP-Betula)
Total pollen sum
365
354
319
350
738
695
633
578

Figure 12.6c

oldest samples show percentages of up to 20% while this species has decreased to less than 5% at the time the barrow was built.

Bronze Age ditch (see figure 12.6c)

The Bronze Age ditch (underneath the Chieftain's grave) shows an arboreal pollen percentage of approximately 60% (ADF is around 50 m). The two dominating tree pollen species are *Alnus* (~45%) and *Corylus* (~35%). *Quercus* pollen is present with a percentage of 10%. Other trees are present in percentages less than 2%. Herbal pollen mainly consists of Ericales with a percentage of 55%.

Urnfield

The ditches belonging to the urnfield of the Oss-Vorstengraf area show arboreal percentages of about 55%, indicating an open space with an ADF of approximately 75-100 m. The herbal vegetation is dominated by Ericales with pollen percentages of 70-80%. The arboreal pollen component is dominated by *Alnus* (35-45%), *Corylus* (35-45%) and *Quercus* (5-10%).

Oss-Zevenbergen

Oss-Zevenbergen 1 (see figure 12.7)

The pollen spectra taken from the old surface, and the ditch belonging to arrow 1, show arboreal pollen percentages of 45-60% (ADF=50-125 m). Tree pollen is dominated by *Alnus* (ca. 50%), indicating that an alder carr was present nearby. *Corylus* (ca. 30%) and *Quercus* pollen (5-10%) represent the forest in the higher and drier environment. Herbal pollen is dominated by Ericales with percentages from 60-120%. Other herbs, including anthropogenic indicators, are almost absent.

Oss-Zevenbergen 2 (see figure 12.8)

The oldest period, which is represented by the sample from the B-horizon, shows a non arboreal pollen percentage (NAP) of about 70%, indicating the open space had an ADF of approximately 300-500 m. The high NAP is mainly the result of a very high percentage of Ericales pollen of over 200%. Some other herbs like Poaceae are present although only in low percentages of less than 5%, indicating that the heathland was poor in species. The arboreal pollen component consists of mainly *Alnus* (ca. 45%), *Corylus* (ca. 30%), *Quercus* (ca. 10%) and *Tilia* (ca. 3%). The following period, represented by the sample taken from the E-horizon, shows a higher arboreal pollen percentage of about 70%, indicating that the open space was probably much smaller at this time. The arboreal component is comparable to the B-horizon, except for an increased percentage of *Corylus* (ca. 45%). The percentage of Ericales decreased to about 40%. The following periods, represented by respectively the sods of period 1 and the old surface and sod belonging to period 2, show similar pollen spectra as the E-horizon with an AP of about 55-70%. Only *Corylus* has decreased slightly till around 35% at the youngest period in favour of *Alnus*, which has increased to approximately 50%. The old surface belonging to period 2 shows a peak of 20% in Poaceae pollen.

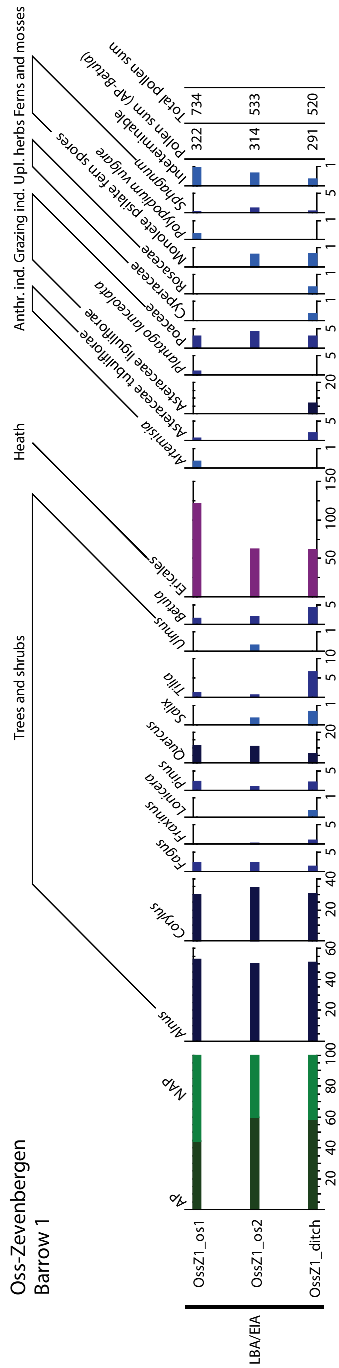


Figure 12.7. Pollen spectra from the samples taken from Oss-Zevenbergen barrow 1. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours. LBA= Late Bronze Age, EIA= Early Iron Age.*

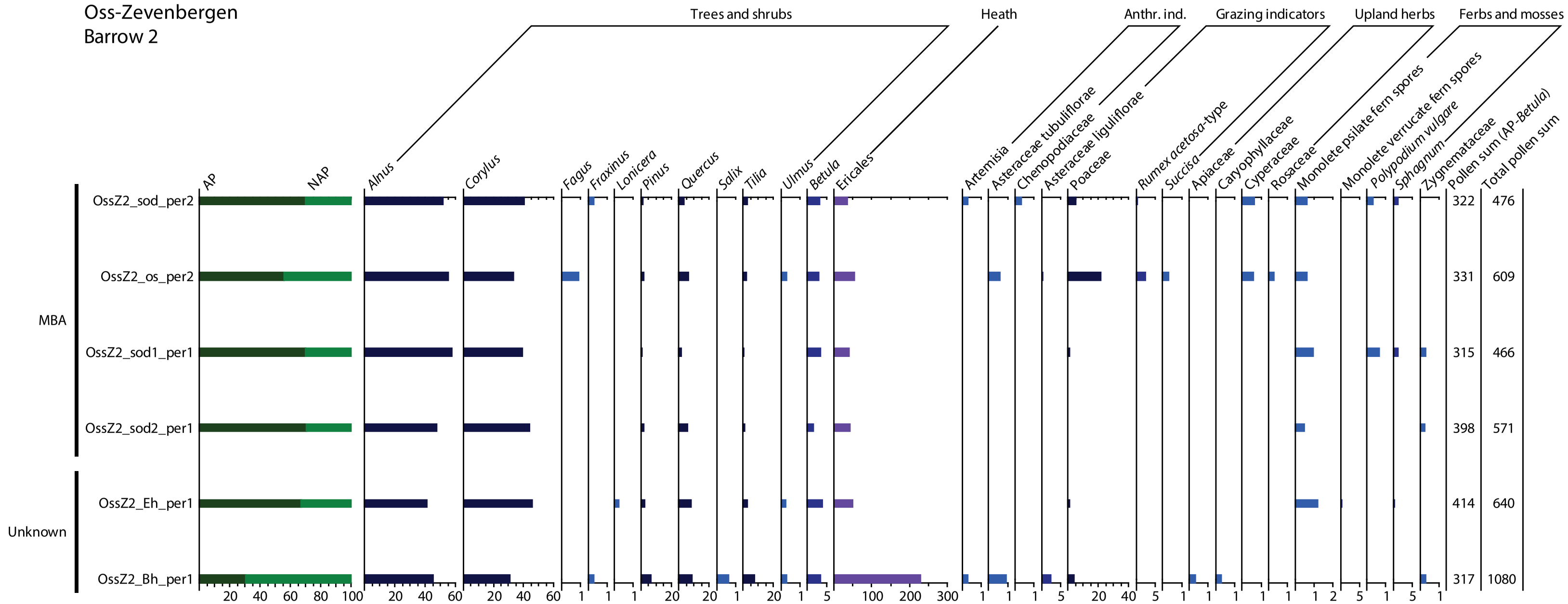


Figure 12.8. Pollen spectra from the samples taken from Oss-Zevenbergen barrow 2. OssZ2_Bh_per1 and OssZ2_Eh_per1 are samples taken from the Bh and Eh horizons of the soil profile underneath the barrow. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours. MBA= Middle Bronze Age.*

Oss-Zevenbergen 3 (see figure 12.9)

The sods and old surface show similar pollen spectra, indicating that the sods were cut in the near vicinity of the barrow location. The old surface and sods of Barrow 3 show arboreal pollen percentages of approximately 55-60%, indicating an open space with an ADF of approximately 75-100 m. The main tree species is *Alnus* with percentages of more than 50%. *Corylus* is also present in high amounts (20-45%), together with *Quercus* (3-15%). Ericales pollen dominates the non arboreal pollen component with percentages of 50-80%. Other herbs are almost absent, except for Poaceae with a percentage of 40% in sod 3.

Oss-Zevenbergen 4 (see figure 12.10)

The oldest sample, from the anthropogenic layer underneath the mound, shows an arboreal pollen percentage of approximately 50% (ADF is around 100 m). This arboreal pollen component consists of *Alnus* (ca. 40%), *Corylus* (ca. 40%), *Quercus* (ca. 10%) and *Tilia* (ca. 10%). The herbal pollen component is mainly Ericales (ca. 50%) and Poaceae (ca. 10%). There are few other herbal pollen species, which are present albeit in very small amounts.

The pollen spectra from the barrow period and the following periods show a decrease in the arboreal pollen percentage, indicating an increasing ADF of the open space. At the time the barrow was built AP was around 60%, which decreased to 15% just before the wind-blown sand covered the barrow. This is mainly due to an increase of Ericales pollen, which increases to over 500%. At that time some changes are visible in the arboreal pollen composition: *Quercus* has increased to approximately 25%, while *Corylus* has decreased to around 20% and *Tilia* has disappeared.

Mound 5 (see figure 12.11)

Pollen spectra from the old surface underneath this naturally formed hill show arboreal pollen percentages of 40-55%. Arboreal pollen is mainly *Alnus* (ca. 45%) and *Corylus* (ca. 45%). *Quercus* is present in percentages of about 10%. Ericales is the dominant herbal pollen with percentages of 75 to 150%.

Oss-Zevenbergen 6 (see figure 12.12)

The ditch of Barrow 6 shows an arboreal pollen percentage of 50% (ADF is around 100 m). Ericales (ca. 90%) is dominant in the non arboreal pollen component. Dominant trees are *Alnus* (ca. 50%) and *Corylus* (ca. 40%). Pollen from other trees like *Quercus*, *Tilia* and *Ulmus* are present in lower percentages (3-5%).

Oss-Zevenbergen 7, sods and grave (see figure 12.13a)

Pollen spectra from the sods and the grave show arboreal pollen percentages of 40-60%, indicative of an open space with an ADF of 75-150 m. The arboreal pollen component consists mainly of *Alnus* (45-65%), indicating an alder carr in the surroundings. Some difference between the sods in the percentages of *Alnus* might indicate that some were taken closer to an alder carr than others. The arboreal component representing the drier forest is dominated by *Corylus* (25-40%) and *Quercus* (5-15%). The herbal pollen component is dominated by Ericales with percentages of 65-150%.

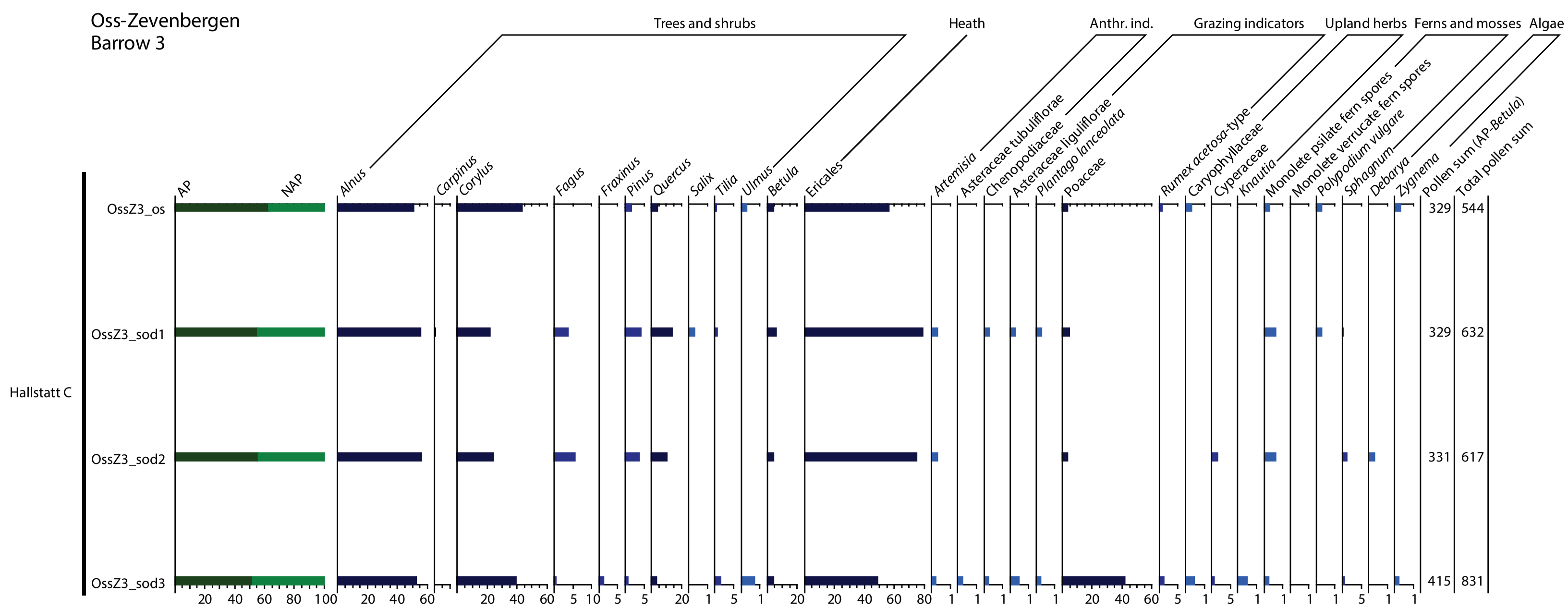


Figure 12.9. Pollen spectra from the samples taken from Oss-Zevenbergen barrow 3 Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

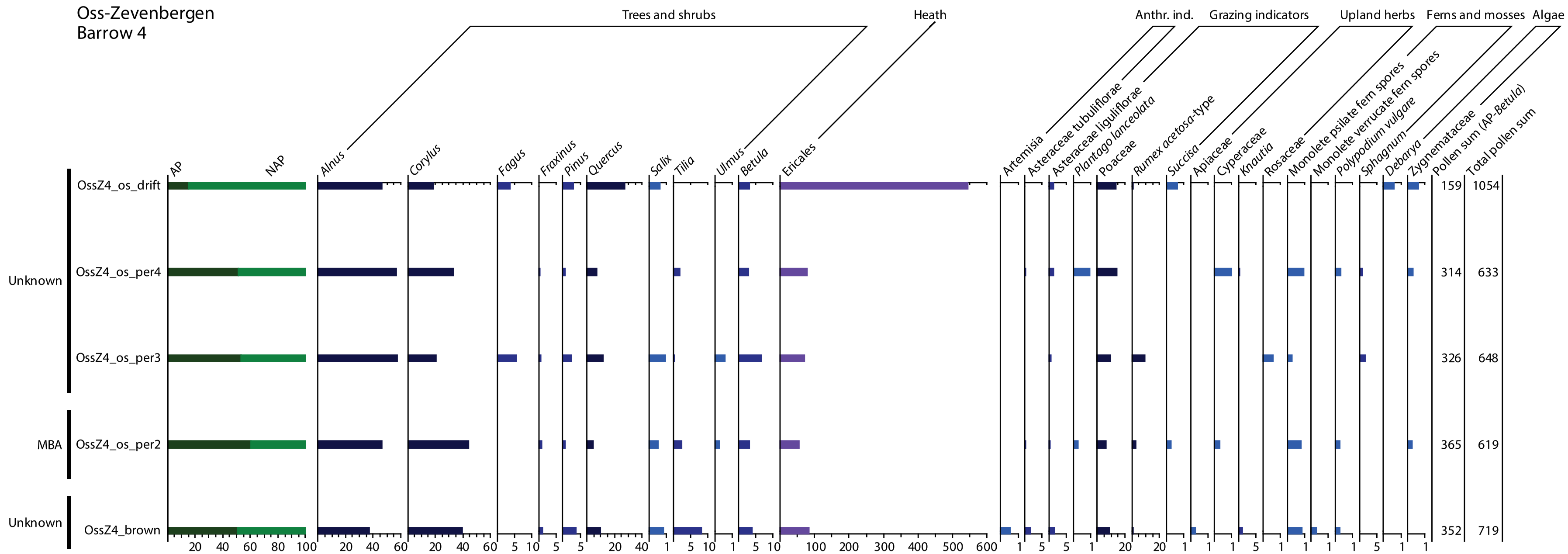


Figure 12.10. Pollen spectra from the samples taken from Oss-Zevenbergen barrow 4. OssZ4_brown is the pollen sample taken from the disturbed brown layer underneath the old surface. OssZ4_os_drift is the pollen sample taken from the old surface underneath the drift sand layer at the southern part of the barrows. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours. MBA= Middle Bronze Age.*

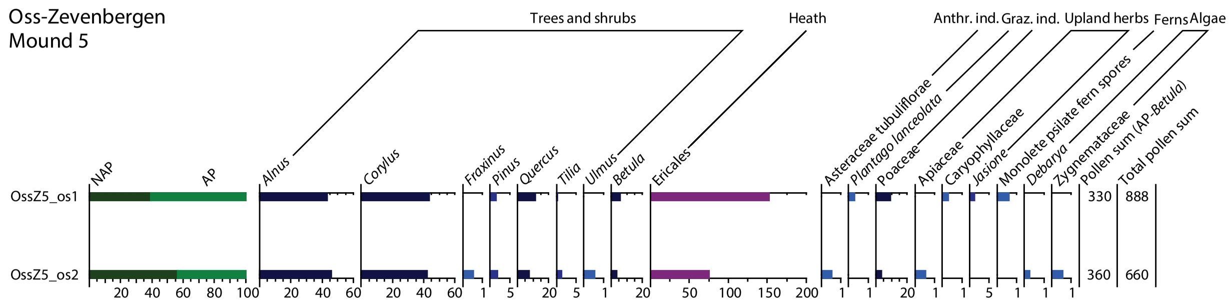


Figure 12.11. Pollen spectra from the samples taken from Oss-Zevenbergen mound 5. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

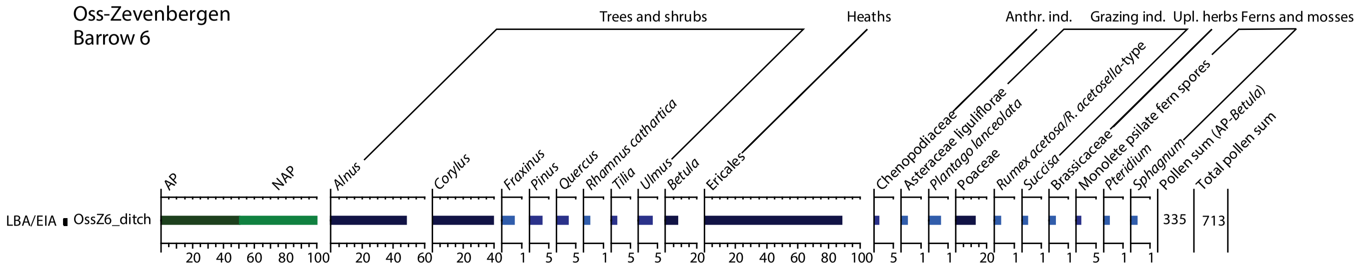


Figure 12.12. Pollen spectra from the samples taken from Oss-Zevenbergen barrow 6. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours. LBA= Late Bronze Age, EIA= Early Iron Age.*

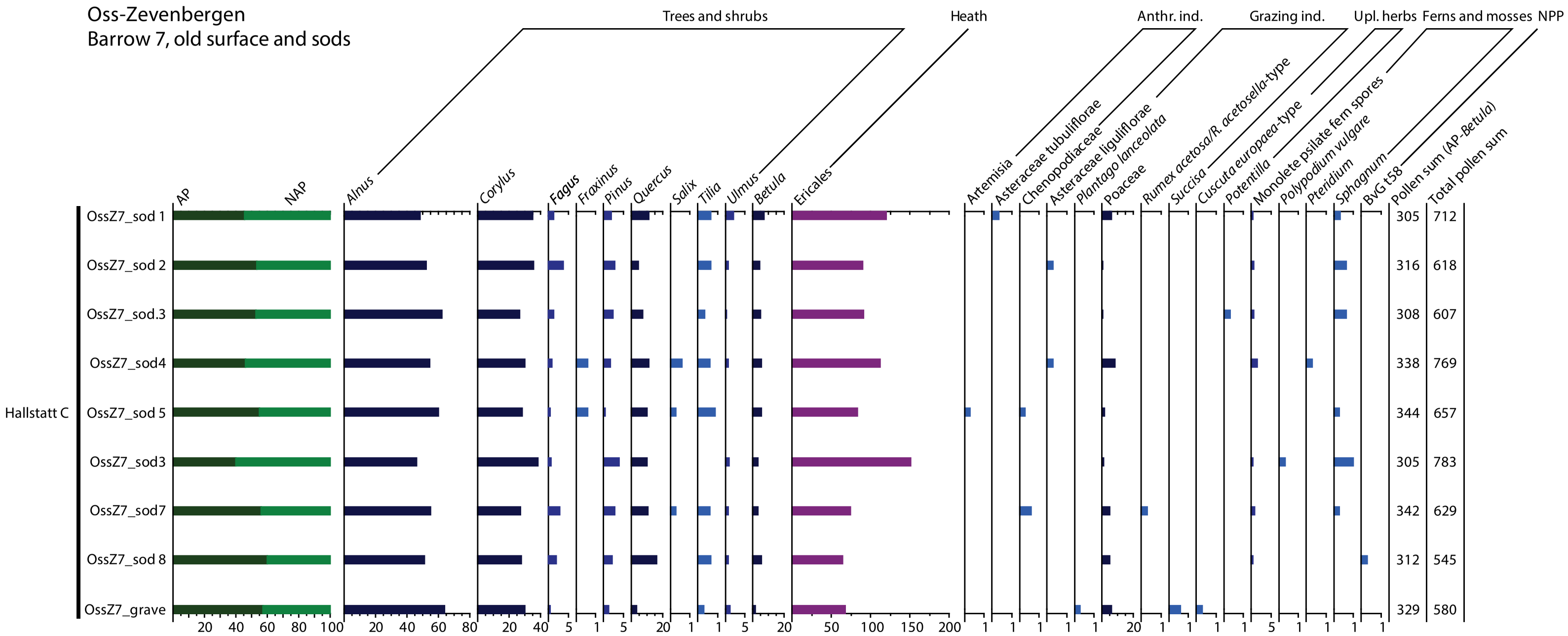


Figure 12.13a

Figure 12.13a-b. Pollen spectra from the samples taken from Oss-Zevenbergen barrow 7. 12.13a: pollen spectra from the samples taken from the sods and the grave. 12.13b: pollen diagram from the section taken underneath barrow 7. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

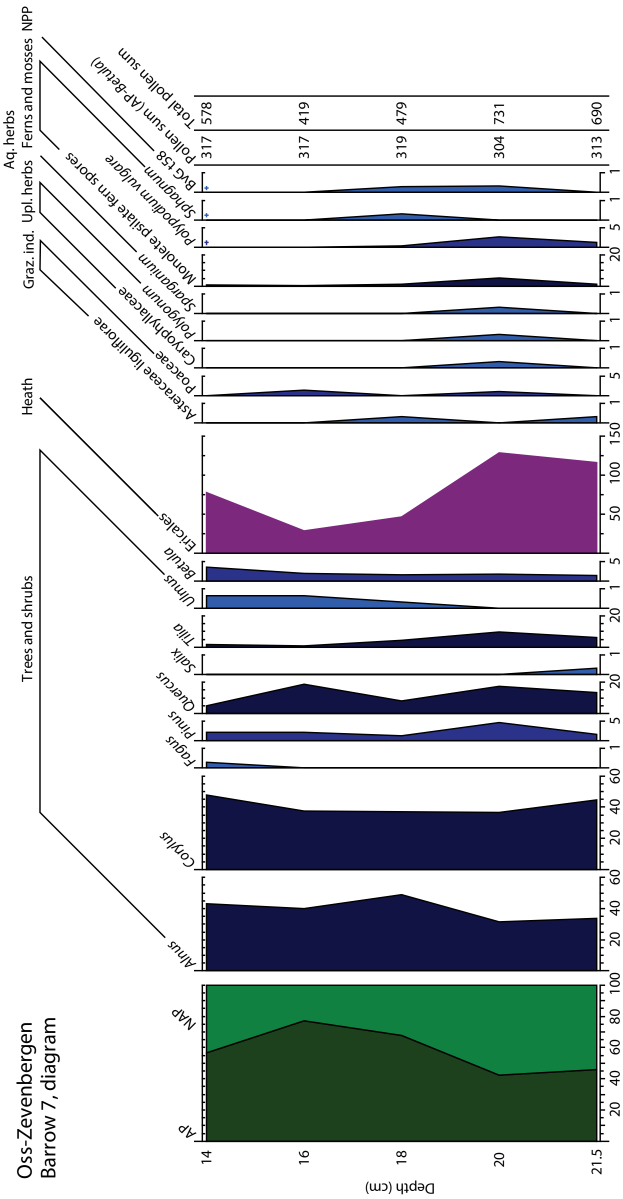


Figure 12.13b

Oss-Zevenbergen 7, pollen diagram (see figure 12.13b)

The pollen diagram shows a vegetation development from the period before the barrow was constructed. The arboreal pollen percentage fluctuated between 42% and 77% and at the time the mound was built an arboreal pollen percentage of approximately 55% can be seen, indicating an ADF of approximately 75-100 m. The herbal vegetation is dominated by Ericales, which fluctuates from over 100% to 30%. The arboreal pollen percentages fluctuate some with *Alnus* (35-50%), *Corylus* (35-45%), *Quercus* (5-20%) and *Tilia* (2-10%) being the main components.

