The process of Neolithization in the Pleistocene areas near the North Sea coast – evidence for early farming by the Swifterbant Culture around 4000 cal BC

Ronald Bakker

Abstract – Sediments from a pingo scar, a relic from the last glaciation, in the province of Drenthe (the Netherlands) are studied for their content of pollen. On the basis of a number of pollen diagrams, the author reconstructs the vegetation of the Atlantic and the first part of the Subboreal. Special attention is given to the beginning of the Neolithic, which marks the beginning of agriculture. A model is developed which describes changes in human-influenced pollen types during the Neolithic in pollen diagrams from Pleistocene areas near the North Sea coast.

The so-called Neolithic Occupation Period (NOP) is divided into three phases, which represent three different types of farming economy. By means of high-resolution ^{14}C dating, the three phases are correlated with archaeological cultures. Phase NOP-1, characterized by small-scale arable farming and livestock foddering with leaves and twigs, is dated to 4050-3450 cal BC, which is in the period of the Swifterbant Culture. This shows that the first farmers on the Drenthe Plateau belonged to the Swifterbant Culture. Phase NOP-2, characterized by more large-scale, grass-based stock keeping, is connected with the Funnel Beaker Culture. Phase NOP-3, in which agriculture was concentrated in smaller areas, is contemporary with the Single Grave and Bell Beaker Cultures.

Keywords – Netherlands, Drenthe Plateau, palynology, human-influenced pollen types, beginning of agriculture, Swifterbant Culture, Funnel Beaker Culture, Neolithic agricultural economies, high-resolution ^{14}C dating, chronology of the Neolithic

Zusammenfassung – Für diese Studie wurden die Sedimente aus einem eiszeitlichen Pingorest in der Provinz Drenthe in den Niederlanden auf ihren Pollengehalt hin untersucht. Auf der Basis von mehren Pollenprofilen rekonstruiert der Autor die Vegetationsgeschichte vom Atlantikum bis zur ersten Phase des Subboreals. Besonders berücksichtigt wird die Phase der Neolithisierung und der Beginn der Landwirtschaft. Auf der Grundlage von Pollendiagrammen aus der norddeutschen und niederländischen Altmoränenlandschaft wird ein Schema erarbeitet, das den Verlauf ausgewählter Pollenkurven während des Neolithikums beschreibt.

Die sogenannte Neolithische Okkupationsperiode (Neolithic Occupation Period, NOP) wird in drei Phasen gegliedert, die drei verschiedene Formen der bäuerlichen Wirtschaft repräsentieren. Mit Hilfe hochauflösender ^{14}C-Datierungen werden diese drei Phasen mit archäologischen Kulturen verbunden. Die Phase NOP-1 wird von 4050 bis 3450 cal BC datiert. Sie ist durch geringe ackerbauliche Aktivitäten und Tierhaltung mit Laub- und Zweigfütterung charakterisiert. Sie fällt in die Zeit der Swifterbantkultur, deren Träger also die ersten Bauern auf dem Drenthe-Plateau gewesen sind. Für die Phase NOP-2, die mit der Trichterbecherkultur verbunden werden kann, ist eine großräumige Viehhaltung charakteristisch. In der Phase NOP-3 dagegen haben die Menschen der Einzelgrab- und der Glockenbecherkultur ihre Landwirtschaft auf eher kleinen Arealen betrieben.

Schlüsselwörter – Niederlande, Plateau von Drenthe, Pollenanalyse, menschlich beeinflußte Pollentypen, Beginn der Landwirtschaft, Swifterbantkultur, Trichterbecherkultur, neolithische Landwirtschaftsmethoden, hochauflösende ^{14}C-Datierung, Chronologie des Neolithikums

1. Introduction

The first farmers in the Netherlands were people of the Linear Pottery Culture (LBK), who occupied the loess soils of southern Limburg, the southernmost part of the Netherlands, between 5300 and 5000 cal BC. From 4900 cal BC onwards, groups who practised stock keeping and somewhat later also cereal cultivation occupied the lower and wetter parts of the central and western Netherlands. These groups, which seem to have had a preference for natural levees and river dunes in the Alblasserwaard (province of Zuid-Holland) and the province of Flevoland represent the Swifterbant Culture (RAEMAEKERS 1999). There are indications that representatives of this culture also occupied the coastal areas as well as the higher Pleistocene soils of the northern Netherlands and adjacent northwestern Germany (KROEZENGA et al. 1991; GEHASSE 1995; LOUWE KOOIJMANS 1998). From ca. 3400 cal BC onwards, the Drenthe Plateau, which comprises the higher Pleistocene soils of the northern Netherlands, saw a relatively dense occupation by farmers of the Funnel Beaker Culture (TRB). Their presence is demonstrated in the first place by their characteristic burial monuments, megalithic tombs (*hunebedden*). But also settlements of this culture are known (J.A. BAKKER 1979; 1982; 1992).

In pollen diagrams, the presence of farmers on the Drenthe Plateau is demonstrated by an increase or first appearance of the so-called culture-indicator pollen types and by a decrease in certain tree pollen types. In the past, these changes in the pollen diagrams were often summarized by the term *landnam*. This term was first used by the Danish palynologists Johs. Iversen and J. Troels-Smith, to refer to the impact of early farming cultures on virgin forests (IVERSEN 1941; 1949; 1973; TROELS-SMITH 1954; KALIS & MEURERS-BALKE 1998). Until recently, the earliest indication of human influence on the vegetation on the Drenthe Plateau was attributed to the activities of farmers of the Funnel Beaker Culture, after 3400 cal BC (VAN ZEIST 1959; 1967; CASPARIE & GROENMAN-VAN WAATERINGE 1980).

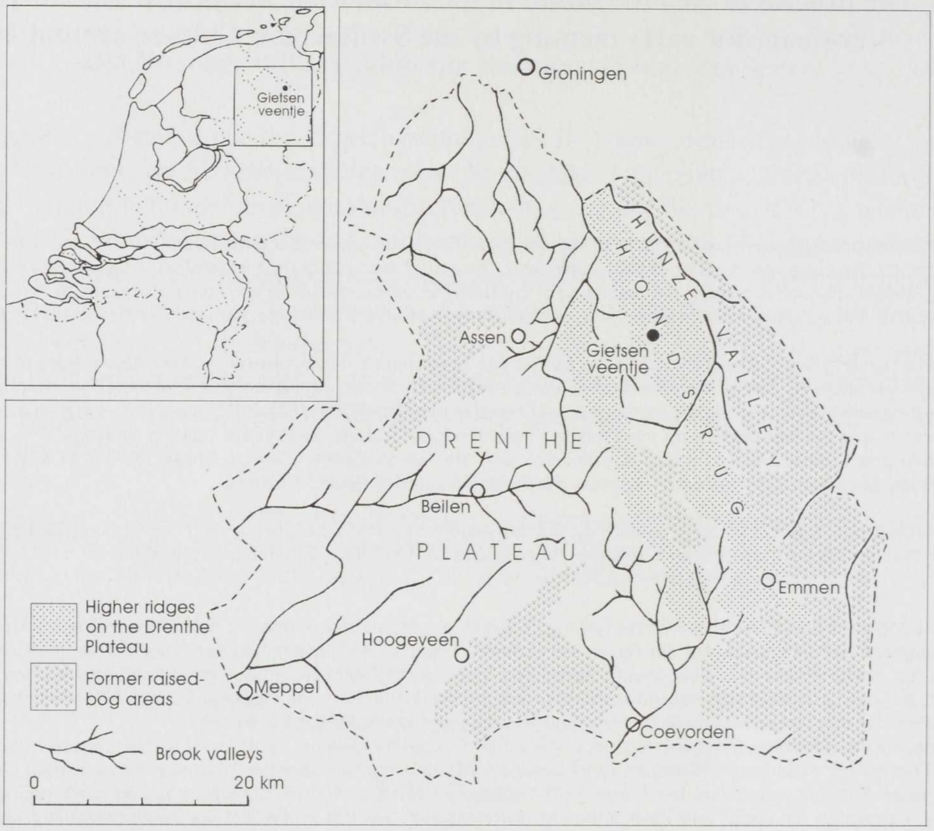


Fig. 1 Location of the Gietsenveentje in the Netherlands and overview of the part of the Drenthe Plateau located in the province of Drenthe.

However, preliminary palynological studies of material from the Gietsenveentje, a small bog on the Drenthe Plateau, had shown a very early occupation phase which did not correspond to that described by Iversen and Troels-Smith for the Funnel Beaker Culture. It was suggested that this early occupation phase in the sediment of the Gietsenveentje could be correlated with a late phase of the Swifterbant Culture. Several authors had already suggested a form of agriculture preceding that of the Funnel Beaker Culture in northern Germany, Denmark and southern Sweden (GÖRANSSON 1988a; 1988b; KOLSTRUP 1988; KALIS & MEURERS-BALKE 1998).

2. Aim and working method

In 1992, an intensive study was started to investigate the possible existence of pre-TRB agriculture on the Drenthe Plateau. The aim of this study was to describe and explain the changes in the natural environment caused by the earliest farmers on the Drenthe Plateau, by means of a detailed palaeobotanical study of the Neolithic as represented in the sediment of the Gietsenveentje. The intention was to construct a palynological model of the Neolithic period for the northern Netherlands and adjacent northwestern Germany, which would be comparable to Iversen's *landnam* model for Denmark.

The following working method was employed: in the centre of the Gietsenveentje, a trench was dug to create an open section. It was possible to sample relatively large volumes of sediment from this section. Furthermore, a series of sequences were cored from the centre to the edges of the Gietsenveentje. The sediment samples from the open section and from the sequences were used for various types of analysis: pollen analysis, ^{14}C dating, pollen concentration and pollen influx analysis, analysis of macroscopic remains and wood, and phosphorus analysis. In order to get a very detailed chronology of the Neolithic period, a large number of samples were ^{14}C-dated.

The part of the Gietsenveentje sediment believed to represent the Neolithic was defined as the Neolithic Occupation Period (NOP). The beginning of the Neolithic Occupation Period was defined palynologically as a decrease in tree pollen, especially *Ulmus*, and an increase in herb pollen, especially the culture-indicator pollen types. The Neolithic Occupation Period was subdivided into three Neolithic Occupation Phases, which were palynologically roughly defined as follows:

NOP-1: still high percentages of tree pollen,
low percentages of culture-indicator types;
NOP-2: lower percentages of tree pollen,
high percentages of culture-indicator types;
NOP-3: stabilization of tree pollen percentages,
somewhat lower percentages of culture-indicator types.

As already mentioned, at least some of these phenomena in pollen diagrams have often been summarized by the term ***landnam***. This term was introduced by Iversen (1941), because he saw a parallel between the immigration and land reclamation of the Neolithic people and the immigration of Viking settlers into Iceland and Greenland, which was traditionally referred to by the Old-Icelandic word *landnam*. Since then, the term *landnam* has been adopted by many palynologists to describe palynological phenomena connected with the first appearance of agriculture. Unfortunately, in the course of time, the original meaning of the term *landnam* almost disappeared from sight. The term was defined definitively by another famous Danish palynologist, Jørgen TROELS-SMITH (1942, 207): *"We may speak of a landnam, when the course of the curves reflects large-scale forest clearances, undertaken by a newly immigrated people making use of agriculture, to create the facilities for practising arable farming and stock keeping."* In the view of Iversen and Troels-Smith, the various phases of a *landnam* only represented a relatively short-lasting, local cycle of clearance, agriculture and forest regeneration. However, when for the first time large numbers of ^{14}C dates became available, it became clear that the phases of a *landnam* represented long-lasting, regional phenomena, which were found in many pollen diagrams of northwestern Europe (see for example ROWLEY-CONWY 1982; GÖRANSSON 1988c, 34; MADSEN 1990, 29; KALIS & MEURERS-BALKE 1998). For this reason, the "charged" term *landnam* is not used here, but is replaced by the term Neolithic Occupation Period (NOP) (see also KALIS & MEURERS-BALKE 1998, 5).

3. Research area

The Gietsenveentje is a bog with a diameter of 200 x 160 m, situated near the village of Gieten in the province of Drenthe, the Netherlands (fig. 1). It is assumed to be a remnant of a pingo, which was formed during the coldest period of the last glaciation, the Weichselian. Nowadays, the Gietsenveentje is almost entirely filled with gyttja and peat sediments; areas of open water inside the bog are the result of relatively recent peat-digging (fig. 2). The Gietsenveentje is situated on the Hondsrug, a ridge that is part of the Drenthe Plateau (fig. 1). The Drenthe

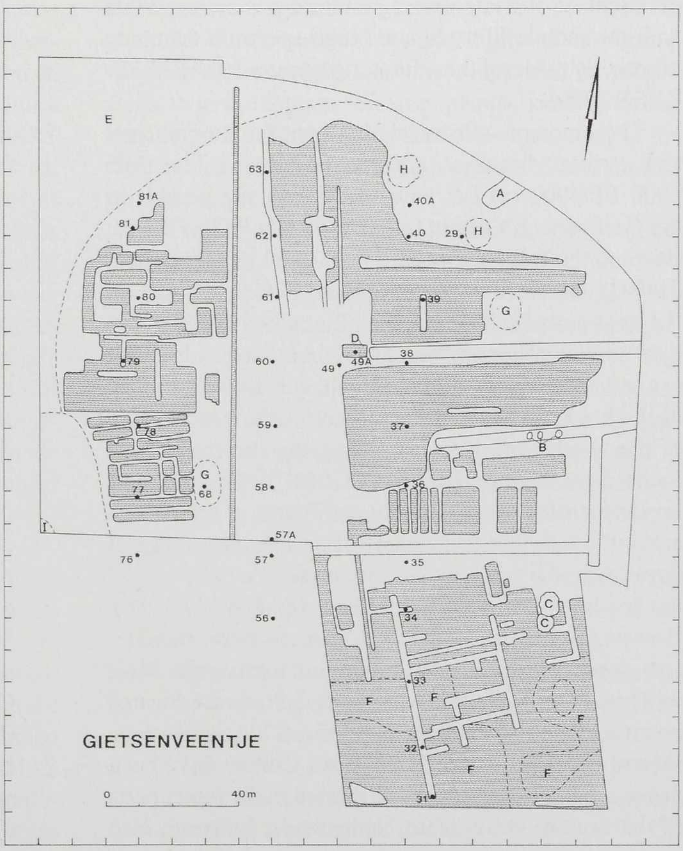


Fig. 2
Topographical map of the Gietsenveentje. All core locations are indicated; the pollen sequences Gieten V-A, V-B, V-C and V-D were cored at core locations 59, 61, 63 and 57, respectively. Areas with a wavy pattern: marshy area or open water.

Plateau is the visible part of a till complex, formed during the Saalian glaciation. In the north and west, the till plain disappears under marine and fen-peat deposits formed in the Holocene. In the east and south, the Drenthe Plateau is bounded by two originally deep valleys, which were also formed during the Saalian glaciation and which since have largely filled up: the Hunze valley and the Vecht valley.

4. The archaeological context

The cultures which are most probably involved in the beginning of the Neolithic of the northern Netherlands as represented in pollen diagrams are the Swifterbant Culture and the Funnel Beaker Culture (TRB). Here, the archaeology of the Neolithic in the Netherlands will be briefly discussed, with an emphasis on these two cultures.

In the Netherlands, the Linear Pottery Culture occupied the loess soils of the southern part of the province of Limburg between 6400 and 6100 BP (5300-5000 cal BC). There must have been contacts between the LBK people of Limburg and foragers living further north: LBK adzes are found up to 100 km north of the settled loess area (LOUWE KOOIJMANS 1998). However, the foragers did not adopt the Neolithic subsistence strategy of the LBK people, possibly because the LBK lifestyle of sedentism and intensive agriculture was incompatible with the mobile lifestyle and broad-spectrum economy of the late-Mesolithic hunter-gatherers (RAEMAEKERS 1999).

The outcome of contacts between hunter-gatherers and farmers becomes archaeologically visible from 6000 BP/4900 cal BC onwards, during the periods of the Großgartach Culture (6000-5800 BP/4900-4700 cal BC) and the Rössen Culture (5800-5400 BP/4700-4300 cal BC), which followed the Linear Pottery Culture on the loess soils (THOMAS 1998; LÜNING 2000). From then on, pottery production and animal husbandry were to a certain extent incorporated in the subsistence strategy of the hunter-gatherer communities of the western part of the North European Plain, defining the start of the Swifterbant Culture (RAEMAEKERS 1999). The most important sites of this culture are found in the coastal areas of the Netherlands; many of these areas are nowadays covered by marine clay, because since 5000 cal BC the sea level has risen by ca. 8 m (ZAGWIJN 1986). However, when parts of the IJsselmeer were impoldered, some of these sites could be excavated. Most settlement sites of the Swifterbant Culture are located on river dunes of the then IJssel river. In recent years, several new sites of the Swifterbant Culture have been discovered, most of which are located in the lower parts of the central and western Netherlands; however, also a few sites are known on the higher sandy soils of the eastern and northern Netherlands (RAEMAEKERS 1999, 108-111). Furthermore, pottery of the Hüde I site in Lower Saxony, Germany, has so many characteristics in common with Swifterbant pottery, that Ten Anscher (cited in GEHASSE 1995, 199) classifies Swifterbant and Hüde pottery in one group: the Hüde-Swifterbant Group. Raemaekers (1999) has distinguished the following three phases of the Swifterbant Culture:

- **Early Phase (SW-1): 4900-4600 cal BC.**
  The excavation of 1994-1995 at the Hoge Vaart, Almere (South Flevoland) showed that this location was inhabited by small groups of people with pottery (partly produced locally), who practised not only hunting, but also animal husbandry (cattle, pig, sheep/goat). The habitation site reflects temporary and possibly even seasonal activities. Maybe this location was used as a base camp for hunting expeditions and possibly also for animal husbandry. So far no indications for arable farming have been found at this location (HOGESTIJN & PETERS 1996). In the subdivision of Ten Anscher (cited in GEHASSE 1995, 199), this phase is called SW-1, with pottery which is characterized by original Swifterbant elements and by Rössen influences.
- **Middle Phase (SW-2 and SW-3/Dronten phase): 4600-3850 cal BC.**
  The large excavations of 1971-1979 at Swifterbant, near the village of Dronten (East Flevoland), revealed habitation on river dunes, now lying 5 m below sea level. The inhabitants of these locations processed cereal products, although it is not clear whether cereals were also cultivated locally. Pottery was produced, also partly locally; furthermore, not only animal husbandry was practised, but also hunting, fishing and gathering of nuts and fruits. On the basis of the range of activities, the group composition (adults and children) and the presumed duration of habitation, these sites are interpreted as semi-permanent principal settlements (DECKERS et al. 1980; HOGESTIJN & PETERS 1996). Ten Anscher (cited in GEHASSE 1995, 199), divides this phase into two subphases: SW-2 and SW-3. The pottery of SW-2 (4600-4350 cal BC) is characterized by Swifterbant elements and by Rössen and Bischheim traits. The pottery of SW-3 (4350-3850 cal BC), in addition to the already mentioned elements, displays faint Michelsberg influences. The finds of Rössen-type adzes also prove contacts between the Swifterbant Culture and the cultures in the southern Netherlands (HOGESTIJN & PETERS 1996). According to Lanting & Van der Plicht (1999/2000), these adzes were produced locally by people of the Swifterbant Culture.

- **Late Phase (SW-4/Nagele phase): 3850-3400 cal BC.**
  The excavation of 1984-1988 near Schokkerhaven (Noordoostpolder, Flevoland) revealed the first permanent principal settlements of the Swifterbant Culture: several sizeable house plans and an accompanying cemetery were discovered. At another location, a habitation area surrounded by a double row of oak posts was excavated. The finds from Schokkerhaven must be seen as the products of a further typological and technological development of the Swifterbant Culture (HOGESTIJN 1990; HOGESTIJN & PETERS 1996). According to Ten Anscher (cited in GEHASSE 1995, 199), the pottery from this phase is characterized, in addition to the already mentioned elements, by early TRB elements. However, LANTING & VAN DER PLICHT (1999/2000) consider these "early TRB elements" to be simply products of the late Swifterbant Culture; there is no connection with the development in Denmark and northeastern Germany, where indeed an Early Neolithic TRB phase occurs.

On the loess soils, the Rössen Culture was followed by the Bischheim Culture (5400-5300 BP/4300-4200 cal BC) and the Michelsberg Culture (5300-5000 BP/4200-3800 cal BC). Apart from the loess areas, representatives of the latter culture also colonized the sandy areas adjacent to the loess, including the southern Netherlands. In this period, crop cultivation was included in the subsistence strategy of the Swifterbant Culture from at least 5300 BP/4100 cal BC (RAEMAEKERS 1999) or between 5700 and 5200 BP (4600-4000 cal BC) (BRINKKEMPER et al. 1999, 82). The start of crop cultivation in the area of the Swifterbant Culture indicates that potential problems relating to the shift of cereal cultivation from loess to sandy soils were resolved at the latest around this time (RAEMAEKERS 1999). From this time onwards, the subsistence base of the Swifterbant Culture can be described as broad-spectrum hunting and gathering, to which animal husbandry and crop cultivation were added, combined with a residential mobility strategy which involved the regular moving of dwelling sites among a series of resource patches (LOUWE KOOIJMANS 1998; RAEMAEKERS 1999). Cultural groups like the Swifterbant Culture in the Netherlands, the Dümmer-Hüde Group in Lower Saxony and the Ertebølle/Ellerbek Culture in Schleswig-Holstein, Denmark and southern Sweden for some centuries formed a kind of "penumbra" around the heartland of agricultural settlement, which was formed by the Rössen and Michelsberg Cultures (THOMAS 1998). The increased extent and intensity of south-to-north contacts primed a slow and gradual process in which various Neolithic elements were added one after another to Late Mesolithic economies (LOUWE KOOIJMANS 1998).

There are indications that around 6200 BP/5100 cal BC, Mesolithic foragers abandoned the river dunes in the central Netherlands. The beginning of the Calais II transgression could be one reason for this migration (HOGESTIJN 1990), but also social factors or exhaustion of the environment could have played a role (GEHASSE 1995, 196). GEHASSE (1995, 196) suggests that the Mesolithic foragers moved to the Pleistocene sandy soils of the northern and central Netherlands. Gehasse assumes that it was here and at this time that the transition to farming occurred (6200-6000 BP/ 5100-4900 cal BC), because the people who migrated back to the central Netherlands after 6000 BP/4900 cal BC were fully-fledged farmers. She bases this conclusion on finds of cereal remains at the base of layer A at the site Schokland P14, which is dated 6000-5300 BP (4900-4100 cal BC) (GEHASSE 1995, 59-60). However, BRINKKEMPER et al. (1999) question the dates of these cereal remains. They believe these finds to be substantially younger than 4900 cal BC. Therefore BRINKKEMPER et al. (1999, 83) reject Gehasse's hypothesis that between 6200 and 6000 BP a radical change took place on the sandy soils outside the IJssel-Vecht basin, from a hunting-and-gathering to a broad-spectrum farming subsistence. With regard to the adoption of agricultural practices, BRINKKEMPER et al. (1999, 85) consider the possibility of intra-group variation an important issue: there may well have been areas where adoption of crop plants occurred much later or on a different scale than elsewhere. Maybe the diffusion of crop plants should be regarded as a kind of percolation process.

