II. Occupation phases in the Neolithic as represented in pollen diagrams: a review

II.1 Iversen's *landnam* model and Troels-Smith's leaf-fodder model

II.1.1 Introduction

The first scientists who made archaeopalynological models of the Neolithization process as early as the 1940s and the 1950s, are the Danish palynologists Johannes Iversen and Jørgen Troels-Smith. They developed their respective models not only on a theoretical, but also on a practical basis, with the help of the archaeologist Axel Steensberg and the palynologist Sven Jørgensen. Recently, the models of Iversen and Troels-Smith were critically reviewed and revalued by Kalis & Meurers-Balke (1998). The following discussion about the models is mainly based on this publication.

II.1.2 Iversen's *landnam* model

In 1941, Iversen published his classical study *Landnam i Danmarks Stenalder - Land Occupation in Denmark's Stone Age, A Pollen-Analytical Study of the Influence of Farmer Culture on the Vegetational Development*. He was the first to use the method of pollen analysis for the study of cultural history. Iversen (1973, 82) summarized the characteristics of primitive agriculture in pollen diagrams as follows:

1. agriculture causes characteristic changes in the forests, which are reflected in the tree pollen curves;
2. agriculture causes the presence of culture followers like *Plantago major, Plantago lanceolata, Artemisia vulgaris* and representatives of the family of Chenopodiaceae;
3. indicator plants for arable farming are in the first place the cultivated plants themselves (the primary indicators), but also arable weeds like *Rumex acetosella, Cruciferae* and *Polygonum* sp. (the secondary indicators);
4. indicator plants for pasture, pointing to stock keeping, are *Rumex acetosa, Plantago lanceolata* and *Trifolium repens*.

Iversen found these characteristics in Danish pollen diagrams just above the Atlantic-Subboreal transition in sediments which were deposited during the fourth Litorina transgression. In 1937, Iversen had demonstrated on geological-stratigraphical grounds that this transgression occurred simultaneously with the Funnel Beaker Culture (TRB) (IVERSEN 1937). In this way, Subboreal pollen spectra could be connected with Neolithic cultures (KALIS & MEURERS-BALKE 1998). Iversen (1949, 16 and legend of fig. 8; 1973, 87) divided his *landnam* model into three phases (fig. 3):

Phase 1: The pollen curves of three common species of the Atlantic forest, *Tilia, Ulmus* and *Fraxinus*, show a slight decline, while the pollen curves of herbaceous plants, especially Gramineae, *Pteridium aquilinum* and Compositae, suddenly increase. Occasional pollen grains of Cerealia and *Plantago* species already appear here. Phase 1 is subdivided into two subphases:

- Phase 1a: Maxima of *Pteridium aquilinum* and Compositae; appearance of *Plantago lanceolata* and *P. major* in very low numbers;
- Phase 1b: Increase in the curves of the pioneer species *Salix, Populus* and *Betula*; decline in the curves of herbaceous plants.

Phase 2: The pioneer species *Betula* is dominant in the pollen picture, while *Corylus* is strongly increasing. Pollen values of *Tilia, Ulmus* and *Fraxinus* drop to minimum values; values of *Salix, Populus* and *Pteridium aquilinum* decline. The pollen curves of *Plantago lanceolata, Artemisia* and Cerealia reach maximum values.

Phase 3: *Corylus* is dominant in the pollen picture; pollen values of *Ulmus, Tilia* and *Fraxinus* increase; the light-demanding species *Fraxinus* and *Quercus* reach higher values than before phase 1. The curves of the culture-indicator types strongly decline. Phase 3 is subdivided into two subphases:

- Phase 3a: rise of *Corylus* curve, all other curves are falling;
- Phase 3b: *Corylus* curve descending steeply, increase of *Ulmus, Tilia* and *Fraxinus*.

In the opinion of Iversen, the above-described changes in the vegetation appeared as a result of clearances by early farmers using flint axes and burning: the "slash-and-burn" method (IVERSEN 1973, 88). Iversen put forward several arguments in favour of clearance by burning:

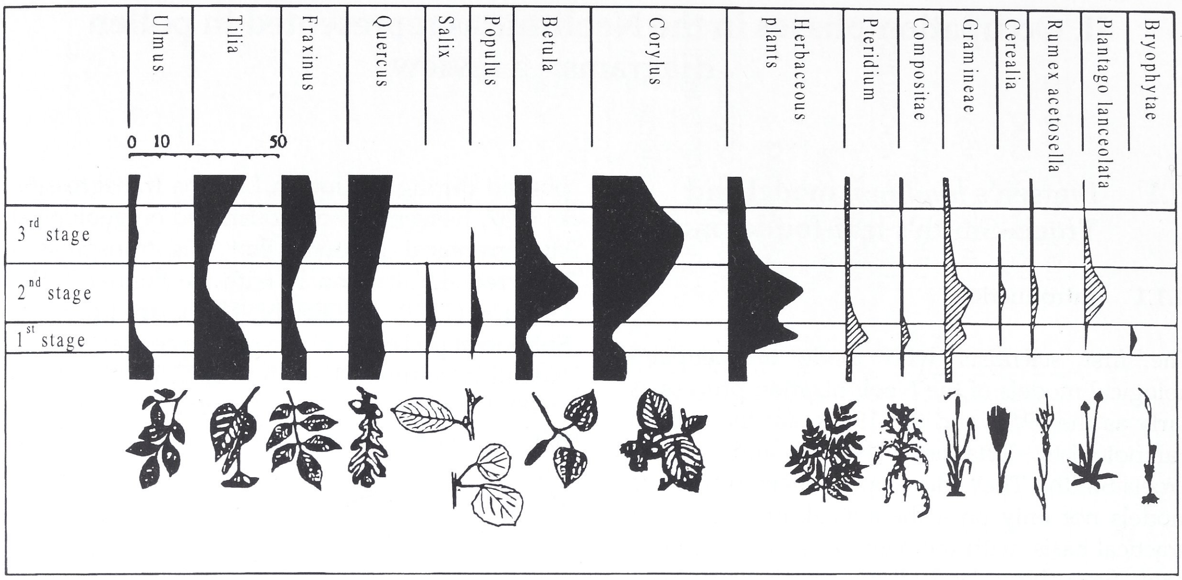

Fig. 3. Generalized pollen diagram of Iversen's *landnam* with its three phases (after IVERSEN 1973).

1. in the sediment of the type site Ordrup Mose, he found a distinct charcoal layer, which occurred contemporaneously with his phase 1a (IVERSEN 1949, 20; 1973, 89);
2. he explained the *Betula* maximum in phase 2 as follows: usually, *Betula* does not occur after ordinary forest clearances on the fertile forest mull in Denmark, because its seed germinates only when soil conditions are favourable. On ashy soil, however, the conditions for *Betula* are exceptionally favourable (IVERSEN 1941, 25);
3. he believed the maximum of *Pteridium aquilinum* in phase 1a also to point to burning: this species is not harmed by fire, because its rhizomes are deep in the ground (IVERSEN 1949, 20).

Iversen connected clearances by burning partly with arable farming: he imagined that the burnt-off forest area between the stubs was sown with grain after only the most superficial ploughing (IVERSEN 1941, 29). However, Iversen thought that the clearance fires were first of all intended for securing food for the animals: after burning, a forest regeneration started, and the fresh leaves of the emerging herbs, bushes and trees were welcome fodder for the livestock, which was free to roam about (IVERSEN 1941, 30). In Iversen's opinion, stock keeping must have been the most important agricultural activity. The free-ranging livestock prevented a real regeneration of the forest; only *Betula* and, in a later stage, *Corylus* scrub could persist. This may explain the *Betula* maximum in phase 2 and the *Corylus* maximum in phase 3 (KALIS & MEURERS-BALKE 1998).

As already mentioned, Iversen connected his *landnam* model with the immigration of people of the Funnel Beaker Culture (TRB) ("Dolmen Period Culture"; IVERSEN 1941, 49).

II.1.3 Troels-Smith's leaf-fodder model

As early as 1954, Jørgen Troels-Smith questioned whether the Iversen *landnam* and the Funnel Beaker Culture really represented the earliest farming culture of Denmark. He noticed that the first pollen grains of the culture-indicator types, especially *Plantago major*, but also *Plantago lanceolata*, Chenopodiaceae and even Cerealia, occurred in his pollen diagram from Aamosen before the Iversen *landnam*. He also recognized this phenomenon in several of the pollen diagrams published by Iversen (TROELS-SMITH 1954).