Oss-Zevenbergen 8 (see figure 12.14)

The arboreal pollen percentage fluctuates between 35 and 60%, indicating a fluctuating size of the open space with an ADF of 50-250 m. Percentages of Ericales fluctuate between 65-180%. Other herbal species show only low pollen percentages, indicating the presence of a species-poor heathland. The arboreal pollen component is dominated by *Alnus*, which seems to increase from about 25% to 45-50%. *Corylus* is fluctuating between 35-45%. Percentages of *Quercus* (5-15%) and *Tilia* (0.5-10%) show a slight decline. Remarkable is the high percentage of *Betula* in the oldest sample, while *Betula* pollen only occurs in low amounts in all other pollen spectra from all mounds. Perhaps a Betula tree was standing nearby.

Oss-Zevenbergen 12 (see figure 12.15)

The pollen spectrum derived from the ditch that remained from barrow 12 shows an AP of approximately 50% (ADF is around 100 m). *Alnus* (ca. 60%) and *Corylus* (ca. 30%) are the main components of this arboreal pollen percentage, while Ericales is the dominating herb (ca. 80%).

Post alignment 1 (see figure 12.15)

The pollen spectrum from one of the posts from the post alignment shows an arboreal pollen percentage of 40%. The main trees are *Alnus* and *Corylus* with a pollen percentage of 45%. Herbs are dominated by Ericales with a percentage of 150%.

Drift-sand layer (see figure 12.15)

The pollen spectrum from underneath the drift-sand layer shows an arboreal pollen percentage of 45%. *Alnus* (ca. 55%) and *Corylus* (ca. 35%) are the main trees, while Ericales (ca. 120%) pollen dominates the herbal vegetation.

Size of the open space

The minimum size of the open spaces can be estimated by the measurements of the barrows and the height of the sods that had been used in the construction of the mounds (see section 7.1 and table 12.2). This leads to the following estimates of sod-cut area:

Chieftain's Grave: 11036 m^2, $r_{openarea} \approx 59$ m, based on a circular open spot
Oss-Zevenbergen_1: 442 m^2, $r_{openarea} \approx 12$ m
Oss-Zevenbergen_2: 284 m^2, $r_{openarea} \approx 9.5$ m
Oss-Zevenbergen_3: 24504 m^2, $r_{openarea} \approx 28$ m

Oss-Zevenbergen_4_{I+II}: 318 m^2, $r_{openarea}$≈10 m, Barrow 4_{III}: 64 m^2, $r_{openarea}$≈4.5 m, Barrow 4_{IV}: 604 m^2, $r_{openarea}$≈14 m
Oss-Zevenbergen_6: 85 m^2, $r_{openarea}$≈5 m
Oss-Zevenbergen_7: 817 m^2, $r_{openarea}$≈10 m
Oss-Zevenbergen_8: 262 m^2, $r_{openarea}$≈9 m

Based on the ratio AP versus NAP of the old surfaces the open spaces the barrows were built in had an ADF of 50-150 m. The sizes of the open spaces will be discussed more in detail in section 12.1.3.

12.1.3 Discussion

The barrow landscape

Middle Bronze Age (Oss-Zevenbergen 2, 4 & 8)

The oldest group of barrows at Oss-Zevenbergen that was sampled for pollen analysis (Barrow 2: sods and old surface period1&2; Barrow 4: period2; Barrow 8: Ah, sods) shows that the mounds were built in species-poor heathland. Based on the similarity of the pollen spectra from the sods and the old surface, the sods that were used to build the barrows were probably cut in the near surroundings of the barrow location. Since the barrows were located close together they were probably constructed in one open space with an ADF of about 25-100 m, based on arboreal pollen percentages of 50-70%. The forest in the environment was probably quite open with a high percentage of *Corylus* at the forest edge. Besides *Corylus* the forest's main components were *Quercus* and some *Tilia*.

Betula is present in all spectra, which could indicate its presence in the forest or perhaps some individual trees in the heathland area. In the wetter parts of the area most likely alder carr was present. This might have been a few hundred metres north of the barrows, the lowest part in the area based, or at the 'groundwater seepage wetland areas*'* in the area (see figure 12.2).

The Bronze Age ditch of the Chieftain's Grave shows an arboreal percentage of about 60%, indicating an open place at the Oss-Vorstengraf area with an ADF of approximately 50 m. The barrow was built in heath vegetation with mainly Ericales. The forest in the surroundings is, as expected, comparable to the forest around the Oss-Zevenbergen barrows. The heath in which Barrows 2, 4 and 8 were situated was most likely separate from the heath in which the Bronze Age barrow of the Vorstengraf area is situated. As has been mentioned in 12.1.1, seepage water occurs in between the Oss-Zevenbergen and the Vorstengraf area, causing conditions that were probably too wet for heath vegetation. One heathland area stretching from the Oss-Zevenbergen area to the Vorstengraf area is therefore very unlikely.

Late Bronze Age/Early Iron Age (Oss-Zevenbergen 1&6)

Compared to the Middle Bronze Age not much seems to have changed. Barrows 1 and 6 were built in an open space covered with species-poor heath vegetation. The estimated ADF of the open space was approximately 50-100 m (AP= 45-60%). The composition of the forest seems unchanged with mainly *Quercus* and *Tilia*. *Corylus* was present at the forest edge. Alder carr was present in the lower and wetter parts of the area. The spectrum of barrow 6 might represent a slightly older period than the spectrum of Barrow 1, since *Fagus* is not present here.

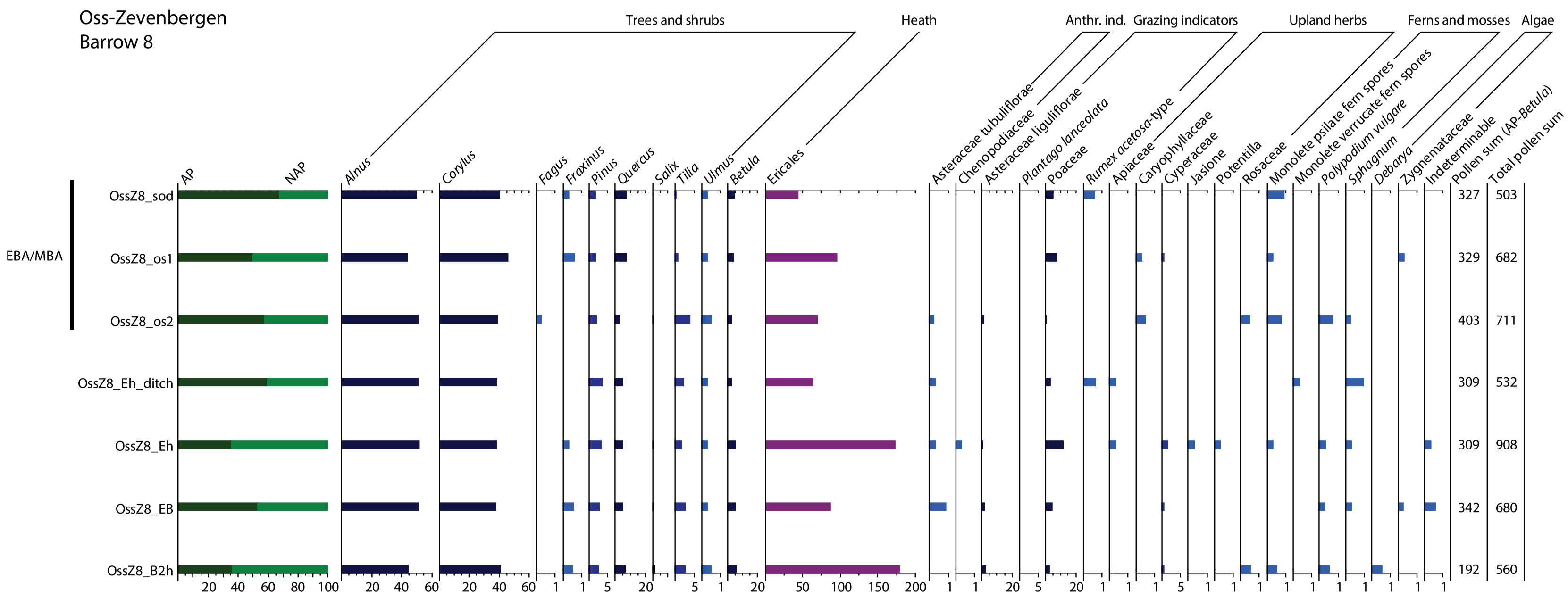


Figure 12.14. Pollen spectra from the samples taken from Oss-Zevenbergen barrow 8. OssZ8_Eh , OssZ8_EB and OssZ8_B2h are samples taken from the profile underneath the barrow, at respectively 6 cm, 10cm and 14 cm underneath the old surface. OssZ8_Eh_ditch is a sample taken from the E horizon in the ditch fill. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours. EBA= Early Bronze Age, MBA= Middle Bronze Age.*

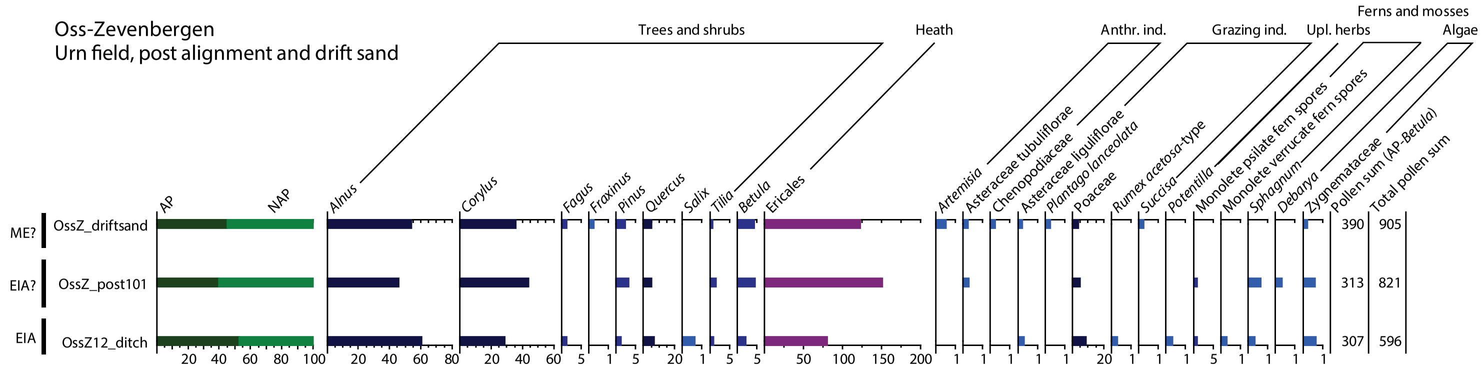


Figure 12.15. Pollen spectra from the samples taken from urn field barrow 12, the posthole fillings, and from the old surface underneath the drift sand layer. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours. EIA= Early Iron Age, ME= Medieval Period.*

Early Iron Age (Hallstatt C) (VG, Oss-Zevenbergen 3 & 7, urnfield)

The younger barrows in the Oss-Zevenbergen area (3, 7) were built in open spaces that were perhaps slightly larger than the older ones were built in (AP=40-60%, ADF≈50-150 m). The composition of the heath vegetation had not changed considerably and it was still poor in species. The forest seemed not to have changed very much, except for *Tilia* being partly replaced by *Fagus*. Some differences can be seen between sods belonging to the same barrow. This could be the result of different locations the sods were been taken from. Some sods might have been taken closer to the alder carr than others.

The Chieftain's Grave, about 500 m to the west, shows a similar picture. It was probably erected at approximately 50-100 m from the forest. Especially an alder carr must have been reasonably close, indicated by high percentages of *Alnus*.

In addition, the pollen spectrum of the ditch of Barrow 12, belonging to the urnfield near Barrow 3, indicates a vegetation composition as described above.

Pre-barrow landscape (Oss-Zevenbergen 2 & 8, Oss-Zevenbergen 7 and Chieftain's grave)

Two of the Bronze Age barrows (2 and 8) provide information about the landscape before barrow building took place. These spectra show that the open space already existed and that it was covered with heath vegetation before the barrows were built. The forest does not seem to differ greatly from later periods with alder carr in the lower parts of the region and *Quercus* and *Tilia* being the main components of the drier forest. However, *Tilia* seems to have a higher share in the forest at the oldest spectra of Barrows 2 (*e.g.* Bh_per1; see figure 12.8) and 8 (*e.g.* Eh, EB and B2h; see figure 12.14). The size of the open space might even have been larger than when the Middle Bronze Age barrows were built, with an ADF up to 200-500 m (AP barrow 2 Bh_per1 and barrow 8 B2h≈30%, see figure 12.8 and section 12.14). A barrow in the Oss-Vorstengraf area that dates to the late Neolithic B period was situated about 200 m southwest of the Chieftain's Grave (figure 12.1b). Although no palynological data are available from this barrow it can be assumed that this barrow was built in heath vegetation as well, based on palynological data discussed in chapter 8-12, showing that all barrows were built in heath vegetation. This could indicate that all barrows were built in a narrow, but long-stretched heath area with a length of about 1 km that was already present in the Neolithic. However, since the area in between the Vorstengraf area and the Oss-Zevenbergen area probably was very wet due to seepage, it is more likely that there were two separate heath areas. In one heath area the Neolithic barrows of the Vorstengraf area were built, in the other heath area the first barrows of the Oss-Zevenbergen group were built.

Barrow 2 was built on an Umbric Podzol (Dutch classification: Moderpodzol). All other investigated barrows were built on a Carbic Podzol (Dutch classicifation: Humuspodzol). It was suggested by de Kort that the open space in which Barrow 2 was built was created from forest recently, since heath vegetation would have caused degradation of the soil to a Carbic Podzol (de Kort 2009). This could indicate that Barrow 2 was one of the first barrows that was built at Oss-Zevenbergen, before the heath vegetation could change the soil into a Carbic Podzol. However, since the formation of a Carbic Podzol underneath heath vegetation can take 250 years (and most likely takes even a longer period; Andersen 1979), it is not likely that the open space was created very recently or for the intention of building a barrow there.

What the heath areas were used for prior to the barrow building is not known. Flint artefacts, dating to the Mesolithic, have been found during the excavation campaigns in 2004 and 2007 (van Hoof 2009, 186), suggesting that the area was in use by prehistoric man long before the first barrows were erected. Indications for a settlement have only been found for the Middle Bronze Age south of the burial complex (see figure 12.1b; Fokkens and Jansen 2004, Jansen and van der Linde 2013a, 43-44). It was suggested that part of the area might have been used as an agricultural field, indicated by the brown layer that was present underneath Barrow 4. This can however not be confirmed by pollen analysis (see figure 12.10). All pollen spectra show that a heath vegetation was present that was comparable to that of the barrow period: very poor in species other than Ericaceae. Based on the arboreal pollen percentages the ADF of the open space has probably fluctuated through time before the barrows were built and probably at some point in time, the ADF was larger than when the barrows were built (*e.g.* maximum AP= 30%-35% in the pollen spectra Bh_per1 of Barrow 2 and B2h of Barrow 8, indicating an ADF of approximately 250-500 m). The fluctuating size of the open space could have been the result of fluctuating human related activities.

As has been explained in previous chapters, to maintain the heath it was probably managed. Changes in grazing pressure could have caused varying ADF, although grazing indicators are not present in high amounts in the pollen spectra. Particles of charcoal that were found in the soil profiles throughout the entire area could indicate that heath vegetation was regularly burned. The heath could also have been managed by sod-cutting. From the Middle Bronze Age onwards sods were cut in the area for the building of barrows, but it is not known whether sods were already cut in the area before. The anthropogenic activities might even have caused local sand drifting events. A layer of wind-blown sand was revealed underneath Barrow 7, indicating such a period of sand-drifting probably in the Neolithic period. This could have been a direct result of (too extensive) heath maintenance activities in the area. When sods are cut a bare soil is left behind. Possibly in combination with intensive grazing activities vegetation was not able to stabilize the soil and the topsoil could be blown away locally. The Middle Neolithic sand-drifting event recorded at Barrow 7 predates the barrow building activities and it is not known whether sod cutting already took place there at that time. Later events of sand-drifting were recorded in the area as well. For example mound 5 appeared to be a natural hill formed of wind-blown sand. Although the mound has not been dated, the pollen spectra from the old surface underneath the sand suggest that the sand was deposited in the Middle Bronze Age (*Fagus* is still absent). The activity of barrow building might very well have contributed to this sand drifting event.

Pollen spectra showing the vegetation composition from before the Iron Age barrows were built can be obtained from Barrow 7 and the Chieftain's Grave. Although the pollen spectra from underneath Barrow 7 and the Chieftain's Grave have not been dated, the pollen composition of both diagrams suggests that they go back to before the Bronze Age barrows were constructed. The lower parts of the diagrams show relatively high percentages of *Tilia*, reaching 5-10%. These percentages can also be observed in the older spectra of the soil underneath Barrow 2 (*e.g.* Bh_per1) and 8 (*e.g.* B2s). Bakels and Achterkamp (2013) suggest that the lowest spectra from the soil underneath Barrow 7 date to the Early Bronze Age, which indeed precedes the Middle Bronze Age barrow building. Then *Tilia* decreases and *Fagus* increases, probably representing the replacing of *Tilia* by *Fagus*.

The pollen diagrams of Barrow 7 and the Chieftain's grave both show a fluctuating ADF much like the older barrows. The species-poor heathland areas were probably fluctuating in size and at some point in time larger than when the Hallstatt C barrows were built (minimum AP≈40%, ADF≈150 m).

Post-barrow landscape

What happened to the area after the barrows were built is only partially known. In the Medieval Period the barrow complex of Oss-Zevenbergen was probably used as an execution site. Two inhumation graves dated to the 13^{th} and 14^{th} century cal AD were found dug into Barrow 2 and a 15^{th} century cal AD inhumation grave was found in Barrow 7 (Fontijn *et al.* 2013b, 313). There are no archaeological traces that could indicate what the area was used for before the Late Medieval Period, but the continued pressure by man is indicated by the pollen spectrum from a sample taken underneath a drift sand layer that had covered Barrow 4. This spectrum shows that the open space had increased, possibly by increased grazing and/or burning activities. Layers of wind-blown sand that were found at the flanks of the barrows could have been the result of this increased activity. It is suggested that they are related to the intensive use of roads in the (post) medieval period (van der Linde and Fokkens 2009, 51).

12.1.4 In conclusion: the history of the Oss-Zevenbergen landscape

A species-poor heathland area was present on top and at the side of a ridge of cover sand in the Oss-Zevenbergen area, long before the first barrows were built. Two heath areas had probably developed, separated by a due to seepage very wet area. The ADF of the open space at Oss-Zevenbergen was probably fluctuating through time and might have reached a maximum of approximately 500 m already long before the barrows were built, according to the pollen spectra of Barrows 2 and 8 (*e.g.* b2: Bh_per1 and b8: B2h). Grazing and burning activities and possibly sod-cutting were probably involved in maintenance of the heath vegetation and varying pressure in these human related activities might have been responsible for the varying heathland size and perhaps even some local sand drifting when the pressure by grazing, sod-cutting and/or burning became too high.

Some indications for a Middle Bronze Age settlement have been found south of Oss-Zevenbergen (see figure 12.1b) and it can be assumed that the community responsible for heath management activities were settled at this location. Alder carr was present in the lower and wetter areas in the region, probably a few hundred metres to the north of the Oss-Vorstengraf area. The forest in the drier surroundings consisted of mainly *Quercus* and *Tilia* with *Corylus* present at the forest edge. In the Middle Bronze Age barrows (barrow 2, 4 and 8) were built in an open space with Ericaceae as the main vegetation and an ADF of approximately 25-100 m. Since they were located on one of the highest locations in the area the barrows were probably highly visible in the landscape. The heathland had perhaps slightly expanded when the youngest group of barrows was built during the Early Iron Age. Not only were new barrows constructed but also present barrows were re-used. The construction of the very rich Chieftain's Grave emphasises the importance of this grave field. At this time the forest had undergone some slight changes and *Fagus* had partly replaced *Tilia*. After this period the area was probably kept in use for grazing. There are no indications that the area had been used as settlement area or for other activities like crop cultivation. All this time the barrows must have occupied a prominent place in the landscape while situated on a relatively high location with the vegetation kept low by management activities.

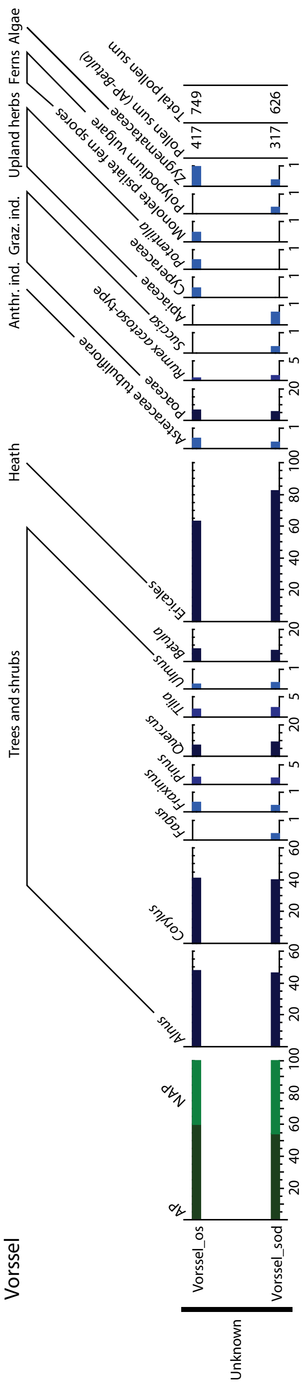


Figure 12.16. Pollen spectra from the samples taken from the Vorssel barrow. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

12.2 Vorssel

Close to Heesch a group of six barrows is located called the Vorssel. One of these barrows was palynologically investigated by de Kort in 2005 after it was reported disturbed (de Kort 2005).