There are only very few Mesolithic dates of the Drenthe Plateau between 6700 and 6000 BP (5600-4900 cal BC) (LANTING & VAN DER PLICHT 1997/1998). Possibly, the Drenthe Plateau at that time was inhabited very sparsely or even deserted (FOKKENS 1990). However, several scattered finds suggest that between ca. 6000 and 4650 BP (4900-3400 cal BC), Drenthe was inhabited by foraging and/or farming groups related to the Swifterbant Culture. These finds are indicated on the map of fig. 3. They mainly occur in the brook valleys. The finds can be divided into three categories:

A. *finds of Swifterbant pottery, most probably indicating the presence of Swifterbant people on the Drenthe Plateau:*

1-1. sherds of a Swifterbant pot, found in combination with two red-deer antlers in the canal Voorste Diep (Kanaal Buinen-Schoonoord) near Bronneger. This is the only dated find of Swifterbant pottery from the Drenthe Plateau: the date of organic remains which stuck to the pot is 5890 ± 90 BP

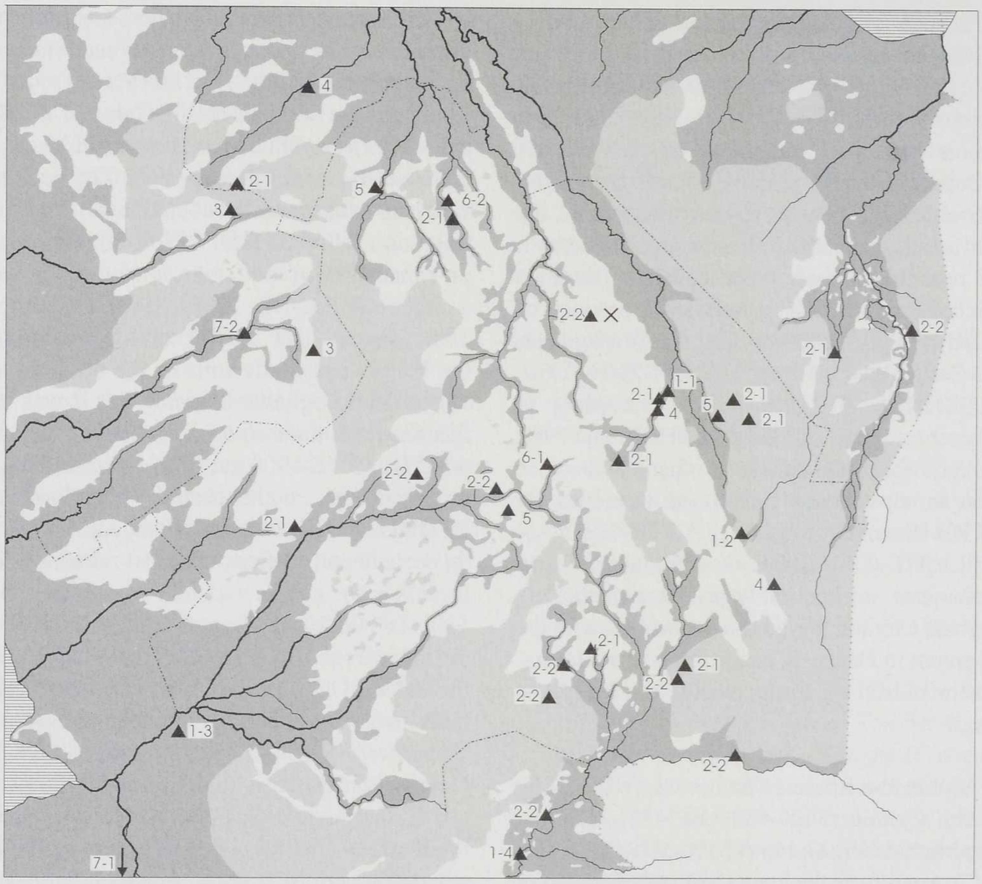


Fig. 3 Map of the Drenthe Plateau and its margins, showing archaeological finds from the period 4900-3400 cal BC, indicated by triangles. The numbers marking the findspots correspond with the numbers in the list presented in the text. The cross indicates the location of the Gietsenveentje. In the light grey areas, raised-bog sediments are found; the dark grey areas represent stream valley sediments.

[OxA-2908]; the dates of the two antlers are 5720 ± 90 BP and 5970 ± 90 BP [OxA-2909 and OxA-2910]. Combined calibration of these dates yields a result of ca. 4700 cal BC. This means that this find belongs in the Early Phase of the Swifterbant Culture (KROEZENGA et al. 1991; LANTING 1992; VAN DER SANDEN 1997);

1-2. a single sherd of a Swifterbant pot, found in the Weerdingerveen peat bog in 1943 (VAN DER SANDEN 1997); most probably, the sherd dates from the Middle Phase of the Swifterbant Culture (LANTING & VAN DER PLICHT 1999/2000);

1-3. pottery, flint material and T-shaped antler tools, found at De Gaste near Meppel, on the edge of the Drenthe Plateau (CLASON 1983; WATERBOLK 1985). Part of the pottery unmistakably belongs to the Swifterbant Culture; some characteristics of the pottery point to the Early Phase (LANTING & VAN DER PLICHT 1999/ 2000);

1-4. pottery, flint material, red deer antlers, bone tools and remains of domesticated animals (cattle, pig, sheep/goat) and several wild animals, found at Heemse (near Hardenberg, Vecht valley) (CLASON 1984; WATERBOLK 1985); the material seems to originate from various periods; according to LANTING & VAN DER PLICHT (1999/ 2000) it is far from certain that it is Swifterbant material.

B. *finds of adzes, most probably imported from the Rössen Culture, which was established on the loess soils of the southern Netherlands and Germany between ca. 4700 and ca. 4300 cal BC; these indicate contacts between the Rössen Culture and contemporary inhabitants of the Drenthe Plateau:*

2. stray finds of Rössen-type adzes, used for woodworking. Two types can be recognized:

2-1. *Hohe durchlochte Schuhleistenkeile* (high perforated adzes), which were found at the following locations in Drenthe: Nieuw-Buinen, Gees and Bargererfscheidenveen (VAN DER WAALS 1972). Since 1972, specimens have been found near Donderen (1979), Diever (1983), Ellertshaar (1984), Bronneger (1986) and Eerste Exloërmond

(1988). In adjacent parts of the province of Groningen, also two specimens turned up: one near De Wilp (VAN DER WAALS 1972) and one near Mussel (GROENENDIJK 1993). These adzes are also indicated on the map (fig. 3).

2-2. *Durchlochte Breitkeile* (perforated wedges), which were found at the following locations in Drenthe: Eext, Veenoord, Zwiggelte, Hijken, Berkmeer (near Dalen) and Oud-Schoonebeek (VAN DER WAALS 1972). In 1974, another was found near Zwinderen. In the bordering part of the province of Overijssel, a specimen was found near Aneveld (VAN DER WAALS 1972).

3. stray finds of *Plättbolzen*, adzes with the shape of a flat-iron; one was found near Fochteloo (JAGER 1981); a second was found near Siegerswoude (FOKKENS 1990, 193: nr. 186); most probably, they were imported from the Linear Pottery or Rössen Cultures, and are related to the Rössen-type adzes.

C. *finds that cannot be related to any particular culture, but which at least indicate habitation on the Drenthe Plateau between 4900 and 3400 cal BC:*

4. stray finds of T-shaped antler tools, which are most probably of early Neolithic age; several specimens were found in the canal Voorste Diep near Borger and east of the Hondsrug near Emmen (ELZINGA 1962); one was found near Tolbert (FOKKENS 1990, 190: nr. 136).

5. stray finds of horn sheaths of cattle: four horn sheaths, found in bogs in Drenthe, were dated to the period of the Swifterbant Culture (PRUMMEL & VAN DER SANDEN 1995):
Een, horn sheath of aurochs (*Bos primigenius*), 5530 ± 30 BP [GrN-20381];
"Drenthe" (findspot unknown, not indicated on the map of fig. 3), horn sheath of aurochs (*Bos primigenius*), 5360 ± 60 BP [GrN-20386];
Buinerveen, horn sheath of domesticated cattle (*Bos taurus*), 4960 ± 40 BP [GrN-20373];
Westerbork, horn sheath of domesticated cattle (*Bos taurus*), 4880 ± 60 BP [GrN-20384];
Prummel & Van der Sanden (1995) believe the horn sheaths to have been deposited deliberately in the bogs and to represent votive gifts. They reflect a sacrificial tradition which started in the early Neolithic and continued until the Middle Ages.

6. hoards of flint tools and material:

6-1. a hoard of one axe with an oval section and two large blades, found near Elp; the blade technique especially points to an early Neolithic origin (HARSEMA 1975; WATERBOLK 1985);

6-2. one arrowhead, several large blades, flakes and core material, found near Donderen; here too, the blade technique points to an early Neolithic origin (HARSEMA 1974);

7. large collections of bone and/or antler tools:

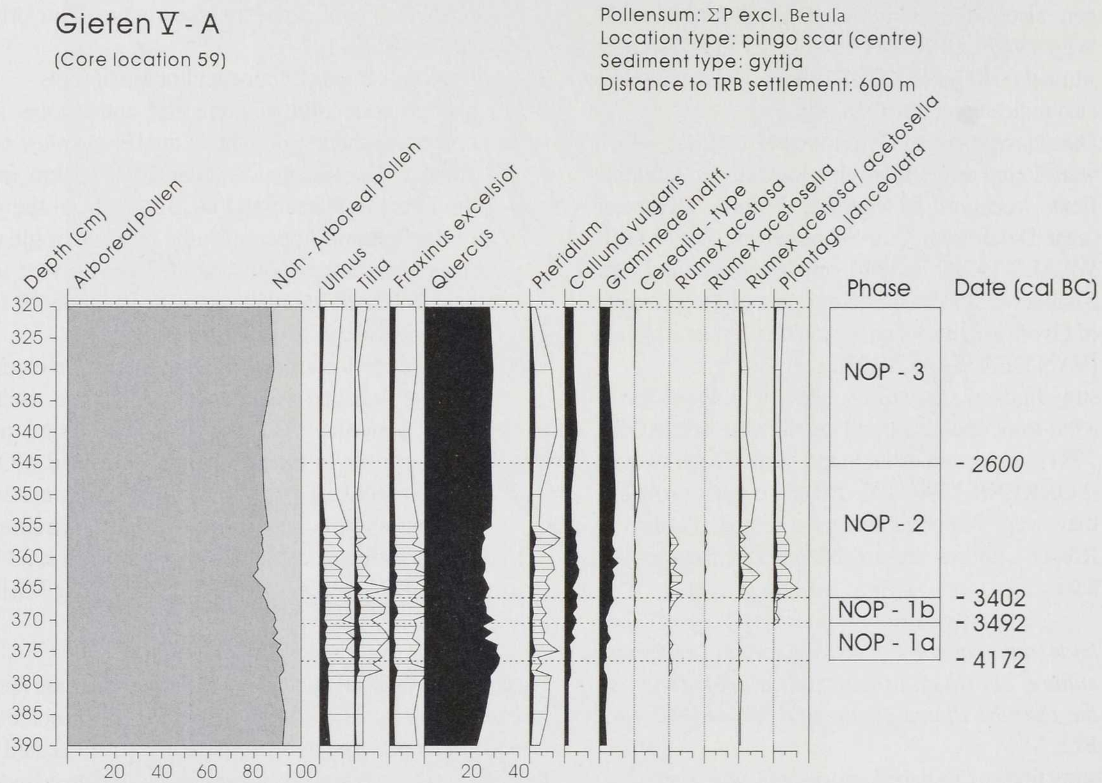
7-1. a large collection of bone and antler tools and objects, found at Spoolde, in the IJssel valley near Zwolle. The findspot is located ca. 15 km from the Drenthe Plateau and ca. 32 km from the site of Swifterbant. Apparently, the material originates from various periods. One T-shaped antler tool was ^{14}C-dated to 6050 ± 30 BP [GrN-8800] (ca. 4900 cal BC) (CLASON 1983).

7-2. a large collection of animal bones, including twelve T-shaped antler tools, which are usually dated between 6000 and 5000 BP, found near Donkerbroek in the province of Friesland (FOKKENS 1990, 97; 197: nr. 268). The material originates from various periods; a worked humerus of domesticated cattle was dated to 4770 ± 80 BP [GrA-12712] (ca. 3520 cal BC) (PRUMMEL 2001).

Furthermore, there are two types of artefact which are found in late Mesolithic as well as in early Neolithic contexts: *Geröllkeulen* and *Spitzhauen* (these are not indicated on the map of fig. 3). A few dozen specimens of *Geröllkeulen*, which are perforated or unperforated pebbles, have been found in Drenthe and bordering provinces (HULST & VERLINDE 1976). In the Swifterbant excavation too, fragments of *Geröllkeulen* were found (VAN DER WAALS 1972). Of the *Spitzhauen*, which are hammer axes with one end blunt and the other pointed, about a dozen specimens have been found in Drenthe, notably at Zeyerveld, Een and Exloërmond (HULST & VERLINDE 1979). The *Spitzhauen* are dated between 7000 and 4300 cal BC (BEUKER et al. 1992, 126). Finally, a recent find of sherds of possibly the Late Phase of the Swifterbant Culture in the Wetsingermaar, ca. 10 km north of the city of Groningen (well north of the area covered by fig. 3), should be mentioned (FEIKEN et al. 2001). The occupation layer was dated to 4700 ± 40 BP [GrA-16659] (ca. 3500 cal BC). The scattered finds together indicate at least a temporary penetration into the North by people whose home territory was in the delta area. Unfortunately, no settlements of these people have so far been found on the Drenthe Plateau.

The Funnel Beaker Culture (TRB) was the first fully agrarian culture on the Drenthe Plateau. The various TRB groups in northwestern Europe have very diverse roots. Influences from the east (Stichband and Baalberg), the west (Dümmer-Hüde, Swifterbant and Michelsberg) and the south (Rössen, Bischheim) can be traced (see for example J.A. BAKKER 1992; MIDGLEY 1992; GEHASSE 1995; THOMAS 1998; LOUWE KOOIJMANS 1998). In the Netherlands and in Lower Saxony,

Fig. 4a


Gieten V - A
(Core location 59)
Pollensum: ΣP excl. Betula
Location type: pingo scar (centre)
Sediment type: gyttja
Distance to TRB settlement: 600 m
Depth (cm)
Arboreal Pollen
Non - Arboreal Pollen
Ulmus
Tilia
Fraxinus excelsior
Quercus
Pteridium
Calluna vulgaris
Gramineae indiff.
Cerealia - type
Rumex acetosa
Rumex acetosella
Rumex acetosa / acetosella
Plantago lanceolata
Phase
Date (cal BC)
NOP - 3
NOP - 2
NOP - 1b
NOP - 1a
- 2600
- 3402
- 3492
- 4172
320
325
330
335
340
345
350
355
360
365
370
375
380
385
390
20
40
60
80
100
20
40

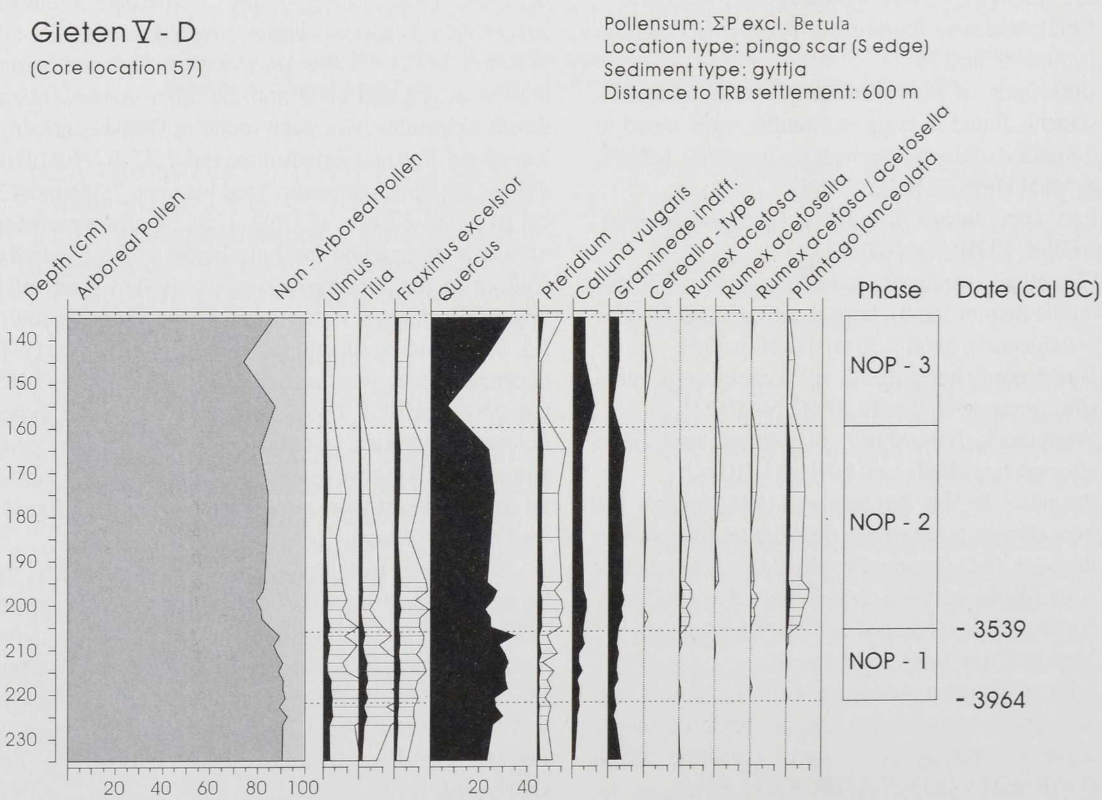

Gieten V - D
(Core location 57)
Pollensum: ΣP excl. Betula
Location type: pingo scar (S edge)
Sediment type: gyttja
Distance to TRB settlement: 600 m
Depth (cm)
Arboreal Pollen
Non - Arboreal Pollen
Ulmus
Tilia
Fraxinus excelsior
Quercus
Pteridium
Calluna vulgaris
Gramineae indiff.
Cerealia - type
Rumex acetosa
Rumex acetosella
Rumex acetosa / acetosella
Plantago lanceolata
Phase
Date (cal BC)
NOP - 3
NOP - 2
NOP - 1
- 3539
- 3964
140
150
160
170
180
190
200
210
220
230
20
40
60
80
100
20
40

Fig. 4b

there is a continuous development from Swifterbant pottery (HOGESTIJN 1990) and Dümmer-Hüde pottery (FANSA & KAMPFFMEYER 1985) to TRB pottery. The later phases of Swifterbant and Dümmer-Hüde pottery demonstrate characteristics which are typical for the oldest TRB pottery in the area north and east of the Elbe. For this reason, Ten Anscher (cited in GEHASSE 1995, 199) assumes that the roots of the earliest TRB groups lie north and east of the Elbe (the Altmark region, see MIDGLEY 1992, fig. 10). Only around 4650 BP/3400 cal BC do major changes take place on the Drenthe Plateau, when several characteristics of the TRB North Group are incorporated here. This event marks the beginning of the TRB West Group, west of the Elbe (J.A. BAKKER 1979; 1992).

5. The pollen diagrams

A total of nine sequences were cored or sampled in the Gietsenveentje for pollen analysis, resulting in nine pollen diagrams. In six of these diagrams the Neolithic Occupation Period (NOP) seemed to be present. Here only three small summary diagrams are presented of sequences in which the NOP occurs most clearly. The complete pollen diagrams of all Gietsenveentje sequences can be found in my Ph.D. thesis (R. BAKKER 2003, figs. 51-60). On the basis of the simplified pollen diagrams in fig. 4, the Neolithic Occupation Period in the Gietsenveentje diagrams, which is subdivided into three Neolithic Occupation Phases, is correlated with the corresponding periods in other diagrams from the province of Drenthe and in several diagrams from northwestern Germany. These diagrams include selected regional pollen types which show clear changes during the Neolithic Occupation Period. The Neolithic Occupation Phases in the Gietsenveentje diagrams (fig. 4a-c) are defined as follows:

NOP-1: Very gradual decline of *Ulmus*; maximum values of *Tilia* and *Quercus*; increase in herb pollen, particularly Gramineae and *Calluna vulgaris*; appearance of *Plantago lanceolata* and Cerealia-type; increase in *Rumex acetosa*. When the decline of *Ulmus* does not coincide with the first appearance of *Plantago lanceolata*, this phase is subdivided into phase NOP-1a (*Ulmus* decline, no *Plantago lanceolata*) and phase NOP-1b (appearance of *Plantago lanceolata*).

NOP-2: Gradual decrease in *Tilia*; high values of *Pteridium*; relatively high values of Gramineae and *Calluna vulgaris*; maximum values of *Plantago lanceolata*, *Rumex acetosa* and Cerealia-type.

NOP-3: Decrease in *Ulmus*; decrease in herb pollen; decrease in Gramineae; increase in *Calluna vulgaris*; decrease in *Plantago lanceolata*, *Rumex acetosa* and Cerealia-type.

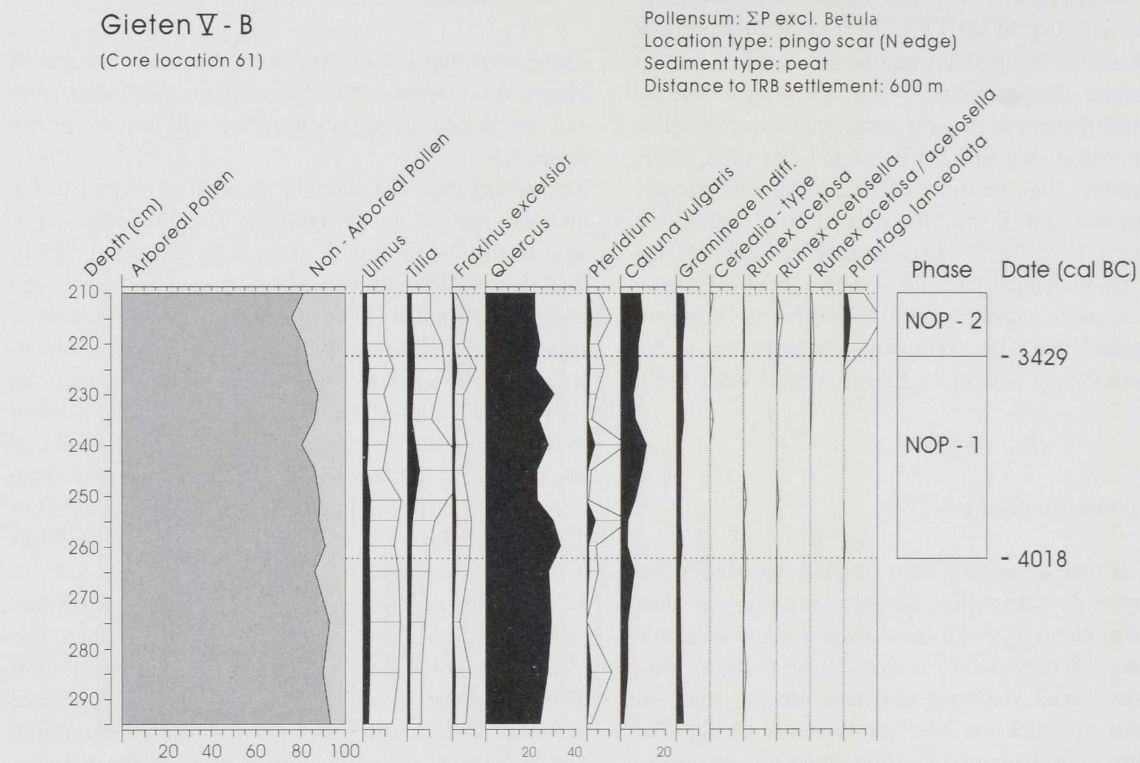
I have been able to distinguish these Neolithic Occupation Phases also in most of the other diagrams. The similarities and differences in the pollen picture will now be briefly discussed.