Troels-Smith noticed that the earliest culture-indicator pollen types appeared simultaneously with the decline of *Ulmus*. In his opinion the *Ulmus* decline was caused by the collection of fodder in *Ulmus* forests by prehistoric stock farmers. The leaves and bark of *Ulmus* are superior to those of all other trees as fodder. Troels-Smith assumed that the *Ulmus* decline reflected the pollarding of the trees for the purpose of reaping their leaves and twigs for fodder. The pollarding prevented the trees blooming and producing pollen or fruit, because *Ulmus* shoots will only flower when they are seven or eight years old. According to Troels-Smith, fodder-gathering arose out of stable feeding: the livestock were stabled throughout the year and the fodder was collected and brought to them. Troels-Smith puts forward palynological evidence to prove this theory: in his opinion, the low values of *Plantago lanceolata* and Gramineae point to the absence of pasture (TROELS-SMITH 1954, 54).

Because the cultural phase recognized by Troels-Smith appeared before the Iversen *landnam*, Troels-Smith assumed that it was caused by agricultural activities of the Ertebølle Culture, the culture which precedes the Funnel Beaker Culture in Denmark: *Ertebøllekultur - Bondekultur* (farming culture) (TROELS-SMITH 1954; KALIS & MEURERS-BALKE 1998). Troels-Smith tried to connect events in his pollen diagrams directly with archaeological finds. He found that funnel beakers of Type A (*sensu* BECKER 1947) as well as finds from the settlement excavation Muldbjerg (in Aamosen), could be located in time between the *Ulmus* decline and the Iversen *landnam*. In the excavation of Muldbjerg, together with Type A funnel beakers, also thick-walled Ertebølle potsherds were found. Because pollen spectra from material adhering to Type A funnel beakers all pointed to the phase between the *Ulmus* decline and the Iversen *landnam*, Troels-Smith saw these Type A beakers as part of the Ertebølle Culture (TROELS-SMITH 1954, 56; 60; KALIS & MEURERS-BALKE 1998). Hence Troels-Smith connected the cultural phase between the *Ulmus* decline and the Iversen *landnam* with the "semi-agricultural" Ertebølle Culture (TROELS-SMITH 1954, 56; 60). Later, this phase was called the "Troels-Smith occupation phase".

II.1.4 Alternatives to Troels-Smith's leaf-fodder model and Iversen's *landnam* model

Before alternatives to the models of Iversen and Troels-Smith will be discussed, it has to be emphasized that these models are framed for the Danish young-moraine landscape and therefore they are only valid for this or a comparable type of landscape with a comparable settlement history. Much criticism against the models of Iversen and Troels-Smith is based on inappropriate applications of the models to other types of landscape and to other archaeological connections (KALIS & MEURERS-BALKE 1998).

Through the years, several non-anthropogenic models have been framed as alternatives to Iversen's and Troels-Smith's models. Nilsson (1948, 1961) has emphasized that the decrease of *Ulmus* and *Tilia* occurs everywhere at the same point in time. In his opinion, such a synchronous, large-scale phenomenon could only be caused by a climatic change. He suggests that warmth-demanding ecotypes or varieties of *Ulmus* and *Tilia* were severely affected by a sudden series of abnormally cold winters. Less sensitive ecotypes would recover first after a transitional period. The regeneration of *Ulmus* and *Tilia* could be explained by the return of more favourable climatic conditions (GÖRANSSON 1988a). The possibility of a climatic change at the beginning of the Neolithic is discussed in II.4.

According to Göransson (1988a, 48), the late Atlantic (Mesolithic) forests were already utilized by man: a garden cultivation of cereals could have taken place below girdled trees. He suggested that the decrease of *Ulmus* and other trees was caused by several interacting factors, abiotic, such as climate, and/or biotic (e.g. disease combined with browsing). He emphasized that these factors were beyond man's control. The Neolithic people would merely have utilized the changed circumstances. He believed no expansion of cultivation to have occurred at the beginning of the Neolithic (GÖRANSSON 1988a, 49). He named the first part of the Neolithic (up to the regeneration phase) the "Early Neolithic Destruction Phase" (GÖRANSSON 1988a, 53). The so-called "catastrophe model" is also supported by Berglund (1991, 315; 428).

According to Groenman-van Waateringe (1968), the appearance of pollen grains of *Plantago lanceolata* and *P. major* in pollen diagrams before and contemporary with the *Ulmus* decline, unless accompanied by pollen of Cerealia and archaeological material, is not necessarily an indication of the presence of Neolithic man in the immediate vicinity. The pollen of these two *Plantago* species in this period may originate from "natural pastures", which occurred in unstable boundary zones - areas at the transition between freshwater and saline environments, wet and dry, and poor and rich in nutrients - along the sea coast and in river valleys. For this reason, Groenman-van Waateringe rejects Iversen's statement that *Plantago major* is so closely related to the appearance of man that this plant would disappear if human cultivation ceased.