12.2.1 Site description and sample locations

Mound 2 of the barrow complex was built from sods on top of a Carbic Podzol (Dutch classification: Humuspodzol). The mound has not been dated. Two other barrows in the complex contained Drakenstein urns, dating them to the Bronze Age. Samples were taken from the old surface and from one of the sods of arrow 2. Two samples were prepared and analysed described by the methods Chapter 4.

12.2.2 Results and discussion

See figure 12.16

The barrow was built in an open space with an ADF of about 50-100 m (AP≈55%) covered with heath vegetation. There were only few other herbs besides Ericales present amongst which some grasses. The dry forest in the surroundings consisted mainly of *Quercus* and *Tilia* with *Corylus* at the forest edge. Alder carr was present in the wetter parts of the region and the main contributor to the arboreal pollen component.

12.3 Slabroek

A grave field that is located at Uden-Slabroekse heide (see figure 12.1) has been partially excavated in 1923 by Remouchamps (Remouchamps 1924, Jansen and Louwen in prep.). After the excavation the area has been partially used for crop cultivation until 2003, when it was bought by Staatsbosbeheer to turn it into a nature reserve area. The grave complex was supposed to form part of the area. It was supposed to be presented and to be visible to the public as an archaeological monument and as such to contribute to the cultural tourism. The area was therefore archaeologically investigated in 2005 (prospectively) and excavated in 2010 (van Wijk and Jansen 2005, Jansen and Louwen in prep.). Several samples for pollen analysis have been taken and analysed.

12.3.1 Site description and sample locations

The area is centrally located on the plateau of the Peel Blok, about 4 km south of the Oss-Zevenbergen complex (see section 12.1.1). The urn field is located on a ridge of cover sand. The size of the complex is unknown, but based on present knowledge it should at least have been 250 by 200 m. The soil is classified as a Carbic Podzol (Dutch classification: Haarpodzol). During the Medieval Period the area was covered with heath vegetation until it was used for crop cultivation between the early 20th century and 2003 (see previous section).

The area was first excavated in 1923. At that time 38 burial mounds were discovered. Most of them were built of sods and they were all surrounded by a ditch. In many of the barrows urns were found that were usually placed on the old surface (some were dug into the old surface) before they were covered with a barrow.

In 2005 and 2010 the area was re-investigated. The area was highly disturbed by the cultivation activities during the last century and in 2005 the remains of only 10 of the 38 monuments recorded by Remouchamps were rediscovered. On the other hand, 26 'new' ring ditches and the remains of two burial mounds were found (van Mourik 2005, 43). The excavation campaign in 2005 revealed that the preservation of all archaeological features was very poor. To document all traces an area of almost two hectares was completely excavated in 2010, when all archaeological features were excavated and recorded. Several 'new' burial monuments were discovered in 2010, amongst which a rich Iron Age inhumation grave and several burials from the Roman Period. This excavation revealed that the cemetery must originally have existed of more than hundred burial monuments and probably has been in use from the Bronze Age until the Roman Period (Jansen and Louwen in prep.). From all the burial monuments and features found during the excavations in 2005 and 2010 several samples for pollen analysis have been taken and analysed of which the details will be described below.

Slabroek 39 and 40

In 2005 the remains of two burial mounds were excavated, Slabroek 39 and 40. Slabroek 39 appeared to be a barrow with a diameter of about 30 m and a height of about 50-60 cm. The burial mound was built of sods that had an average length of 50 cm and were between 7 and 29 cm thick. The central grave was looted. The base of the barrow was dated by OSL to the Middle Bronze Age (1765-1500 cal BC; van Mourik 2005). Samples for pollen analysis were taken and analysed by de Kort and van Mourik. De Kort analysed a sample from a sod and a sample from the old surface underneath the mound (de Kort and van Mourik 2005). Van Mourik analysed a sample from the old surface and two samples were taken respectively 5 and 10 cm below the old surface underneath the mound (de Kort and van Mourik 2005).

Slabroek 40 was heavily disturbed and only 10 cm of its original height had been preserved. It could still be observed that the barrow was built of sods and was surrounded by a ditch with a diameter of 12 m. Three samples were taken from this ditch by de Kort of which two were analysed for pollen: one sample from the base of the primary ditch fill and one sample from the B horizon that had developed in the ditch fill (see figure 12.17; de Kort and van Mourik 2005).

Urnfield

During the excavation of 2005, 26 new ring ditches were discovered. At the north of the burial complex three ring ditches were found, of which one, Slabroek ditch 43 (see figure 12.17) the ditch fill has been sampled for pollen analysis by de Kort (de Kort and van Mourik 2005).

In 2010 all discovered ring ditches belonging to the urnfield have been excavated and recorded. Ditch 43 has been sampled for pollen analysis again and in addition samples were taken from Slabroek ditch 12 (see figure 12.17) by the author of this thesis (see also 6.1). Although none of the ring ditches has been dated urnfields are generally assumed to date to the Late Bronze Age/Early Iron Age. The dating of the urn field of Slabroek can probably be further specified to the Early Iron Age, based on the finds of several Early Iron Age pottery by Remouchamps (Remouchamps 1924).

Slabroek ditch 43 and 12

Ditch 43 has a diameter of 13-14 m. De Kort has taken four samples from the northern part of the ditch. Three of these samples have been analysed: one sample from the B horizon that had developed in the ditch fill, one sample from the base of the E horizon and one sample from the top of the Eh (de Kort and van Mourik 2005). In 2010 ditch 43 has been sampled for pollen again, but this time samples were taken from the southern part of the ditch (referred to as ditch 43A).

Ditch 12 has a diameter of 7 m. This ring ditch had already been discovered by Remouchamps in 1923, who found an urn that was most likely filled with cremation remains[19]. From the section of the ditch fill of both ditches 43 and 12 samples were taken from the top to the bottom every cm downwards. Samples from the bottom of the fill have been analysed since it has been argued that samples from the bottom of the ditch fill will probably provide the most reliable information about the period that is closest to the period the ditch was dug (see for argumentation 4.1.4).

Ditch 'landweer'

At the western part of the burial complex a 340 m long ditch was discovered in 2005 that was partially filled with sods. The ditch was probably part of a Late Medieval defence system called '*landweer*' generally dating to around 1400 cal AD. Three samples were taken for pollen analysis by de Kort. One sample from the bottom of the primary fill and one sample from bottom of the secondary fill were analysed (de Kort and van Mourik 2005).

12.3.2 Results and discussion

All pollen spectra (fig 12.18) show heath vegetation with mainly Ericales (most likely *Calluna* as has been found in the urnfield ditches 12 and 43) and some grasses. Through time, the heath area varied in size and was probably smallest at the time (Middle Bronze Age) barrow 39 was built with an ADF of approximately 50 m (AP=60%). The heath expanded in the following period when several ditches were dug in the area during the Early Iron Age, although ditch 12 seemed to have been dug closer to the forest. The heath was probably larger than in the period the ditch of the *landweer* was dug. AP was only 10-30% in the samples from the B-horizon in that ditch. The pollen spectra are in agreement with the Late Medieval dating suggested by the excavators (see section 12.3.1). This is indicated by the relatively high percentage of *Secale*, which was not commonly introduced in the Netherlands before the Roman Period (van Zeist 1976, Behre 1992). The find of this species and some other Cerealia indicate that crop cultivation took place nearby. There are no indications that this was also the case in the earlier periods, when the Iron Age ditches and the Middle Bronze Age barrow were created. Some anthropogenic indicators were found, but only in very low numbers.

During the entire period represented by the samples the forest composition did not seem to change much. Alder carr was present in the surroundings on the lower and wetter locations (probably west of the area, see figure 12.1b). *Corylus* and *Quercus* dominated the forest on the higher and drier areas. *Betula* might have been part of the forest or have been present in the heathland area as individual trees. Although not all pollen spectra can be placed exactly in time, it is likely that the area was covered with heath vegetation for centuries and that the area must have been kept open to maintain this heath vegetation.

19 Cremation remains were not considered interesting at that time and were often discarded.

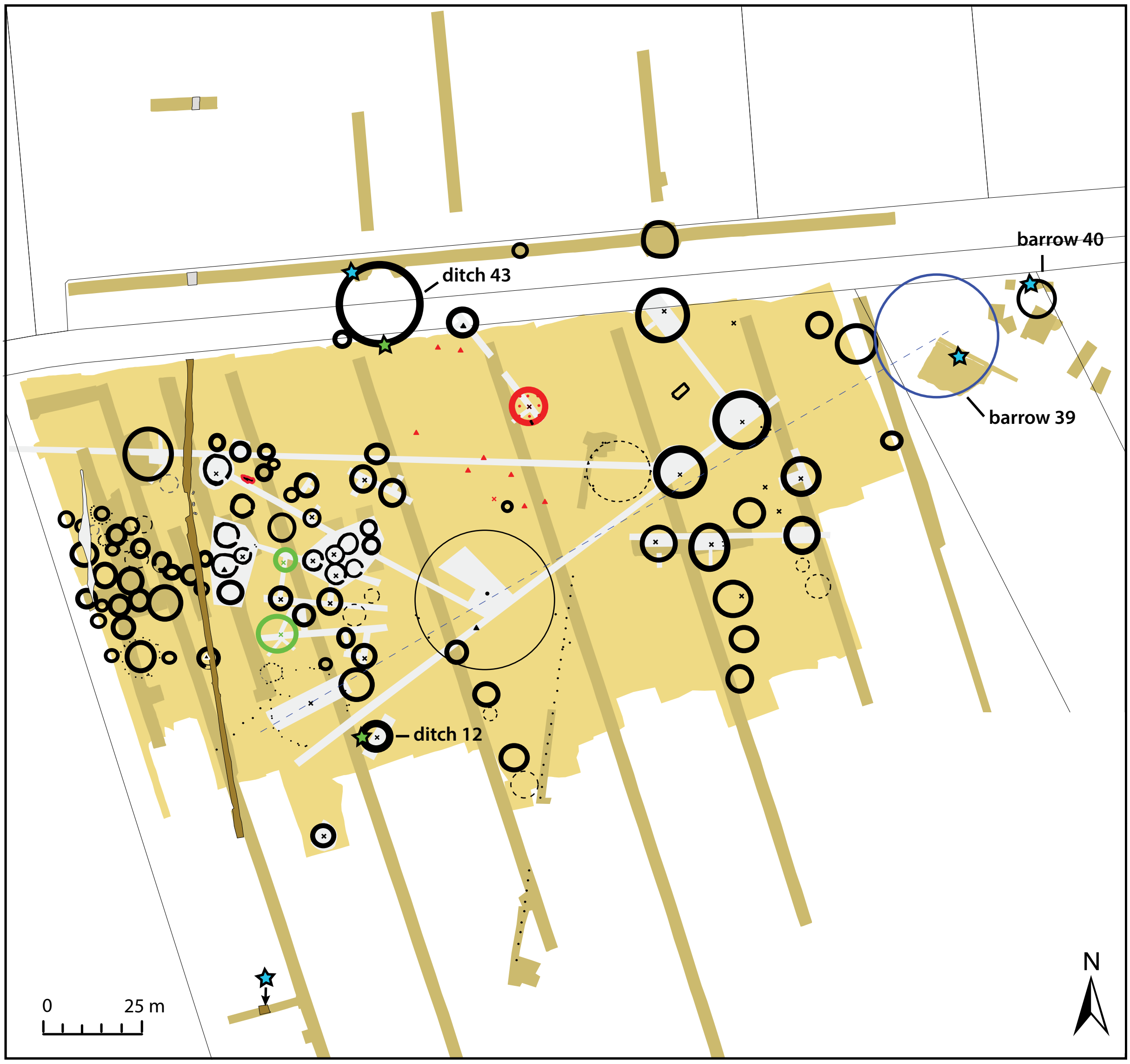


Figure 12.17. Locations of the samples taken at Slabroek. Figure after Jansen and Louwen (in prep.).

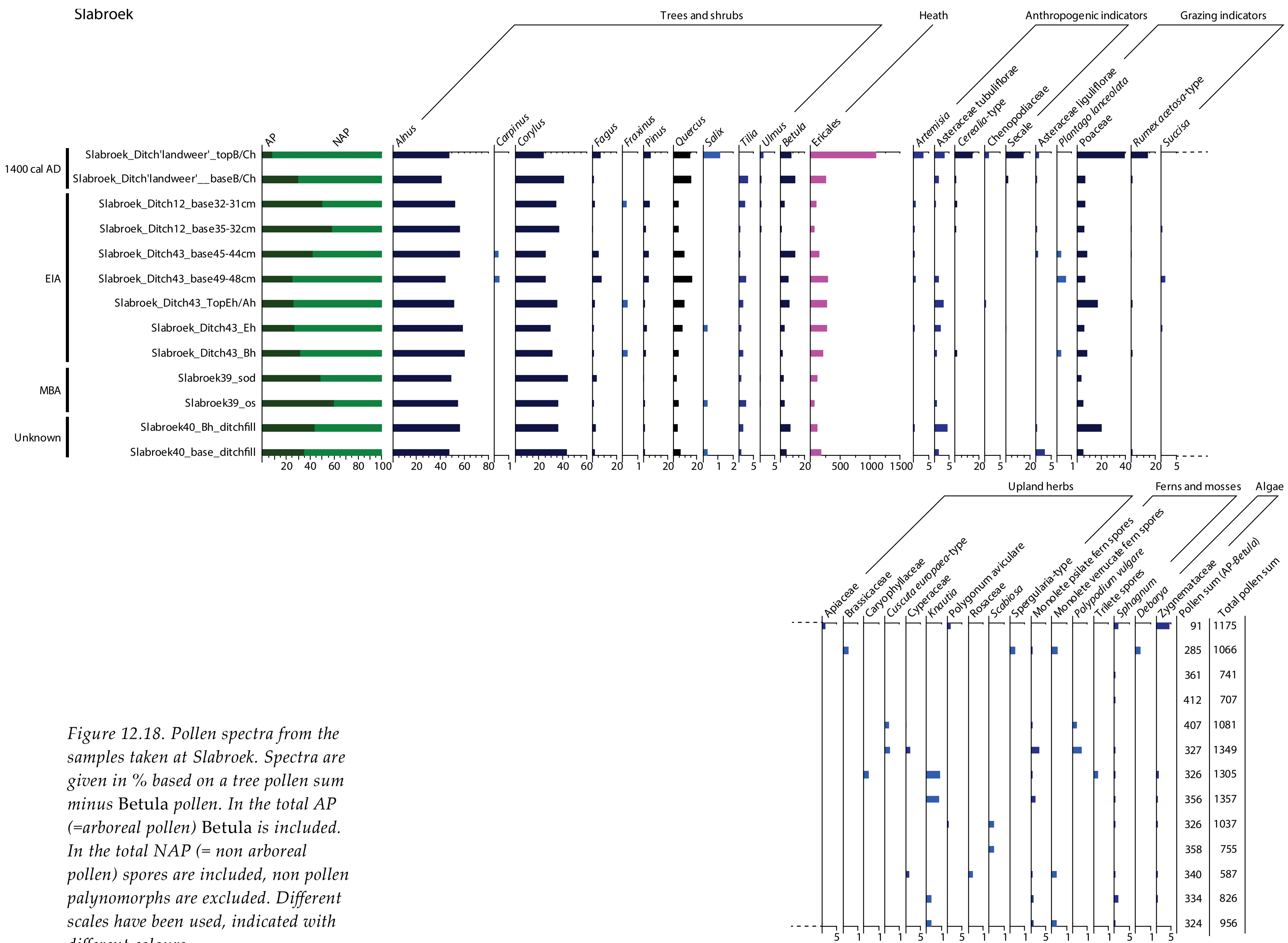


Figure 12.18. Pollen spectra from the samples taken at Slabroek. Spectra are given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

12.4 Schaijk

12.4.1 Site description and sample locations

Near Schaijk five barrows were excavated in 1937 by van Giffen (van Giffen 1949). The old surface of one of these barrows (Tumulus 3) was sampled and analysed for pollen by Waterbolk (van Giffen 1949, Waterbolk 1954). This barrow has not been dated.

12.4.2 Results and discussion

See figure 12.19

The barrow was built in an extensive heath area with an ADF that could have reached approximately 500 m (AP≈25%). Other herbs besides heath were practically absent. The forest in the surroundings was dominated by alder carr in the wetter regions. The drier regions were covered with mainly *Tilia*, *Quercus* and *Betula* with *Corylus* present numerously at the forest edge.

12.5 Palynological results from palaeosoils, peat and lake sediments

In the environment of the Slabroekse heide van Mourik has palynologically investigated several palaeosols (fossilized soils), peat and lake sediments (see figure 12.1; van Mourik *et al.* 2012b). In addition he applied OSL-dating to these soils and sediments and in combination with ^{14}C-dating he could make a reconstruction of the evolution of agricultural soils and land forms in the area. The data of his results will be used by the author to make a regional vegetation reconstruction of the area around Oss-Zevenbergen from around 4700 cal BC.

12.5.1 Site description and sample locations

Schaijksche heide

The Schaijksche heide is a former heath area that was used for sod cutting in the 12th and 13th century AD. The most part of the area has been planted with pine forest in the early 20th century, which is the main vegetation at present times. It is located approximately 5.5 km southeast of Oss-Zevenbergen and about 2.5 km northeast of the urnfield of Slabroek (see figure 12.1). The profile that was sampled for pollen analysis consists of a podzol, developed in wind-blown sand, which was deposited on top of a podzol developed in cover sand. The wind-blown sand deposits were dated to around 4700 BC by OSL (three OSL dates were determined: 4790 ± 308 BC, 4666 ± 377 BC, 4684 ± 337 BC). Samples for pollen analysis were taken at 5 cm interval (van Mourik 1985).

Sint Annabos

Sint Annabos is a wetland nature reserve that used to be an extensive alder carr. It is situated about 7 km south of Oss-Zevenbergen and about 3.5 km southwest of the urnfield of Slabroek (see figure 12.1). Peat formation has taken place in the area, which started between 4710 and 4530 cal BC. The profile that was sampled for pollen consisted of three layers. The 2A layer developed in cover sand; the H2 and H1 horizons consisted of peat. The H2 layer consisted of humified

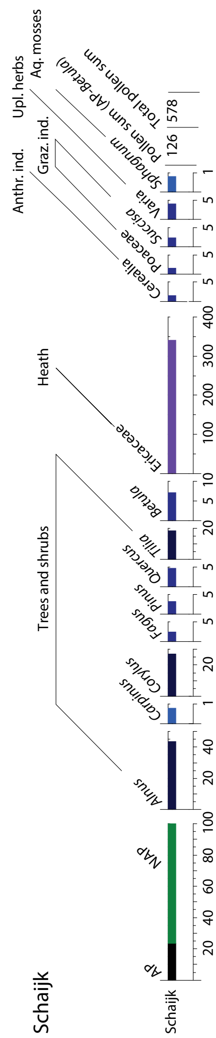


Figure 12.19. Pollen spectrum from the sample taken the Schaijk barrow. The spectrum is given in % based on a tree pollen sum minus Betula *pollen. In the total AP (=arboreal pollen)* Betula *is included. In the total NAP (= non arboreal pollen) spores are included, non pollen palynomorphs are excluded. Different scales have been used, indicated with different colours.*

organic plant remains and the H1 horizon consisted of humified plant remains with blown in mineral grains (see figure 12.21,). Samples were taken every 5 cm (van Mourik 1987).

Venloop

The Venloop is a stream valley where peat formation had taken place on top of a mineral soil (cover sand). Most of the peat had disappeared due to drainage of the area. At some locations the peat was preserved and one of these locations was sampled for pollen analysis (van Mourik and Pet 2001). Samples were taken every 5 cm. According to the ^{14}C-dating peat formation started between 750 and 410 cal BC. The sampled profile was situated approximately 5 km southwest of Oss-Zevenbergen and 1 km southwest of the urnfield of Slabroek (see figure 12.1).

12.5.2 Results and discussion

See figure 12.20-12.22

At the Schaijksche heide, about 3 km west of the Slabroekse heide, a deciduous forest developed after the wind-blown sand event of around 4700 cal BC. This forest was dominated by *Corylus* and *Quercus*. Some *Alnus* was present in the environment, but probably not in the form of the extended alder carrs that were recorded in the barrow pollen spectra. Heath was already present in considerable amounts. Around 4700 cal BC a short period of sand drifting occurred. Very interesting is to realise that such early events of sand drifting have also been recorded in the Laarder Wasmeren area (see 10.2) and as has been discussed in Chapter 10, this might indicate an over-exploitation of the soil. The cause of the sand drifting can however not be deduced from the pollen data. Sand drifting might have been a local event; it has not been recorded at St Annabos, which is located about 5.5 km southwest of Schaijksche heide. At the time peat started to accumulate (between 4710 and 4539 cal BC) at St Annabos a birch carr (*cf.* high percentages of *Betula*) was present, which probably evolved into an alder carr. The development of an alder carr is probably reflected in the pollen diagram of Schaijksche heide as well, shown by an increase in *Alnus* pollen. Also at the Venloop, approximately 2.5 km southwest of Schaijksche heide and 1 km south of Slabroekse heide alder carr was dominating the local vegetation when peat accumulation started between 750 and 410 cal BC.

The extensive heath areas that must have been present from the Late Neolithic onwards according to the barrow pollen spectra have not been recorded in the peat diagram of St Annabos as such. This confirms that peat diagrams are not suitable for a total landscape reconstruction, as has already been subject of discussion in section 6.1. Expansion of heath is not recorded before deforestation started accompanied by an expansion of grasses and some Cerealia, shown by all three diagrams. The appearance of *Fagopyrum* in the diagrams of Venloop and St Annabos indicates that the vegetation development of the area is recorded at least until far into the Medieval period.

12.6 Summary: the barrow landscape of Oss-Zevenbergen and surroundings

The barrow landscape of Oss-Zevenbergen and surroundings is, like the barrow landscapes discussed in the previous chapters, a landscape dominated by open spaces with heath vegetation.

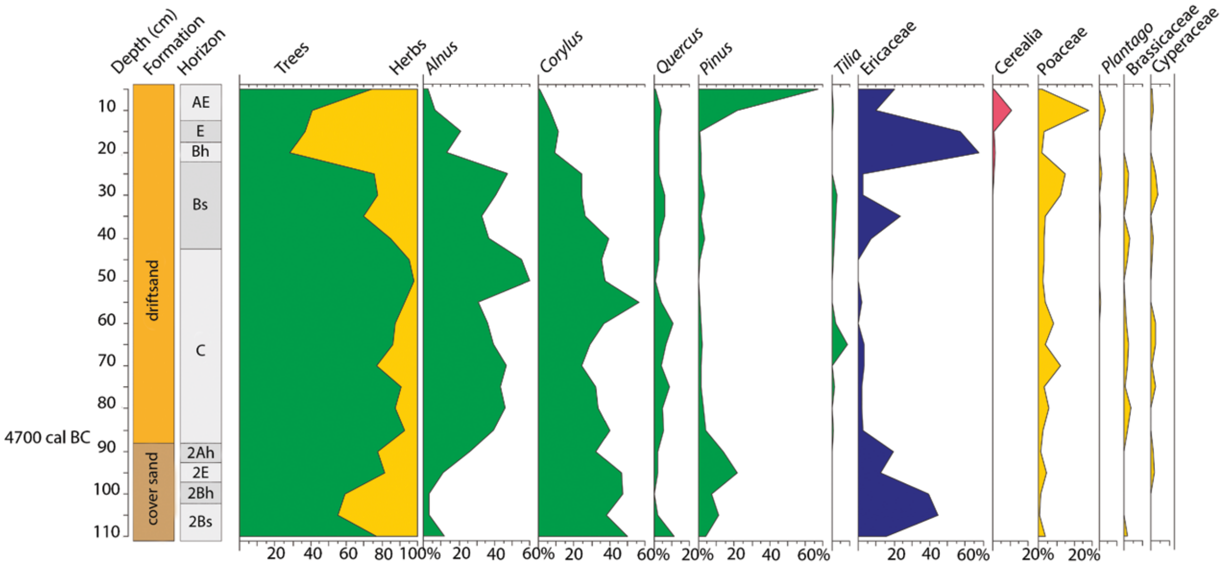


Figure 12.20. Pollen diagram from the Schaijkse Heide. Redrawn from the pollen diagram of van Mourik et al. (2012b, figure 9). A percentage diagram is shown, with % based on a total tree pollen sum.