Eexterveld (fig. 4d), a small pingo scar located in the northern part of the province of Drenthe, only 2 km west of the Gietsenveentje (J.A. BAKKER et al. 1999). Remains of TRB pots were found inside the bog. In the pollen diagram, the *Ulmus* decline occurs before the first appearance of *Plantago lanceolata*. The values of *Ulmus* and *Tilia* are lower than in the Gietsenveentje. The NOP-1b/NOP-2 transition is marked by a strong increase in Gramineae and an increase in Cerealia-type. *Plantago lanceolata* and *Rumex acetosa*-type do not increase at the beginning of NOP-2. Gramineae reach higher values, but the culture-indicator types have far lower values here than in the Gietsenveentje.

Emmererfscheidenveen (fig. 4e), a large raised bog near the city of Emmen in the southeastern part of the province of Drenthe (VAN ZEIST 1955). The *Tilia* maximum in NOP-1 is rather weak. Very high values of Ericaceae indicate that this pollen has a predominantly local origin. The highest values of Gramineae occur in the Atlantic. During phases NOP-1, NOP-2 and NOP-3, Gramineae values remain constant. Pollen grains of Cerealia-type are found in the Atlantic; these grains were possibly misidentified, otherwise they must originate from wild grasses, which is not very probable (a Cerealia-type curve is not included in the pollen diagram of the original publication by VAN ZEIST [1955]). Values of *Rumex acetosa*-type and *Plantago lanceolata* are lower than in the Gietsenveentje. The ^{14}C date of the NOP-1/NOP-2 boundary (ca. 2700 cal BC) is much younger than the corresponding date in the Gietsenveentje (ca. 3450 cal BC, see paragraph 6). *Quercus* reaches maximum values in NOP-3. A ^{14}C date of the end of phase NOP-3 (ca. 1700 cal BC) indicates that this phase extends into the Bronze Age.

Swienskuhle (fig. 4f), a small kettlehole situated within *Siedlungskammer* (limited habitation area) Flögeln, which is located in northwestern Germany, not far from the coast between the rivers Weser and Elbe (BEHRE & KUČAN 1994). It is an isolated Pleistocene area surrounded by raised bogs, the soils mainly consisting of poor sands. In the pollen diagram, after its initial decline, *Ulmus* recovers in phase NOP-2. *Tilia* shows the same values in the Atlantic and in phase NOP-1; the decline at the end of NOP-2 is pronounced. *Quercus* shows maximum values in NOP-1 and again in NOP-3. The values of *Calluna vulgaris* and Gramineae are high to very high in NOP-2, which indicates that this pollen is for the most part local. The values of the culture-indicator types are relatively high in this

Fig. 4c


Gieten V - B
(Core location 61)
Pollensum: ΣP excl. Betula
Location type: pingo scar (N edge)
Sediment type: peat
Distance to TRB settlement: 600 m
Depth (cm)
Arboreal Pollen
Non - Arboreal Pollen
Ulmus
Tilia
Fraxinus excelsior
Quercus
Pteridium
Calluna vulgaris
Gramineae indiff.
Cerealia - type
Rumex acetosa
Rumex acetosella
Rumex acetosa / acetosella
Plantago lanceolata
Phase
Date (cal BC)
NOP - 2
NOP - 1
- 3429
- 4018
210
220
230
240
250
260
270
280
290
20 40 60 80 100
20 40
20

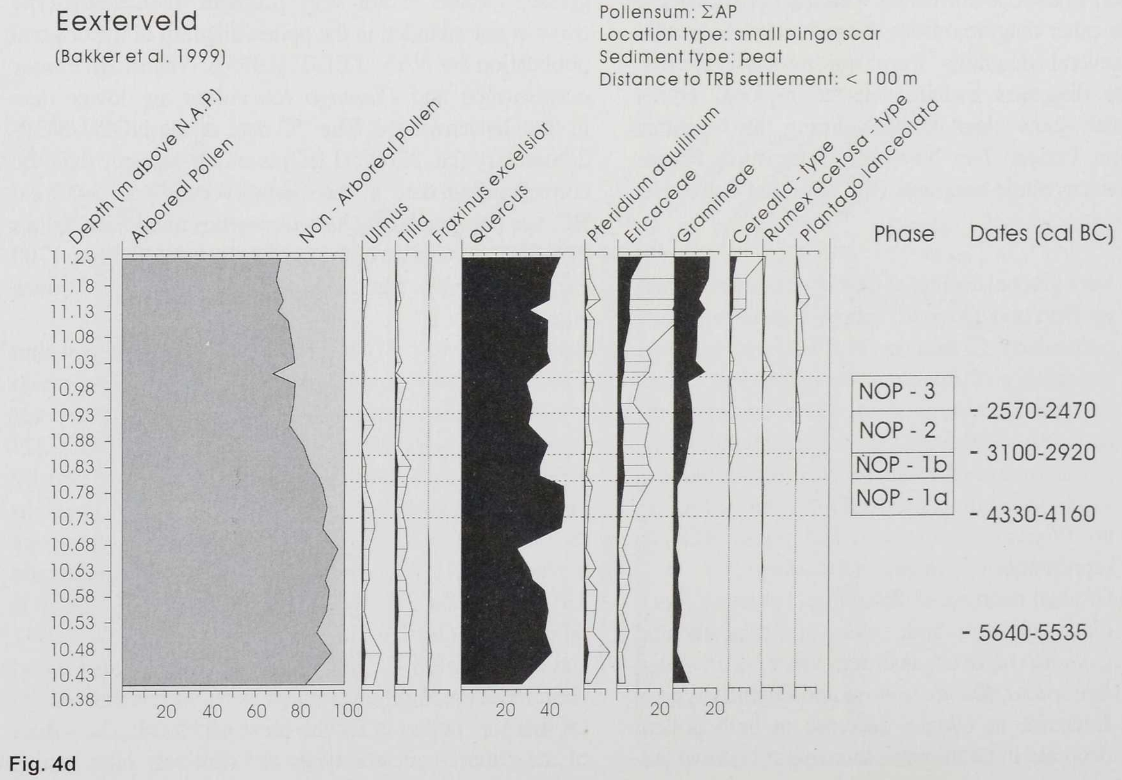

Eexterveld
(Bakker et al. 1999)
Pollensum: ΣAP
Location type: small pingo scar
Sediment type: peat
Distance to TRB settlement: < 100 m
Depth (m above N.A.P.)
Arboreal Pollen
Non - Arboreal Pollen
Ulmus
Tilia
Fraxinus excelsior
Quercus
Pteridium aquilinum
Ericaceae
Gramineae
Cerealia - type
Rumex acetosa - type
Plantago lanceolata
Phase
Dates (cal BC)
NOP - 3
NOP - 2
NOP - 1b
NOP - 1a
- 2570-2470
- 3100-2920
- 4330-4160
- 5640-5535
11.23
11.18
11.13
11.08
11.03
10.98
10.93
10.88
10.83
10.78
10.73
10.68
10.63
10.58
10.53
10.48
10.43
10.38
20 40 60 80 100
20 40
20 20

Fig. 4d

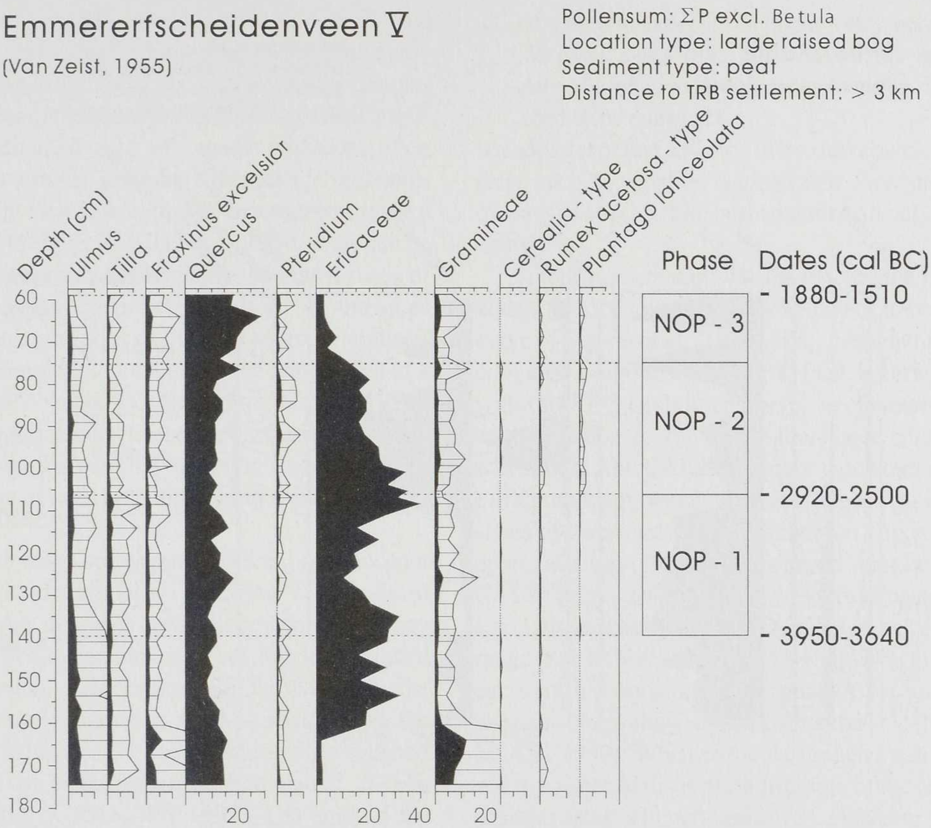


Fig. 4e

diagram. The NOP phases can be correlated with the phases distinguished by Behre & Kučan (1994) in the diagrams of *Siedlungskammer* Flögeln:

NOP-1: Phase 1 in Behre & Kučan
NOP-2: Phase 2 in Behre & Kučan
NOP-3: not distinguished by Behre & Kučan

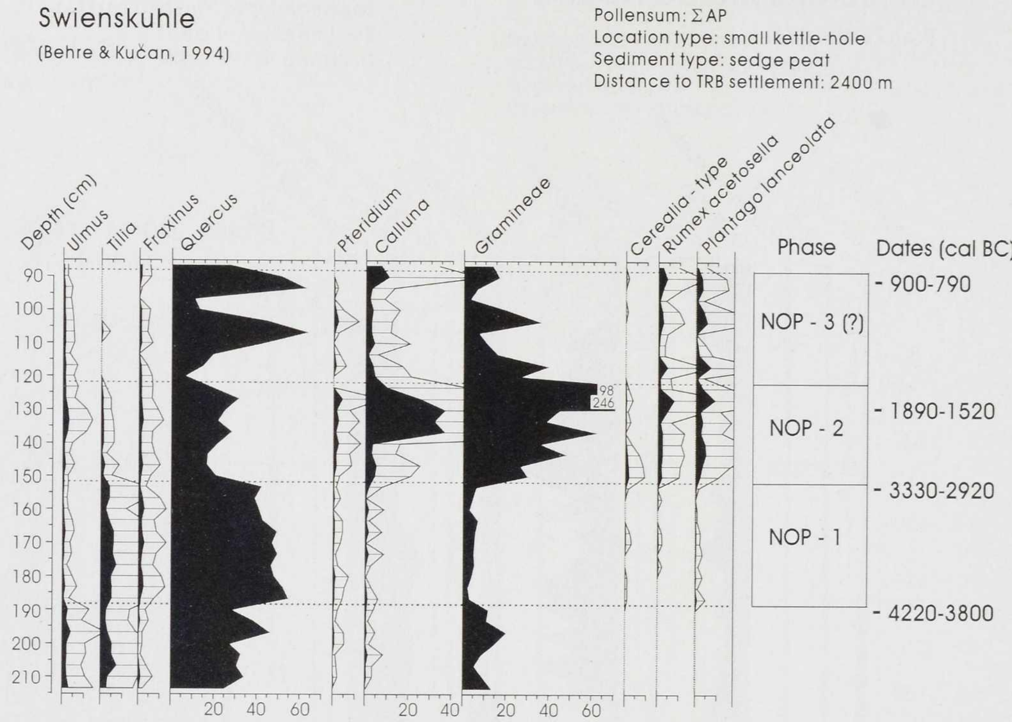
In the Swienskuhle diagram, a date of ca. 1700 cal BC is obtained for the depth of 130 cm, which is in the middle of NOP-2. This suggests that the last part of NOP-2 and the entire phase NOP-3 are part of the Bronze Age. However, the NOP-2/NOP-3 boundary is not very clear in this diagram. It is also possible that NOP-2 ends at 130 cm, and that NOP-3 is completely missing.

Jagen 20 (fig. 4g), a small kettlehole situated not far from Swienskuhle in *Siedlungskammer* Flögeln (BEHRE & KUČAN 1994). In the pollen diagram, the *Ulmus* decline occurs before the first appearance of *Plantago lanceolata*. After its initial decline, *Ulmus* recovers for a short period at the end of NOP-1. *Quercus* reaches very high values in NOP-1 (up to 80% of the AP!). The *Tilia* and *Quercus* declines at the end of NOP-1b are very pronounced. *Calluna vulgaris* and Gramineae reach exceptionally high values in NOP-2, indicating that the pollen of these taxa has a largely local origin. The culture-indicator types are very poorly represented in this diagram. There is no increase, but a decrease in these types in NOP-2. The NOP-1b/NOP-2 boundary is dated at ca. 2750 cal BC, which is on the young side (BEHRE & KUČAN 1994, 106). The NOP-2/ NOP-3 boundary is dated at ca. 1900 cal BC, which means that phase NOP-3 is part of the Bronze Age.

6. Radiocarbon dating

In the Gietsenveentje, radiocarbon dating has been used to date the organic sediments (gyttja as well as *Sphagnum* peat) which were deposited during the Neolithic. The most important method used for this was Accelerator Mass Spectrometry (AMS) dating. A great advantage of AMS dating is that very small samples can also be dated. The Gietsenveentje was one of the first cases in which several large sets of AMS dates from organic sediments were used to achieve more reliable dating of important events in vegetation history and archaeology: in five Gietsenveentje sequences, series of at least eight samples, located at relatively short distances from each other, have been dated (the complete list with all dates and calibrations can be found in my Ph.D. thesis, R. BAKKER 2003, table 9). In four of these sequences, the beginning of the Neolithic Occupation Period is located within the series of dates. With the help of the calibration curve given by STUIVER et al. (1998), the radiocarbon

Fig. 4f



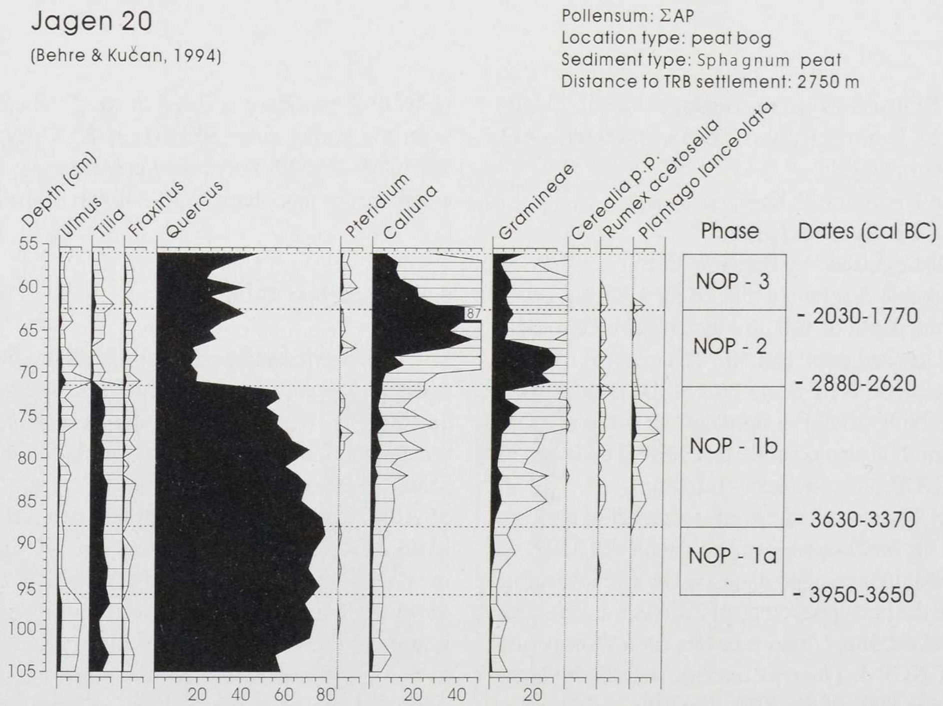


Fig. 4g

Fig. 4 Five simplified pollen diagrams of sequences from Drenthe (the northern Netherlands) and two from *Siedlungskammer* Flögeln (northwestern Germany). The various phases of the Neolithic Occupation Period (NOP) and corresponding ^{14}C dates are indicated. The dates in the Gietsenveentje diagrams (figs. 4a-c) are calibrated using the method of wiggle matching of sub-datasets (see paragraph 6, Method II); the dates in the diagrams of figs. 4d-g are calibrated using a calibration method which takes into account the fixed stratigraphical sequence of the dated samples but assumes no constant growth rate (see paragraph 6, Method I); here the 1σ ranges of the calibrated dates are given. ^{14}C dates in italics are extrapolated dates.

ages were transformed to calendar ages. First, each date was calibrated individually. However, because of many "wiggles" in the calibration curve, representing changes in the ^{14}C content of the atmosphere, the Gaussian distribution of an individual date of organic sediment often corresponds to a rather irregular calendar-age probability distribution, which in some cases encompasses quite a long period (VAN DER PLICHT et al. 1990). This can be seen in fig. 5, where the individually calibrated dates of one Gietsenveentje sequence (Gieten V-B) are shown as grey bars. By using a series of ^{14}C ages of stratigraphically successive samples, a much better age assignment of a sequence can be obtained (VAN GEEL & MOOK 1989). There are various methods to use the fixed stratigraphical sequence of a series of samples to improve the accuracy of the calendar age of each individual sample. Two methods were used:

Method I: The dates are calibrated taking into account only the fixed stratigraphical sequence of the dated samples. Different distances between the samples and any differential in sedimentation rates are not incorporated in the calibration. The option SEQUENCE of the OxCal calibration program is used to incorporate the stratigraphical evidence. The calibrated dates are obtained with the help of a statistical method called "Gibbs sampling" (BRONK RAMSEY 1995). The error of the dates is in most cases strongly reduced when the fixed stratigraphical sequence of the samples is taken into account. This can be seen in fig. 5: the ranges of the Method I-calibrated dates are considerably smaller than the bars representing the individually calibrated dates.

Method II (wiggle matching): An attempt is made to obtain the best fit of a series of stratigraphically fixed dates on the calibration curve, assuming a constant sedimentation rate. When a series of dates from a subfossil tree is to be calibrated, it is easy to match the particular wiggles found in the dates of the wood to the same wiggles in the calibration curve, because the relation between radiocarbon years and treering (calendar) years is fixed. This method is called wiggle matching. However, when a series of dates from a peat or gyttja sequence is to be calibrated, and no annually laminated sediments are present, as is the case in the Gietsenveentje, there is only a relation between radiocarbon years and sampling depth. The depths of the dated samples are related to chronology by the accumulation rate of the sediment, which is unknown. When wiggle matching is applied to peat or gyttja sequences, it must be on the assumption that the accumulation rate between the dated samples is constant. So, when a series of radiocarbon dates from a peat or gyttja sequence are to be matched to the calibration curve, in order to find the corresponding age in calendar years, there are two unknown factors:

- ❑ location of the series of dates on the calibration curve;
- ❑ absolute distance in calendar years between the individual dates (this depends on the accumulation rate; the relative distance between the dates is assumed to be constant).

It is a matter of one equation in two unknowns. Mathematically, such an equation is insolvable: there are an infinity of ways to solve it. The best solution can only be approximated.

Initially, an attempt was made to match the complete dataset of each Gietsenveentje sequence to the calibration curve of Stuiver et al. (1998). With the help of the CAL25 computer program (VAN DER PLICHT 1993), updated with the 1998 calibration curve, as close as possible an approximation to the above-mentioned "best solution" was sought: the CAL25 program calculates a goodness-of-fit parameter, which expresses the extent to which the series of dates matches the calibration curve. The nearest approximation of the "best solution" can be obtained in CAL25 by manually shifting the series of dates in calendar age and increasing or decreasing its total calendar age range (KILIAN et al. 1995). The wiggles in the calibration curve can be very useful in this process, because individual wiggles often show specific features (VAN GEEL & MOOK 1989). When particular wiggles can be recognized in a series of dates, the attribution of the calendar ages of these dates is hugely improved. However, because the obtained calibrated dates are only approximations, made under the assumption of a constant sedimentation rate, the confidence intervals of each date could not be calculated. In the Ph.D. thesis of M. BLAAUW (2003, chapter 3), which was published more or less at the same time as my Ph.D. thesis, a new numerical approach to wiggle-match dating is presented, by which these confidence intervals indeed can be calculated. A condition for the use of wiggle matching is that the series of dates is taken from small samples which are located at short distances from each other in the sediment. The Gietsenveentje samples, having a volume of less than 1 cm^3, in most sequences located no more than a few centimetres apart, comply with this condition.