From an archaeological point of view, the models

of Iversen and Troels-Smith have been severely criticized. The criticism focused mainly on two points: the stall-feeding of cattle, postulated by Troels-Smith and the use of the "slash-and-burn" method postulated by Iversen.
Rowley-Conwy (1982, 205) made some calculations concerning the scale of tree pollarding and leaf foddering of permanently stalled cattle needed to explain the *Ulmus* decline in the Danish pollen diagrams. He reaches the conclusion that the total number of cattle would have been between 500,000 and 1,000,000. This number of animals seems impossibly high for the prehistoric period. However, he does admit that calculations of this nature are fraught with problems, because they are based on many assumptions. Rackham (1980, 266) made comparable calculations for Britain. In his opinion the pollarding of Britain's huge area of *Ulmus* so efficiently as to halve its pollen production would require a population much larger and more elm-centred than any archaeologist has hitherto proposed. Rackham's estimate is that a minimum population of about 500,000 adults would be needed, a population at least ten times too large for Early Neolithic Britain.
New evidence for leaf foddering of stalled cattle was found by Troels-Smith himself in Switzerland: near a Neolithic settlement at Weier, in an outwash layer of a field, besides charred grains of wheat also pupae of the house fly *Musca domestica* were found. These pupae could not derive from cowpats of cows grazing in the harvested fields because house flies do not place their eggs in cowpats. The manure must have been carried out from the byres into the field (TROELS-SMITH 1984, 22). On the basis of an analysis of goat/sheep faeces from Egolzwil, also in Switzerland, Rasmussen (1993) has demonstrated that the local Neolithic farmers harvested leafless twigs and branches (mainly of *Corylus, Alnus* and *Betula*) in the early spring, which they used for foddering their livestock.
Rowley-Conwy (1981; 1982) also criticizes Iversen's ideas of the use of the "slash-and-burn" method in the Neolithic. In his opinion, there is no need for "slash-and-burn" on adequate, fertile soils like those of the Danish young-moraine landscape (ROWLEY-CONWY 1981, 89). Furthermore, there is no need for domestic animals in a shifting-cultivation system. In a permanent field system, however, sheep, cattle and pig are essential for weeding and manuring. In spite of these objections, the high values of *Betula* and *Pteridium aquilinum* in the pollen diagrams and the charcoal layers point indirectly and directly to the use of fire. Possibly, only the initial clearance was aided by fire, either to burn felled trees or to remove trees ringbarked and left standing; however, it would not seem necessary for this to be done cyclically, particularly if agriculture was on a more permanent basis than that envisaged by the shifting-cultivation theory (ROWLEY-CONWY 1982, 208). As already mentioned, Iversen himself (1941, 30) thought that the Neolithic clearance fires were in the first place intended for securing food for the animals. The use of the cleared areas for stock keeping would explain why forest regeneration was stopped in an early stage and remained in the *Betula* forest phase with lush undergrowth for about two hundred years (KALIS & MEURERS-BALKE 1998).

II.1.5 Recalculation of the original diagrams of Iversen and Troels-Smith

Because the leaf-fodder model of Troels-Smith and the *landnam* model of Iversen today still have a great significance for the archaeopalynological interpretation of pollen diagrams, Kalis & Meurers-Balke (1998) have critically examined the original diagrams of Iversen and Troels-Smith. It concerns Iversen's diagram of Ordrup Mose, a filled-up bay in the northern city area of Copenhagen (fig. 6, no. 1) (IVERSEN 1949) and Troels-Smith's diagram of Aamosen (Øgårde complex), a raised-bog area in the western part of Zealand (fig. 6, no. 2) (TROELS-SMITH 1954). In order to compare these diagrams with more recent pollen diagrams, it was necessary to recalculate the pollen percentages, because Iversen and Troels-Smith used tree pollen sums with corrected values for most trees. The updated versions of the diagrams of Ordrup Mose and Aamosen are shown in figs. 4 and 5. It can still be seen that in the diagram of Troels-Smith, a distinct cultural phase occurs before the Iversen *landnam*. In several Danish pollen diagrams, including Iversen's diagram of Ordrup Mose, pollen grains of Cerealia occur before the Iversen *landnam*. J. Stockmarr (cited in KOLSTRUP 1988) dated the first pollen grains of *Triticum*-type at Aamosen to 4200 cal BC, which is clearly within the time range of the Ertebølle Culture. The recalculation of the diagrams of Iversen and Troels-Smith also leads to the following conclusions (KALIS & MEURERS-BALKE 1998, 13):