When and how these heath areas came into existence is not known, but an anthropogenic origin is indicated. Heath vegetation was probably part of the landscape already long before the first barrows were built, as has been recorded for instance in the pollen diagram of the Schaijksche heide. The area might even have been intensively exploited, causing sand-drifting as early as around 4700 cal BC. Such early sand-drifting is also known for the Laarder Wasmeren area (see section 10.2) and is remarkable for this period, since man-caused sand-drifting was assumed to have started not before the Early Middle Ages (Castel *et al.* 1989, Riksen *et al.* 2006). Heath was able to regenerate at the Schaijksche heide and it is likely that heath was also present at other locations in the area. This is at least the case for the Early and Middle Bronze Age period when several barrows were constructed. It is not known whether the heath at the burial complexes around Oss-Zevenbergen originated from the same early period as at the Schaijksche heide, but heath was probably present at that location since the Late Neolithic, when the first barrows were built. This heath area remained until at least the Iron Age, when the Hallstatt C barrows were created. At that time, when the burial complexes of Oss-Zevenbergen and Oss-Vorstengraf were at their most extensive size, an extensive heath area must have been present.

To conclude, heath was present in the area for thousands of years. To maintain such areas heath management must have taken place, which probably involved grazing and burning. Other human activities were hardly recorded in the area. It is not exactly clear where people lived and where they cultivated their crops. Indications for crop cultivation have hardly been found in the barrow pollen spectra, so it is not very likely that crop cultivation took place close to the burial complexes.

Forest was also part of the barrow landscape. Before the barrows were built, at the time of the sand-drifting (around 4700 cal BC), forest mainly consisted of *Quercus* and *Corylus,* with birch carr in the wetter surroundings. Alder brook was starting to expand at the wetter areas like Sint Annabos. At the time the barrows were built extensive alder carrs were present as has been shown by the high amounts of *Alnus* pollen in all the pollen spectra. These alder carrs could most likely be found at locations like Sint Annabos and Venloop. In the dry forest dominating trees were now *Quercus* and *Tilia* with high amounts of *Corylus* at the forest edge.

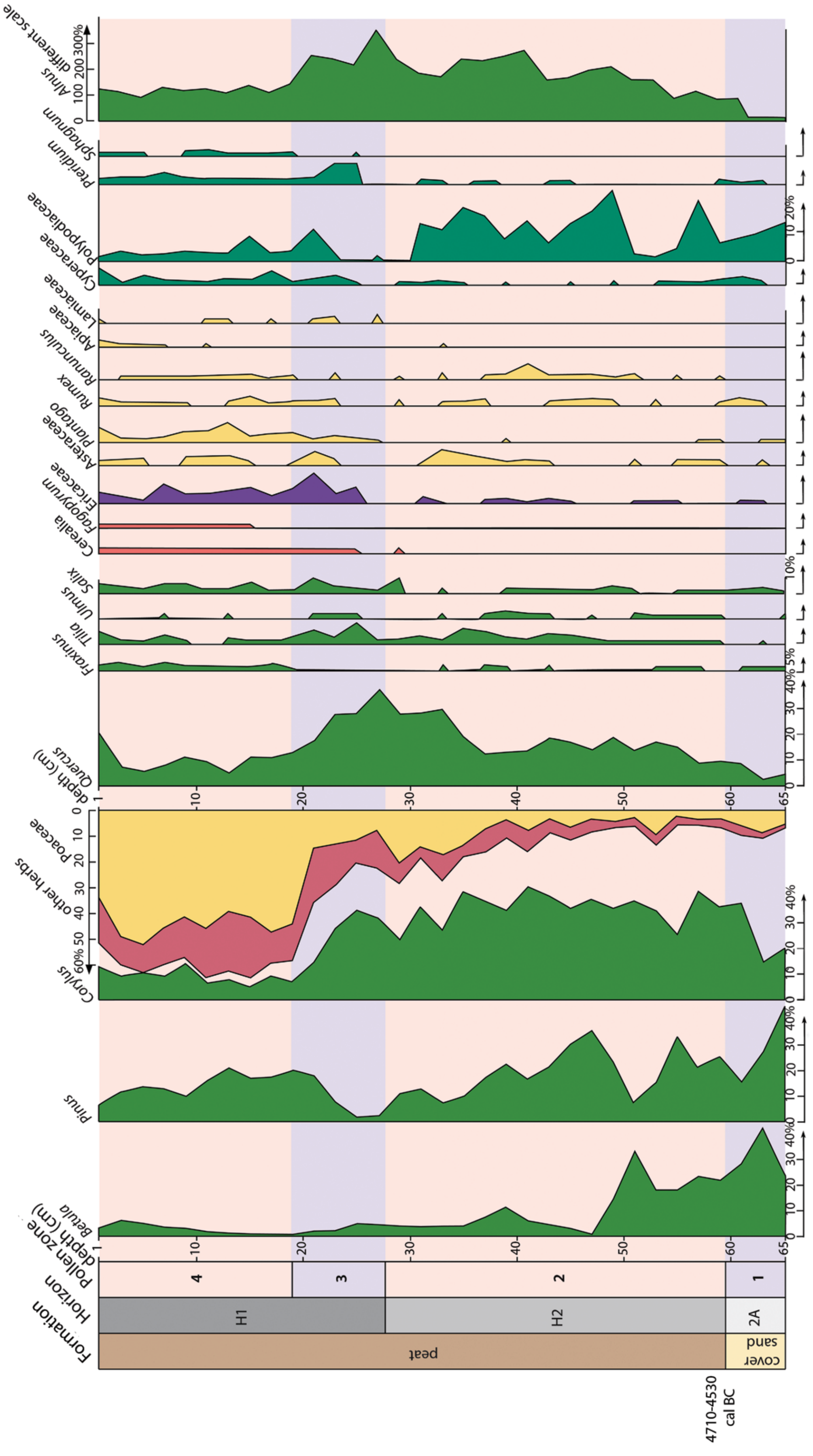


Figure 12.21. Pollen diagram from St Annabos. Redrawn from the pollen diagram of van Mourik (1987, figure 6). A percentage diagram is shown, with % based on total tree pollen sum.

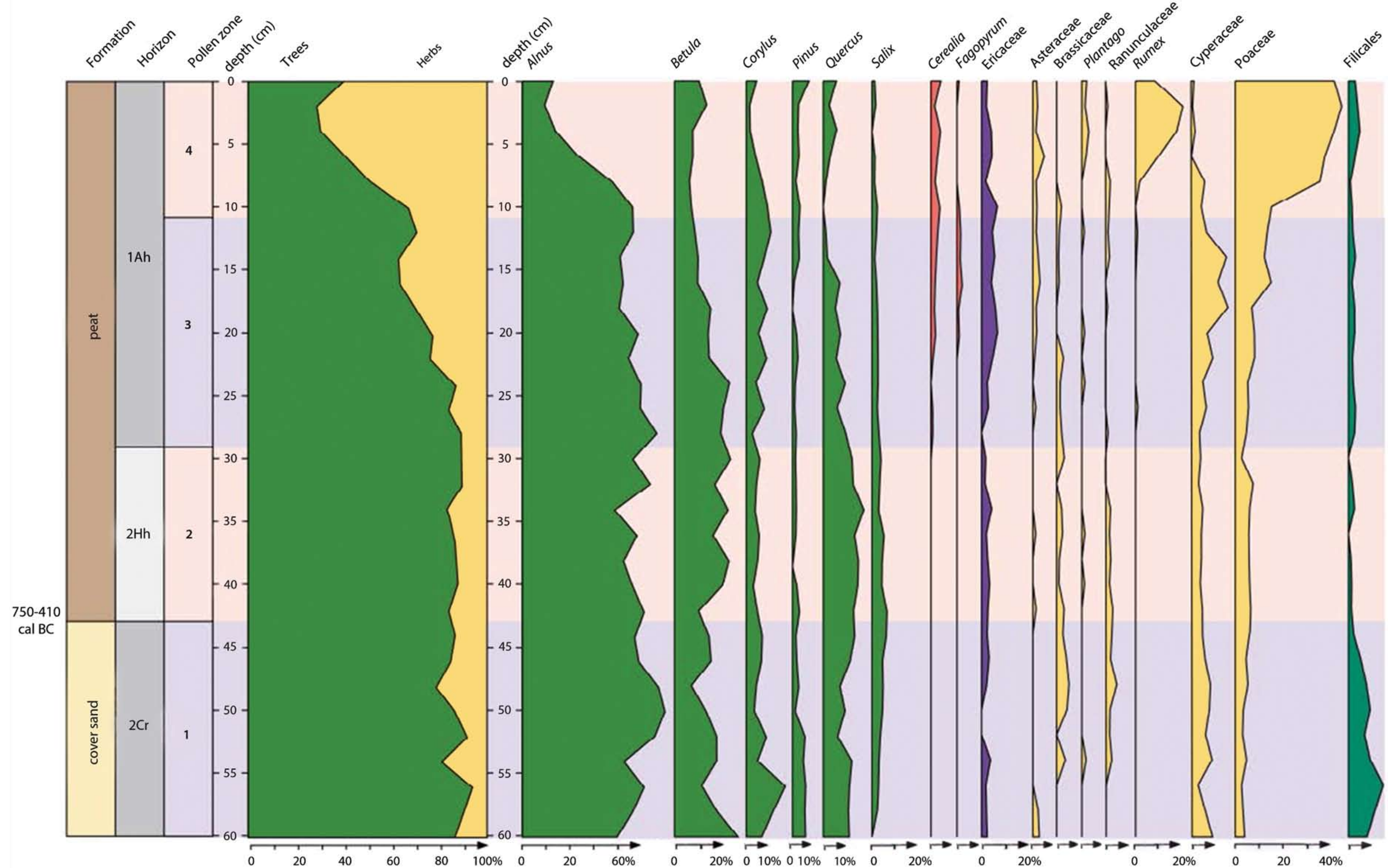


Figure 12.22. Pollen diagram from the Venloop. Redrawn from the pollen diagram of van Mourik et al. (2012b, figure 5). A percentage diagram is shown, with % based on total tree pollen sum.

In conclusion, the barrow landscape of Oss-Zevenbergen and surroundings was a managed landscape of heath areas that could be quite extended, surrounded by *Corylus*, *Quercus* and *Tilia* forest at the drier regions and alder carr in the brook valleys. Part of this managed landscape had its origin probably thousands of years before the first barrows became part of it (in the fifth millennium, see section 12.5). The barrow landscape existed as such for at least several centuries and seems to have been a very stable element in the landscape.

Table 12.2. The minimum size of the open space per barrow based on the sods used to build the barrows.

	Diameter (m)	Height (m)	Sod thickness (m)	Sod area (m2)	Radius (m)
Oss-Chieftain's grave	53	1	0.1	11036.15	59.27
Chieftain's grave BA-barrow	16	unknown			
Oss-Zevenbergen 1	4.7x23.5	0.6	0.13	442.00	11.86
Oss-Zevenbergen 2	12.5	0.6	0.13	284.07	9.51
Oss-Zevenbergen 3	30	0.9	0.13	2449.75	27.92
Oss-Zevenbergen 4	14.5	0.5	0.13	318.06	10.06
Oss-Zevenbergen 6	7.5	0.5	0.13	85.46	5.22
Oss-Zevenbergen 7	22.8	0.8	0.2	817.90	16.14
Oss-Zevenbergen 8	12	0.6	0.13	261.86	9.13
Vorssel	unknown				
Slabroek 39	30	0.5	0.18	982.11	17.68
Slabroek 40	unknown				
Schaijk	unknown				

Chapter 13

Ancestral heaths: understanding the barrow landscape

In Chapter 8-12 several case-studies have been described and discussed. In this chapter these chapters will be summarized and interpreted in relation to the role of barrows in the landscape.

13.1 The barrow landscape

13.1.1 What did the barrow landscape look like in the central and southern Netherlands during the 3rd to 1st millennium cal BC?

In Chapters 8-12, 97 barrows and 11 urnfield barrows have been discussed in 5 regions on the Pleistocene soils in the central and southern Netherlands. It was concluded that all barrows were built in open spaces that were covered with heath vegetation. Barrows were built in open spaces that varied in size from small, with an average distance to the forest (ADF) of 50-100 m, to rather large (ADF=300-500 m), although the latter were only been found in the relatively young Middle-Late Iron Age barrows of the Echoput. Besides the barrows that were discussed in the case-studies (Chapters 8-12) palynological data are known from 21 more barrows in the central and southern Netherlands (see Appendix I) which show that these barrows too, were built in heaths. Nevertheless, palynological data are only available for a small part of the barrows that are still present in the Netherlands. As has been shown in figures 3.1, 8.1b, 9.1b, 10.1b, 11.1b-d and 12.1b there are numerous barrows in the investigated regions. Bourgeois suggests that only a fraction of the barrows has been preserved, and that the original number of barrows in the Netherlands was higher (Bourgeois 2013, 40). All investigated barrows were built in heath vegetation and it is therefore probable that the non-investigated barrows on the Pleistocene coversand areas in the Netherlands were built in a setting featuring heath vegetation as well. As a consequence, the Dutch barrow landscape must have been dominated by patches of heathland. The open spaces seem to be small, however, and this in itself could be misleading. Many barrows are often situated close to other barrows and sometimes forming long alignments. It is therefore likely that many barrows were not built in their own small patch of heathland, but clustered in larger open spaces that were long and narrow. This has already been found to be the case for the oldest barrows. For example at Renkum (Chapter 9) a long alignment of barrows can be seen. Not all barrows in this alignment have been dated, at least 12 barrows can be placed in the late Neolithic A period. Assuming that these barrows were all built in heath vegetation, as has been demonstrated for four of them, it is likely that the open spaces were connected to each other, forming a long-stretched heathland area with a length of about 4.5 km (see figure 13.1a-c). These long-stretched heath areas could possibly be seen as corridors in the landscape, although this research has only focussed on the barrow landscape and not on the greater landscape. Other examples of this barrow alignment can also be seen at Vaassen-Nierssen (Chapter 8, see figure

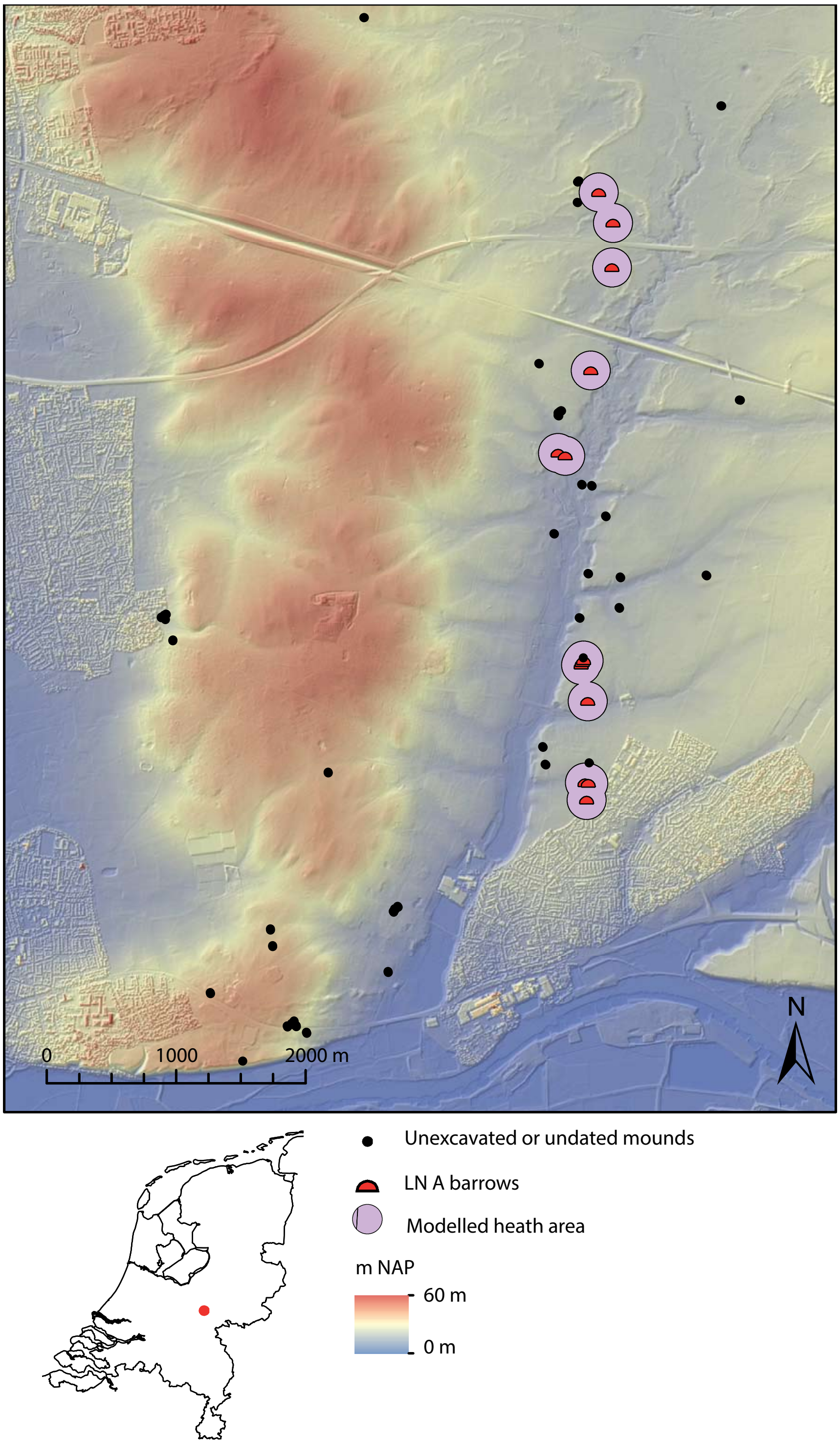
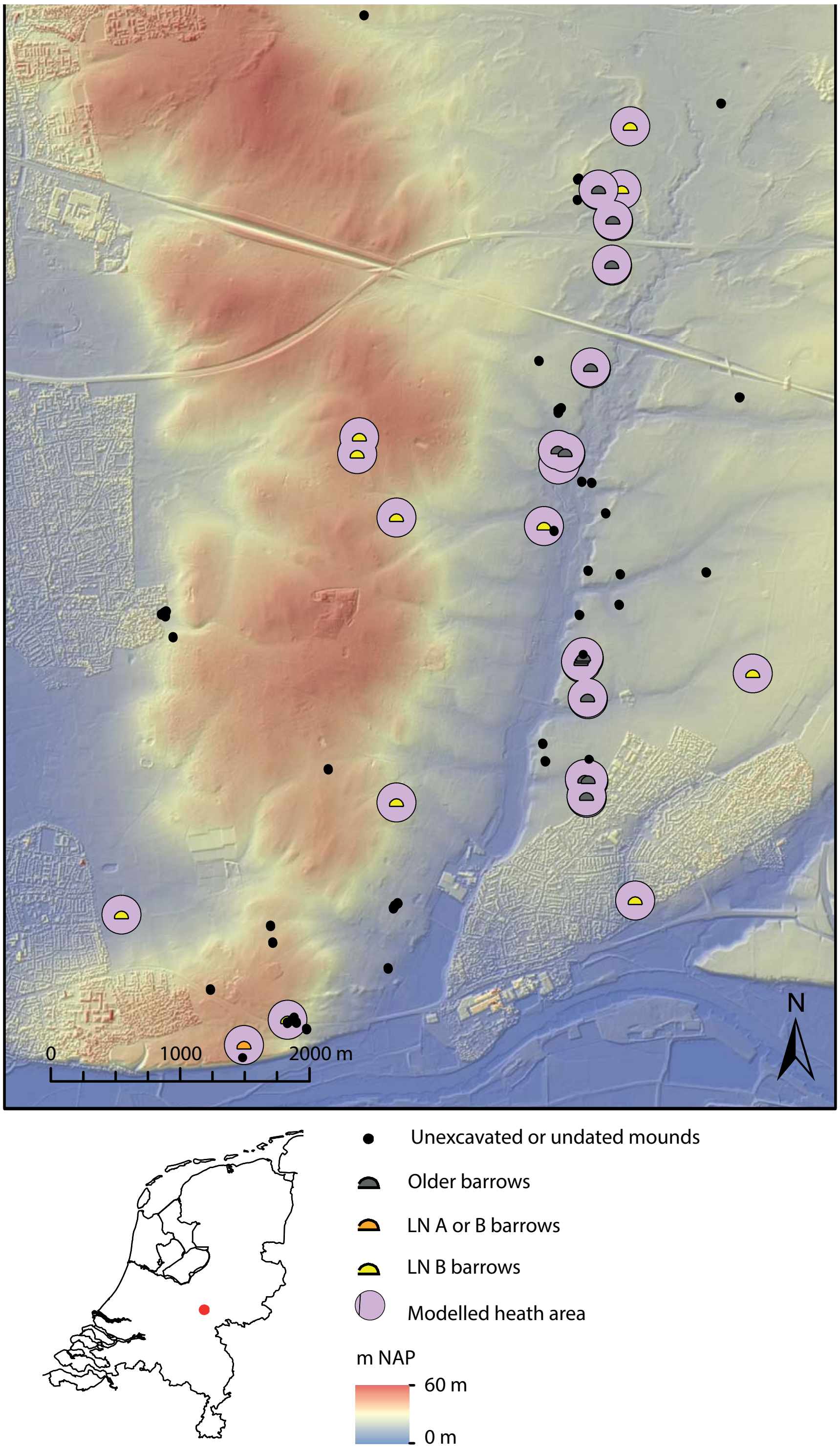


Figure 13.1a-b. Barrow alignment of Renkum at two consecutive phases Late Neolithic A and Late Neolithic B. The modeled heath area around each barrow is indicated. Based on digital elevation model of the AHN (copyright www.ahn.nl). Figure after Doorenbosch (2013), figure 11.a-b. Figure by Q. Bourgeois and M. Doorenbosch.



0
1000
2000 m
N
Unexcavated or undated mounds
Older barrows
LN A or B barrows
LN B barrows
Modelled heath area
m NAP
60 m
0 m

Figure 13.1b.