In fig. 5, in which calibrated dates of one Gietsenveentje sequence are plotted against depth, the results of Method II calibration of the complete dataset of each sequence are shown as a series of dates lying on a straight line. This is no surprise, because a linear time-depth relation, i.e. a constant sedimentation rate, was assumed for this calibration method. However, it can be seen that three Method II-calibrated dates fall outside the range of the individually calibrated dates. This may indicate that the assumption of a constant sedimentation rate in the part of the sediment covered by the complete dataset of these particular sequences, is incorrect. To show this problem in more detail, fig. 6a shows the best fit of the complete dataset of Gietsenveentje sequence Gieten V-B on the calibration curve. This figure clearly shows that it is

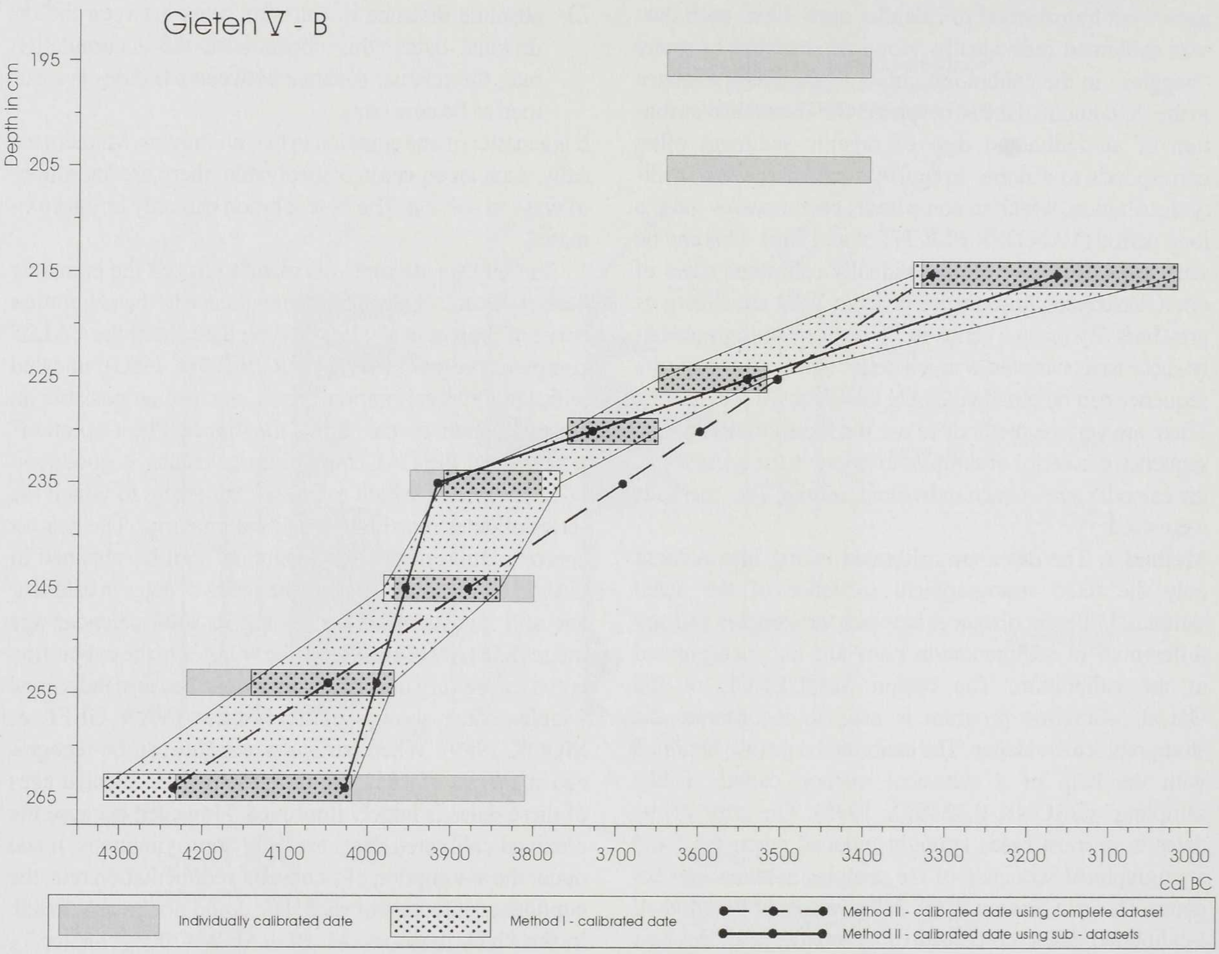


Fig. 5 Various calibration methods of the Gietsenveentje ^{14}C dates from sequence Gieten V-B are compared by plotting the calibrated dates against depth in the sediment. The results of three calibration methods are shown: individual calibration; Method I, a method which incorporates the fixed stratigraphical sequence of a series of dates into the calibration; Method II (wiggle matching), in which the best fit of a series of stratigraphically fixed dates on the calibration curve is sought, assuming a constant sedimentation rate. An attempt is made to improve the results of wiggle matching, viz. the fit of the dates on the calibration curve, by dividing the complete dataset into sub-datasets with different sedimentation rates (shown by different inclination angles in the figure) (see fig. 6).

impossible to fit the complete dataset to the curve with a reasonable degree of accuracy. When it is not possible to fit a series of dates fairly exactly to the curve, other factors are playing a role. Probably a changing sedimentation rate is the foremost among these factors. To solve this problem, the complete dataset has to be divided into sub-datasets, each of which has to be individually wiggle-matched (see KILIAN et al. 2000; SPERANZA et al. 2000). The number of sub-datasets is determined by the minimum number of straight lines which can be drawn through the ranges of the individually calibrated dates. In this way the complete dataset of Gieten V-B was divided into two sub-datasets; the best fit for each of these sub-datasets on the calibration curve was sought. This is shown in fig. 6b. It is quite clear that the dates now fit the curve far better than when the complete dataset is used. Fig. 6 also shows the period covered by the first phase of the Neolithic Occupation Period, NOP-1, as recognized in the corresponding pollen diagram. These dates are calculated by the CAL25 program on the basis of the uncalibrated dates of the sediment at the depth where the beginning and the end of NOP-1 occur in the corresponding pollen diagram. When the complete dataset is wiggle-matched, phase NOP-1 ranges from 4210 to 3450 cal BC (fig. 6a); when the two sub-datasets are separately wiggle-matched, phase NOP-1 runs from 4020 to 3430 cal BC (fig. 6b).

On the basis of the calibrated dates of all Gietsenveentje sequences with a Neolithic Occupation Period, absolute dates for the beginning of phases NOP-1 and NOP-2 of the Neolithic Occupation Period in the Gietsenveentje were sought. In the far right column of table 1, average dates are given for the beginning of NOP-1 and the beginning of NOP-2. Because it is not permitted to average calibrated dates of the same event, only average values of the uncalibrated dates are given; these average values

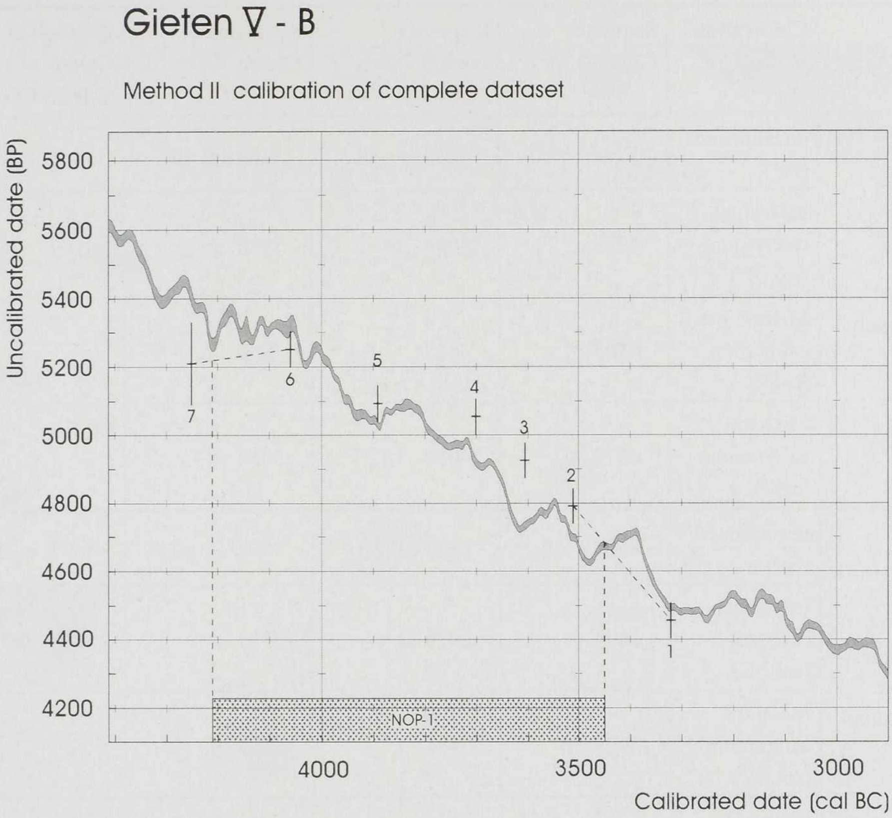


Fig. 6a

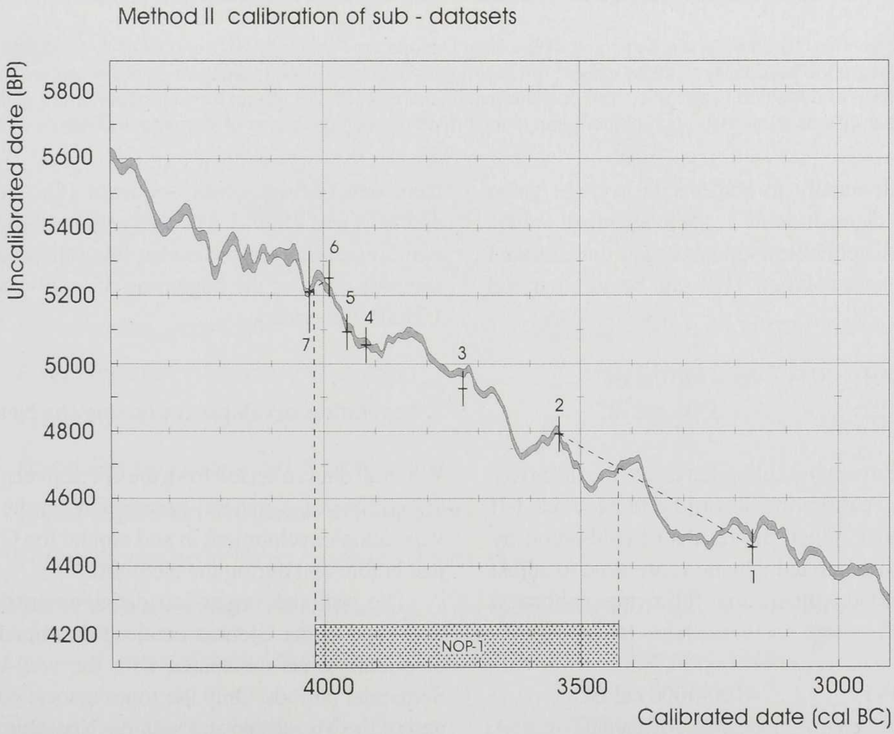


Fig. 6b

Fig. 6 Wiggle matching of ^{14}C dates of Gietsenveentje sequence Gieten V-B. Better results are obtained by dividing the complete dataset into two sub-datasets which are separately matched to the calibration curve. For each calibration result, the corresponding period covered by the first phase of the Neolithic Occupation Period (NOP-1) is indicated.

Event	Calibration method	Sequence Gieten V-A	Sequence Gieten V-B	Sequence Gieten V-D	Average of Gieten V-A, V-B and V-D
beginning of first Neolithic Occupation Phase: NOP-1	uncalibrated (BP)	5395 ± 55	5230 ± 88 †	5165 ± 50	5263 ± 34
	individual calibration (cal BC)	4225 *	4095 †*	3930 *	4100 @*
	Method I calibration (cal BC)	4195 *	4147 †*	3930 *	
	Method II calibration (cal BC)	4172 #	4018 †#	3964 #	
beginning of second Neolithic Occupation Phase: NOP-2	uncalibrated (BP)	4690 ± 50	4623 ± 50 †	4778 ± 50 †	4697 ± 28
	individual calibration (cal BC)	3495 *	3430 †*	3580 †*	3495 @*
	Method I calibration (cal BC)	3408 *	3464 †*	3559 †*	
	Method II calibration (cal BC)	3402 #	3429 †#	3539 †#	

Table 1 Gietsenveentje ^{14}C dates of the beginning of Neolithic Occupation Phases NOP-1 and NOP-2. † extrapolated value; * in order to improve the readability of these values, not the ranges of the calibrated value are given, which are the result of individual calibration and Method I calibration, but only the middle points of the 1σ range; # no standard errors of these values could be calculated; @ individual calibration of the mean uncalibrated date of the values of sequences Gieten V-A, V-B and V-D.

are calibrated individually to achieve an average value for the calibrated dates. In table 1, these averaged values are shown immediately below the averaged uncalibrated values in the far right column. They can be summarized as follows:

beginning of NOP-1: ca. 4100 cal BC
beginning of NOP-2: ca. 3500 cal BC

However, in these averaged calibrated dates, the improvements obtained by calibration according to Methods I-II are not incorporated. When the results of calibration by Methods I-II, as summarized in table 1, are used to adjust the above-mentioned values, the following calibrated dates are obtained:

beginning of NOP-1: 4100-4000 cal BC
beginning of NOP-2: 3500-3400 cal BC

There are no exact dates for the NOP-2/NOP-3 boundary in Gietsenveentje sequences; there are only three dates from one Gietsenveentje sequence (Gieten V-A) of the end of phase NOP-3. For this reason, the dates of these two boundaries are somewhat less reliable than the very accurate dates of the beginning of NOP-1 and the NOP-1/NOP-2 boundary.

7. Vegetation development during the Neolithic

When all data collected from the Gietsenveentje sequences are combined, a general description can be made of the vegetation development in and around the Gietsenveentje just before and during the Neolithic.

The regional vegetation development in the neighbourhood of the Gietsenveentje is described on the basis of pollen zones connected with the well-known Blytt/Sernander periods. Only the zones associated with the last part of the Mesolithic and with the Neolithic are indicated here; a description of all Gietsenveentje pollen zones between 9800 cal BC and the present day can be found in my Ph.D. thesis (R. BAKKER 2003, 213-223). Also, the

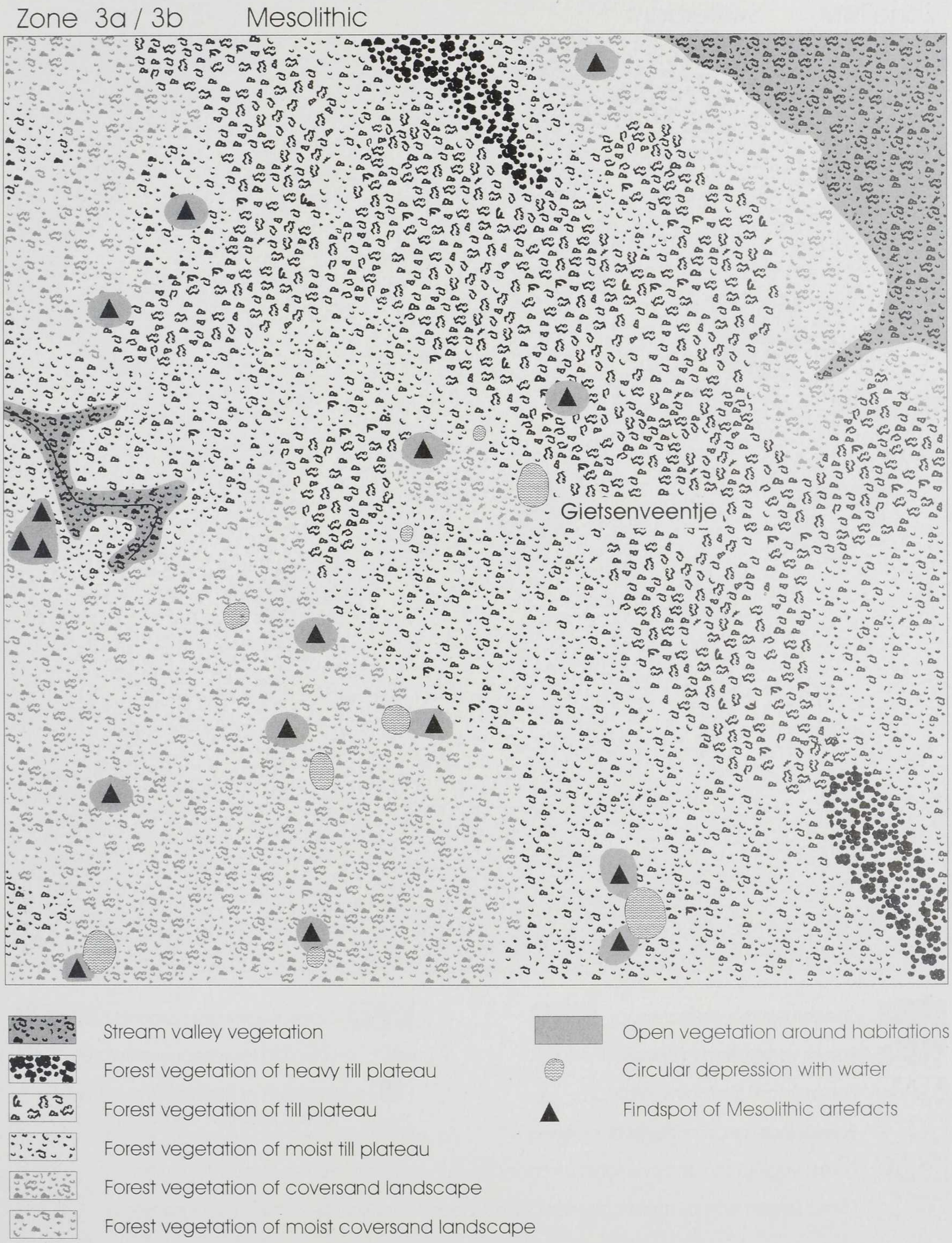


Fig. 7 Reconstruction of the landscape in the surroundings of the Gietsenveentje in regional pollen zone 3 (Atlantic). This map and the following three maps represent an area of 4 x 4 km. The potential natural vegetation of the area is constructed on the basis of the soil map. The findspots of Mesolithic artefacts are indicated.

dates of the zones are given. Dates in *italics* are estimated on the basis of comparison with other studies (LANTING & VAN DER PLICHT 1995/1996; 1997/1998; 1999/2000) or by extrapolation; dates in regular type are Gietsenveentje ^{14}C dates. Maps are presented showing the vegetation around the Gietsenveentje in the last part of the Atlantic (coinciding with the last part of the Mesolithic) and in the three phases of the Neolithic Occupation Period

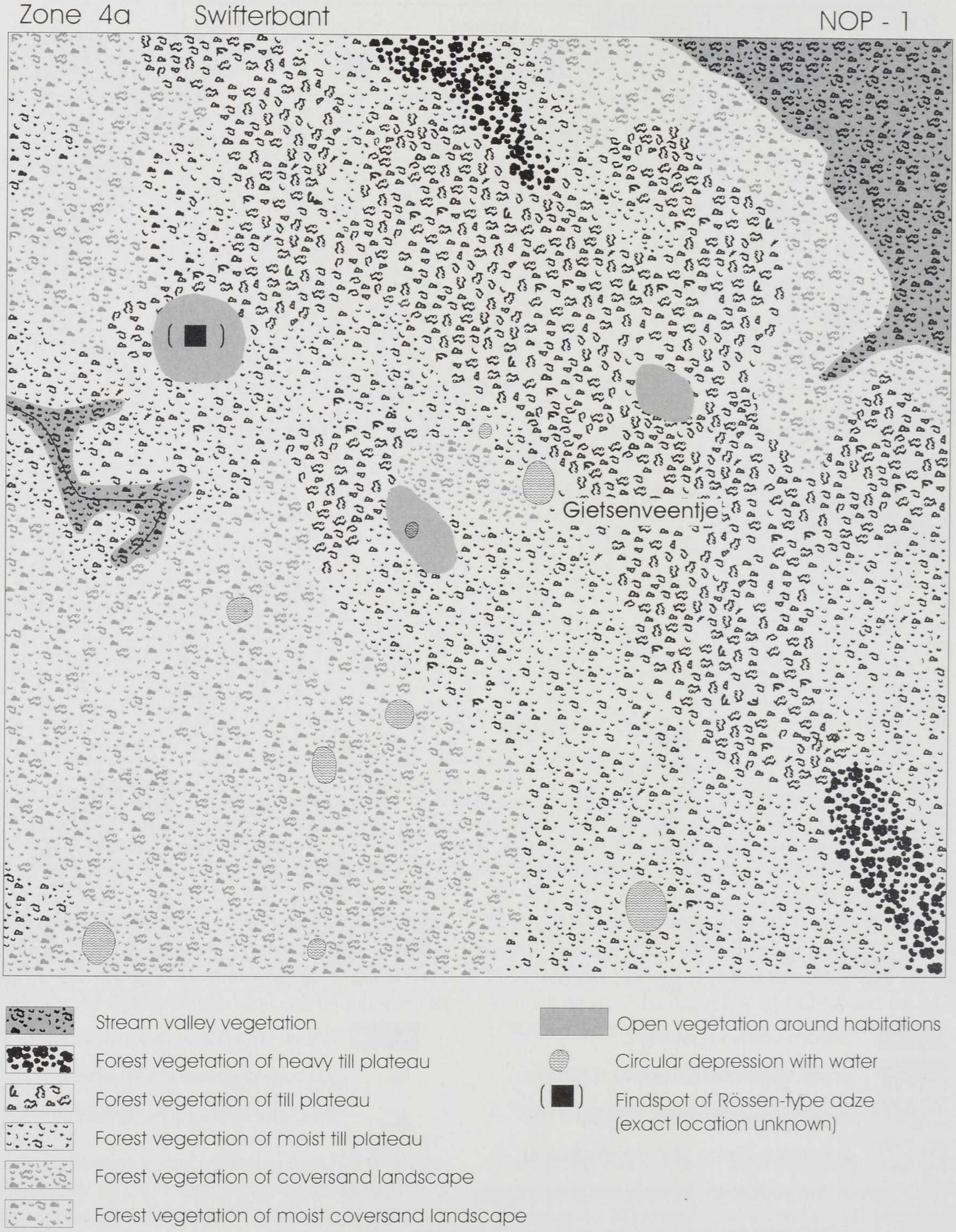


Fig. 8 Reconstruction of the landscape in the surroundings of the Gietsenveentje in phase NOP-1, which is a part of regional pollen zone 4a (first part of the Subboreal). Phase NOP-1 is associated with the Swifterbant Culture. The only findspot (approximate) of a possible Swifterbant artefact is indicated.

(figs. 7-10). The potential natural vegetation is reconstructed on the basis of the recent soil map (see SPEK 1993; R. BAKKER 2003, 58-61). On each map, the archaeological finds of the contemporary cultures are indicated. The Gietsenveentje pollen diagrams reveal the changes in the vegetation caused by the people of these cultures. The maps are intended to offer a global idea of the scale of human interference in the Neolithic Occupation Period.