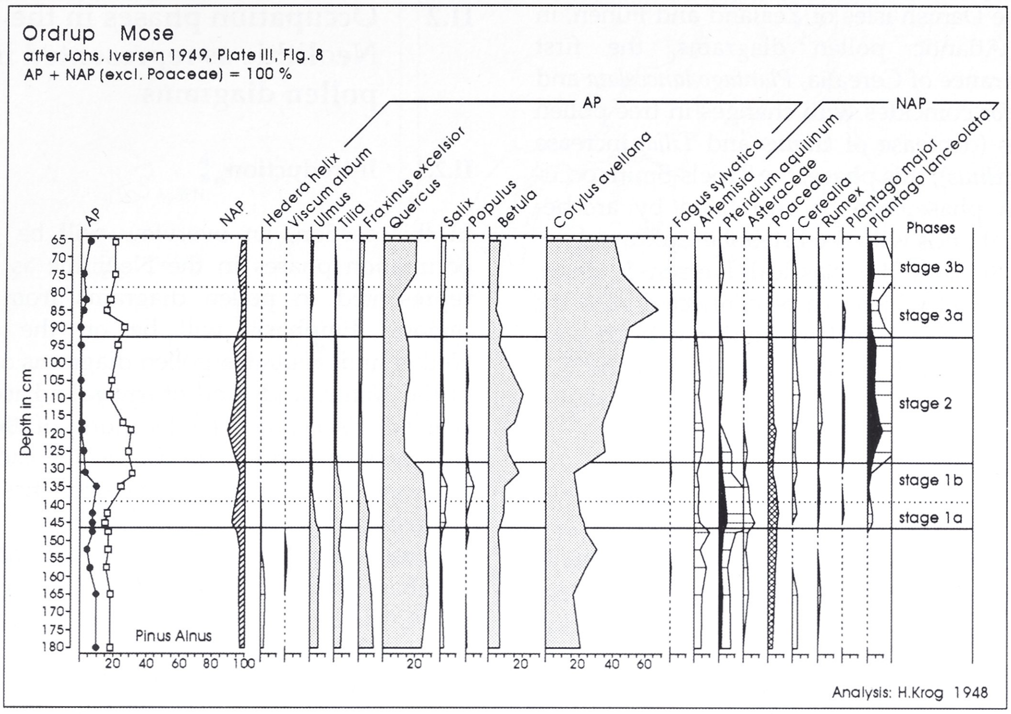

Fig. 4. Recalculated version of Iversen's pollen diagram of Ordrup Mose, with indication of PREFACT phases (after KALIS & MEURERS-BALKE 1998, Abb. 2).