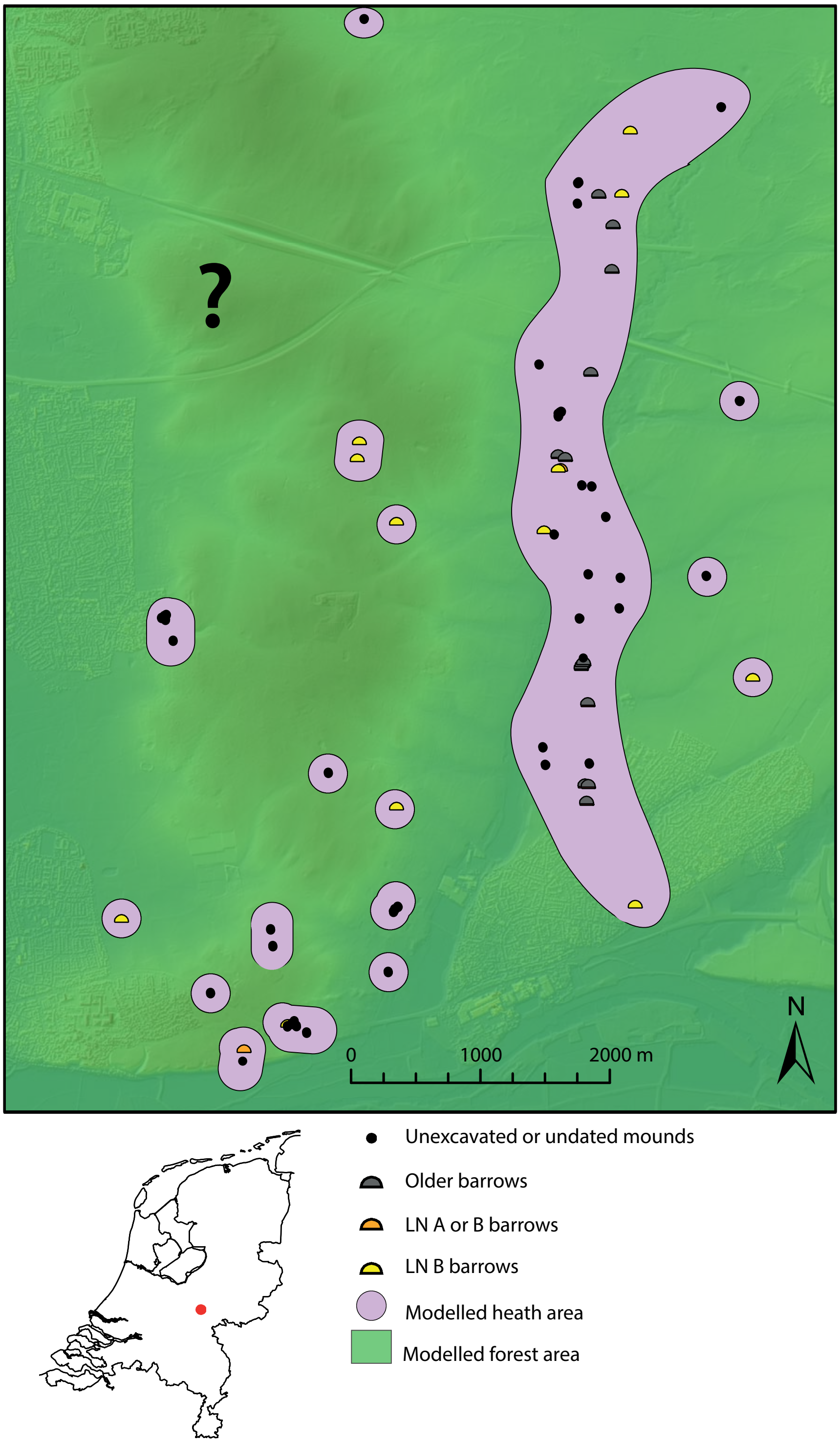


Figure 13.1c. Barrow alignment of Renkum, situated in a (hypothetical) long-stretched heath area surrounded by forest. The vegetation reconstruction is based on palynological data from barrows. An exact reconstruction of the forest area is therefore not possible (indicated by the question mark), since barrows are not present in those areas. The figure is based on digital elevation model of the AHN (copyright www.ahn.nl).

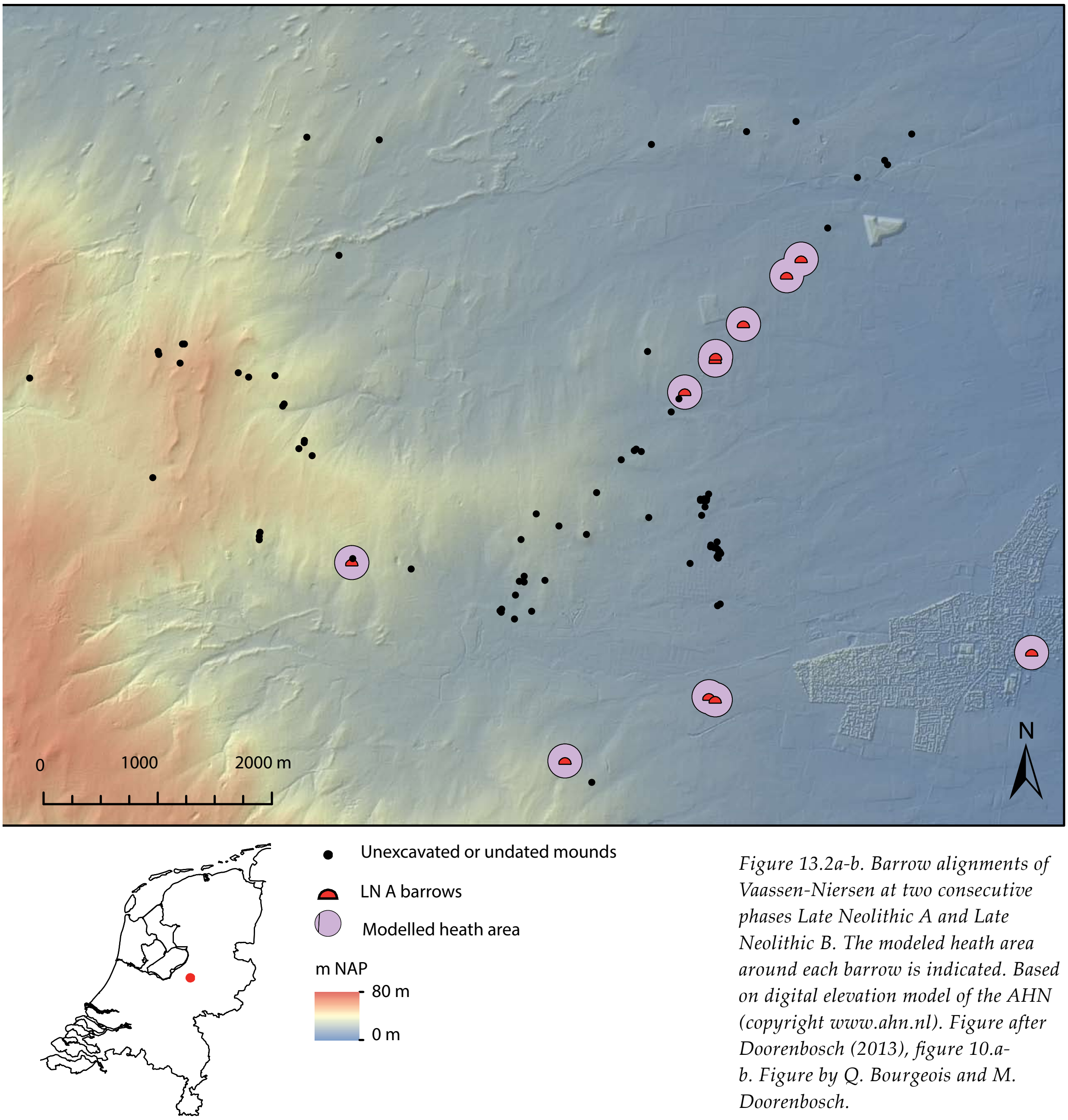


Figure 13.2a-b. Barrow alignments of Vaassen-Niersen at two consecutive phases Late Neolithic A and Late Neolithic B. The modeled heath area around each barrow is indicated. Based on digital elevation model of the AHN (copyright www.ahn.nl). Figure after Doorenbosch (2013), figure 10.a-b. Figure by Q. Bourgeois and M. Doorenbosch.

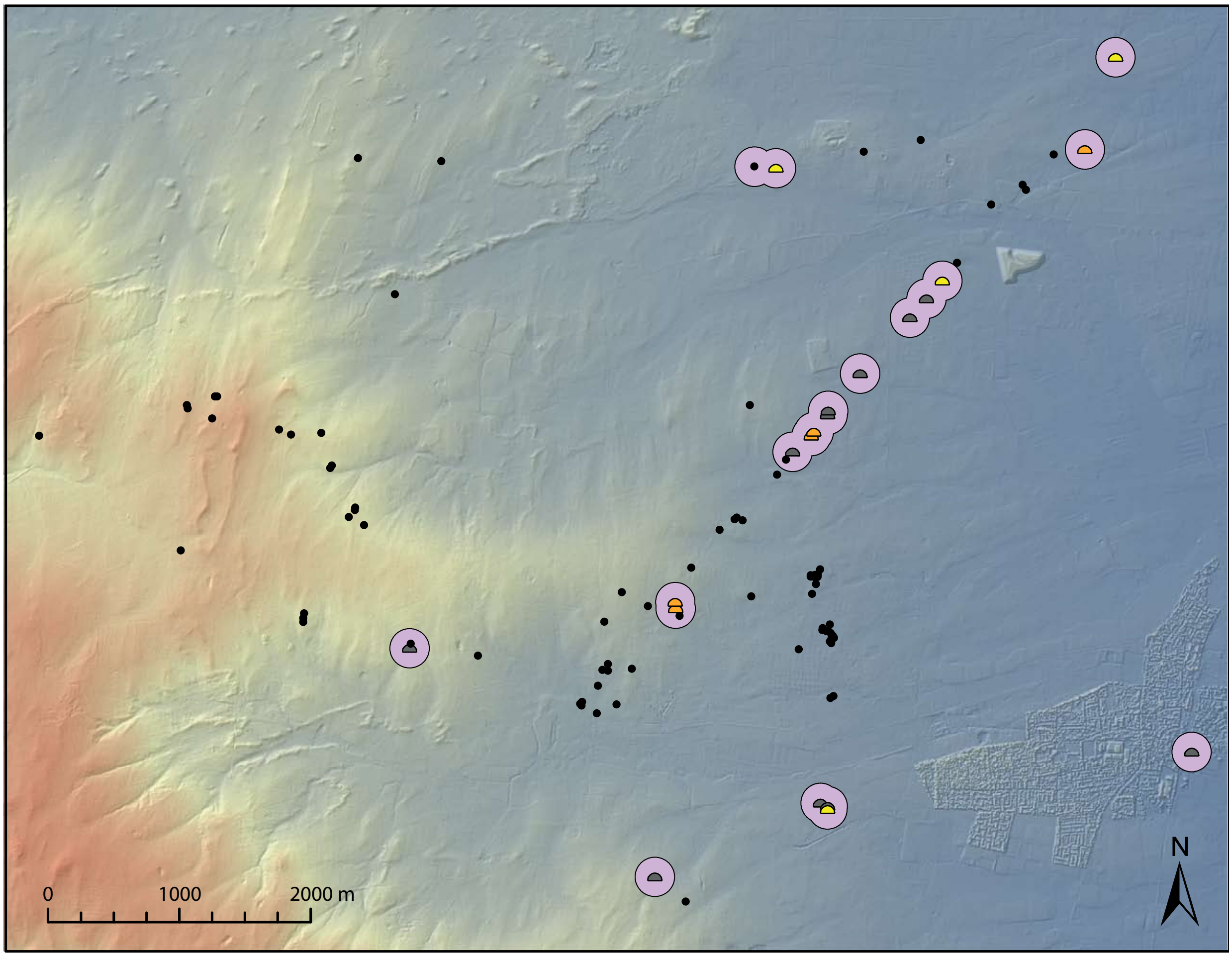
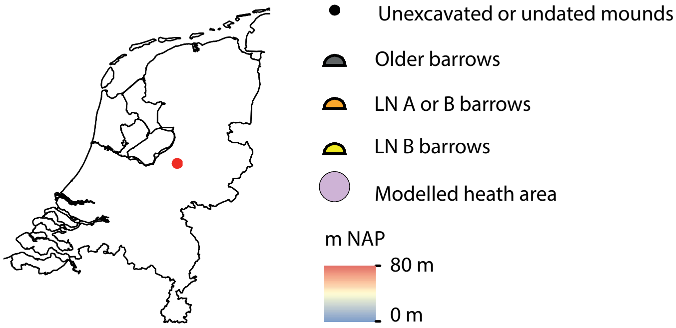
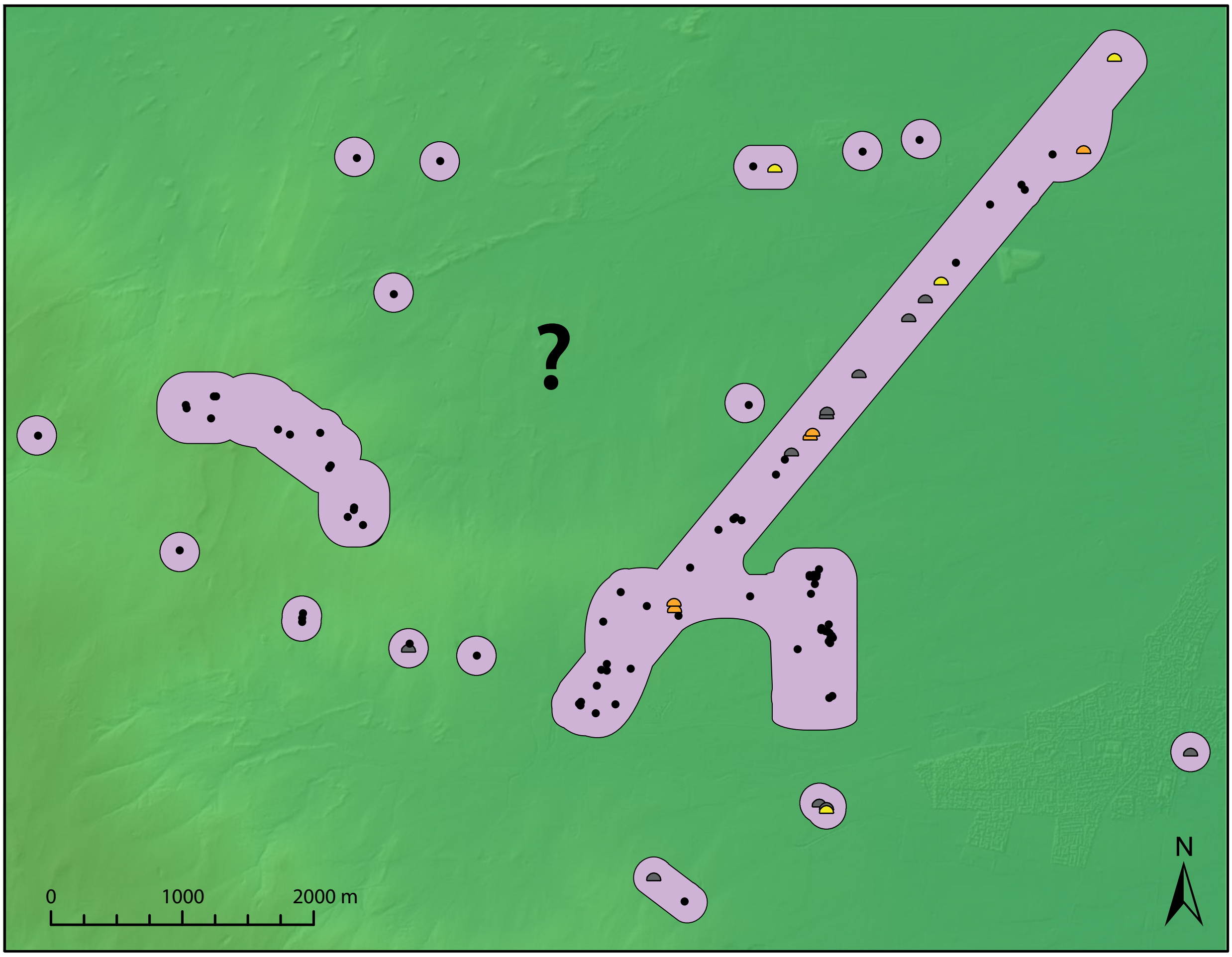


Figure 13.2b. Barrow alignment of Vaassen-Niersen during the late Neolithic B.



13.2a-c), Toterfout-Halve Mijl (Chapter 11) and Oss-Zevenbergen (Chapter 12). The formation of barrow alignments have been extensively investigated and discussed by Bourgeois (2013). He has found many other examples of barrow alignments, indicating that this was a fairly common way to spatially order burial mounds in the barrow landscape. Not all barrows, however, were built into such alignments. Alignments were mainly a feature of barrows constructed during the Late Neolithic A, while from the Late Neolithic B onwards barrows are also found outside the alignments at presumably more random places in the landscape (Bourgeois 2013). These dispersed barrows were built in heath as well as has been shown at for example Toterfout-Halve Mijl (Chapter 11). Altogether, the barrow landscape must have been dominated by patches of heath, which all contained one or more barrows, and which were possibly often connected to each other, forming corridors in the landscape.



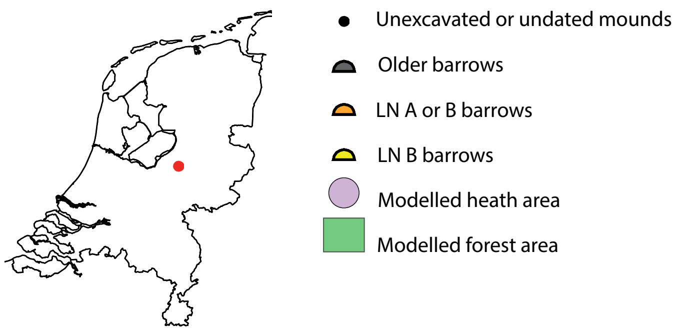


Figure 13.2c. Barrow alignments of Vaassen-Niersen, situated in a (hypothetical) long-stretched heath area surrounded by forest. The vegetation reconstruction is based on palynological data from barrows. An exact reconstruction of the forest area is therefore not possible (indicated by the question mark), since barrows are not present in those areas. The figure is based on digital elevation model of the AHN (copyright www.ahn.nl).

Although dominated by heath, forest was also part of the barrow landscape. This forest can be divided into two main components. In the lower and wetter parts of the area extensive alder carrs could be found. At the drier locations a mixed oak forest was present. This forest was probably fairly open and consisted mainly of *Quercus*. *Tilia* was part of the forest as well, especially during the Neolithic and Bronze Age. *Fagus* appeared later. *Fagus* could be noticed in the Bronze Age period at Toterfout-Halve Mijl. It had partially replaced Tilia in the Iron Age period as shown at the Echoput barrows (chapter 8) and at Oss-Zevenbergen (chapter 12). *Corylus*, a light demanding tree, was dominant close to the barrows and profusely growing at the edge of this forest.

Figure 13.3a-b. 13.1a: Grazing sheep at the Tafelbergheide, a heatland area near Huizen (the Netherlands). 13.1b: Grazing cattle at the Zuiderheide, a heathland area near Laren (the Netherlands).

As has been explained in Chapter 2 it was previously thought that differences in barrow landscapes were culturally linked (Waterbolk 1954, van Zeist 1967a). Casparie and Groenman-van Waateringe already concluded that this assumption could not be true and that differences between sites were caused by differences in soil type and hydrology (Casparie and Groenman-van Waateringe 1980). They emphasized the uniformity of the barrow landscape for all barrows. This uniformity has been confirmed by this research, where (part of) the data collected by Casparie and Groenman-van Waateringe have been supplemented and re-interpreted.

A mosaic managed heath open-forest passage landscape

As has been extensively discussed in Chapters 8-12 the heath vegetation the barrows were built in must have been managed to persist. Management activities could involve grazing (or mowing), burning and/or sod-cutting (Stortelder *et al.* 1996, 287). Indications for large scale sod-cutting have not been found, but sod-cutting must certainly have taken place as sods were used as construction material for the burial mounds and could therefore have contributed in the maintenance of the heath vegetation. Grazing has been indicated in most of the case-studies. During the Neolithic, prehistoric man in the Netherlands switched from hunter-gatherer to farming activities, including crop cultivation and animal husbandry. Faunal evidence from shows that the livestock of farming communities mainly consisted of cattle and sheep (Fokkens 2005a, 409, 427; Brinkkemper and van Wijngaarden-Bakker 2005, 493). The heath in the barrow landscape was consequently most likely being grazed by these animals (see figure 13.3a-b). The number of livestock belonging to late Neolithic farming communities has not been estimated, but for the Middle Bronze Age B has been suggested that a livestock of up to 30 animals could be kept per household. It has been suggested that these animals were mainly grazing at natural pasture areas in the stream valleys (IJzereef 1981, Fokkens 1991, 2005a).

Another possibility is that they were grazing the barrow heath areas. To maintain a heath area about 1 sheep per hectare and/or 1 head of cattle per 5-6 hectare is required. The heath area around a barrow with an estimated ADF of about 100 m could be simplified to a (hypothetical) circular patch of heath with an estimated radius of 100 m, indicating an area of about 3 ha. Each barrow requires then about 3 sheep or 0.5 head of cattle to maintain this heath area. It

Figure 13.3b

has been estimated that in the area of Ermelo 52 barrows were built in the Late Neolithic A, 26 barrows in the Late Neolithic B, 7 barrows in the Early Bronze Age and 48 barrows in the Middle Bronze Age. This assumes that in total about 134 barrows were present at Ermelo in the Middle Bronze Age (Bourgeois 2013, table 8.1, p. 178). Assuming that all barrows were situated in heath vegetation in the Middle Bronze Age, this implies a total estimated heath area of about 420 ha. To maintain such a heath area about 420 sheep are required and/or 70 head of cattle. Alternatively, when assumed that one household kept 20 head of cattle and 10 sheep, 3-4 households were able to maintain the heath. When the average ADF in an area for each barrow is 250 m, around 2630 ha of heathland should be maintained, requiring 20 households with each 20 head of cattle and 10 sheep. This implies that several households, forming heath communities, must have worked together to maintain the heathland.

Grazing in relation to the barrow landscape is also mentioned in barrow research from for other regions in Europe. Andersen showed that barrows in West Jutland (Denmark) were built in open places that were used as pasture (Andersen 1996-97). The oldest barrows (3500-3300 cal BC) were built in open places in birch woodland that was grazed and from the Early Middle Neolithic barrows (3300-3100 cal BC) onwards they were often built in heathland that served as pasture. Bunting and Tipping concluded for a Middle Bronze Age barrow cemetery (1500-900 cal BC) in Orkney (Scotland) that the burial mounds were constructed on pasture land (Bunting and Tipping 2001).

Burning is the third heath management method. Indications for burning have only been found in a few case-studies in this research by the recording of charcoal that was probably not just related to the burial itself. At the Echoput and Oss-Zevenbergen for example (chapter 8.1 and 12) small fragments of charcoal were found throughout the entire profile underneath the barrows. Karg showed for a barrow in Western Jutland (Denmark) dating to the 14th century cal BC that it was built in a heathland where burning had taken place. In addition the heathland had been managed by grazing and sod-cutting (Karg 2008).

It should be noticed that the heath management activities described above, especially grazing, might not have been practiced by prehistoric man with the aim of managing the heath. They might just have been carried out by the barrow builders as part of their daily (agricultural) activities. Managing the heath at the same time might just have been incidental. Nevertheless, whether deliberately managed or as an additional consequence of other activities, heath vegetation was a very important if not the most important component of a barrow landscape. To conclude, the barrow landscape must have been a very characteristic landscape. A landscape that could perhaps best be described as a mosaic managed heath open forest-passage landscape.