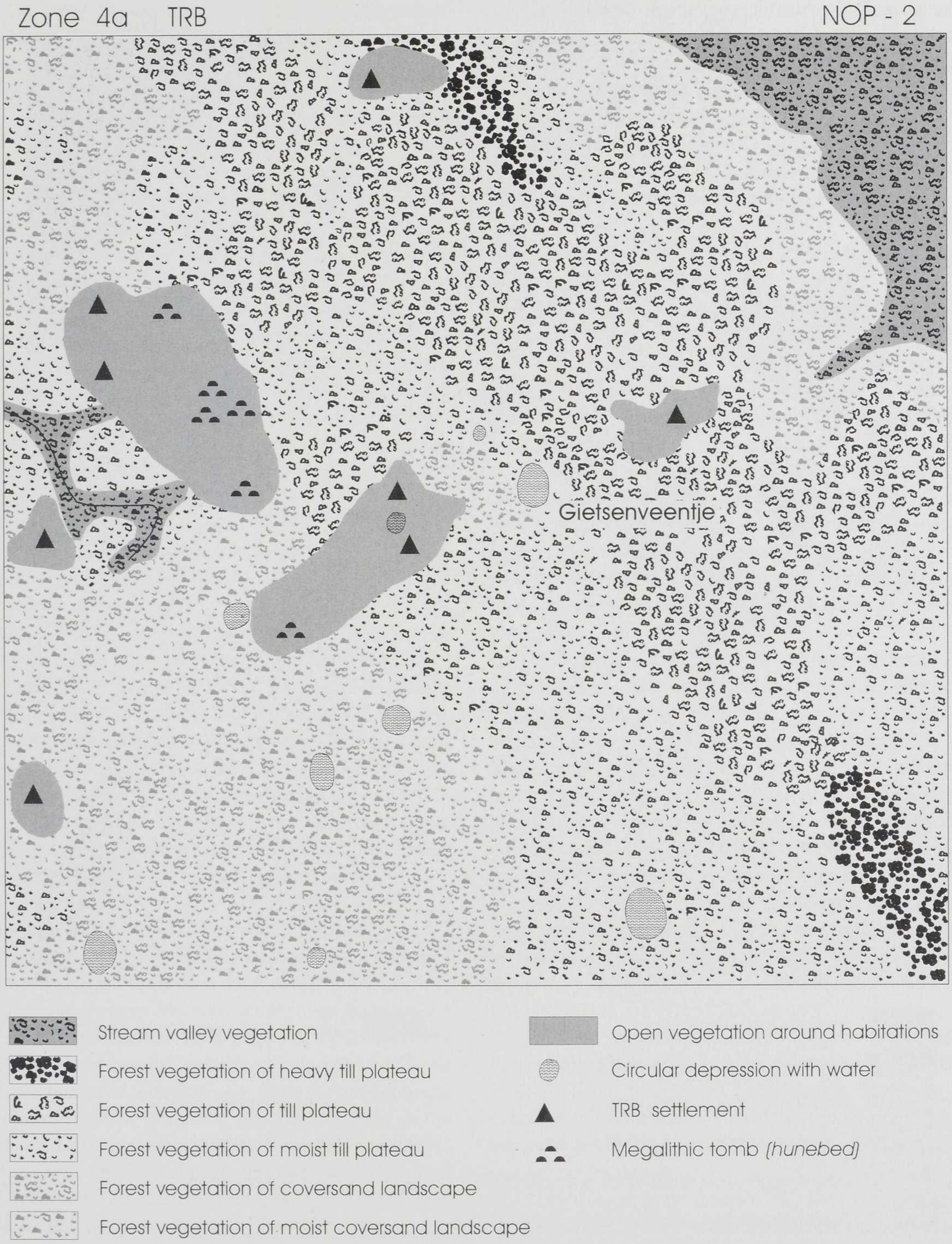


Fig. 9 Reconstruction of the landscape in the surroundings of the Gietsenveentje in phase NOP-2, which is a part of regional pollen zone 4a (first part of the Subboreal). Phase NOP-2 is associated with the Funnel Beaker Culture (TRB). The locations of megalithic tombs (*hunebedden*) and possible settlements are indicated.

Regional zone 3 - *6950*-4050 cal BC: Atlantic

Because of optimal climatic conditions, stable climax forests were formed. In this period, *Alnus*, *Fraxinus* and *Tilia* occurred for the first time in the vicinity of the Gietsenveentje. Different soil types would carry different types of forest. In fig. 7, the potential natural vegetation of the Gietsenveentje area is shown for the Atlantic (regional zone 3). Findspots of Mesolithic artefacts are indicated.

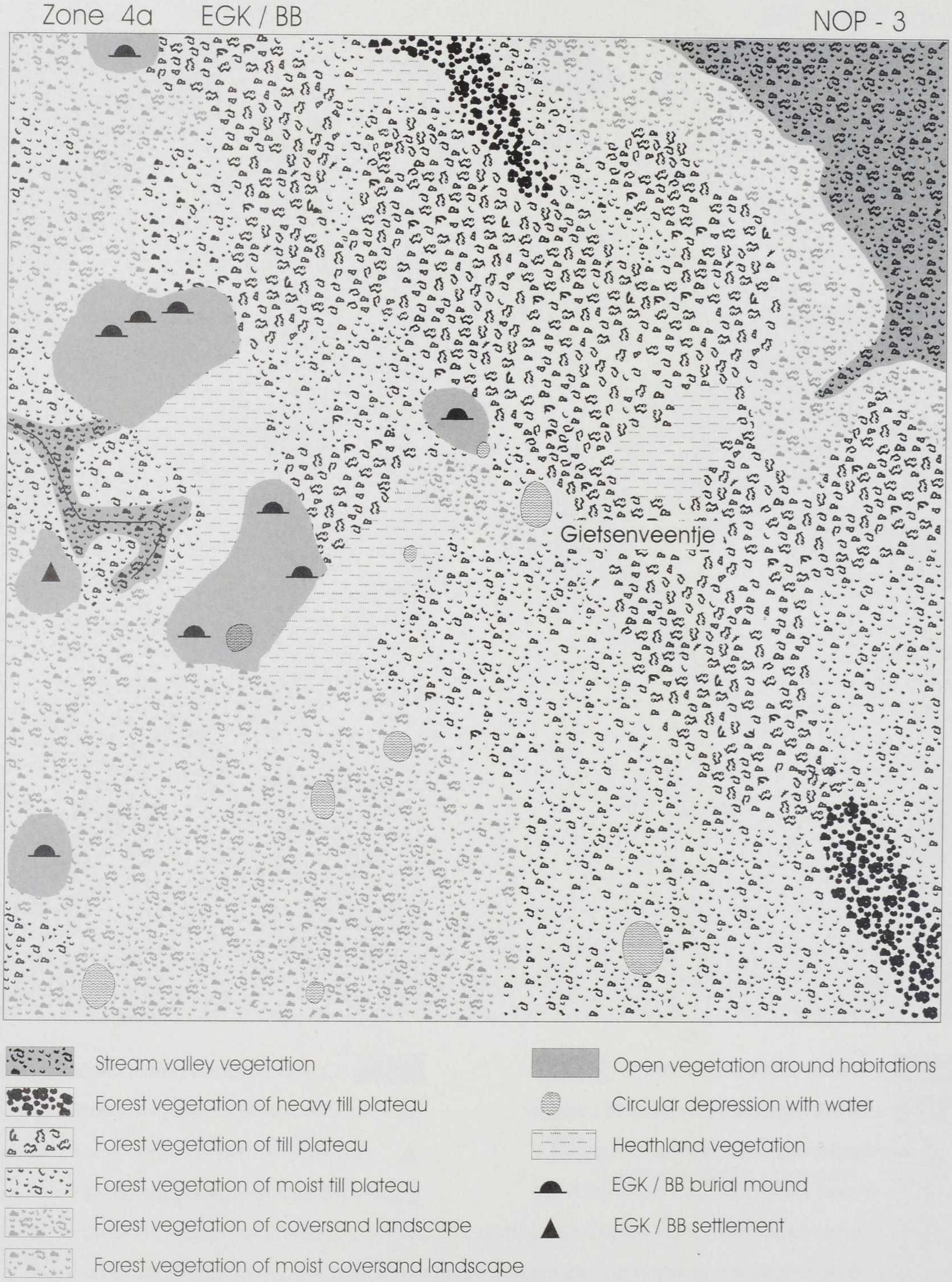


Fig. 10 Reconstruction of the landscape in the surroundings of the Gietsenveentje in phase NOP-3, which is a part of regional pollen zone 4a (first part of the Subboreal). Phase NOP-3 is associated with the Single Grave Culture (EGK) and the Bell Beaker Culture (BB). The locations of burial mounds and a possible settlement are indicated.

It can be seen that most Mesolithic sites are located near open water, either circular depressions or brooks.

In the pollen diagrams, *Alnus*, *Corylus* and *Quercus* are the dominant tree pollen types in this period. *Alnus* most probably occurred (together with *Betula*) in carr forests in the direct vicinity of the Gietsenveentje. On the till plateau, which forms the highest part of the Hondsrug ridge near the Gietsenveentje, fairly dense forests rich in species occurred, possibly of types related to the present oak-hornbeam forest (*Stellario-Carpinetum*, but without

Carpinus) and the oak-beech forest (*Fago-Quercetum*, but without *Fagus*) (STORTELDER et al. 1999). In these forests, *Quercus*, *Ulmus*, *Tilia* and *Fraxinus* were the most common trees, but *Corylus* and *Pinus* also occurred quite frequently. The coversand areas, which are located to the west and the southwest of the Gietsenveentje, carried more open forests, less rich in species, possibly forest types related to the present birch-common oak forest (*Betulo-Quercetum roboris*). In these forests, *Quercus* and *Betula* were the most common trees (STORTELDER et al. 1999). In the second part of this zone, the share of *Pinus* and *Betula* in the forests slowly fell, while the share of *Quercus* and *Ulmus* increased. At the end of this zone, a few grains of *Fagus* were found in several diagrams. Possibly, *Fagus* was already present somewhere in the neighbourhood; because of the relatively poor distribution of *Fagus* pollen grains – they are only seldom found in surface samples –, long-distance transport of *Fagus* pollen seems unlikely (oral comm. A.J. Kalis).

In the Atlantic forests, only a very scanty undergrowth was present, including Gramineae species. In all pollen diagrams, spores of *Pteridium aquilinum* reach relatively high values in this zone. *Pteridium aquilinum* especially grows in the undergrowth and in light spots in forests of the *Betulo-Quercetum roboris* and the *Fago-Quercetum* (WEEDA et al. 1985). According to Iversen (1949), *Pteridium* maxima are indicative of burning. The occurrence of fires in this zone is indicated also by high peaks of charcoal particles in several pollen diagrams. Presumably, natural fires are the cause of these peaks; however, the possibility cannot be excluded that Mesolithic people burnt vegetation in the neighbourhood of the pingo scar in order to create open spaces.

Regional zone 4a, 4050-1770 cal BC: Subboreal

The Subboreal is the first period in which human influence on the landscape becomes visible in the pollen picture. However, the changes observed in the pollen diagrams are only small. It seems that the influence of the first farmers on the vegetation was limited: the major part of the forests remained unaltered. *Quercus* and *Alnus* are the dominant tree pollen types in this zone. *Quercus* occurred in the forests on the till plateau and in the coversand areas; *Tilia* and *Fraxinus*, which grew in the forests on the till plateau, reach relatively high values, while *Ulmus*, which occurred in the same type of forest, slowly decreases. *Alnus* grew in carr forests at the edge of the Gietsenveentje. A strong decrease in *Betula* pollen demonstrates that *Betula* lost ground in these carr forests. *Fagus* pollen is frequently present in this zone, indicating that this tree became more important in the forests on the till plateau. Furthermore, the first pollen grains of *Carpinus* are found in this zone. These possibly indicate the immigration of this tree into Drenthe, but they may also originate from long-distance transport.

The influence of the first farmers on the vegetation is predominantly reflected in the herb pollen: Gramineae, Cyperaceae, *Calluna* and *Rumex acetosa* increase, while *Plantago lanceolata* and Cerealia-type appear. In Drenthe the Atlantic-Subboreal transition coincides with the beginning of the Neolithic Occupation Period (NOP). Regional pollen zone 4a coincides with the complete NOP. The NOP is subdivided into three phases:

Phase NOP-1: 4050-3450 cal BC, Swifterbant Culture (Middle and Late Phase)

In this phase, *Ulmus* very slowly decreases. However, the other components of the forests on the till plateau, *Quercus*, *Tilia* and *Fraxinus*, do not decrease; *Tilia* and *Quercus* even reach maximum values in this phase. Because the *Ulmus* decline is so slow, it is unlikely to have been caused by a pathogenic attack. Just as KALIS & MEURERS-BALKE (1998) assumed for the western Baltic area, an anthropo-zoogenic cause seems more plausible. Large browsing mammals like to eat the nutritious leaves of *Ulmus*, *Fraxinus* and *Tilia*; most probably, branches of these trees were cut and fed to cattle. Apparently, in this phase *Ulmus* was the only tree which suffered from this treatment.

Of the herb pollen types, the culture-indicator types in particular can provide useful evidence about the influence of the first farmers on the vegetation. At the beginning of the NOP, Gramineae, Cyperaceae and *Rumex acetosa* show a slight increase, while *Plantago lanceolata* first appears. These taxa point to the presence of moist grass-rich vegetation with a moderate to high nutrient availability (BEHRE 1981). Pollen of Cerealia-type (*Hordeum* group as well as *Triticum* sp.) appears and occurs in low values, pointing to the presence of arable fields. A small increase in *Calluna* and maximum values of *Genista*-type and *Jasione montana* are indicative of dry grass-rich vegetation with a low nutrient availability (BEHRE 1981; RUNHAAR et al. 1987).

The herb pollen types point to the presence of arable fields and various types of grass-rich vegetation that were most probably maintained by livestock. However, the extent of this arable and grass-rich vegetation must have been very small, because almost no decrease in tree pollen can be seen in this phase.

According to very accurate ^{14}C dates (see paragraph 6), the pollen picture probably reflects the agricultural activities of people belonging to the Middle and Late Phase of the Swifterbant Culture. The presence of Swifterbant people on the Drenthe Plateau is also demonstrated by increasing numbers of archaeological finds (see fig. 3).

Fig. 8 shows the landscape in the neighbourhood of the Gietsenveentje as it might have been in phase NOP-1. The larger part of the Atlantic forest was undisturbed. Only a few small-scale clearances in the forests on the till plateau and on the poorer, sandy soils revealed the presence of Swifterbant people. Up till now, the only archaeological find contemporary with the Swifterbant Culture near the Gietsenveentje is a Rössen-type adze, found "on the heath near Eext" (VAN DER WAALS 1972, 172). However, this find most probably dates from the period of the Rössen Culture (4700-4300 cal BC), which is a few hundred years before the beginning of NOP-1. Habitations of Swifterbant people have so far not been found on the Drenthe Plateau.

Phase NOP-2: 3450-*2600* cal BC, TRB Culture

In this phase, the tree pollen values do not change, except for small decreases in *Tilia* and *Quercus*. The decline of these two taxa resembles that found by BEHRE & KUČAN (1994) in northwestern Germany. Most probably, more extensive clearances occurred in the dense forests on the till plateau. By now not only *Ulmus*, but also *Tilia* and *Quercus* suffered from these clearances. However, the values of *Fraxinus*, another component of the forests on the till plateau, remain constant. Possibly, the branches of *Ulmus*, *Tilia* and *Fraxinus* were still being fed to livestock; owing to more intensive branch-cutting than in the preceding phase, not even *Tilia* could properly regenerate. The more open forests were to the advantage of *Fraxinus*, a tree which prefers light forests (WEEDA et al. 1988). Pollen of *Fagus* occurs more regularly in this phase, but still only sporadically, and therefore it seems unlikely that this tree was replacing *Tilia*. This conclusion was also reached by VAN ZEIST (1959, 177).

Of the herb pollen types, Gramineae, Cyperaceae, *Calluna*, *Pteridium*, *Plantago lanceolata*, *Rumex acetosa* and Cerealia-type (*Hordeum* group as well as *Triticum* sp.) reach relatively high values. Also a small increase in the number of charcoal particles is observed. Maxima of charcoal particles and *Pteridium* spores might point to burning (IVERSEN 1949). However, the values of *Pteridium* in this phase reach only 3-4%. Only very small-scale burning could have taken place. Burning would also benefit *Quercus*, because this tree has a thicker bark than most other trees (WEEDA et al. 1985). However, the low values of *Betula* in this phase argue against the use of burning: IVERSEN (1941) states that the pioneer tree *Betula* is one of the first trees to regenerate in the ashy soil after a fire. The increase in Gramineae, Cyperaceae, *Rumex acetosa* and *Plantago lanceolata* points to larger areas of grass-rich vegetation with a moderate to high availability of nutrients.

Cerealia-type (*Hordeum* group as well as *Triticum* sp.) occurs more regularly in this phase, which points to an increased importance of arable fields.

According to the ^{14}C dates, the pollen picture of this phase reflects the agricultural activities of people of the Funnel Beaker Culture (TRB) and possibly the first part of the Single Grave Culture (EGK). Unfortunately, there are no datings of the NOP-2/NOP-3 transition; the date of 2600 cal BC is an extrapolated value, and therefore far less reliable than the date of the NOP-1/NOP-2 transition. It seems probable that the NOP-2/NOP-3 transition coincides with the transition from TRB to EGK, but in the absence of accurate ^{14}C dates, definite proof is lacking. Still it seems safe to conclude that the largest part of phase NOP-2 has to be ascribed to the TRB Culture. The presence of TRB people in the vicinity of the Gietsenveentje is documented by many archaeological finds.

Fig. 9 shows the landscape around the Gietsenveentje as it might have been in phase NOP-2. All TRB "settlement sites" (findspots of flint and pottery) and megalithic tombs (*hunebedden*) are shown. The megalithic tombs and also most "settlements" are located on the western edge of the till plateau (western part of the map area), near the valley of the Scheebroekerloop. To create the necessary open spaces, TRB people predominantly cleared forest vegetation on the till plateau, of a type related to present-day oak-beech forest (*Fago-Quercetum*). A few "settlements" are located on the highest part of the till plateau (eastern and northern part of the map area). Here, it was mostly forest on heavy till, of a type related to present-day oak-hornbeam forest (*Stellario-Carpinetum*), that was cleared. However, the major part of the Atlantic forest remained undisturbed.

Phase NOP-3: *2600*-1770 cal BC, EGK/BB Culture

In this phase, the pollen diagrams show no changes in the tree pollen values except for a small increase in *Corylus*, while the total herb pollen value decreases slightly. The values of Gramineae, *Calluna* and the culture-indicator pollen types remain constant or slightly fall. The pollen picture reflects a period of temporarily reduced pressure on the vegetation: apparently not much new forest clearance took place in this phase.

According to the ^{14}C dates, this phase reflects the agricultural activities of people of the Single Grave Culture (EGK), the Bell Beaker Culture (BB) and possibly the first part of the Bronze Age. There are only a few dates of the end of phase NOP-3; for this reason, the date of 1760 cal BC is less accurate than the dates of the beginning of NOP-1 and the NOP-1/NOP-2 boundary. The end of phase NOP-3 probably coincides with the BB/Bronze Age boundary; however, in this case too more ^{14}C dates are needed to provide clarity. It is clear that the major part of phase NOP-3 is attributable to the EGK and BB Cultures.

In fig. 10, the landscape in the vicinity of the Gietsenveentje is shown as it might have been in phase NOP-3. Also the archaeological findspots relating to this period are shown: one EGK/BB "settlement" and a number of burial mounds. Compared to the TRB period, the density of habitation seems to be less. The burial mounds are situated on the western edge of the till plateau, very close to the megalithic tombs. Possibly, part of the land which

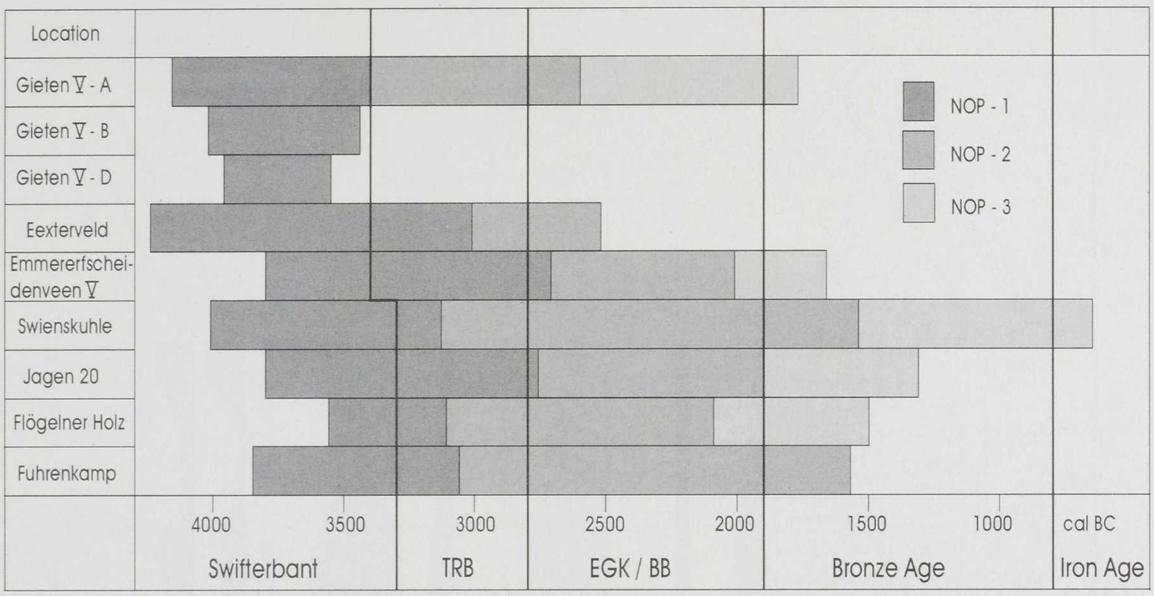


Fig. 11 Duration of the three phases of the Neolithic Occupation Period (in as far as they are present) in calendar years in the pollen diagrams from Drenthe (upper five) and *Siedlungskammer* Flögeln (lower four), compared to the periods of the cultures.

for several centuries had been cultivated by TRB people, was by now exhausted, resulting in the first, small, grass-rich heathfields. The presence of EGK people on the very edge of the Gietsenveentje is documented by the find of a horn sheath in the pingo scar itself; Prummel & Van der Sanden (1995) believe this horn sheath was thrown into the water for ritual purposes.

8. A model of the Neolithic Occupation Period in Pleistocene areas near the North Sea coast

The pollen data of the Gietsenveentje sequences were combined with data from the literature, in order to construct a model of the Neolithic Occupation Period in pollen diagrams which is valid for a larger area than only the Gietsenveentje or the Drenthe Plateau. The aim was to construct a model of the Neolithic Occupation Period that would be valid for Pleistocene areas near the North Sea coast, because these areas are characterized not only by roughly similar geological and edaphic conditions, but also by finds of the same archaeological cultures. The diagrams of the Gietsenveentje have formed the basis for the model. Furthermore, other diagrams from the province of Drenthe and diagrams from northwestern Germany (*Siedlungskammer* Flögeln) were incorporated (see paragraph 5). Now first the calibrated ^{14}C dates of the boundaries of the three phases of the Neolithic Occupation Period in these diagrams will be compared (fig. 11). The similarities and differences are discussed below.

NOP-1: The ^{14}C dates of the beginning and end of this phase correspond quite well. The average date of the beginning in the Gietsenveentje and Eexterveld is ca. 4100 cal BC; in Emmererfscheidenveen and the diagrams from *Siedlungskammer* Flögeln, the phase begins on average ca. 3800 cal BC. In the Gietsenveentje diagrams, the phase ends ca. 3450 cal BC; in the other diagrams, it continues on average until ca. 3000 cal BC.
In all diagrams, this phase starts hundreds of years before the beginning of the TRB Culture (fig. 11), which means that it has to be attributed to the Swifterbant Culture.

NOP-2: The ^{14}C dates of the end of this phase are not unambiguous: in the Gietsenveentje and Eexterveld, they are on average ca. 2550 cal BC, while in *Siedlungskammer* Flögeln they are on average ca. 1825 cal BC.
In the Gietsenveentje diagrams, phase NOP-2 covers the entire TRB period and a small part of the EGK/BB period; in the Eexterveld diagram, it covers the last third part of the TRB period and a small part of the EGK/BB period; in the Emmererfscheidenveen and Jagen 20 diagrams, it falls entirely in the EGK/BB period; in the three other diagrams from Flögeln, it starts a few centuries after the beginning of the TRB period and also covers the entire EGK/BB period. In Swienskuhle and Fuhrenkamp, phase NOP-2 even extends into the Bronze Age.

NOP-3: This phase could not be identified in diagram Gieten V-B because of disturbed sediment. In two diagrams from *Siedlungskammer* Flögeln, Fuhrenkamp and Flögeln V, this phase is entirely

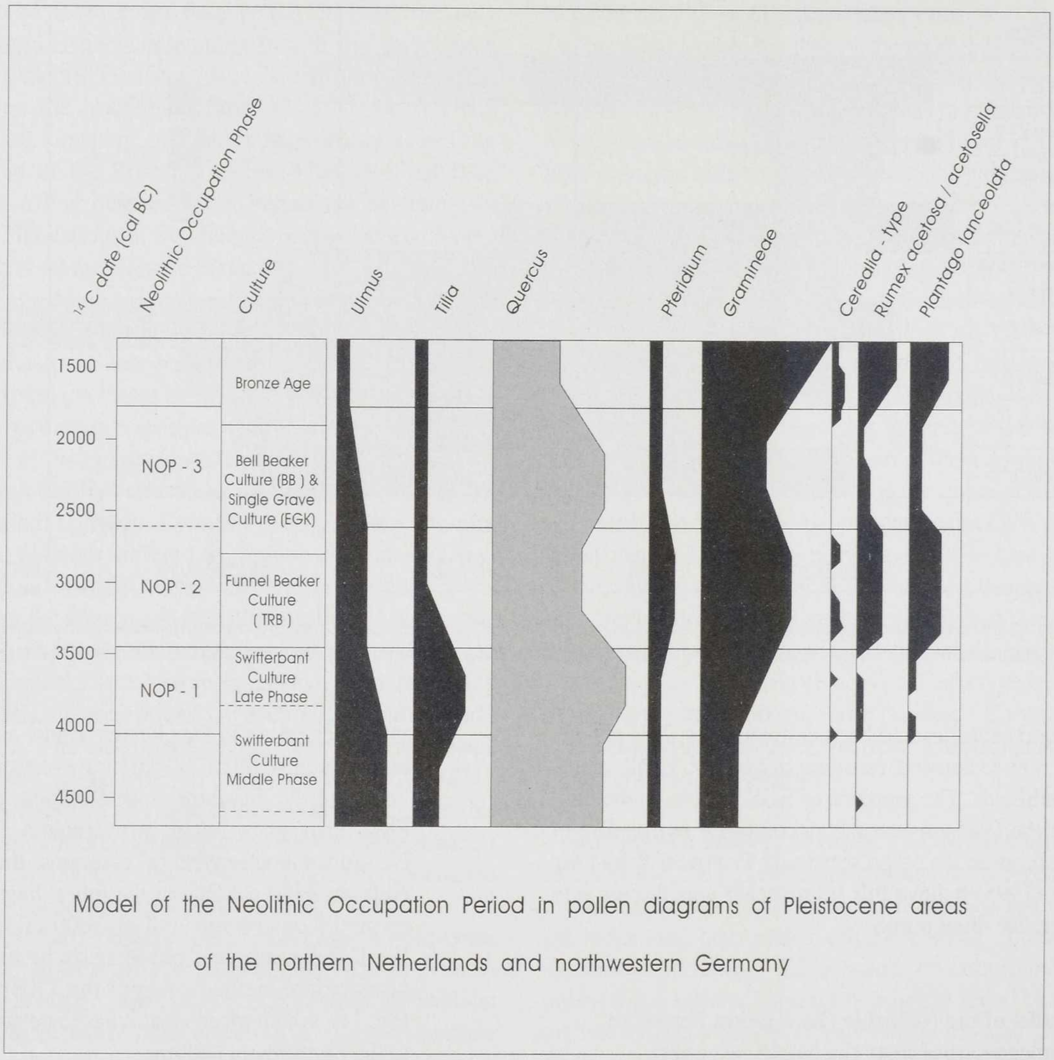


Fig. 12 Model of the Neolithic Occupation period. The grey curve is a five times magnification of the black curves.

absent. The dates of the end of this phase also vary considerably, between ca. 1800 cal BC in the Gietsenveentje and as late as ca. 650 cal BC in Swienskuhle.

In the Gietsenveentje, phase NOP-3 covers almost the entire EGK/BB period; in Emmererfscheidenveen and in three diagrams from Flögeln, it begins in the last phase of the EGK/BB period and extends into the Bronze Age (fig. 11).

It is remarkable that the dates of the zone boundaries, especially of the zone boundary NOP-2/ NOP-3 and the end of NOP-3, differ so much. Part of these differences can be explained by uncertainties in the ^{14}C dates: all phase boundaries at all locations except for the Gietsenveentje are based on individual ^{14}C dates, most dates even on extrapolations of individual ^{14}C dates. Because of irregularities in the calibration curve caused by changes in the ^{14}C content of the atmosphere, an individual date often corresponds to a relatively long period in real calendar years, which makes such a date suitable only for a global period indication. But even when this is kept in mind, the differences in the dates of the boundaries of phase NOP-3 in particular seem too large. This raises the question whether this phase in the various diagrams is really the same and caused by the same type of human interference in the vegetation. At the moment, there are too few accurate dates of the boundaries of this phase to answer this question.

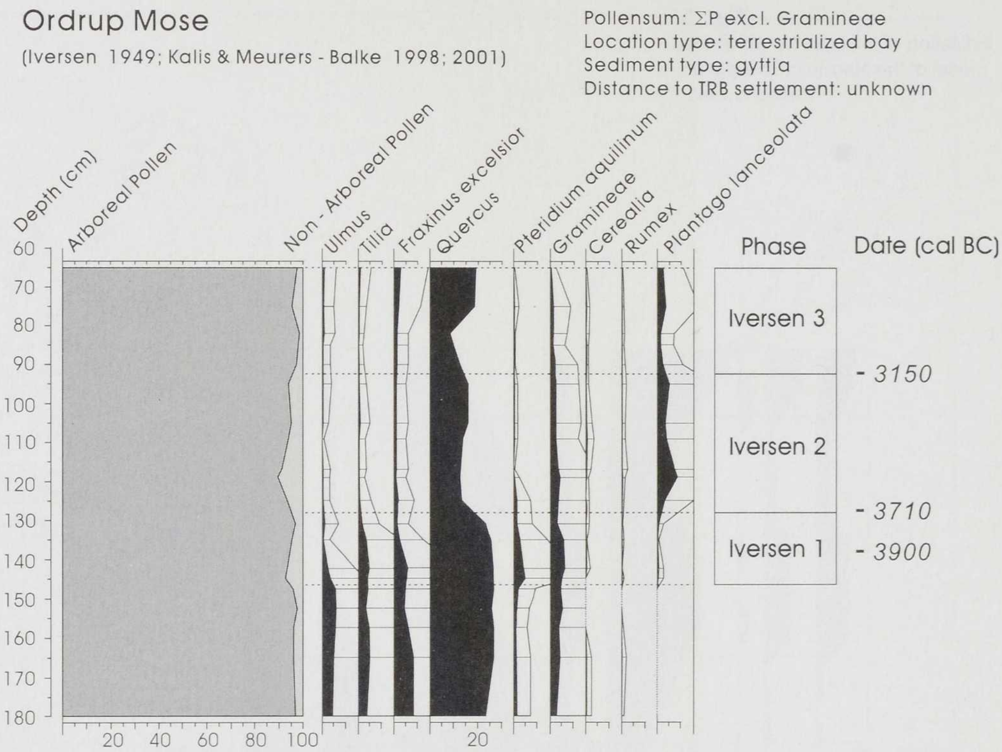
Since in the Gietsenveentje all zone boundaries except for NOP-2/NOP-3 are defined by series of at least three dates, the Gietsenveentje dates of the zone boundaries were taken as a starting point for drawing up a model for the Neolithic Occupation Period in Pleistocene areas near the North Sea coast, describing the course of selected pollen curves. Especially those pollen types are included which are expected to have been most strongly influenced

Fig. 13
Indication of the area for which the model of the Neolithic Occupation Period is valid.

by human interference in the vegetation. Compared to the simplified pollen diagrams of fig. 4, two pollen types are omitted: *Fraxinus excelsior* and *Calluna vulgaris*. The changes in the pollen values of *Fraxinus excelsior* during the NOP are so slight that it is useless to include this pollen type in the model. *Calluna vulgaris*, clearly a regional pollen type in the diagrams of the Gietsenveentje and Eexterveld, shows very high and irregular values in the diagrams of the large raised bogs of southeastern Drenthe and in most diagrams of *Siedlungskammer* Flögeln, indicating that at these locations it is a local pollen type. With the help of a large number of ^{14}C dates, especially from the Gietsenveentje, the various phases of the NOP are linked to archaeological cultures. The model is shown in fig. 12. It is evident from this figure that the boundaries of the Neolithic Occupation Phases do not always coincide with those of the cultures. Yet it is noteworthy that the boundary which is most accurately dated in the Gietsenveentje, namely NOP-1/NOP-2, almost exactly coincides with the Swifterbant/TRB transition. The beginning of NOP-1 is also dated quite accurately, but this date seems not to coincide with any boundary between phases of the Swifterbant Culture. As already indicated above, the NOP-2/NOP-3 boundary and the end of NOP-3 are dated far less closely. It is most likely that in the northern Netherlands, phase NOP-3 coincides with the EGK/BB period. In northwestern Germany, phase NOP-2 also seems to cover the largest part of the EGK/BB period, while phase NOP-3 does not start until the end of the EGK/BB period and extends into the Bronze Age (fig. 11). It is certain that more ^{14}C dates are needed to determine the boundaries of phase NOP-3 and the correlation of this phase with archaeological cultures. The area to which the model of fig. 12 applies, is indicated in fig. 13. When any particular diagram from this area is considered, deviations from the model of course will always be found. But in general, the trends as described in the model can be recognized in almost every diagram from the area in fig. 13.

9. Comparison with the "classical" diagrams of Iversen and Troels-Smith

Now that a model of the Neolithic Occupation Period is defined for pollen diagrams from Pleistocene areas near the North Sea coast, this model can be compared with the Iversen and Troels-Smith occupation phases which are distinguished by KALIS & MEURERS-BALKE (1998; 2001) in pollen diagrams from the western Baltic (northeastern Germany, eastern Denmark and southern Sweden). Fig. 14 shows simplified versions of the original pollen diagrams by Iversen and Troels-Smith,



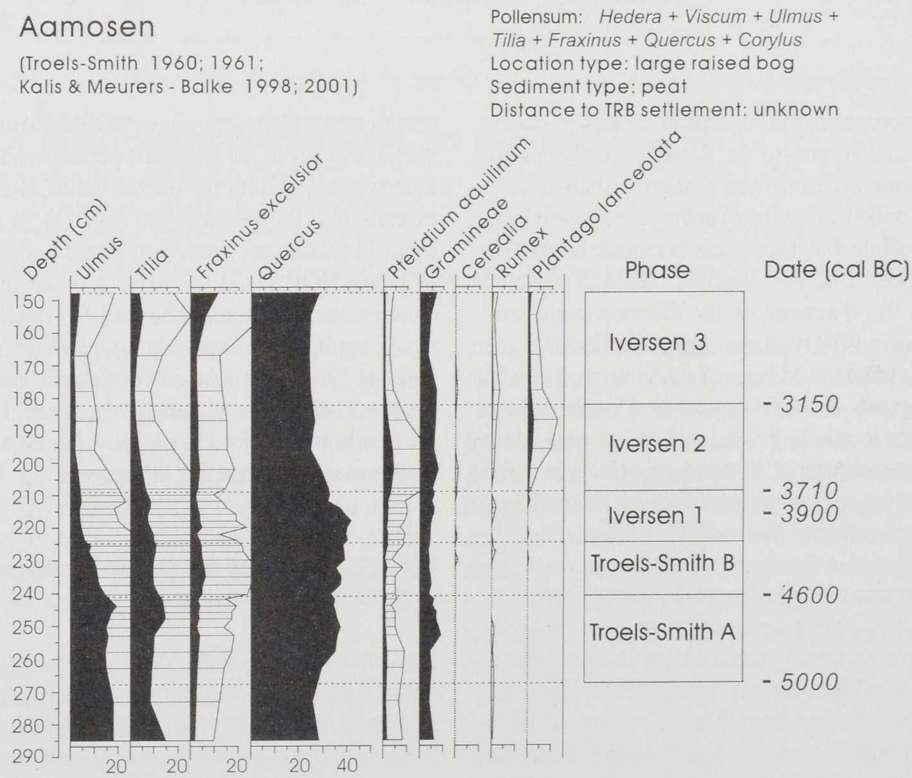


Fig. 14 Two simplified pollen diagrams of the original Danish sequences used by Iversen and Troels-Smith for the construction of their respective models of Neolithic occupation: Ordrup Mose, a filled-up bay in the northern city area of Copenhagen, and Aamosen, a raised-bog area in the western part of Zealand. Various Iversen and Troels-Smith occupation phases, distinguished by KALIS & MEURERS-BALKE (1998), and corresponding ^{14}C dates are indicated. The ^{14}C dates are all extrapolated dates from dated pollen sequences from eastern Holstein (see KALIS & MEURERS-BALKE 2001).

with updated phase indications and (extrapolated) dates added by Kalis & Meurers-Balke. In the diagram of Aamosen, the first phase of human activity, Troels-Smith-PREFACT phase A, begins as early as 5000 cal BC, which is approximately 1000 years before the "classic" *Ulmus* decline. Phase NOP-1 in diagrams of Pleistocene areas near the North Sea coast has some affinity with the Troels-Smith-PREFACT phases and with Iversen-PREFACT phase 1 in diagrams of the western Baltic. However, a major difference is that in Pleistocene areas near the North Sea coast, the "classic" *Ulmus* decline occurs at the beginning of phase NOP-1, while in the western Baltic, the "classic" *Ulmus* decline occurs approximately halfway along Iversen-PREFACT phase 1, which is completely after the Troels-Smith-PREFACT phases. These various phases were caused by completely different cultures: phase NOP-1 is attributed to the Swifterbant Culture; the Troels-Smith-PREFACT phases are correlated with the Ertebølle Culture (5100-4100 cal BC), and Iversen-PREFACT phase 1 correlates with the Early Neolithic TRB Culture (4100-3400 cal BC), an early farming culture which has not been demonstrated in the northern Netherlands and northwestern Germany. A conclusion must be that quite different cultures in different areas and in different periods may cause similar pollen pictures. In spite of the difference in cultures, the *Ulmus* decline occurs contemporaneously both in Pleistocene areas near the North Sea coast and in the western Baltic, namely around 4000 cal BC.

Kalis & Meurers-Balke correlate Iversen-PREFACT phase 2 with the last part of the Early Neolithic TRB and with the first part of the Middle Neolithic TRB (3400-3150 cal BC). The pollen picture of this phase is characterized by low values of *Ulmus* and *Tilia* and relatively high values of the culture-indicator types. Phase NOP-2 in diagrams of Pleistocene areas near the North Sea coast has some affinity with Iversen-PREFACT phase 2 in diagrams of the western Baltic. Both phase NOP-2 and the latter and major part of Iversen-PREFACT phase 2 are associated with strongly related cultures: the West Group and the North Group of the Middle Neolithic Funnel Beaker Culture (TRB), respectively.

Iversen-PREFACT phase 3 is correlated by KALIS & MEURERS-BALKE (2001) with the last part of the Middle Neolithic TRB (3150-2900 cal BC). The pollen picture is characterized by small increases in *Ulmus*, *Tilia* and *Fraxinus* and a decrease in Gramineae and the culture-indicator types. Phase NOP-3 in diagrams of Pleistocene areas near the North Sea coast has some affinity with Iversen-PREFACT phase 3 in diagrams of the western Baltic. A difference is that in phase NOP-3, *Ulmus*, *Tilia* and *Fraxinus* remain constant, while in Iversen-PREFACT phase 3, these taxa increase. Clearly, these two phases were caused by different cultures: phase NOP-3 by people of the Single Grave Culture (EGK), the Bell Beaker Culture (BB) and possibly the Bronze Age, and Iversen-PREFACT phase 3 by the Middle Neolithic TRB.

10. The agricultural economies of the Neolithic cultures on the Drenthe Plateau

Combining the model of the Neolithic Occupation Period proposed in paragraph 8 with data more directly related to archaeology may finally lead us to a more complete picture of the agricultural economies of the first farming cultures on the Drenthe Plateau. Yet it is not justified to speak of "the" agricultural economy of the Swifterbant Culture or the TRB Culture. The concluding remarks in the following primarily apply to the Drenthe Plateau, and most probably also to areas with comparable geomorphological and edaphic conditions in northwestern Germany. For each phase of the Neolithic Occupation Period, observed phenomena will be interpreted in terms of archaeology.

Phase NOP-1: 4050-3450 cal BC, Swifterbant Culture (Middle and Late Phase)

On the Drenthe Plateau, the first signs pointing to agriculture appear in the pollen diagrams around 4050 cal BC. Apparently, agriculture was introduced on the Drenthe Plateau by people of the Swifterbant Culture.
The pollen picture has some affinity with the occupation phase as described by Troels-Smith for Denmark and Switzerland. Troels-Smith explained his occupation phase by the leaf-foddering theory. He linked stable feeding with the use of leaves as fodder for livestock. The possibility of leaf foddering and possibly stable feeding has to be considered for the Drenthe Plateau.

Not many changes are observed in the regional tree pollen values in this period, except for a gradual decline of *Ulmus* and an increase in *Tilia* and *Quercus*. As already stated, the *Ulmus* decline in this area was probably caused mainly by human interference in the vegetation. Because most other tree percentages remain constant, it seems that *Ulmus* trees were used selectively by the first farmers. It is possible that the trees were pollarded, and that the leaves and branches were fed to the cattle. Another possibility is that the cattle, which was allowed to roam freely, predominantly consumed the tasty young shoots of *Ulmus* in the natural and man-made open spaces, thus preventing the regeneration of this tree. In my opinion, the increase in *Tilia* in this phase can also be attributed to activities of the first farmers. It has already been noted by several authors (VAN ZEIST 1959; GROENMAN-VAN WAATERINGE 1992; KALIS & MEURERS-BALKE 1998) that different tree species react differently to the practice of pollarding. *Ulmus* would suffer most severely, while *Fraxinus* and *Tilia* would take advantage of the situation:

when it is assumed that the branches were cut every 3-4 years, *Ulmus* would not be able to flower in the intervening period, in contrast to *Fraxinus* and *Tilia*, species which regenerate much faster than *Ulmus*. In the pollen diagrams of the northern Netherlands and northwestern Germany, a pronounced maximum of *Tilia* is found in this phase, while *Fraxinus* remains more or less constant (fig. 4).

S.T. ANDERSEN (1988; 1992b) found pronounced *Tilia* maxima in two diagrams from very small hollows in eastern Denmark. He obtained a picture of local changes in the vegetation. The *Tilia* maxima were accompanied by a decrease in all other trees. His explanation for the local *Tilia* maxima is that all trees were felled except for the *Tilia* trees, which were maintained for the harvesting of leaf-fodder. The now freestanding *Tilia* trees could flower far more abundantly than they could in the dense Atlantic forests. IVERSEN (1960, note 11) already established that especially under favourable light conditions, *Tilia* is a great pollen producer; in dense forest, however, flowering of *Tilia* is greatly reduced. The *Tilia* maximum in the diagrams from the northern Netherlands and northwestern Germany seems to point to a more open forest. Possibly, the (freestanding?) *Tilia* trees were pollarded for fodder. The *Tilia* trees could also have been maintained for bee-keeping and the making of rope from the bark.

In historical times, the system of leaf lopping has always been closely connected with the system of forest grazing: forest grazing was used to feed the cattle in summer, while leaf lopping served to feed the animals in winter. At the end of summer, the deciduous trees would be lopped and the leaves dried for use as winter fodder (BURRICHTER & POTT 1983).

TROELS-SMITH (1954; 1960) explained his occupation phase by assuming that the cattle were fed exclusively on leaves. Low values of Gramineae and *Plantago lanceolata* in his opinion pointed to the absence of pastures. As argued by GROENMAN-VAN WAATERINGE (1986; 1992) it is very unlikely that cattle were fed exclusively on leaf fodder: cattle are grazers and not browsers. This means that cattle must have their major food intake from grass. Leaves can only be used as a major food source for short periods of time, or be a supplement to the staple fodder. These facts make Troels-Smith's explanation for his occupation phase unconvincing. In his own diagram from Aamosen (fig. 14), a clear increase in Gramineae is observed in the Troels-Smith occupation phase; in many diagrams from the northern Netherlands and northwestern Germany, increasing values of Gramineae and *Plantago lanceolata* are observed during phase NOP-1, which is characterized by a pollen picture resembling the Troels-Smith occupation phase. These observations suggest that in these areas, this phase did see some kind of grass-rich vegetation, most probably woodland pasture. This situation can be compared to that in Switzerland, where TROELS-SMITH (1984) and RASMUSSEN (1990; 1993) convincingly demonstrated on the basis of macroscopic analysis that foddering took place in the Neolithic. The animals were held inside the settlements, in some kind of byre, during the winter. The fodder consisted of twigs and leaves. However, in contrast to northwestern and northern Europe, where in the Neolithic herb pollen values of more than 10% are often reached, in Switzerland the values of herb pollen and particularly Gramineae remain below 10% throughout the Neolithic (RASMUSSEN 1990, 76). In the Swiss Neolithic, open areas with grass must have been very limited. Apparently, leaf foddering was practised on a far larger scale here than in northwestern and northern Europe. This is in agreement with the observation by BURRICHTER & POTT (1983) that in mountain districts there is more need for leaf foddering in winter than in maritime regions, because of the shorter growing season and the longer and heavier snow cover.