13.1.2 What was the history of the barrow landscape before the barrows were built?

In five cases it has been shown that this heath vegetation was already present some time before the barrow was built by pollen diagrams derived from the soil profile underneath the barrow (2 barrows at the Echoput, chapter 8.1; Oss-Zevenbergen barrow 2, 7 and 8 and the Chieftain's Grave, chapter 12.1). In other cases the presence of diverse herbal vegetation suggests that the area must have been open for some time. Otherwise this vegetation would not have had the chance to get established. No indications have been found that the open space was created recently before a barrow was built. Some barrows were built on top of an Umbric Podzol (Dutch classification: Moderpodzol; *Echoput*, chapter 8.1; Oss-Zevenbergen Barrow 2, Chapter 12), which is common underneath forest vegetation. It has been suggested that this could be an indication that heath vegetation had not been present for a very long time, since underneath heath vegetation eventually a Carbic Podzol (Dutch classification: Humuspodzol) would develop (de Kort 2009). It should be noted that this is only relative to the length of time soil development can take; heath vegetation can transform an Umbric Podzol into a Carbic Podzol in approximately 250 years (Andersen 1979) which is rather long relative to a human life. To conclude, in most cases the open spaces were present well before the construction of the barrow and it is therefore unlikely that they were created specifically for funerary purposes. When, how and why the clearings have been created is unknown. The open spaces might have originally been natural open spaces in the forest (see 2.3.1) and turned into heathland by human influence. They might also have been man-made clearings from the start. It is also not easy to reconstruct what the open spaces have been used for prior to the barrow building. Possible traces of abandoned settlements have been found underneath a barrow in only a few cases (Vaassen, chapter 8.1; Putten, chapter 8.4; Stroe, chapter 8.10) and only in some cases barrows were possibly (although questionable) constructed on former arable land (Toterfout-Halve Mijl barrow 12 and 18, chapter 11.1; Eersel, chapter 11.6). Besides, Casparie and Groenman-van Waateringe (1980) conclude that barrows were seldom constructed on or close to arable land that was in use when the barrows were built, a conclusion that was confirmed by the present research. It is therefore not likely that the barrow builders had a preference for (recently abandoned) settlement sites and/or arable fields. On the other hand it is clear that in all cases prehistoric man must have been present at the sites prior to the barrow building, since at least some management was required to maintain the heath vegetation. Probably most open spaces were used as pasture already before the barrows were built, since grazing is indicated in several cases (Echoput, section 8.1; Oss-Zevenbergen Chapter 12).

13.1.3 What does this mean?

The Late Neolithic landscape in the southern and central Netherlands is often seen as dominated by a fairly closed forest. As has been described in Chapter 2, deciduous forest is in general assumed to be the natural landscape in the Netherlands that had developed since the start of the Holocene. During the

Neolithic prehistoric man started to interfere with the landscape when they started to clear the forest to expand their agricultural activities. This was assumed to have happened only at local scale, in the close surroundings of a settlement site (Waterbolk 1954, Groenman-van Waateringe 1978). In general the open spaces were small and did not have a great impact on the landscape yet. Casparie and Groenman-van Waateringe (1980) concluded from their research that large open areas did not yet occur during the Neolithic in the central Netherlands. During the Bronze Age and Iron Age the Dutch landscape was transformed into a cultural open landscape, with heath and fields replacing the forest. During the Neolithic period man also started to build barrows to bury their dead. Neolithic barrows were pictured as being in small man-made open spaces in the forest, but it is not clear how these fitted in the landscape organization at large. The results described in Chapters 8-12 suggest that the landscape was probably already more open than previously thought. Based on the reconstructions from barrows the landscape must certainly have been open. All barrows were built in heath vegetation and the surrounding forest was open in character. Barrows were numerous and plentiful from the earliest Neolithic period. All these barrows being built in heath paint a different picture of the landscape than a closed forest with some small, open spaces.

For the Bronze Age it has long been thought that a barrow's location was determined by the location of the settlement (Roymans and Fokkens 1991). This theory was mainly based on sites like Elp, where a barrow was located close to Middle Bronze Age houses (see figure 13.4). Bourgeois and Fontijn showed that this theory could not be confirmed (Bourgeois and Fontijn 2008). Most barrows predate the Middle Bronze Age houses, and settlements dating to the late Neolithic and Early Bronze Age, the period in which most barrows were built, have rarely been found (see also 2.3.2). In fact, it is not known where the people who built the barrows and who were buried in the barrows lived. Settlements have rarely been found close to barrows (Bourgeois 2013). In addition, this research has shown that palynological data seldom show the presence of arable fields in the near surroundings of a barrow, which are generally assumed to be located close to settlements (van Gijn and Louwe Kooijmans 2005, 338-340).

The barrow landscape was a managed landscape, with numerous patches of heath. As was previously thought that prehistoric man just started to interfere with the landscape during the Neolithic, these managed barrow landscapes assume large scale control of the landscape by man. And even long before the barrows were built, prehistoric man may have already overexploited some areas, as indicated by very early sand-drifting events at Oss-Zevenbergen in de Middle Neolitic (Chapter 12), the Schaijksche heide around 4700 cal BC (Chapter 11) and the Laarder Wasmeren area around 4000 cal BC (Chapter 10). Although the cause of these sand-drifts is unknown, they show that the landscape was open and that heath vegetation was already present by then. This is further indication of the presence and activity of man and implies a landscape that was maintained by this activity of man and even perhaps overexploited by him.

To summarize, despite not being built very close to settlements, the barrows seem to be integrated into the everyday life of prehistoric man. The barrow landscape was a managed landscape, which most likely was at least partially maintained by grazing, and seems to form as such part of the economic zone of the people living in the area. It is however not clear where the settlements of these communities were located. The evidence for settlements is elusive for the late Neolithic and the first half of the Middle Bronze Age. It seems likely that settlements were located not too far away, at 'grazing' distance from the barrows.

Elp
barrow
postholes of houses and ancillary buildings
other postholes
stones
pits inside the house
other pits
grave
iron pan formation in and near houses
0
10 m

Grazing grounds, ancestral grounds?

One of the questions this research is trying to answer is whether the barrow builders had a preference for ancestral grounds to place their mounds. Based on the data that are available now, discussed above and in the previous chapters, this question can most likely be answered affirmatively. In general barrows were built on grazing grounds. Grazing took place concurrently and prior to the barrows being built. The barrows that were investigated were never built in areas that were recently cleared and it is not very likely that the barrow builders created heath areas especially for the construction of a burial mound. Instead, all barrows were built in areas that had been in use by prehistoric (heath) communities for a long period of time. These communities might very well have consisted of the ancestors of the people who built the barrows. The heathland areas where barrows were built in can be considered as ancestral heaths: not only did they serve as burial places for ancestors, they had also been used by these ancestors prior to the barrow building. The builders of the barrows built on the investment of their ancestors.

13.1.4 What was the role of barrows in the landscape?

Barrows were often located in alignments in long-stretched heath areas. It is not hard to imagine that visibility must have played an important role in the placement of the mounds as has already been suggested in Chapter 2. From one mound the next mound could be seen and so on. Such corridors/passageways in the landscape must have been an impressive sight. Bourgeois (2013, Chapters 6 and 8) investigated visibility for several barrow alignments and clusters. He performed view-shed analyses to determine whether barrows were built on visible places in the landscape. How visible was a barrow in the landscape and what part from the landscape could be seen from a barrow? Besides the land relief (elevation, slope and orientation of terrain features) the vegetation and especially the trees are determining factors on the degree of visibility. The vegetation data that were derived from the pollen analyses described in Chapter 8-12 provided valuable information in this respect. Models have been developed to get a better grip on the relation between pollen spectra and the corresponding vegetation abundance. In Chapter 7 these models have been applied to barrow pollen spectra to be able to improve our visualization of a barrow landscape. Based on these models, barrows in the view-shed analysis were placed in (hypothetical) circular heathland areas with an average radius of 250 m. In addition the vegetation reconstructions have shown that alder carr made up a considerable part of the forest in the lower and wetter surroundings of all investigated barrows. For the view-shed analyses alder carr with a height of 15 m was placed at locations with high groundwater level, taking the recent lowering of groundwater by modern canalization and use of groundwater into account (Bourgeois 2013, 132). The dry *Quercus* forest obviously would also be of influence and although its exact location cannot be determined a forest with a height of 30 m was placed at the places that were not covered with heath or alder carr to get a rough impression of the visibility of barrows. Bourgeois concluded that barrows were more visible *than* their environment, but not all barrows were equally visible *from* their environment. Some barrows were highly visible and could probably be seen from long distances, while other barrows were only visible from the edge of the heath area. Also in alignments visibility varied between barrows. Some barrows could be seen from anywhere in the alignment, while others could only be seen from the barrow next to it and still others appeared only at the skyline from specific positions in the landscape. As Bourgeois (2013, 156) puts it: "*Especially in the case of the alignments, visibility was manipulated in order to reveal a succession of monuments*." Although the degree of visibility seems

Figure 13.4. Excavation plan of the barrow and settlement of Elp. The barrow was found very close to the settlement. Figure after Fokkens (2005a, figure 18.4).

to have differed between barrows it cannot be denied that visibility must have played an important role in the placement of barrows. Even when a barrow could only be seen when entering the heath area it was built in, it was probably still an eye catcher within that heath area. Visibility played an important role in the placement of the barrows. Their visibility might have been enhanced when the sods for barrow construction were taken in the direct environment of the barrow, as has been shown at the Echoput (Section 8.1). These barrows were located on one of the highest places in the environment in an open area that was covered with heath vegetation, while the direct surroundings were completely stripped from vegetation. This might have been undertaken to emphasize their characteristic sight in the landscape.

Barrows and the importance of visibility have also often been discussed in barrow research outside the Netherlands. Early Bronze Age Barrows in Thy, Denmark, were all built in a rather treeless landscape that was used as pastureland (Andersen 1996-97). Hannon *et al.* showed that five Bronze Age mounds (1800-500 cal BC) at the Bjäre peninsula (southern Sweden) were built in an open landscape that was probably grazed (Hannon *et al.* 2008). They concluded that these barrows were probably designed to be visible in the landscape. Also Downes suggested that the location of barrows in Orkney (Scotland) were probably related to visibility (Downes 1994). Dreibrodt disagreed with the theory that all barrows were built in an open landscape (the landscape openness hypothesis; Dreibrodt *et al.* 2009). He showed that some barrows were built on hilltops while the hill flanks were probably covered with forest, since no soil erosion had taken place at these hills. However, he also mentions the possibility of a well suited system of pasture that could have maintained a vegetation cover preserving the hill from soil erosion. Fyfe rejected the landscape openness hypothesis as well (Fyfe 2012). He stated that there is no single blueprint for the vegetation composition on and around a barrow site and that barrows were built in landscapes that varied from very open to forested. He also mentions however, that barrows were built in the relatively most open places in the environment. Casparie and Groenman-van Waateringe (1980, 61) conclude: "*The environment in the immediate vicinity of a barrow varied from only slightly degraded forest to extremely degraded, heath-rich vegetations, with all possible intermediate stages*." The research in this thesis shows that barrows were built in open spaces that varied in size from small to large. Besides, it was shown that visibility could still have played a role in small open spaces especially while they might have been connected forming a narrow long-stretched corridor heathland. In addition, a forested site does not necessarily imply that visibility played no role in the barrow building. Especially when multiple barrows were built in a region small views might even have emphasised their special place in the landscape (figure 13.5). Visibility was maintained while the heathland was managed. This could have been a ritual activity purely to preserve the visibility of the barrows in the landscape, it is however much more likely that the management also had an economic aspect. As has been discussed above and in the Chapters 8-12 grazing was probably involved and to maintain such extensive areas of heathland considerable livestock was necessary. It is therefore expected that the barrow landscape was in use as part of the agricultural organization of the prehistoric farmers.

To conclude, the role of barrows in the landscape of the central and southern Netherlands seemed to be twofold. On the one hand they were assigned a special place in the landscape, separate from settlements and fields, where visibility seemed to have played an important role. On the other hand they were integrated into everyday life, while they formed part of the economic zone of the people living in the area. Prehistoric landscape undergoes impressive changes from the Neolithic

Figure 13.5. A small alignment of barrows at Toterfout-Halve Mijl. The small view emphasizes the 'specialness' of barrows.

to the Iron Age (and further on), when prehistoric man gradually changed it to a cultural landscape. The heaths of the barrow landscape, however, were very stable elements in this changing landscape that existed as such for thousands of years.

13.2 The heath open-forest passage landscape as part of the Dutch prehistoric landscape

Peat and lake sediments have been proven to be good pollen preservers, as has been explained in section 2.2.1. Therefore, information about the Dutch prehistoric landscape is mainly derived from palynological analyses of peat and lake sediments. Pollen in peat and lake sediments is assumed to represent the regional vegetation. However, this mainly accounts for the arboreal pollen component. Most herbal pollen does not travel long distances and therefore open places in the region of the peat or lake will be underrepresented or not be recorded at all. As has been shown by the palynological analyses of the Venloop and Slabroek (see chapter 6.1) a peat diagram does not necessarily represent the vegetation composition of a burial complex at only 1 km distance. It is therefore not realistic to generalize the landscape that was shown by peat and lake sediment analyses, since they only represent a specific type of landscape. For Late Neolithic times, when barrows were started being built, the general view of the Dutch landscape is that it is dominated by deciduous woodland (see 2.1). This research has shown that this view should be reconsidered and that the landscape was probably already more open than previously thought. In addition, palynological analyses of barrows only show a particular part of the landscape and the landscape picture drawn from this research can certainly not just be extended to for example settlements sites, neither can it be applied to sites with completely different environmental circumstances like wetland sites. Other researchers have argued that palynological sampling of peat and lake sediments alone are not suitable for a detailed vegetation reconstruction. Behre (1986) for example has reconstructed the development of landscape and prehistoric habitation within an isolated (surrounded by bogs) prehistoric settlement area called Flögeln (Northwest Germany) by creating a dense network of ten pollen diagrams. Palynological data were collected from a large raised bog just north of the settlement area, which provided the history of a regional vegetation development. However, habitation phases were hardly reflected in these diagrams. Only pollen diagrams derived from kettle-hole bogs within the settlement area showed a detailed overview of the several habitation phases in the area. Behre concluded that many pollen diagrams only show part of the (settlement) landscape, even when a settlement area was situated very close to the sample location. To get a most complete reconstruction of landscape and habitation development sampling at multiple locations in the area is necessary. Also Groenewoudt *et al.* stated that the distance of most peat remnants to settlement areas is too large to provide reliable data about them (Groenewoudt *et al.* 2007). They collected palynological data from (man-made) pools and wells in or close to Late Bronze Age to Medieval settlements in a small-scale cover sand area in the eastern part of the Netherlands to get a more detailed understanding of the vegetation development in that settlement area. They concluded that during the Neolithic the settlements were situated in natural open spaces as islands in a forest landscape, after which rapid deforestation reversed the landscape structure with islands of woodland in a cultivated landscape. This was already established during the Iron Age, much earlier than suggested by most peat pollen diagrams. The data used in their research still do not provide a complete picture of the total landscape, since these samples were all taken in a settlement setting and as a consequence all represent a by humans influenced vegetation composition. Nevertheless this research is another confirmation that peat and lake pollen diagrams do not necessarily reflect a complete image of a landscape, since they might miss valuable local information.

The prehistoric landscape did not just consist of deciduous woodland, neither does deciduous woodland with settlement islands show the whole picture or is the barrow heathland landscape representative for the total landscape. To get a complete image of a landscape sampling of multiple locations in different settings is necessary. The sampling of barrows has proven to be a valuable addition to reconstruct the landscape at a more local level.

In conclusion, the barrow landscape was a landscape dominated by heath. Heath communities worked together for many generations to maintain these heathland areas. These heaths were not only the final resting places for their ancestors, but they had also been used and maintained by these ancestors. These ancestral heaths were very stable elements in the landscape and were kept in existence as such for thousands of years, forming the most important factor in structuring the barrow landscape.

Chapter 14

Conclusions: answers to the research questions

14.1 What did a barrow landscape look like and what was the vegetation (history) around barrows?

From the Late Neolithic onwards barrows were built in open spaces that were covered with heath vegetation. The heath the barrows were raised in originated from before the barrows were built and must have been maintained by heath management activities before and after the barrows were built. Management activities most likely involved grazing and possibly also burning and sod cutting. On the one hand these activities might have been applied intentionally to maintain the heath. On the other hand maintenance of the heath might have been a side-effect to the agricultural activities prehistoric man carried out in their everyday life. The oldest barrows were built in heath areas with an average distance to the forest (ADF) varying from 50 m up to 150 m. These heath areas were often connected to each other, forming long-stretched heath areas with a length of several kilometres, while in the late Neolithic A long alignments of barrows were formed. From the Late Neolithic B barrows onwards barrows were also built outside these alignments. These barrows too were built in heath areas with an ADF of 50 to 150 m. At the same time the long-stretched heath areas were maintained as well, while barrows in the alignments were re-used or new barrows were added to the alignments. The open spaces the youngest (Middle to earlier Late Iron Age) barrows were built in might have been larger in size, with an ADF that could reach 500 m. The barrow heath was surrounded by deciduous forest. In the relatively dry parts of the environment this deciduous forest was fairly open of character and consisted mainly of *Quercus* (oak) and *Tilia* (lime; from the Bronze Age onwards partly replaced by beech *e.g. Fagus*) with probably *Corylus* (hazel) profusely present at the forest edge. The forest in the wetter parts of the area was dominated by *Alnus* (alder).

In summary, the barrow landscape must have been dominated by managed patches of heath surrounded by open forest. These heath areas contained one or more barrows and were often connected to each other, forming passage ways in the landscape. The barrow landscape was a stable, managed mosaic heath open-forest passage landscape that was must have been maintained as such for many generations.

14.2. Were barrows built on ancestral grounds? What is the relationship with pastoral zones?

Based on the data that are currently available, discussed in the previous chapters, it is most likely that barrows indeed were built on ancestral grounds. Most barrows were situated in pastoral areas that were not only grazed when the barrows had been built, but probably also prior to the barrow building. None of the investigated barrows was built in areas that were very recently cleared especially for the construction of a burial mound. No indications have been found that barrows were built in the near vicinity of a settlement or an arable field, but in all cases barrows were built on land that had been in use by prehistoric man who could very well be the ancestors of the builders.

14.3 What was the size of the open space barrows were constructed in and what was the distance to the forest?

Open spaces barrows were built in varied in size from small, with an average distance to the forest of 50-100 m, until rather large, with an average distance from the barrow to the forest of 300-500 m, although the latter has only been found in the relatively young Early Iron Age barrows of the Echoput. Most barrows were probably built in open spaces with an ADF of approximately 50-150 m. Although the forest might have been rather close to most barrows, the heathland area barrows were built in could still have been relatively extended. Long-stretched heathland areas with a length of several kilometres were probably not exceptional. Such extensive heathland areas already existed in the Late Neolithic and continued to exist for thousands of years.

14.4 What was the role of barrows in the landscape? How can the history of the barrow environment be linked to that of the natural and cultural landscape in the surroundings?

The role of barrows in the landscape of the central and southern Netherlands appeared to have been twofold. First, they occupied a special place in the landscape. Barrows were built in heath areas that were probably at a distance from settlements and arable fields. Visibility seemed to have played an important role. Second, they were part of the daily life of prehistoric man. The barrow landscape was included in the economic zone of farming communities in the area, while the heath areas were used as grazing grounds. Prehistoric landscape seems to undergo impressive changes from the Neolithic to the Iron Age (and further on), when prehistoric man gradually changed it to a cultural landscape. The heaths of the barrow landscape, however, probably were very stable elements in this changing landscape that existed as such for thousands of years.

14.5 Supplying Staatsbosbeheer with advice and suggestions, to aide in reconstructing the original environment around barrows for purposes of tourism

In the previous chapters has been attempted to sketch what the barrow landscape of the 3rd and 2nd millennium BC in the central and southern Netherlands looked like. In Chapter 1 (1.2) the societal significance of this barrow research has been stated. Combined with the theses of Bourgeois (on the genesis of the barrow landscape; Bourgeois 2013) and Wentink (on the social and ideological identity of the dead; Wentink in prep.) this thesis should provide a most detailed possible story about the barrow landscape, the barrows, who and what is buried inside the barrows and who built them: a story that could be told to the public. The owners of Dutch nature reserves want to present the barrows to the public in their original environmental context (if possible). Therefore they are interested in what the original environment looked like, information which would enable them to adjust their management and development regime [to achieve this original environment as much as possible].

The barrow landscape as reconstructed in the previous chapters has provided a general view on what it must have looked like in reality. The reconstruction pictures with circular patches of heath are simplifications of what the barrow landscape must have been looked like in reality. Nevertheless, they must certainly give a good impression of the visual impact of the heathlands barrows were built in. For the owners of nature reserve areas that want to include barrows in their development and management this would be a good starting point. To show the public what the barrow landscape looked like they should be situated in a heathland area in such a way that the barrow (or barrows) is well visible when entering that heathland area. The size of the heathland differed from case to case and the size of the area that should be reconstructed is probably more dependent on present day environmental and logistical circumstances. Current environmental circumstances are different than they were in the barrow period. Present day acidification, fertilization and dehydration have changed the soil conditions. Consequently, these factors will be of great influence on the maintenance of heath areas and surrounding forest. As for heritage management: only the barrow itself is considered a monument and in some cases the area around the barrow to a maximum of 10 metres (see 1.2). This research has shown that a barrow was inextricably linked to the heathland around it. The heath was most likely wider than 10 m around the monument. In addition, the excavation of Oss-Zevenbergen (Chapter 12.1) and the Echoput (Chapter 8.1) have shown that the area around a barrow could be of great archaeological value (post hole structures) and it does make sense to enlarge the protected environment around the barrow to preserve valuable Dutch cultural heritage. This thesis provides a guide line of what the barrow landscape probably looked like in general and it is now up to the landowners (and the cultural heritage management) how to use it.