It must have been very difficult to harvest leaves of *Ulmus* and *Tilia* selectively in the dense Atlantic forests, because most leaves grew in the tops of the trees, and the trees lacked lateral branches. Therefore I assume that if the technique of leaf foddering was applied in phase NOP-1 by people of the Swifterbant Culture, this was done only in combination with small-scale woodland pastures. Especially leaves and twigs of *Ulmus* and *Tilia* must have been harvested; a recovered bundle of *Ulmus* twigs at the Swifterbant site S3, probably intended as fodder, supports this theory (CASPARIE et al. 1977, 54). Possibly, the woodland pastures were created by the felling of trees which were not used for pollarding. There is no indication at all that burning was used in this phase to create open spaces in the forest.

In pollen diagrams from Pleistocene areas near the North Sea coast, Cerealia-type pollen grains are first found at the very beginning of phase NOP-1, which is ca. 4050 cal BC (Eexterveld, Swienskuhle, see fig. 4). In the Gietsenveentje diagrams, grains of Cerealia-type do not appear until around 3500 cal BC. *Triticum* sp. and *Hordeum* group are more or less equally represented. Apart from the role of cereals in the human food supply, the remains of these plants were possibly used as winter fodder beside leaves and twigs. The date of 4050 cal BC has to be considered as a *terminus ante quem* for the introduction of cereal crops in Pleistocene areas near the North Sea coast. The date is more or less in agreement with the data published by BRINKKEMPER et al. (1999), who deemed the incorporation of crop plants into the subsistence strategy of the Swifterbant Culture to have taken place around ca. 4200 cal BC at the earliest.

As already indicated, the pollen picture of phase NOP-1 displays similarities both with Troels-Smith-PREFACT phases A and B, associated with the Ertebølle Culture, and with Iversen-PREFACT phase 1, caused by the Early

Neolithic TRB, in northeastern Germany and Denmark (KALIS & MEURERS-BALKE 1998). In archaeological terms, the Ertebølle Culture and the (early) Swifterbant Culture do not show many similarities, but certain parallels in their pottery show that there is indeed a relationship of some kind between the Early Neolithic TRB and the (late) Swifterbant Culture (RAEMAEKERS 1999, 166). Madsen (1990) described the agricultural economy of the Early Neolithic TRB in Denmark as adaptive to the environment, resulting in only minor interference with nature; it was a system that required a dispersed and mobile society. I believe the same description also applies to the Swifterbant Culture in the northern Netherlands and northwestern Germany.

Phase NOP-2: 3450-*2600* cal BC, TRB Culture

It was already concluded from macroscopic remains found in Swifterbant and TRB contexts that crop cultivation and stock keeping played a far more important role in the subsistence strategy of the TRB Culture than they did in that of the Swifterbant Culture. This picture is confirmed by the phases attributed to these respective cultures in pollen diagrams from Pleistocene areas in the northern Netherlands and northwestern Germany. The TRB Culture can be considered the first fully agrarian culture on the Drenthe Plateau.

In the pollen picture, a clear decline of *Tilia* attracts attention. This *Tilia* decline is particularly pronounced in the diagrams from northwestern Germany (fig. 4f-g); it is often accompanied by a decline of *Quercus*. BEHRE & KUČAN (1994) interpreted these phenomena as large-scale forest clearings, especially for the purpose of forest grazing. S.T. ANDERSEN (1988; 1992a) also found a *Tilia* decline at the beginning of the Middle Neolithic TRB in eastern Denmark. According to S.T. Andersen, leaf lopping of *Tilia* was discontinued and the tree was suppressed to remove its shade (S.T. ANDERSEN 1988, 402). The forests with *Tilia* were replaced by open secondary forests dominated by *Corylus*, which were maintained by the farmers for browsing and grazing by cattle or sheep. In the northern Netherlands and northwestern Germany, however, no evidence for such secondary forests is found in the TRB period. Here, more intensive clearances may well have been responsible for the *Tilia* decline: it seems that the cattle were now for the larger part fed on grass instead of leaves. The possibly freestanding *Tilia* trees, which had been used for pollarding or shredding, might have been cleared by the TRB farmers to eliminate their shade.

Maximum values of *Pteridium* and a small increase in charcoal values possibly point to the use of burning for forest clearance (IVERSEN 1949). A number of pollen samples taken under barrows in Drenthe almost exclusively consist of charcoal particles. Apparently, the local vegetation was destroyed by fire shortly before the barrow was constructed (CASPARIE & GROENMAN-VAN WAATERINGE 1980, 60). However, the use of fire for clearing forest was not very widespread among the TRB farmers on the Drenthe Plateau; in northwestern Germany, BEHRE & KUČAN (1994) also failed to find clear indications for burning in this period. This seems to be different from the situation in northeastern Germany, Denmark and Sweden, where fire was more commonly used in the TRB period (IVERSEN 1949; S.T. ANDERSEN 1988; 1992a; 1992b; BERGLUND 1991; KALIS & MEURERS-BALKE 1998). In these areas, nearly always maximum values of *Betula* are found in the Middle Neolithic TRB period, which are generally connected with the use of fire; such a *Betula* maximum is completely absent in pollen diagrams from northwestern Germany and the northern Netherlands. Apparently the slash-and-burn method of clearing forest for agricultural land was not commonly used in the TRB period in Drenthe. It is more likely that the forest was cleared by felling and/or girdling.

Another question that can be asked concerning agricultural methods in the TRB period, is: Was shifting cultivation applied, or were the fields more permanent? There has been a lot of discussion about this topic among palynologists and archaeologists (for example ROWLEY-CONWY 1981; GROENMAN-VAN WAATERINGE 1979). Like MIDGLEY (1992, 386), I believe it is very difficult or even impossible to answer this question by means of pollen analysis alone. Other types of evidence are necessary, preferably including findings from experimental archaeology (see for example MEURERS-BALKE & LÜNING 1990).

On fertile loess and clay soils, fields could have been cultivated for fairly long periods without interruption. It was demonstrated by experiments by MEURERS-BALKE & LÜNING (1990) on loess soils in Germany, that even on permanently cultivated fields, a heavy weed flora could develop among the cereals; very intensive weed control seemed to be necessary. This weed flora consisted especially of weed species of the forest and of forest margins. On the sandy, less fertile soils of the Drenthe Plateau, however, different conditions prevailed: after 3-5 years of cultivation, the soil was already exhausted, and a fallow period of 10-15 years was necessary before the field could be used again. During such a long fallow period, the ground became penetrated by roots of weeds to such an extent, that an ard could not break up the soil (FOKKENS 1982). Probably it was easier to clear a new plot of forest for new fields, than to try removing the roots of weeds from the former fields: the undergrowth of the Atlantic forests was composed of shrubs and especially herbs which rooted only shallowly in the loose forest soil, so that it must have been easy to remove them with an ard after felling and maybe burning the trees (GROENMAN-VAN WAATERINGE 1979).

In the experiments of MEURERS-BALKE & LÜNING (1990) in *Stellario-Carpinetum* forests on loess soils, it seemed quite difficult to plough the forest soil with an ard, because the ard often caught on thick tree roots. However, when the ploughing was regularly repeated, it became increasingly easy, because the root network was progressively destroyed. In the opinion of GROENMAN-VAN WAATERINGE (1979), no specific arable weed associations could develop when newly created fields were used only for a period of 2-3 years. However, the results of the experiments by MEURERS-BALKE & LÜNING (1990, 88) point in another direction: after harvesting, the fields became totally overgrown with weeds within a few weeks (!). It is clear that with the present state of knowledge, it cannot be decided whether the fields in the Neolithic were cultivated only briefly or on a more permanent basis. This study has demonstrated that in TRB times the larger part of the Drenthe Plateau was still covered by a relatively dense forest (see fig. 9). Without deciding between shifting cultivation or permanent fields, it can only be remarked that there was enough forest left for the TRB farmers to practise shifting cultivation for hundreds of years, even if they should clear the forests on the more fertile soils of the till ridges (BAKKER & GROENMAN-VAN WAATERINGE 1988). BEHRE & KUČAN (1994, 149) conclude from the fairly constant values of pollen types pointing to arable farming in the pollen diagrams of *Siedlungskammer* Flögeln during the TRB period, that the fields were shifted only slightly, or possibly even were permanent.

The small decrease in tree pollen and the increase in Gramineae, Ericaceae and the culture-indicator types demonstrate the presence of more open areas than in the preceding phase. Since Cerealia-type displays a far smaller increase than Gramineae, *Plantago lanceolata* and *Rumex acetosa*, it is probable that most of the newly created treeless areas were used for keeping livestock. The increased importance of stock keeping in the Middle Neolithic TRB period has already been emphasized by several authors (IVERSEN 1941; VAN ZEIST 1959; MADSEN 1990; KALIS & MEURERS-BALKE 1998). The wooden fence with cattle locks excavated near Anloo (only a few kilometres from the Gietsenveentje) shows that the TRB farmers separated the settlement and arable land from areas where the livestock were allowed to graze (WATERBOLK 1960; HARSEMA 1982; JAGER 1985). We should imagine the open spaces in the Atlantic forests created by the TRB farmers as a mosaic of arable fields in use, abandoned arable fields which served as (winter?) pasture and permanent grazing.

The pastures were probably in part woodland pastures. However, there is a clear link between canopy cover and grass yields: only with a reduction of canopy cover to less than 50% will the grass yields increase significantly (GROENMAN-VAN WAATERINGE 1986; 1993). Therefore, the increasing Gramineae values in the pollen diagrams of this phase to my mind point either to treeless pastures or to very open woodland pastures. Given the relatively small increase in Cerealia-type compared to phase NOP-1, the use of cereals in the food economy had not much increased. Finds of macroscopic remains in northwestern Germany suggest that *Hordeum* was the commonest cereal in the TRB West Group (HOPF 1961). *Hordeum* is well suited to cultivation on the varied lowland soils and is more resistant to cold than *Triticum*. These are the most likely reasons for its increased popularity during the later TRB (MIDGLEY 1992, 366). However, this is not confirmed by the finds of Cerealia-type pollen in the Gietsenveentje diagrams: *Hordeum* and *Triticum* are more or less equally represented in the TRB period.

The beginning of phase NOP-2 is marked by an expansion and alteration of the agricultural economy in the sense that the adaptive strategy was changed to a manipulative one: relatively large areas of land were made suitable for livestock grazing (cf. MADSEN 1990). Nevertheless, farming settlements were widely scattered and farming still was of an extensive nature.

Phase NOP-3: *2600*-1770 cal BC, EGK/BB Culture

The TRB Culture was followed by the EGK and BB Cultures. The phase in the pollen diagrams which represents these two cultures is characterized by a temporarily decreased pressure on the vegetation, which is especially evident from the constant or even slightly decreasing herb pollen values. This phase has affinity with the "regeneration phase" in pollen diagrams from northeastern Germany, eastern Denmark and southern Sweden. In these areas, the "regeneration phase" is often dominated by *Corylus*. Generally this is explained as the presence of coppice woods with predominantly *Corylus* (GÖRANSSON 1988b). The following use of the coppice woods can be imagined: leaves and twigs were cut as winter fodder for the livestock, hazelnuts were gathered for human consumption and larger twigs were used for wattle. According to GÖRANSSON (1988b) this so-called "regeneration phase" does not really represent a decreasing influence of the farmers on the vegetation, but rather a more efficient use of the landscape, with a more intensive use of smaller areas.

Is there also evidence for coppice woods in this phase in the pollen diagrams from the northern Netherlands and northwestern Germany? In two Gietsenveentje diagrams, an increase in ca. 5% of *Corylus* is observed in this phase; in the diagrams from southeastern Drenthe, relatively high values of *Corylus* are found; in northwestern Germany, however, no higher *Corylus* values are observed in this phase. BURRICHTER (1969) has indicated two possible interpretations of a *Corylus* increase in pollen diagrams:

a. a *Corylus* increase on sandy soils generally points to decreasing human influence on the vegetation: in pe-

NOP phase, dates and culture	Characteristics of the agricultural economy
NOP-1 4050-3450 cal BC Swifterbant Culture	clearance by felling and/or girdling, not by burning harvesting of leaves and twigs, especially of *Ulmus* and *Tilia*, and use of remains of cereal plants to feed livestock in winter small-scale woodland pasture with Gramineae, *Plantago lanceolata* and *Rumex* to feed livestock in summer small-scale cultivation of cereals: *Hordeum* sp. as well as *Triticum* sp. larger part of primeval forests untouched
NOP-2 3450-*2600* cal BC TRB Culture	diminishing use of leaves and twigs for fodder: use of grass for fodder in summer, use of heather for fodder in winter use of shifting cultivation, but with a limited use of fire increasing treeless areas and areas with woodland pasture, used particularly for livestock grazing small-scale cultivation of cereals: *Hordeum* sp. as well as *Triticum* sp. increasing areas of exhausted, abandoned fields major part of primeval forests still untouched
NOP-3 *2600*-1770 cal BC EGK/BB Culture	decreased human pressure on the vegetation possible presence of small-scale *Corylus* coppice woods; the *Corylus* leaves and twigs were used as winter fodder abandonment of areas with woodland pasture intensively grazed (and fertilized?) open areas which covered a smaller area than in the preceding phase ever-increasing area of abandoned fields: these change partly into secondary woodland, partly into heathfields major part of primeval forests still untouched

Table 2 Characteristics of the agricultural economies of Neolithic cultures on the Drenthe Plateau.

riods poor in settlements, its former biotopes became available again, and it could increase considerably, because for this pioneer species the growing conditions were much better than in a closed forest;

b. a *Corylus* increase on moist, loamy soils generally points to increasing human influence on the vegetation: when these soils, which were not suitable for arable farming, were not too intensively used for woodland pasture, *Corylus* could increase considerably because of the favourable light conditions.

The conclusion is that a *Corylus* increase can point to increasing as well as decreasing human influence on the vegetation. The relatively small *Corylus* increase observed in certain diagrams from Drenthe certainly does not automatically point to the presence of coppice woods. It may also be caused by the abandonment of woodland pastures by the EGK and BB people. All in all, I subscribe the view of GROENMAN-VAN WAATERINGE (1992, 20) that there is no direct evidence for coppicing practices in the Dutch Neolithic and Bronze Age. The shifts within the tree pollen are simply too slight to reflect a change to a form of woodland management based on coppicing.

In the Gietsenveentje diagrams, a small decrease is observed in the values of Gramineae and the culture-indicator types (fig. 4a-c). As we have seen, this is generally explained in terms of decreased pressure of man on the vegetation. However, GROENMAN-VAN WAATERINGE (1993) has demonstrated, on the basis of grazing experiments and surface samples, that continuous, intensive grazing results in a decrease in grass pollen production and a pollen picture which appears to reflect a closed forest cover! Following this reasoning, there is a possibility that the decreasing Gramineae values in this phase point to (locally?) increased grazing pressure. Unfortunately, nothing is known about the density of habitation of the TRB, EGK and BB Cultures in Drenthe; there seems to be a tendency towards more concentrated habitation in the EGK/BB period (oral comm. J.N. Lanting). This is in agreement with the generally accepted interpretation of the pollen picture of the EGK and BB periods, which assumes a decreased pressure of man on the vegetation compared to the TRB period. WIETHOLD (1998, 267) attributed the decrease in herb pollen, especially Gramineae and culture-indicator types, in the EGK phase in pollen diagrams from eastern Schleswig-Holstein (northeastern Germany) to a marked population decrease and the end of the economic system of the TRB Culture.

The decrease in Gramineae and the culture-indicator types possibly also points to the ongoing exhaustion of soils, resulting in increasingly large areas that became useless for crop cultivation and in a later stage even for grazing. However, soil exhaustion is generally indicated by an increase in *Calluna vulgaris*. In phase NOP-3 of the various diagrams of the northern Netherlands and northwestern Germany, little if any increase in *Calluna vulgaris* is found. The last stage in the process of exhaustion is the forming of driftsand, which has been found in EGK-dated layers in a few sequences from the Drenthe Plateau (MOOK-KAMPS & VAN ZEIST 1987; CASPARIE 1992). In this period, driftsand was certainly not formed on a large scale, but only very locally.

Phase NOP-3 is marked by people moving into much larger and more permanent settlement units. The agricultural economy changed from an extensive to a more intensive one: the utilisation of nearby resources was intensified, while more distant resources were dropped (cf. MADSEN 1990). Most probably, livestock were grazed on cleared land directly associated with the large settlement sites, and less in woodland pasture. The more intensive use of a smaller area would have necessitated the use of some kind of fertilizer.

The above-mentioned characteristics of the agricultural economies of Neolithic cultures on the Drenthe Plateau are summarized in table 2.

11. The spread of agriculture

The occupation phase associated with the Swifterbant Culture in pollen diagrams of the northern Netherlands and northwestern Germany (phase NOP-1) not only resembles the occupation phases of the Ertebølle Culture and the subsequent Early Neolithic TRB in pollen diagrams of northeastern Germany, Denmark and Sweden (Troels-Smith-PREFACT phases A/B, Iversen-PREFACT phase 1), but also the occupation phase of the Rössen Culture in pollen diagrams of the loess zone (KALIS & MEURERS-BALKE 1988; 1998). The finds of Rössen-type adzes in both Swifterbant and Ertebølle contexts are evidence for the presence of fairly intensive contacts between the Rössen Culture and these two cultures. The same time also saw the spread of knowledge about agricultural methods, which initiated the process of Neolithization in the north (KALIS & MEURERS-BALKE 1998, 20). It is interesting to compare the spread of agriculture, in space as well as in time, by the Swifterbant Culture and the Ertebølle Culture. They obtained their knowledge from the same source: the Rössen Culture of the loess areas, but the process of diffusion seems to be somewhat different. Let us first consider the Ertebølle Culture. In Denmark and southern Sweden, no macroscopic remains from Ertebølle contexts pointed to cereal cultivation or stock keeping (S.H. ANDERSEN 1998); in pollen diagrams from these areas, the Troels-Smith occupation phase clearly points to small-scale agriculture in Ertebølle times (KOLSTRUP 1988; GÖRANSSON 1988b; KALIS & MEURERS-BALKE 1998). In eastern Holstein, cattle bones were found which were dated to ca. 4850 cal BC, which is definitely within the Ertebølle period (HARTZ et al. 2000, 136). This date more or less tallies with dates of the beginning of the Troels-Smith occupation phase in the pollen diagrams (KALIS & MEURERS-BALKE 1998).

This evidence shows that agriculture spread from the loess zone to the north, first reaching eastern Holstein around 4850 cal BC, then Denmark and finally Sweden. Because the situation in Denmark and Sweden is still not entirely clear, it is not possible to say how long it took for agriculture to spread from the loess zone to Sweden.

My Ph.D. thesis (R. BAKKER 2003) and some other recent studies (e.g. GEHASSE 1995; RAEMAEKERS 1999; BRINKKEMPER et al. 1999) have shed new light on the spread of agriculture in the small country of the Netherlands. ^{14}C Dating of macroscopic remains from the wetland sites in the western and central Netherlands has put the earliest evidence for stock keeping at ca. 4750 cal BC and the earliest evidence for crop cultivation at ca. 4200 cal BC (RAEMAEKERS 1999, fig. 5.1). The beginning of phase NOP-1 in pollen diagrams from the Pleistocene sandy areas in the northern Netherlands is dated to ca. 4050 cal BC. In phase NOP-1, evidence for crop cultivation as well as stock keeping was found. This seems to indicate that agriculture was adopted somewhat earlier by the wetland communities than by the upland communities. It is not possible to draw definitive conclusions on this point until upland sites of the Swifterbant Culture are found with macroscopic remains.

However, it is quite plausible that, as in the case of the Ertebølle Culture, the use of agriculture spread from the Rössen Culture on the loess soils first to the nearby wetland areas in the western and central Netherlands, and only in a later stage to the upland areas in the northern Netherlands, which are at a greater distance.

Thus the Rössen Culture seems to be responsible for the people of the Ertebølle and Swifterbant Cultures first encountering agriculture. But it was only in the period of the Michelsberg Culture, which extended its habitation area between 4100 and 4000 cal BC from the loess soils to nearby sandy soils, that agriculture considerably gained in importance in the Ertebølle and Swifterbant communities, to become an inextricable part of their way of life. In the Netherlands, the expansion of the Michelsberg Culture is roughly contemporaneous with the oldest cereal finds in a Swifterbant context (RAEMAEKERS 1999, 191), while in eastern Holstein and Denmark this expansion is connected with the transition from the Ertebølle Culture to the Early Neolithic TRB (HARTZ et al. 2000).

Given the current state of knowledge, it seems that in eastern Holstein the transition to agriculture occurred somewhat earlier than it did in the Netherlands, namely around 4850 cal BC, against 4750 cal BC at the earliest in the wetland areas of the Netherlands. In both the Ertebølle Culture and the Swifterbant Culture, the Neolithic elements appear to have been incorporated gradually into the subsistence strategy.

References

ANDERSEN, S.H. (1998) Ertebølle trappers and wild boar hunters in eastern Jutland. A survey. *Journal Danish Arch. 12, 1998, 13-59.*

ANDERSEN, S.T. (1988) Changes in agricultural practices in the Holocene indicated in a pollen diagram from a small hollow in Denmark. *In: BIRKS, H.H., BIRKS, H.J.B., KALAND, P.E. & D. MOE (eds.) The Cultural Landscape: Past, Present and Future.* Cambridge 1988, *395-407.*

– (1992a) Early and Middle-Neolithic agriculture in Denmark: pollen spectra from soils in burial mounds of the Funnel Beaker Culture. *Journal of European Archaeology 1, 1992, 153-180.*

– (1992b) Pollen proxy data for human impact on vegetation (based on methodological experiences). *In: FRENZEL, B. (ed.) Evaluation of land surfaces cleared from forests by prehistoric man in Early Neolithic times and the time of migrating Germanic tribes. Special Issue: ESF Project. European Palaeoclimate and Man 3.* Stuttgart 1992, *1-11.*

BAKKER, J.A. (1979) The TRB West Group. Studies in the chronology and geography of the makers of hunebeds and Tiefstich pottery. *Ph.D. thesis, University of Amsterdam.* Amsterdam 1979.

– (1982) TRB settlement patterns on the Dutch sandy soils. *Analecta Praehistorica Leidensia 15, 1982, 87-124.*

– (1992) The Dutch hunebedden - megalithic tombs of the Funnel Beaker Culture. *International Monographs in Prehistory, Archaeological Series 2.* Michigan 1992.

BAKKER, J.A. & W. GROENMAN-VAN WAATERINGE (1988) Megaliths, soils and vegetation on the Drenthe Plateau. *In: GROENMAN-VAN WAATERINGE, W. & M. ROBINSON (eds.) Man-made soils. B.A.R. Int. Ser. 410.* Oxford 1988, *143-181.*

BAKKER, J.A., GROENMAN-VAN WAATERINGE, W. & M.D. VAN DER KAMP (1999) Palynological and archaeological investigation of a small bog with TRB pottery in the Eexterveld, province of Drenthe, The Netherlands. *Probleme der Küstenforschung im südlichen Nordseegebiet 26, 1999, 77-96.*

BAKKER, R. (2003) The emergence of agriculture on the Drenthe Plateau - A palaeobotanical study supported by high-resolution ^{14}C dating. *Archäologische Berichte 16.* Bonn 2003.

BEHRE, K.-E. (1981) The interpretation of anthropogenic indicators in pollen diagrams. *Pollen et Spores 23(2), 1981, 225-245.*

BEHRE, K.-E. & D. KUČAN (1994) Die Geschichte der Kulturlandschaft und des Ackerbaus in der Siedlungskammer Flögeln, Niedersachsen, seit der Jungsteinzeit. *Probleme der Küstenforschung im südlichen Nordseegebiet 21.* Wilhelmshaven/ Oldenburg 1994.

BERGLUND, B.E. (ed.) (1991) The cultural landscape during 6000 years in southern Sweden - the Ystad Project. *Ecological Bulletins No. 41.* Copenhagen 1991.

BEUKER, J.R., DRENTH, E., LANTING, A.E. & A.P. SCHUDDEBEURS (1992) De stenen bijlen en hamerbijlen van het Drents Museum: een onderzoek naar de gebruikte steensoorten. *Nieuwe Drentse Volksalmanak 109, 1992, 111-139.*

BLAAUW, M.A. (2003) An investigation of Holocene sun-climate relationships using numerical ^{14}C wiggle-match dating of peat deposits. *Ph.D. thesis, University of Amsterdam.* Amsterdam 2003.

BRINKKEMPER, O., HOGESTIJN, W.-J., PEETERS, H., VISSER, D. & C. WHITTON (1999) The Early Neolithic site at Hoge Vaart, Almere, the Netherlands, with particular reference to non-diffusion of crop plants, and the significance of site function and sample location. *Veget. Hist. Archaeobot. 8, 1999, 79-86.*

BRONK RAMSEY, C. (1995) Radiocarbon calibration and analysis of stratigraphy: the OxCal program. *Radiocarbon 37, 1995, 425-430.*

BURRICHTER, E. (1969) Das Zwillbrocker Venn, Westmünsterland, in moor- und vegetationskundlicher Sicht. *Abh. d. Landesmuseums f. Naturkunde Münster Westfalen 31/1, 1969, 1-60.*

BURRICHTER, E. & R. POTT (1983) Verbreitung und Geschichte der Schneitelwirtschaft mit ihren Zeugnissen in Nordwestdeutschland. *Tuexenia 3, 1983, 443-453.*

CASPARIE, W.A. (1992) Neolithic deforestation in the region of Emmen (The Netherlands). *In: FRENZEL, B. (ed.) Evaluation of land surfaces cleared from forests by prehistoric man in Early Neolithic times and the time of migrating Germanic tribes. Special Issue: ESF Project. European Palaeoclimate and Man 3.* Stuttgart 1992, *115-127.*

CASPARIE, W.A., MOOK-KAMPS, E., PALFENIER-VEGTER, R.M., STRUIJK, P.C. & W. VAN ZEIST (1977) The palaeobotany of Swifterbant. A preliminary report. *Swifterbant contribution 7. Helinium 17, 1977, 28-55.*

CASPARIE, W.A. & W. GROENMAN-VAN WAATERINGE (1980) Palynological analysis of Dutch barrows. *Palaeohistoria 22, 1980, 7-65.*

CLASON, A.T. (1983) Spoolde. Worked and unworked antlers and bone tools from Spoolde, De Gaste, the IJsselmeerpolders and adjacent areas. *Palaeohistoria 25, 1983, 77-130.*
– (1984) Die früheste Viehzucht und der frühe Haustierbestand in Belgien und in der Niederlanden bis zur frühen Bronzezeit. *In: NOBIS, G. (Hrsg.) Der Beginn der Haustierhaltung in der „Alte Welt". Die Anfänge des Neolithikums vom Orient bis Nordeuropa 9. Fundamenta Reihe B, 1984, 106-117.*

DECKERS, P.H., DE ROEVER, J.P. & J.D. VAN DER WAALS (1980) Jagers, vissers en boeren in een prehistorisch getijdengebied bij Swifterbant. *ZWO-jaarboek, verslagen en beschouwingen, 1980, 111-145.*

ELZINGA, G. (1962) Prehistorische werktuigen van edelhert- en elandgewei uit Drenthe. *Nieuwe Drentse Volksalmanak 80, 1962, 185-219.*

FANSA, M. & U. KAMPFFMEYER (1985) Vom Jäger und Sammler zum Ackerbauern. *In: WILHELMI, K. (Hrsg.) Ausgrabungen in Niedersachsen, Archäologische Denkmalpflege 1979-1984.* Stuttgart 1985, *108-111.*

FEIKEN, H., NIEKUS, M.J.L.Th. & H.R. REINDERS (2001) 'Wetsingermaar'. Een Neolithische vindplaats in de gemeente Winsum (Gr.). *Paleo-Aktueel 12, 2001, 54-59.*

FOKKENS, H. (1982) Late Neolithic occupation near Bornwird (Province of Friesland). *Palaeohistoria 24, 1982, 91-113.*
– (1990) Verdrinkend landschap: archeologisch onderzoek van het westelijk Fries-Drents Plateau 4400 BC tot 500 AD. *Ph.D. thesis, University of Groningen.* Groningen 1990.

GEHASSE, E.F. (1995) Ecologisch-archeologisch onderzoek van het Neolithicum en de vroege Bronstijd in de Noordoostpolder met de nadruk op vindplaats P14, gevolgd door een overzicht van de bewoningsgeschiedenis en bestaanseconomie binnen de Holocene Delta. *Ph.D. thesis, University of Amsterdam.* Amsterdam 1995.

GÖRANSSON, H. (1988a) Neolithic Man and The Forest Environment around Alvastra Pile Dwelling. *Theses and papers in North-European Archaeology 20.* Stockholm 1988.
– (1988b) Pollen Analytical Investigations at Skateholm, Southern Sweden. *In: LARSSON, L. (ed.) The Skateholm Project. Acta Regiae Societati Humaniorum Litterarum Lundensis 1.* Stockholm 1988, *27-32.*
– (1988c) Comments on remodelling the Neolithic in Southern Norway: On pollen analytical myths. *Norw. Arch. Rev. 21(1), 1988, 33-37.*

GROENENDIJK, H.A. (1993) Landschapsontwikkeling en bewoning in het Herinrichtingsgebied Oost-Groningen 8000 BC - 1000 AD. *Ph.D. thesis, University of Groningen.* Groningen 1993.

GROENMAN-VAN WAATERINGE, W. (1979) Weeds. *In: RYAN, M. (ed.) Proceedings of the Fifth Atlantic Colloquium.* Dublin 1979, *363-368.*
– (1986) Grazing possibilities in the Neolithic of the Netherlands based on palynological data. *In: BEHRE, K.-E. (ed.) Anthropogenic Indicators in Pollen Diagrams.* Rotterdam 1986, *187-202.*
– (1992) The impact of man on the Neolithic and Bronze Age landscape of The Netherlands from a general methodological aspect. *In: FRENZEL, B. (ed.) Evaluation of land surfaces cleared from forests by prehistoric man in Early Neolithic times and the time of migrating Germanic tribes. Special Issue: ESF Project. European Palaeoclimate and Man 3.* Stuttgart 1992, *13-24.*

– (1993) The effects of grazing on the pollen production of grasses. *Veget. Hist. Archaeobot. 2, 1993, 157-162.*
HARSEMA, O.H. (1974) Kroniek van opgravingen en vondsten in Drenthe in 1972. *Nieuwe Drentse Volksalmanak 91, 1974, 195-209.*
– (1975) Kroniek van opgravingen en vondsten in Drenthe in 1973. *Nieuwe Drentse Volksalmanak 92, 1975, 143-148.*
– (1982) Settlement site selection in Drenthe in later prehistoric times: criteria and considerations. *Analecta Praehistorica Leidensia 15, 1982, 145-159.*

HARTZ, S., HEINRICH, D. & H. LÜBKE (2000) Frühe Bauern an der Küste. Neue ^{14}C-Daten und aktuelle Aspekte zum Neolithisierungsprozeß im norddeutschen Ostseeküstengebiet. *Praehistorische Zeitschrift 75, 2000, 129-152.*

HOGESTIJN, J.W. (1990) From Swifterbant to TRB in the IJssel-Vecht basin - Some suggestions. *In: JANKOWSKA, D. (Hrsg.) Die Trichterbecherkultur: neue Forschungen und Hypothesen.* Poznań 1990, *163-180.*

HOGESTIJN, J.W. & H. PEETERS (1996) De opgraving van de Mesolithische en Vroegneolithische bewoningsresten van de vindplaats "Hoge Vaart" bij Almere (Prov. Fl.): een blik op een duistere periode van de Nederlandse prehistorie. *Archeologie 7, 1996, 80-113.*

HOPF, M. (1961) Bearbeitung und Auswertung vorgeschichtlicher pflanzlicher Funde. *Berichte des 5. internationalen Kongresses der Vor- und Frühgeschichte, 1958.* Hamburg 1961, *404-407.*

HULST, R.S. & A.D. VERLINDE (1976) Geröllkeulen aus Overijssel und Gelderland. *Berichten R.O.B. 26, 1976, 93-126.*
– (1979) Spitzhauen aus den Niederlanden. *Berichten R.O.B. 29, 1979, 185-207.*

IVERSEN, J. (1941) Landnam i Danmarks Stenalder. En pollenanalytisk Undersøgelse over det første Landbrugs Indvirkning paa Vegetationsudviklingen.
(Land Occupation in Denmark's Stone Age. A Pollen-Analytical Study of the Influence of Farmer Culture on the Vegetational Development.) *Danmarks Geol. Unders. II. Række, Nr. 66.* København 1941.
– (1949) The Influence of Prehistoric Man on Vegetation. *Danmarks Geol. Unders. IV. Række, Bd. 3, Nr. 6.* København 1949.
– (1960) Problems of the early post-glacial forest development in Denmark. *Danmarks Geol. Unders. IV. Række 4, 3.* København 1960.
– (1973) The development of Denmark's nature since the last glacial. *Danmarks Geol. Unders. V. Række, Nr. 7-C.* København 1973.

JAGER, S.W. (1981) Een grote vuurstenen bijl en een "Plättbolzen" uit Fochteloo, gem. Ooststellingwerf, prov. Friesland. *Helinium 21, 1981, 227-245.*

– (1985) A prehistoric route and ancient cart-tracks in the gemeente of Anloo (Province of Drenthe). *Palaeohistoria 27, 1985, 185-245.*

KALIS, A.J. & J. MEURERS-BALKE (1988) Wirkungen neolithischer Wirtschaftsweisen in Pollendiagrammen. *Arch. Inf. 11(1), 1988, 39-53.*
– (1998) Die „Landnam"-Modelle von Iversen und Troels-Smith zur Neolithisierung des westlichen Ostseegebietes - ein Versuch ihrer Aktualisierung. *Praehistorische Zeitschrift 73(1), 1998, 1-24.*
– (2001) Zur Landnutzung der Trichterbecherkultur in der Norddeutschen Jungmoränenlandschaft. *In: KELM, R. (Hrsg.) Zurück zur Steinzeitlandschaft - Archäobiologische und ökologische Forschung zur jungsteinzeitlichen Kulturlandschaft und ihre Nutzung in Nordwestdeutschland. Albersdorfer Forschungen zur Archäologie und Umweltgeschichte, Band 2.* Heide 2001, *56-69.*

KILIAN, M.R., VAN DER PLICHT, J. & B. VAN GEEL (1995) Dating raised bogs: new aspects of AMS ^{14}C wiggle matching, a reservoir effect and climatic change. *Quaternary Science Reviews 14, 1995, 959-966.*

KILIAN, M.R., VAN GEEL, B. & J. VAN DER PLICHT (2000) ^{14}C AMS wiggle matching of raised bog deposits and models of peat accumulation. *Quaternary Science Reviews 19, 2000, 1011-1033.*

KOLSTRUP, E. (1988) Late Atlantic and Early Subboreal Vegetational Development at Trundholm, Denmark. *Journ. Arch. Sc. 15, 1988, 503-513.*

KROEZENGA, P., LANTING, J.N., KOSTERS, R.J., PRUMMEL, W. & J.P. DE ROEVER (1991) Vondsten van de Swifterbantcultuur uit het Voorste Diep bij Bronneger (Dr.). *Paleo-Aktueel 2, 1991, 32-36.*
LANTING, J.N. (1992) Aanvullende ^{14}C-dateringen. *Paleo-Aktueel 3, 1992, 61-63.*

LANTING, J.N. & J. VAN DER PLICHT (1995/1996) De ^{14}C-chronologie van de Nederlandse pre- en protohistorie. I: Laat-Paleolithicum. *Palaeohistoria 37/38, 1995/1996, 71-125.*
– (1997/1998) De ^{14}C-chronologie van de Nederlandse pre- en protohistorie. II: Mesolithicum. *Palaeohistoria 39/40, 1997/1998, 99-162.*
– (1999/2000) De ^{14}C-chronologie van de Nederlandse pre- en protohistorie. III: Neolithicum. *Palaeohistoria 41/42, 1999/2000, 1-110.*

LOUWE KOOIJMANS, L.P. (1998) Understanding the Mesolithic/Neolithic frontier in the Lower Rhine Basin, 5300-4300 cal BC. *In: EDMONDS, M. & C. RICHARDS (eds.) Understanding the Neolithic of North-Western Europe.* Glasgow 1998, *407-427.*

LÜNING, J. (2000) Steinzeitliche Bauern in Deutschland - Die Landwirtschaft im Neolithikum. *Universitätsforsch. Prähist. Arch. 58.* Bonn 2000.

MADSEN, T. (1990) Changing patterns of land use in the TRB culture of south Scandinavia. *In: JANKOWSKA, D. (Hrsg.) Die Trichterbecherkultur: neue Forschungen und Hypothesen.* Poznań 1990, *27-41.*

MEURERS-BALKE, J. & J. LÜNING (1990) Experimente zur frühen Landwirtschaft. *In: FANSA, M. (Hrsg.) Experimentelle Archäologie in Deutschland. Archäologische Mitteilungen aus Nordwestdeutschland 4.* Oldenburg 1990, *82-92.*

MIDGLEY, M. (1992) TRB Culture - The First Farmers of the North European Plain. Edinburgh 1992.

MOOK-KAMPS, E. & W. VAN ZEIST (1987) Een palynologisch onderzoek van prehistorisch akkerland in de Oosterpoortwijk te Groningen. *Groningse volksalmanak 97, 1987, 125-132.*

PRUMMEL, W. (2001) Dierenvondsten uit het dal van de Tjonger tussen Donkerbroek, Oosterwolde en Makkinga (Fr.). *Paleo-Aktueel 12, 2001, 30-35.*

PRUMMEL, W. & W.A.B. VAN DER SANDEN (1995) Runderhoorns uit de Drentse venen. *Nieuwe Drentse Volksalmanak 112, 1995, 84-131.*

RAEMAEKERS, D.C.M. (1999) The Articulation of a 'New Neolithic'. The meaning of the Swifterbant Culture for the process of neolithisation in the western part of the North European Plain (4900-3400 BC). *Ph.D. thesis, University of Leiden. Archaeological Studies Leiden University 3.* Leiden 1999.

RASMUSSEN, P. (1990) Leaf foddering in the earliest Neolithic agriculture - Evidence from Switzerland and Denmark. *Acta Archaeologica 60, 1990, 71-86.*
– (1993) Analysis of Goat/Sheep Faeces from Egolzwil 3, Switzerland: Evidence for Branch and Twig Foddering of Livestock in the Neolithic. *Journ. Arch. Sc. 20, 1993, 479-502.*

ROWLEY-CONWY, P. (1981) Slash and Burn in the Temperate European Neolithic. *In: MERCER, R. (ed.) Farming Practice in British Prehistory.* Edinburgh 1981, *85-96.*
– (1982) Forest grazing and clearance in temperate Europe with special reference to Denmark: an archaeological view. *In: BELL, M. & S. LIMBREY (eds.) Archaeological Aspects of Woodland Ecology. B.A.R. Int. Ser. 146.* Oxford 1982, *199-215.*

RUNHAAR, J., GROEN, C.L.G., VAN DER MEIJDEN, R. & R.A.M. STEVERS (1987) Een nieuwe indeling in ecologische groepen binnen de Nederlandse flora. *Gorteria 13, 1987, 277-359.*

SPEK, T. (1993) Milieudynamiek en locatiekeuze op het Drents Plateau (3400 v. Chr. - 1850 na Chr.) - Een model getoetst in het natuurgebied De Strubben/Kniphorstbos nabij Anloo. *In: ELERIE, J.N.H., JAGER, S.W. & T. SPEK Landschapsgeschiedenis van De Strubben/Kniphorstbos - Archeologische en historisch-ecologische studies van een natuurgebied op de Hondsrug. Regio- en landschapsstudies nr. I.* Groningen 1993, *171-236.*

SPERANZA, A., VAN DER PLICHT, J. & B. VAN GEEL (2000) Improving the time control of the Subboreal/ Subatlantic transition in a Czech peat sequence by ^{14}C wiggle-matching. *Quaternary Science Reviews 19, 2000, 1589-1604.*

STORTELDER, A.F.H., SCHAMINÉE, J.H.J. & P.W.F.M. HOMMEL (1999) De Vegetatie van Nederland. Deel 5: Ruigten, struwelen, bossen. Uppsala/Leiden 1999.

STUIVER, M., REIMER, P.J., BARD, E., BECK, J.W., BURR, G.S., HUGHEN, K.A., KROMER, B., MACCORMAC, F.G., VAN DER PLICHT, J. & M. SPURK (1998) INTCAL98 Radiocarbon Age Calibration, 24,000 - 0 cal BP. *Radiocarbon 40(3), 1998, 1041-1083.*

THOMAS, J. (1998) Towards a Regional Geography of the Neolithic. *In: EDMONDS, M. & C. RICHARDS (eds.) Understanding the Neolithic of North-Western Europe.* Glasgow 1998, *37-60.*

TROELS-SMITH, J. (1942) Geologisk Datering af Dyrholm-Fundet. *In: MATHIASSEN, T., DEGERBØL, M. & J. TROELS-SMITH Dyrholmen, en Stenalder Boplads paa Djursland. Arkæol. Kunsth. Skr. K. Dansk. Vidensk. Selsk. 1(1), 1942, 137-212.*
– (1954) Ertebøllekultur - Bondekultur. Resultater af de didste 10 Aars Undersøgelser i Aamosen, Vestsjælland. *Aarbøger 1953, 1954, 5-62.*
– (1960) Ivy, Mistletoe and Elm: Climate Indicators - Fodder Plants. A Contribution to the Interpretation of the Pollen Zone Border VII-VIII. *Danmarks Geol. Unders. IV. Række 4, 4.* København 1960.
– (1961) Probleme im Zusammenhang mit Europas ältester Bauernkultur in naturwissenschaftlicher Bedeutung. *Bericht über den 5. Internat. Kongreß für Vor- und Frühgeschichte, 1958.* Hamburg 1961, *825-832.*
– (1984) Stall-feeding and field-manuring in Switzerland about 6000 years ago. *Tools and Tillage 5(1), 1984, 13-25.*

VAN DER PLICHT, J. (1993) The Groningen radiocarbon calibration program. *Radiocarbon 35, 1993, 231-237.*

VAN DER PLICHT, J., MOOK, W.G. & H. HASPER (1990) Automatic calibration of radiocarbon ages. *In: MOOK, W.G. & H.T. WATERBOLK Proc. of the 2nd International Symposium ^{14}C and Archaeology, 1987. PACT 29 - II.5.* Groningen 1990, *81-94.*

VAN DER SANDEN, W.A.B. (1997) Aardewerk uit natte context in Drenthe: het vroeg- en laat-neolithicum en de vroege bronstijd. *Nieuwe Drentse Volksalmanak 114, 1997, 127-141.*

VAN DER WAALS, J.D. (1972) Die durchlochten Rössener Keile und das frühe Neolithikum in Belgien und in den Niederlanden. *In: SCHWABEDISSEN, H. et al. Die Anfänge des Neolithikums vom Orient bis Nordeuropa, Teil Va: Westliches Mitteleuropa. Fundamenta, Reihe A, Band 3, 1972, 153-184.*

VAN GEEL, B. & W.G. MOOK (1989) High-resolution ^{14}C dating of organic deposits using natural atmospheric ^{14}C variations. *Radiocarbon 31, 1989, 151-155.*

VAN ZEIST, W. (1955) Some radio-carbon dates from the raised bog near Emmen (Netherlands). *Palaeohistoria 4, 1955, 113-118.*
– (1959) Studies on the Post-Boreal vegetational history of south-eastern Drenthe (Netherlands). *Acta Bot. Neerl. 8, 1959, 156-185.*
– (1967) Archaeology and palynology in the Netherlands. *Rev. Palaeobot. Palynol. 4, 1967, 45-65.*

WATERBOLK, H.T. (1960) Preliminary report on the excavations at Anloo in 1957 and 1958. *Palaeohistoria 8, 1960, 59-90.*
– (1985) Archeologie. *In: HERINGA, J. (ed.) Geschiedenis van Drenthe.* Meppel 1985, *15-90.*

WEEDA, E.J., WESTRA, R., WESTRA, C. & T. WESTRA (1985) Nederlandse Oecologische Flora: wilde planten en hun relaties. Deel 1. Amsterdam 1985.
– (1988) Nederlandse Oecologische Flora: wilde planten en hun relaties. Deel 3. Amsterdam 1988.

WIETHOLD, J. (1998) Studien zur jüngeren postglazialen Vegetations- und Siedlungsgeschichte im östlichen Schleswig-Holstein. *Universitätsforsch. Prähist. Arch. 45.* Bonn 1998.

ZAGWIJN, W.H. (1986) Nederland in het Holoceen. Haarlem 1986.

Dr. R. Bakker
Heesterlaan 6
NL - 9713 NW Groningen
The Netherlands
r.bakker@supermail.nl