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Appendix 1

Northern and Central Veluwe	Barrow name	Coordinates	Barrow ID Bourgeois (2013)	Synonym Casparie and Groenman-van Waateringe 1980	Original synonyms	Original pollen data
Boeschoten	Boeschoten	174040/469844 ?	-		tumulus Huneweg (Waterbolk 1954)	Waterbolk 1954
Echoput	Echoput 1	188431/472100	-		mound 1 (Fontijn *et al.* 2011)	Doorenbosch (this volume)
	Echoput 2	188440/472080	-		mound 2 (Fontijn *et al.* 2011)	Doorenbosch (this volume)
Emst, Langeweg	Emst	191868/482135	ID 631	S30	Emst (Hulst 1972)	Casparie and Groenman-van Waateringe 1980
Ermelo	Ermelo III	174832/478453	ID 326	S9	barrow III (Modderman 1954)	Casparie and Groenman-van Waateringe 1980
	Ermelo I	174949/478453	ID 324	S15	barrow I (Modderman 1954)	Casparie and Groenman-van Waateringe 1980
Epe	Vaassen 1	192215/477315	ID 273	S2	tumulus I (Lanting and van der Waals 1971d)	Casparie and Groenman-van Waateringe 1980
	Vaassen 2	192262/477262	ID 274	S24	tumulus II (Lanting and van der Waals 1971d)	Casparie and Groenman-van Waateringe 1980
	Vaassen 3	192251/477294	ID 275	S3	tumulus III (Lanting and van der Waals 1971d)	Casparie and Groenman-van Waateringe 1980
Niersen	Niersen 4	191092/478801	ID 635		Galgenberg 4 (Holwerda 1908)	Doorenbosch (this volume)
	Niersen 6	191226/479004	ID 637		Galgenberg 6 (Holwerda 1908)	Doorenbosch (this volume)
Putten	Putten	170800/476200	ID 409	S12	Putten (Waterbolk 1954)	Waterbolk 1954
Stroe	Stroe	178759/466801	-	S21	Stroe (Butler and van der Waals 1967, 124)	Casparie and Groenman-van Waateringe 1980
Uddelermeer	Uddelermeer 1	180411/473379	-		barrow 223 (ROB 1989)	Doorenbosch (this volume)
	Uddelermeer 2	180441/473390	-		barrow 224 (ROB 1989)	Doorenbosch (this volume)
Ugchelen	Ugchelen 1	191550/465163 ?	-		barrow 1 (Waterbolk 1954, 95)	Waterbolk 1954
	Ugchelen 4	191550/465163 ?	-		barrow 4 (Waterbolk 1954, 95)	Casparie and Groenman-van Waateringe 1980
Vierhouten	Vierhouten	185941/483081 ?	-	S26	Vierhouten (Lanting and van der Waals 1972c)	Casparie and Groenman-van Waateringe 1980

Renkum	Barrow name	Coordinates	Barrow ID Bourgeois (2013)	Synonym Casparie and Groenman-van Waateringe 1980	Other synonyms	Original pollen data
Doorwerth	Doorwerth	181748/443820	ID 400	S16	Doorwerth (Hulst *et al.* 1973)	Casparie and Groenman-van Waateringe 1980
Renkum	Bennekom 1	178638/446023	ID 322		Bennekom Kwade Oord, tumulus I (van Giffen 1954)	Van Giffen 1954
	Bennekom Oostereng	178750/446501	ID 427	S25	Bennekom Oostereng, heuvel 12 (Bursch 1933)	Casparie and Groenman-van Waateringe 1980
	Ede 1	179301/449114	ID 4103	S27	Heuvel Amber, Ede 5 (Lanting and van der Waals 1971a)	Casparie and Groenman-van Waateringe 1980
	Ede 2	179234/448629	ID 4010	S20	Girhen (Lanting and van der Waals 1976)	Casparie and Groenman-van Waateringe 1980
	Renkum 1	178925/444982	ID 4106	S4	Kwadenoord, heuvel Q (Lanting and van der Waals 1972b)	Casparie and Groenman-van Waateringe 1980
	Renkum 2	178933/445000	ID 4107	S6	Kwadenoord, heuvel S (Lanting and van der Waals 191972b)	Casparie and Groenman-van Waateringe 1980
	Renkum 3	178980/444070	ID 4501	S7	Keyenberg (Modderman 1964)	Casparie and Groenman-van Waateringe 1980
	Renkum 4	178975/444702	ID 4002	S8	Kwadenoord	Casparie and Groenman-van Waateringe 1980
	Renkum 5	179340/443150	ID 4524	S28	Ketsberg (van Giffen 1958)	Casparie and Groenman-van Waateringe 1980
Warnsborn, Arnhem	Warnsborn 1	187220/446888 ?	-	S1	Schaarsbergen, barrow 1 (Waterbolk 1954, 95-98)	Casparie and Groenman-van Waateringe 1980
	Warnsborn 2	187116/447009 ?	-		Schaarsbergen, barrow 2 (Waterbolk 1954, 95-98)	Waterbolk 1954, Casparie and Groenman-van Waateringe 1980
	Warnsborn 3	187000/447080 ?	-		Schaarsbergen, barrow 3 (Waterbolk 1954, 95-98)	Waterbolk 1954
	Warnsborn 4	186908/447054 ?	-		Schaarsbergen, barrow 4 (Waterbolk 1954, 95-98)	Waterbolk 1954
	Warnsborn 5	186891/447033 ?	-		Schaarsbergen, barrow 5 (Waterbolk 1954, 95-98)	Waterbolk 1954
	Warnsborn 6	186808/446941	-		Schaarsbergen, barrow 6 (Waterbolk 1954, 95-98)	Waterbolk 1954
Wolfheze	Wolfheze	183491/446004	-	S31	Wolfheze (Hulst 1971)	Casparie and Groenman-van Waateringe 1980

Gooi	Barrow name	Coordinates	Barrow ID Bourgeois (2013)	Synonym Casparie and Groenman-van Waateringe 1980	Other synonyms	Original pollen data
Baarn (Groot Drakenstein/ Lage Vuursche)	Baarn 1	144240/466040	ID 414	S13	Groot-Drakenstein, tumulus I (van Giffen 1930)	Casparie and Groenman-van Waateringe 1980
	Baarn 2	144270/466080	ID 415	S14	Groot-Drakenstein, tumulus III (van Giffen 1930)	Casparie and Groenman-van Waateringe 1980
	Baarn 3	144231/466122	-	S29	Groot-Drakenstein, tumulus V (van Giffen 1930)	Casparie and Groenman-van Waateringe 1980
Hilversum (Erfgooierstraat)	Hilversum 1	141400/472800	ID 291	S18	Erfgooiersstraat, heuvel 1 (Bursch 1935)	Casparie and Groenman-van Waateringe 1980
	Hilversum 2	141130/471130	ID 295	S32	Erfgooiersstraat, heuvel 5 (Bursch 1935)	Casparie and Groenman-van Waateringe 1980
	Hilversum 3	141130/471130	ID 296	S33	Erfgooiersstraat, heuvel 6 (Bursch 1935)	Casparie and Groenman-van Waateringe 1980
Laren	Laren 1	143080/471890	ID 384	S10	t Bluk, heuvel 6 (Remouchamps 1928)	Casparie and Groenman-van Waateringe 1980
	Laren 2	143140/472100	ID 388	S17	t Bluk, heuvel 10 (Remouchamps 1928); De Zeven Bergjes, heuvel 10 (Modderman 1954)	Casparie and Groenman-van Waateringe 1980
	Laren 3	143400/472200	ID 380	S19	t Bluk, heuvel 2 (Remouchamps 1928); De Zeven Bergjes, heuvel 2 (Modderman 1954)	Casparie and Groenman-van Waateringe 1980
Roosterbos	Roosterbos	146560/468680	ID 413	S11	Roosterbos, Grabhugel II (van Giffen 1930)	Casparie and Groenman-van Waateringe 1980

Toterfout-Halve Mijl	Barrow name	Coordinates	Barrow ID Bourgeois (2013)	Synonym Casparie and Groenman-van Waateringe (1980)	Other synonyms	Original pollen data
THM eo: Alphen, de Kiek	Alphen 1	127220/389900	ID 92	S34	Alphen Op de Kiek (Modderman 1955)	Casparie and Groenman-van Waateringe 1980
THM eo: Alphen, de Kwaalberg	Alphen 2	123935/387020	ID 91	S35	Alphen de Kwaalberg (Beex 1964c)	Casparie and Groenman-van Waateringe 1980
THM eo: Bergeijk	Bergeijk	146650/367250	ID 403		Bergeijk Witrijt (Beex 1957)	Beex 1957, Waterbolk 1957
THM eo: Eersel	Eersel	150620/376030	ID 133		De Gloeiende Engelsman (Beex 1964b)	Van Zeist 1967b
THM eo: Goirle	Goirle	129270/389430	ID96		barrow 1 (Glasbergen 1954)	Waterbolk 1954
THM eo: Hoogeloon	Hoogeloon 1	146220/379600	ID 137		Zwartenberg (Waterbolk 1954)	Waterbolk 1954
	Hoogeloon 2	146500/379570	ID 138		Smousenberg (Beex 1954)	Beex 1954
THM eo: Knegsel Moormanlaan	Knegsel, Moormanlaan	153275/377835	ID 113		Moormanlaan (Modderman and Bakels 1971)	Modderman and Bakels 1971
THM eo: Knegsel Urnenweg	Knegsel 1	150715/378274	ID 78		tumulus E (Waterbolk 1954, 104-108)	Waterbolk 1954
	Knegsel 2	150738/378384	ID 79		tumulus F (Waterbolk 1954, 104-108)	Waterbolk 1954
THM eo: Steensel	Steensel				Steensel (Waterbolk 1954, 103, 109-110)	Waterbolk 1954
THM: Toterfout Halve Mijl	THM 1	152242/380911	ID 645		barrow 1 (Glasbergen 1954)	Glasbergen 1954
	THM 1B	151903/380957	ID 10		barrow 1b (Glasbergen 1954)	Glasbergen 1954
	THM 2	151912/381044	ID 11		barrow 2 (Glasbergen 1954)	Glasbergen 1954
	THM 3	151860/380937	ID 12		barrow 3 (Glasbergen 1954)	Glasbergen 1954
	THM 4	151511/381357	ID 646		barrow 4 (Glasbergen 1954)	Glasbergen 1954
	THM 5	151290/380984	ID 13		barrow 5 (Glasbergen 1954)	Glasbergen 1954
	THM 6	151242/380985	ID 14		barrow 6 (Glasbergen 1954)	Glasbergen 1954
	THM 7	151176/380986	ID 15		barrow 7 (Glasbergen 1954)	Glasbergen 1954
	THM 8	151165/380950	ID 16		barrow 8 (Glasbergen 1954)	Glasbergen 1954

Toterfout-Halve Mijl	Barrow name	Coordinates	Barrow ID Bourgeois (2013)	Synonym Casparie and Groenman-van Waateringe (1980)	Other synonyms	Original pollen data
	THM 8A	151176/381050	ID 17		barrow 8A (Glasbergen 1954)	Glasbergen 1954
	THM 9	151067/381092	ID 18		barrow 9 (Glasbergen 1954)	Glasbergen 1954
	THM 10	151074/380864	ID 19		barrow 10 (Glasbergen 1954)	Glasbergen 1954
	THM 11	151087/380835	ID 20		barrow 11 (Glasbergen 1954)	Glasbergen 1954
	THM 13	150860/380713	ID 22		barrow 13 (Glasbergen 1954)	Glasbergen 1954
	THM 14	150825/380710	ID 23		barrow 14 (Glasbergen 1954)	Glasbergen 1954
	THM 15	150793/380711	ID 24		barrow 15 (Glasbergen 1954)	Glasbergen 1954
	THM 16	150773/380706	ID 25		barrow 16 (Glasbergen 1954)	Glasbergen 1954
	THM 17	150750/380759	ID 26		barrow 17 (Glasbergen 1954)	Glasbergen 1954
	THM 19	150723/380751	ID 28		barrow 19 (Glasbergen 1954)	Glasbergen 1954
	THM 20	150714/380771	ID 29		barrow 20 (Glasbergen 1954)	Glasbergen 1954
	THM 21	150643/380738	ID 30		barrow 21 (Glasbergen 1954)	Glasbergen 1954
	THM 22	150610/380731	ID 31		barrow 22 (Glasbergen 1954)	Glasbergen 1954
	THM 22A	150640/380753	ID 32		barrow 22A (Glasbergen 1954)	Glasbergen 1954
	THM 23	150601/380713	ID 33		barrow 23 (Glasbergen 1954)	Glasbergen 1954
	THM 24	150582/380725	ID 34		barrow 24 (Glasbergen 1954)	Glasbergen 1954
	THM 25	150572/380712	ID 35		barrow 25 (Glasbergen 1954)	Glasbergen 1954
	THM 26	150553/380734	ID 36		barrow 26 (Glasbergen 1954)	Glasbergen 1954
	THM 28	150562/380704	ID 38		barrow 28 (Glasbergen 1954)	Glasbergen 1954
	THM 29	150546/380722	ID 39		barrow 29 (Glasbergen 1954)	Glasbergen 1954

Oss-Zevenbergen	Barrow name	Coordinates	Barrow ID Bourgeois (2013)	Synonym Casparie and Groenman-van Waateringe (1980)	Other synonyms	Original pollen data
Schaijk	Schaijk	173060/416560	ID 3		tumulus 3 (van Giffen 1949)	Van Giffen 1949, Waterbolk 1954
Slabroek	Slabroek 39		-		heuvel 39 (van Wijk 2005b)	De Kort and van Mourik 2005
	Slabroek 40		-		heuvel 40 (van Wijk 2005b)	De Kort and van Mourik 2005
Vorssel	Vorssel		-		Vorssel (de Kort 2005)	De Kort 2005
Oss Vorstengraf	Oss Chieftain's grave	167070/415780	-		Vorstengraf (Bursch 1937)	De Kort 1999
	Chieftain's grave BA-barrow		-		Bronstijdgraf (Fokkens and Jansen 2005)	De Kort 1999
Oss Zevenbergen	Oss-Zevenbergen 1	168105.58/416117.24	-		heuvel 1 (Fokkens *et al.* 2009b)	De Kort 2009
	Oss-Zevenbergen 2	167914.44/416042.36	-		tumulus III (Verwers 1966), heuvel 2 (Fokkens *et al.* 2009b)	De Kort 2009
	Oss-Zevenbergen 3	167930.87/416129.25	-		tumulus IV (Verwers 1966), heuvel 3 (Fokkens *et al.* 2009b)	De Kort 2009
	Oss-Zevenbergen 4	167867.76/416087.00	-		heuvel 4 (Fokkens *et al.* 2009b)	De Kort 2009
	Oss-Zevenbergen 6	168006.61/416082.51	-		tumulus V (Verwers 1966), heuvel 6 (Fokkens *et al.* 2009b)	Bakels and Achterkamp 2013
	Oss-Zevenbergen 7	168034.35/416097.91	-		tumulus VI (Verwers 1966), heuvel 7 (Fokkens *et al.* 2009b)	Achterkamp 2009, Bakels and Achterkamp 2013
	Oss-Zevenbergen 8	167972.48/416073.16	-		tumulus I (Verwers 1966), heuvel 8 (Fokkens *et al.* 2009b)	De Kort 2009
	Oss-Zevenbergen 9	167968.60/416085.79			heuvel 9 (Fokkens *et al.* 2009b)	-
	Oss-Zevenbergen 10	167922.36/416087.00			heuvel 10 (Fokkens *et al.* 2009b)	-
	Oss-Zevenbergen 11	167902.44/416072.72			heuvel 11 (Fokkens *et al.* 2009b)	De Kort 2009
	Oss-Zevenbergen 12	167913.70/416085.77			heuvel 12 (Fokkens *et al.* 2009b)	De Kort 2009
	Mound 5	167953.77/416063.81			tumulus V (Verwers 1966), heuvel 5 (Fokkens *et al.* 2009b)	De Kort 2009
Total number of barrows in thesis	**97**					

Appendix 2

Trees and shrubs

Scientific	English	Dutch
Alnus	Alder	Els
Betula	Birch	Berk
Carpinus	Hornbeam	Haagbeuk
Corylus	Hazel	Hazelaar
Fagus	Beech	Beuk
Fraxinus	Ash	Es
Hedera helix	Ivy	Klimop
Pinus	Pine	Den
Populus	Popular	Populier
Quercus	Oak	Eik
Rubus	Bramble	Braam
Salix	Willow	Wilg
Tilia	Lime	Linde
Ulex	Gorse	Gaspeldoorn
Ulmus	Elm	Iep
Castanea	Chestnut	Kastanje
Sambucus nigra	Elder	Vlier

Herbs and alga

Scientific	English	Dutch
Angelica archangelica	Garden angelica	Grote engelwortel
Anthriscus sylvestris	Cow parsley	Fluitenkruid
Apiaceae	Umbellifer family	Schermbloemenfamilie
Artemisia	Mugwort	Alsem
Asteraceae	Composite family	Composietenfamilie
Asteraceae liguliflorae	Composite family (liguliflorae refers to morphology)	Lintbloemige composieten
Asteraceae tubuliflorae	Composite family (tubuliflorae refers to morphology)	Buisbloemige composieten
Botryococcus	Green microalga	Groene algensoort
Brassicaceae	Crucifer family	Kruisbloemenfamilie
Calluna vulgaris	Common heather	Struikhei
Cannabis sativa	Hemp	Hennep
Caryophyllaceae	Carnation family	Anjerfamilie
Cerealia	Cereals	Granen
Chenopodiaceae	Goosefoot family	Ganzenvoetfamilie
Chrysosplenium	Golden saxifrage	Goudveil
Cyperaceae	Sedges	Cypergrassenfamilie
Debarya glyptosperma	Green alga	Groene algensoort
Empetrum nigrum	Black crowberry	Kraaiheide
Ericaceae	Heather	Heidefamilie
Galium	Bedstraw	Walstro
Huperzia selago	Fir club moss	Dennenwolfsklauw
Jasione montana	Sheepsbit	Zandblauwtje

Scientific	English	Dutch
Liliaceae	Lily family	Leliefamilie
Monolete psilate fern spores	Monolete psilate fern spores	Monolete psilate varensporen
Monolete verrucate fern spores	Monolete verrucate fern spores	Monolete verrucate varensporen
Narthecium ossifragum	Bog asphodel	Beenbreek
Plantago lanceolata	Plantain	Smalle weegbree
Poaceae	Grasses	Grassenfamilie
Polypodium vulgare	Common polypody	Gewone eikvaren
Pteridium	Bracken	Adelaarsvaren
Rosaceae	Rose family	Rozenfamilie
Rubiaceae	Cleaver family	Sterbladigenfamilie
Rumex	Dock	Zuring
Secale	Rye	Rogge
Solanum dulcamara	Bittersweet	Bitterzoet
Sparganium	Bur-reed	Egelskop
Spergula arvensis	Corn spurrey	Gewone spurrie
Sphagnum	Peat moss	Veenmos
Stratiotes aloides	Water soldier	Krabbenscheer
Succisa	Devil's bit	Blauwe knoop
Triglochin	Arrowgrass	Zoutgras
Trilete fern spores	Trilete fern spores	Trilete varensporen
Zygnemataceae	Green algae family	Groene algenfamilie

Pollen types

Scientific	English	Dutch
Astragalus-type	Milkvetch-type	Hokjespeul-type
Cerastium-type	Mouse-ear chickweed-type	Hoornbloem-type
Cuscuta europaea-type	Greater dodder-type	Groot warkruid-type
Digitalis/Scrophularia-type	Foxglove/figwort-type	Vingerhoedskruid/helmkruid-type
Filipendula-type	Meadowsweet-type	Spirea-type
Galium-type	Bedstraw-type	Walstro-type
Hypericum perforatum-type	St John's wort	Sint-janskruid
Jasione montana-type	Sheepsbit-type	Zandblauwtje-type
Mentha-type	Mint-type	Munt-type
Papaver rhoeas-type	Poppy-type	Gewone klaproos-type
Prunella-type	Self-heal-type	Brunel-type
Ranunculus acris-type	Buttercup-type	Scherpe boterbloem-type
Saxifraga granulata-type	Meadow saxifrage-type	Knolsteenbreek-type
Spergularia-type	Sea-spurry-type	Schijnspurrie-type
Trifolium-type	Clover-type	Klaver-type
Vaccinium-type	Bilberry-type	Bosbes-type
Veronica-type	Speedwell-type	Ereprijs-type

Appendix II. Scientific names of all the taxa that have been identified in the palynological analyses of this thesis. Taxa have been divided into three groups: trees and shrubs, herbs and alga and so-called pollen-types. The pollen-types refer to morphologically similar pollen-types and do not necessarily represent the taxa the types are named after. According to Beug (2004, 33):

"Three or more taxa are possible alternatives, but further distinction is not possible on the basis of pollen or spore morphology alone."

Samenvatting

Dit proefschrift gaat over de geschiedenis van prehistorische grafheuvellandschappen in Midden- en Zuid-Nederland, gereconstrueerd door middel van palynologisch onderzoek (onderzoek met behulp van pollenanalyses). Het proefschrift bestaat uit drie delen. In deel 1 wordt de achtergrond van het onderzoek behandeld (hoofdstuk 1). Vervolgens wordt een overzicht gegeven van hoe palynologisch onderzoek van grafheuvels zich ontwikkeld heeft (hoofdstuk 2) en tenslotte worden de onderzoeksvragen die de basis vormen van dit promotieonderzoek uiteengezet (hoofdstuk 3).

In deel 2 wordt de methodologie die gebruikt is om de onderzoeksvragen te kunnen beantwoorden besproken en bediscussieerd. Hoofdstuk 4 geeft een overzicht van de technieken die gebruikt zijn om grafheuvels te bemonsteren. In hoofdstuk 5 komt de discussie over hoe pollendiagrammen gebaseerd op pollen uit minerale bodems gebruikt kunnen worden om een vegetatiegeschiedenis te reconstrueren aan de orde. In hoofdstuk 6 wordt de zogenaamde pollensom die gebruikt wordt in grafheuvel-pollenonderzoek besproken en opnieuw vastgesteld. Hoofdstuk 7 gaat over de vraag hoe je de grootte van een open plek waar een grafheuvel in gebouwd werd kunt bepalen.

In het laatste deel, deel 3, komt het palynologisch onderzoek naar grafheuvels in vijf gebieden aan de orde (hoofdstuk 8-12). In hoofdstuk 13 en 14 worden de resultaten van deze deelonderzoeken samengevoegd en bediscussieerd om zo tot een reconstructie van de geschiedenis van het grafheuvellandschap te komen.

Hieronder volgt een samenvatting per hoofdstuk.

Deel 1

H1: Er zijn in Europa honderdduizenden grafheuvels bekend, waarvan er zo'n 3000 in Nederland liggen. De meeste van deze grafheuvels dateren uit het 3^{e} en 2^{e} millennium voor Christus en in die tijd waren ze zo talrijk dat ze waarschijnlijk hele 'grafheuvellandschappen' vormden. Maar welke rol speelden grafheuvels eigenlijk in het landschap en hoe zag zo'n grafheuvellandschap er uit? Er zijn in de vorige eeuw veel reconstructies gemaakt van de vegetatie in de directe omgeving van een grafheuvel, maar een totale landschapsreconstructie ontbreekt. Om te kunnen begrijpen welke betekenis grafheuvels hadden in het landschap is het van belang om niet alleen te kijken naar de locale vegetatiereconstructies, maar om het landschap waarin de grafheuvels gebouwd werden in een breder perspectief te bekijken. Ook is het van belang meer te weten te komen over de ontstaans- en gebruiksgeschiedenis van deze landschappen.

Vragen over deze grafheuvellandschappen komen niet alleen voort uit wetenschappelijke, maar ook uit maatschappelijke interesse. Staatsbosbeheer, als beheerder van vele natuurreservaten in Nederland waar grafheuvels te vinden zijn, is bijvoorbeeld geïnteresseerd in hoe het landschap rond deze heuvels er oorspronkelijk uitzag. De organisatie wil meer informatie aan het publiek kunnen geven over de grafheuvels en ze, indien mogelijk, laten zien in hun oorspronkelijke omgeving. Informatie over het oorspronkelijke landschap waarin heuvels lagen is voor de organisatie van belang om hun (landschappelijk) beleid hierop aan te kunnen passen.

H2: Over het algemeen wordt aangenomen dat het grootste deel van Midden- en Zuid-Nederland (de gebieden waar dit onderzoek zich op gericht heeft) ten tijde dat de eerste grafheuvels gebouwd werden (tijdens het Subboreaal) nog grotendeels bedekt was met bos. In de vorige eeuw is al veel onderzoek gedaan naar de directe omgeving van grafheuvels, waaruit is gebleken dat grafheuvels gebouwd werden op open plekken. Over het ontstaan en gebruik van deze open plekken is nauwelijks iets bekend. Wellicht was het landschap van nature in deze tijd al veel meer open dan over het algemeen wordt aangenomen. Daarnaast kunnen bijvoorbeeld storm of overstromingen de oorzaak zijn van open plekken. Een andere mogelijkheid is dat open plekken ontstaan zijn door toedoen van de mens. Zo is in het Neolithicum veel bos verdwenen (bijvoorbeeld gekapt of verbrand) om bijvoorbeeld ruimte te maken voor landbouwactiviteiten, het bouwen van nederzettingen (huizen, schuurtjes, hekwerken etc.) of misschien wel om een open plek te creëren om een grafheuvel in te bouwen. Het is op dit moment niet duidelijk wat voor open plekken gebruikt werden om grafheuvels in te bouwen en of de oorsprong van zo'n open plek belangrijk was voor de grafheuvelbouwers. Wellicht had men een voorkeur voor voorouderlijke gronden, dat wil zeggen gronden die al lange tijd in gebruik waren geweest door de voorouders van de grafheuvelbouwers. Ook is het onbekend hoe groot de open plekken waren die uitgekozen werden voor grafheuvels.

H3: Om antwoord te geven op de vragen die in de voorgaande hoofdstukken naar voren komen is er een vijftal onderzoeksvragen geformuleerd:

1. Hoe zag een grafheuvellandschap eruit en wat is de ontstaans- en gebruiksgeschiedenis van zo'n landschap?
2. Werden grafheuvels gebouwd op voorouderlijke gronden?
3. Wat was de grootte van een open plek waar grafheuvels in gebouwd werden en wat was de afstand van een grafheuvel tot de bosrand?
4. Welke rol speelden grafheuvels in het landschap? Hoe stond de geschiedenis van een grafheuvellandschap in verband met het natuurlijke en culturele landschap in de omgeving van grafheuvels?
5. Welk advies is te geven aan Staatsbosbeheer en andere instanties met betrekking tot het herstellen van oorspronkelijke grafheuvellandschappen voor publieke doeleinden?

Om deze onderzoeksvragen te beantwoorden is het onderzoek gericht op het midden en zuiden van Nederland, aangezien daar veel grafheuvels te vinden zijn. Deze grafheuvels stammen uit de periode van het Laat-Neolithicum tot de Midden-Bronstijd (2900-1100 BC). Van deze grafheuvels zijn al veel gegevens beschikbaar van waaruit verder onderzoek gedaan kon worden. Om de vragen te beantwoorden is vooral gebruik gemaakt van palynologisch onderzoek. Zowel bestaande als voor dit onderzoek nieuw gegenereerde pollendata zijn gebruikt om uitgebreide vegetatiereconstructies te maken.

Deel 2

H4: Palynologisch onderzoek, oftewel onderzoek met behulp van pollen (stuifmeel) analyses, is gebaseerd op het feit dat pollen over het algemeen erg goed bewaard blijft onder de juiste omstandigheden. Pollenkorrels worden verspreid en komen uiteindelijk terecht op het bodemoppervlak. Dit pollen zal in de loop van de tijd verder de bodem inzakken of verdwijnen door corrosie. Omdat er een evenwicht is tussen het verdwijnen en opnieuw neerregenen van pollen, zullen de pollenkorrels die in de bovenste laag van de bodem te vinden zijn representatief zijn voor de planten die in de (nabije en verdere) omgeving staan en deze pollenkorrels verspreiden. Op het moment dat er een grafheuvel gebouwd wordt, wordt de toplaag van de bodem waarin zich dit pollen bevindt afgesloten van de buitenlucht. Er kunnen geen nieuwe pollenkorrels meer bijkomen en pollenkorrels die al aanwezig zijn zullen niet zo snel meer verdwijnen. Het pollenspectrum dat verkregen wordt uit pollen dat onder een grafheuvel ligt (van het zogenaamde oud oppervlak) is dus representatief voor de vegetatie die in de omgeving stond op het moment dat de grafheuvel opgeworpen werd. In hoofdstuk 4 wordt de techniek van de pollenbemonstering van de bodem in en onder grafheuvels, van greppels rondom grafheuvels en van sporen in de omgeving van grafheuvels beschreven.

H5: een relatief nieuwe methode is gebruikt om meer informatie te krijgen over de vegetatiegeschiedenis van een open plek. Deze methode houdt in dat een bodemprofiel verticaal centimeter voor centimeter onder een grafheuvel bemonsterd en geanalyseerd wordt op pollen. Er wordt vanuit gegaan dat hoe dieper in de bodem, hoe ouder het vegetatiebeeld is dat een pollenspectrum geeft. Deze methode en de interpretatie ervan worden uitgebreid bediscussieerd in hoofdstuk 5.

H6: Het absolute aantal pollen in een pollenmonster kan aanzienlijk variëren. Om pollenspectra van verschillende monsters met elkaar te kunnen vergelijken worden de pollentypes uitgedrukt als percentages van een zogenaamde pollensom. Deze pollensom kan bestaan uit alle pollentypes of uit een selectie daarvan. Welke pollensom het beste is om te gebruiken is afhankelijk van de onderzoeksvraag en het onderzoeksgebied. De vraag is nu welke pollensom het meest geschikt is om te gebruiken bij het reconstrueren van grafheuvellandschappen. De meest gebruikte pollensom in het grafheuvelonderzoek is de zogenaamde boompollensom minus *Betula* (berk). De pollentypes van de kruidenvegetatie en de *Betula* worden uit de pollensom gelaten, omdat deze soorten lokaal veel voorkomen en daardoor sterk kunnen variëren in pollenspectra, zelfs als deze spectra komen van grafheuvels die dicht bij elkaar liggen of van een en dezelfde grafheuvel. Deze pollensom is echter maar eenmalig vastgesteld en daarna niet meer gecontroleerd. Daarom is besloten om nogmaals onderzoek te doen naar de meest geschikte pollensom voor grafheuvelonderzoek. Dit onderzoek wordt besproken in hoofdstuk 6.

Er zijn twee methoden gebruikt voor dit onderzoek. Als eerste is er een vergelijking gemaakt tussen een pollenspectrum van een monster uit veen en een gelijktijdig pollenspectrum uit een greppel die rondom een nabijgelegen grafheuvel gegraven is. Een pollenspectrum uit veen wordt geacht de *regionale* vegetatie weer te geven en door dit spectrum te vergelijken met het greppelspectrum zou vastgesteld moeten kunnen worden welke pollentypes de *lokale* grafheuvelvegetatie weergeven en welke dus uit de pollensom gelaten moeten worden. Ten tweede zijn meerdere pollenspectra van oude oppervlakten vanonder gelijktijdige en bij elkaar in de buurt gelegen grafheuvels met elkaar vergeleken. Deze pollenspectra zouden een (vrijwel) identiek beeld van de vegetatie moeten geven.

Uit het onderzoek is gebleken dat de meest geschikte pollensom voor grafheuvelonderzoek een boompollensom is, dus een pollensom waaruit alle kruiden weggelaten zijn. Of *Betula* al dan niet ook weggelaten moet worden lijkt te verschillen per site. Om alle grafheuvelpollenspectra met elkaar te kunnen vergelijken is besloten om voor alle pollenanalyses in dit onderzoek een boompollensom minus *Betula* te gebruiken.

H7: In hoofdstuk 7 worden drie typen onderzoek beschreven naar de grootte van een open plek waar een grafheuvel in gebouwd werd. Bij het eerste type onderzoek wordt er vanuit gegaan dat de plaggen die gebruikt werden om de grafheuvel te bouwen in de directe omgeving gestoken werden. Uit onderzoek is gebleken dat de plaggen gestoken zijn in heidevegetatie. Het aantal plaggen dat nodig is geweest om een grafheuvel te gebruiken kan dan uitgedrukt worden in de oppervlakte die minimaal vrij geweest moet zijn van bomen.

Voor het tweede type onderzoek zijn er (oppervlakte) pollenmonsters genomen in huidige heidevelden die zoveel mogelijk lijken op de heidevelden ten tijde van de grafheuvelbouw. Deze pollenmonsters zijn op verschillende afstanden van de bosrand genomen om op deze manier de relatie te kunnen bepalen tussen een boompollenpercentage en de afstand van de monsterlocatie tot de bosrand. Dit heeft geresulteerd in een zogenaamde ADF (average distance to the forest) per boompollenpercentage. Op deze manier kan dus bij een bepaald percentage boompollen in een grafheuvelmonster de gemiddelde afstand vanaf de grafheuvel tot de bosrand bepaald worden.

Het derde onderzoek heeft zich gericht op simulatiemodellen die vrij recentelijk ontwikkeld zijn (en nog steeds in ontwikkeling zijn). Met deze simulatiemodellen kunnen landschappen met een bepaalde vegetatiesamenstelling vertaald worden in pollenpercentages die daarbij horen. Voor deze modellen zijn verschillende parameters nodig die kunnen verschillen per regio. Deze parameters zijn nog niet beschikbaar voor Nederland. De parameters die gebruikt zijn voor dit onderzoek zijn afkomstig uit eerder onderzoek uit Zuid-Zweden en voor dit onderzoek getest op een Nederlands landschap met een bekende vegetatiesamenstelling en bijbehorende pollenpercentages. Hieruit bleek dat de Zuid-Zweedse parameters toepasbaar zijn in Nederland. Vervolgens zijn van een van de grafheuvellocaties uit dit onderzoek verschillende landschapsscenario's gemaakt, met gebruikmaking van de simulatiemodellen. Het landschapsscenario waaruit pollenpercentages kwamen die het dichtst lagen bij de werkelijk gevonden pollenpercentages uit de grafheuvels is gekozen als het meest waarschijnlijke landschapsscenario.

Deel 3

H8-13: In deze hoofdstukken worden vijf verschillende case-studies besproken. Ruim 100 grafheuvels in vijf verschillende gebieden zijn palynologisch onderzocht om een antwoord te krijgen op de onderzoeksvragen uit hoofdstuk 3. Een deel van de pollendata is verkregen uit nieuw onderzoek, gebaseerd op de methoden die beschreven zijn in hoofdstuk 4. Het grootste deel van de pollendata is afkomstig uit eerder onderzoek dat verricht is door verschillende andere onderzoekers. Deze pollendata zijn voor het huidige onderzoek opnieuw geanalyseerd en geïnterpreteerd met behulp van de methoden en theorieën beschreven in hoofdstukken 5-7. In hoofdstuk 13 worden de resultaten van alle case-studies samengevoegd en bekeken in een breder perspectief om een grafheuvellandschap beter te kunnen definiëren.

Het is gebleken dat grafheuvels op de Pleistocene zandgronden van Midden- en Zuid-Nederland gebouwd werden in open plekken die bedekt waren met heide. Deze open plekken varieerden in grootte. De kleinste open plekken hadden een ADF (gemiddelde afstand vanaf de grafheuvel tot de bosrand) van 50-100 m, terwijl de grootste open plekken een ADF hadden van 300-500 m. Het originele aantal grafheuvels in Nederland was nog vele malen groter dan het aantal dat tegenwoordig nog bewaard is gebleven. Er vanuit gaande dat alle niet onderzochte grafheuvels ook in heide opgeworpen zijn, zal het Nederlandse landschap dus vele open plekken met heide gekend hebben. De pollendata geven aan dat de meeste grafheuvels in redelijk kleine open plekken lagen, maar dit kan een misleidend beeld geven. Vele grafheuvels, vooral in het Laat-Neolithicum, werden namelijk gebouwd in zogenaamde alignments, rijen van grafheuvels, die kilometers lang konden zijn. Het is zeer aannemelijk dat de heideveldjes waarin deze grafheuvels gebouwd werden met elkaar verbonden waren, zodat weliswaar redelijk smalle (100-200 m breed), maar kilometers lange heidevelden ontstonden. Dit is waarschijnlijk het geval geweest in Renkum (hoofdstuk 8), Niersen-Vaassen (hoofdstuk 8), Toterfout-Halve Mijl (hoofdstuk 11) en Oss-Zevenbergen (hoofdstuk 12).

De heidevelden werden omgeven door bos, dat ook deel uitmaakte van het grafheuvellandschap. De bossen in de drogere delen van het landschap werd over het algemeen gedomineerd door *Quercus* (eik) met aan de bosranden vooral *Corylus* (hazelaar). In de nattere gebieden was voornamelijk elzenbroekbos te vinden, gedomineerd door *Alnus* (els).

Heidevelden, waar het grafheuvellandschap voor het grootste gedeelte uit bestond, hebben een bijzondere eigenschap, namelijk dat ze onderhouden moeten worden om te kunnen blijven bestaan. Als heide niet onderhouden wordt zullen andere plantensoorten de heide verdringen. Heidemanagement kan gedaan worden door middel van begrazen (of maaien), afplaggen en/of afbranden. Het afplaggen op grote schaal is in dit onderzoek niet aangetoond, maar aangezien plaggen gebruikt werden om grafheuvels te bouwen zal dit zeker hebben plaatsgevonden. Ook zijn er geen aanwijzingen dat er op grote schaal heide afgebrand is. Uit dit onderzoek is gebleken dat de grafheuvelheidevelden waarschijnlijk voornamelijk begraasd werden door vee: koeien en schapen. Om een heideveld te onderhouden is 1 schaap per hectare nodig en/of 1 rund per 5-6 hectare. Een gemiddelde ADF van 100 m per grafheuvel staat gelijk aan een heideveldje van 3 ha per grafheuvel. Om zo'n heideveld te onderhouden zijn dus 3 schapen en/of 0.5 runderen nodig. Er is een schatting gemaakt dat in de omgeving van Ermelo ongeveer 134 grafheuvels lagen in de Midden- Bronstijd. Deze grafheuvels lagen waarschijnlijk allemaal in een heideveld, wat neerkomt op een totale oppervlakte aan heide van ongeveer 420 ha. Om deze heide te onderhouden zijn 420 schapen nodig en/of 70 runderen. Waarschijnlijk bezat een huishouden in de Midden-Bronstijd B een veestapel van ongeveer 30 dieren, waarvan 2/3 rund en 1/3 schaap. Dit houdt in dat 3-4 huishoudens een gebied van 420 ha konden onderhouden. Een ADF van 100 m is een voorzichtige schatting. Als uitgegaan wordt van een ADF van 250 m, dan is de oppervlakte aan heidevegetatie 2630 ha geweest. Daarvoor waren 20 huishoudens nodig met elk 20 runderen en 10 schapen. Deze huishoudens zullen samengewerkt moeten hebben als zogenaamde heidegemeenschappen om de heide te kunnen onderhouden.

Het is niet te zeggen of het onderhouden van de heidevelden daadwerkelijk het doel was van de begrazing, het kan ook onderdeel geweest zijn van de dagelijkse agrarische activiteiten van de prehistorische mensen die in dat gebied woonden. In elk geval was dan een bijkomend gevolg dat vele heidevelden onderhouden werden, heidevelden die een zeer belangrijk onderdeel, zo niet het belangrijkste onderdeel, vormden van het grafheuvellandschap.

Dit onderzoek heeft aangetoond dat de open plekken al langere tijd bestonden voordat er grafheuvels in gebouwd werden. Het is niet altijd duidelijk waar deze open plekken voor gebruikt werden, maar in de meeste gevallen lijkt er al langere tijd sprake geweest te zijn van een begroeiing met heidevegetatie die begraasd werd. Dit betekent niet alleen dat het landschap waarschijnlijk al behoorlijk open geweest moet zijn voordat de eerste grafheuvels gebouwd werden, in tegenstelling tot wat over het algemeen aangenomen wordt (zie hoofdstuk 2), maar ook dat grote delen van het landschap (namelijk de heide) al intensief onderhouden werden. De begrazing van heidevelden maakte onderdeel uit van het dagelijkse leven van de prehistorische mensen, al is niet bekend waar zij dan precies woonden. Wel is duidelijk dat ze niet in directe omgeving van een grafheuvel woonden, maar het is aannemelijk dat ze binnen 'begrazingsafstand' woonden.

Een van de onderzoeksvragen is of grafheuvels gebouwd werden op voorouderlijke gronden. Het antwoord hierop is hoogstwaarschijnlijk 'ja'. Grafheuvels werden gebouwd in heidevelden die al lange tijd onderdeel uitmaakten van het dagelijkse leven van hun voorouders en de heidevelden kunnen dus gezien worden als voorouderlijke heidevelden. Tevens is aangetoond dat grafheuvels een belangrijke rol gespeeld moeten hebben in het landschap. Het beeld dat we krijgen vanuit de grafheuvel pollenanalyses is natuurlijk niet representatief voor het totale landschap en laat alleen het deel met grafheuvels zien. Maar het maakt wel duidelijk dat grafheuvels een speciale plek innamen. Dit onderzoek heeft aangetoond dat de ligging van grafheuvels niet gebonden is aan de ligging van akkers en nederzettingen en dat de zichtbaarheid van de grafheuvels vaak een belangrijke rol speelde. Tegelijkertijd werden grafheuvels geïntegreerd in het dagelijks leven en maakten ze deel uit van de economische zone (door middel van begrazing) van de prehistorische mens. Het grafheuvellandschap werd gedomineerd door heide. Vele generaties heidegemeenschappen werkten samen om deze heidevelden te onderhouden. Niet alleen vormden heidevelden de laatste rustplaats voor voorouders, ook waren de heidevelden al lange tijd gebruikt en onderhouden door deze voorouders. Terwijl de rest van het landschap enorme veranderingen onderging in de vorm van cultivatie in de periode van het Laat-Neolithicum naar de IJzertijd, vormden de heidevelden waar grafheuvels in lagen een zeer stabiel en structurerend element in het landschap gedurende duizenden jaren.

H14: In hoofdstuk 14 wordt een synthese gegeven op basis van de voorafgaande hoofdstukken. De onderzoeksvragen die in hoofdstuk 3 gesteld zijn worden beantwoord.

1. Hoe zag een grafheuvellandschap eruit en wat is de ontstaans- en gebruiksgeschiedenis van zo'n landschap?

Het grafheuvellandschap werd gedomineerd door heidevelden die al langere tijd bestonden voordat er grafheuvels in gebouwd werden. Ze werden omgeven door loofbos. Deze heidevelden moesten onderhouden worden, wat hoogstwaarschijnlijk gebeurde door middel van begrazing. In deze grafheuvel-heidevelden lagen een of meerdere grafheuvels en de heidevelden waren vaak met elkaar verbonden. Op deze manier vormden ze uitgestrekte (smalle) heidevelden, als corridors in het landschap. Het grafheuvellandschap was zeer stabiel en werd gedurende vele generaties in stand gehouden.

2. Werden grafheuvels gebouwd op voorouderlijke gronden?

Gebaseerd op dit onderzoek is het zeer waarschijnlijk dat grafheuvels op voorouderlijke gronden gebouwd werden. Grafheuvels werden gebouwd in heidevelden die begraasd werden, niet alleen toen de grafheuvel gebouwd was, maar ook al lange tijd daarvoor. Deze heidevelden werden dus al gedurende lange tijd gebruikt door waarschijnlijk de voorouders van de grafheuvelbouwers.

3. Wat was de grootte van een open plek waar grafheuvels in gebouwd werden en wat was de afstand van een grafheuvel tot de bosrand?

De open plekken waar grafheuvels in gebouwd werden varieerden in grootte van vrij klein (ADF = 50-100 m) tot behoorlijk groot (ADF = 300-500 m), hoewel zulke grote open plekken alleen aangetoond zijn bij de allerjongste onderzochte grafheuvels. Waarschijnlijk werden de meeste grafheuvels gebouwd in open plekken met een ADF van 50-150 m. Deze smalle open plekken konden echter wel vele kilometers lang zijn.

4. Welke rol speelde grafheuvels in het landschap? Hoe kan de geschiedenis van een grafheuvellandschap gekoppeld worden aan het natuurlijke en culturele landschap in de omgeving van grafheuvels?

De rol van grafheuvels in het landschap lijkt tweeledig te zijn. Ten eerste namen grafheuvels een speciale plek in. Ze werden gebouwd in heidevelden die waarschijnlijk niet direct bij een nederzetting of akkers lagen en waar zichtbaarheid een belangrijke rol speelde. Ten tweede waren grafheuvels geïntegreerd in het dagelijkse leven van de mensen. Het grafheuvellandschap was onderdeel van hun economische zone en werd gebruikt voor begrazing. In de periode van het Laat-Neolithicum naar de IJzertijd werden grote delen van het landschap steeds meer gecultiveerd. In deze periode van verandering vormden de heidevelden waar grafheuvels in lagen een zeer stabiel element in het landschap gedurende duizenden jaren.

5. Advies aan Staatsbosbeheer en andere instanties met betrekking tot het herstellen van oorspronkelijke grafheuvellandschappen voor publieke doeleinden.

De gebieden waar grafheuvels in liggen maken tegenwoordig vaak onderdeel uit van natuurreservaten. De beheerders van deze natuurreservaten willen de grafheuvels graag zo veel mogelijk in hun oorspronkelijke omgeving aan het publiek tonen. De reconstructie van het grafheuvellandschap zoals hierboven besproken is geeft een goede indicatie van hoe de omgeving van een grafheuvel eruit gezien moet hebben. In elk geval lagen de grafheuvels in heide. De grootte van het heideveld verschilde van grafheuvel tot grafheuvel. De grootte van het heideveld dat om een grafheuvel gerealiseerd kan worden is waarschijnlijk meer afhankelijk van de hedendaagse dan van de vroegere omstandigheden. De huidige omstandigheden verschillen enorm ten opzichte van de grafheuvelperiode. Verzuring, bemesting en uitdroging hebben de conditie van de bodem beïnvloed en zullen dus ook van invloed zijn op het onderhouden van een heideveld en het omliggende bos.

Wat betreft het beheer van het Nederlandse cultureel erfgoed: nu wordt vaak alleen de grafheuvel zelf als monument beschouwd en in sommige gevallen een zone van 10 m rondom een grafheuvel. Dit onderzoek heeft aangetoond dat de heide rondom een grafheuvel onlosmakelijk verbonden was met de grafheuvel en deze heide strekte zich veel verder uit dan 10 m rondom een grafheuvel. Daarnaast is in een aantal grafheuvelgroepen aangetoond (Oss-Zevenbergen, hoofdstuk 12.1 en Echoput, hoofdstuk 8.1) dat de omgeving van een grafheuvel van zeer grote archeologische waarde kan zijn. ZO werden er bijvoorbeeld ceremoniële palenrijen gebruikt. Het is dan ook belangrijk om het te beschermen gebied rondom een grafheuvel te vergroten om waardevol Nederlands cultureel erfgoed te behouden.

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Curriculum Vitae

Marieke Doorenbosch was born in 1980 in Amsterdam. From 1992 to 1998 she went to the Gymnasium of the Rijksscholen Gemeenschap Lingecollege in Tiel. In 1998 she started studying Biology at the Free University of Amsterdam from which she graduated in 2003. For her doctoral thesis she studied the effect of UV-B radiation on the vegetation at Svalbard and in addition she studied the vegetation and climate history of Svalbard through palynological analysis.

In 2003-2004 she worked as an adjunct researcher at the Faculty of Systems Ecology at the Free University of Amsterdam and continued the research she started during her doctoral study. As a result she co-authored two articles.

In 2004 she started with the study physical therapy at the Hogeschool Thim van de Laan in Nieuwegein, from which she graduated in 2007. After deciding her heart was still at Biology, she applied for a PhD position in the NWO-funded Ancestral Mounds project at the Faculty of Archeology, Leiden University. Throughout her PhD she wrote a chapter in two books and presented several lectures at national and international conferences. Currently she's working as a researcher on a project basis.

Changes in the second edition

page 45
Line 7: post quem → ante quem

page 81
Line 18 of ‘Results and discussion’: arboreal pollen → non arboreal pollen

page 84
Line 10 of ‘Conclusions’: table 7.2 → table 7.5
Line 12 of ‘Conclusions’: table 7.1 → table 7.2

page 114
Line 12: before → after
Line 13: post quem → ante quem

ANCESTRAL HEATHS

Barrows, *i.e.* burial mounds, are amongst the most important of Europe's prehistoric monuments. Across the continent, barrows still figure as prominent elements in the landscape. Many of these mounds have been excavated, revealing much about what was buried inside these intriguing monuments. Surprisingly, little is known about the landscape in which the barrows were situated and what role they played in their environment. Palynological data, carrying important clues on the barrow environment, are available for hundreds of excavated mounds in the Netherlands. However, while local vegetation reconstructions from these barrows exist, a reconstruction of the broader landscape around the barrows has yet to be made. This makes it difficult to understand their role in the prehistoric cultural landscape.

In this book a detailed vegetation history of the landscape around burial mounds is presented. Newly obtained and extant data derived from palynological analyses taken from barrow sites are (re-)analysed. Methods in barrow palynology are discussed and further developed when necessary. Newly developed techniques are applied in order to get a better impression of the role barrows played in their environment.

It is argued in this book that barrows were built on existing heaths, which had been and continued to be maintained for many generations by so-called heath communities. These heaths, therefore, can be considered as 'ancestral heaths'. The barrow landscape was part of the economic zone of farming communities, while the heath areas were used as grazing grounds. The ancestral heaths were very stable elements in the landscape and were kept in existence for thousands of years. In fact, it is argued that these ancestral heaths were the most important factor in structuring the barrow landscape.

Marieke Doorenbosch studied Biology at the Free University of Amsterdam and specialized in paleoecology. From 2008-2013 she worked as a PhD student within the NWO-funded project Ancestral Mounds at the Faculty of Archaeology at Leiden University of which this dissertation is the result.

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