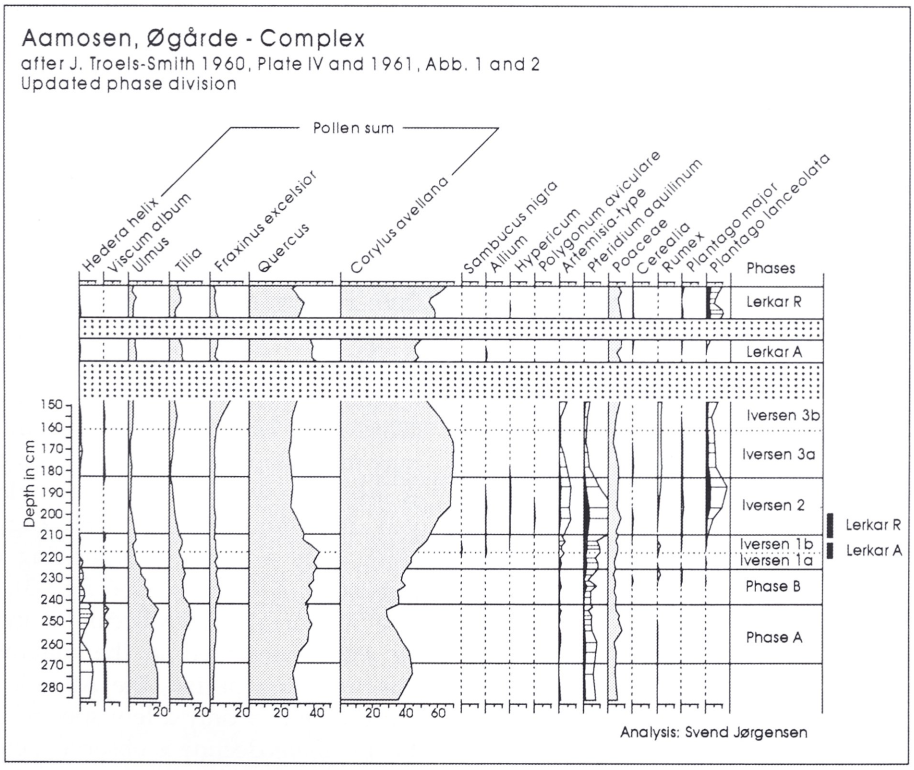

Fig. 5. Recalculated version of Troels-Smith's pollen diagram of Aamosen, with indication of PREFACT phases (after KALIS & MEURERS-BALKE 1998, Abb. 4).

1. On the Danish isles of Zealand and Fünen, in late Atlantic pollen diagrams, the first appearance of Cerealia, *Plantago lanceolata* and *P. major* coincides with changes in tree pollen values (decrease of *Ulmus* and *Tilia*, increase of *Fraxinus*); this phase, the Troels-Smith occupation phase, can be correlated by archaeological finds with the Ertebølle Culture.
2. Then follows the classical Iversen *landnam*, phase 1a of which can be connected with the Type A funnel beakers, and phase 1b with Type B funnel beakers (*sensu* BECKER 1947).

II.1.6 A regional *landnam* model for the western Baltic area

Kalis & Meurers-Balke (1998) have attempted to correlate the pollen diagrams of Ordrup Mose and Aamosen with diagrams of neighbouring eastern Holstein (northeastern Germany; see II.2.9). They divided the Neolithic period in the pollen diagrams into PREFACT phases (**P**alynological **R**eflection of **E**arly **F**arming **ACT**ivities). As for the Iversen *landnam* phase, the PREFACT phases follow Iversen's 1949 subdivision into five phases (the so-called Iversen-PREFACT phases 1a, 1b, 2, 3a, 3b). The Troels-Smith occupation phase, which precedes the Iversen *landnam*, is subdivided into two phases: Troels-Smith-PREFACT phase A, characterized by an initial decrease of *Ulmus* and *Tilia* and sporadic occurrence of *Artemisia, Pteridium aquilinum* and *Rumex*, and Troels-Smith-PREFACT phase B, characterized by a pronounced decrease of *Ulmus* and the first occurrence of *Plantago major, P. lanceolata* and Cerealia. The PREFACT model of Kalis & Meurers-Balke (1998) gives a very good description of the vegetation development during the Neolithic and its relation to archaeology in the western Baltic area. The present study aims to formulate a comparable model for the northern Netherlands and northwestern Germany.

II.2 Occupation phases in the Neolithic as represented in pollen diagrams

II.2.1 Introduction

In this section, an overview will be given of occupation phases in the Neolithic as they are represented in pollen diagrams from various regions. Emphasis will be on the northern Netherlands, but also pollen diagrams of the rest of the Netherlands and of several adjacent areas will be discussed. The locations of the pollen diagrams are shown in fig. 6. Of each pollen diagram, the following characteristics will be discussed:
1. description and interpretation of occupation phases occurring during the Neolithic;
2. ^{14}C dates of the occupation phases, when available (a global calibration table of ^{14}C dates is shown in appendix IV);
3. connection of the occupation phases with Neolithic cultures.

This overview by no means pretends to be complete, but it is hoped that it will sketch a representative picture of the course of the Neolithic as observed in pollen diagrams of the Netherlands and some adjacent parts of northwestern Europe.

II.2.2 Pingo scars in the northern and central Netherlands

Hijkermeer (province of Drenthe)
The Hijkermeer, located near the village of Hijken, is a large pingo scar with a diameter of ca. 250 m. Today, it still for the larger part contains open water. The coordinates of the centre are 229.35/545.28. The infill reaches a maximum depth of 5.10 m, and consists of gyttja. A sequence was analyzed palynologically by T. van der Hammen and W.H. Zagwijn in 1951-1953. Only a small summarizing diagram was published (ZAGWIJN 1956, fig. 43).
The Subboreal, which occurs in gyttja, seems to be well-represented in the diagram. However, the preceding period, the Atlantic, seems to be represented by only a few spectra. In spectra 13-14, an *Ulmus* decline is observed, coinciding with a decrease of *Betula*. *Tilia* reaches maximum values. A few spectra higher up, *Plantago lanceolata* and *Rumex acetosa/acetosella* appear; they remain present in each subsequent spectrum in

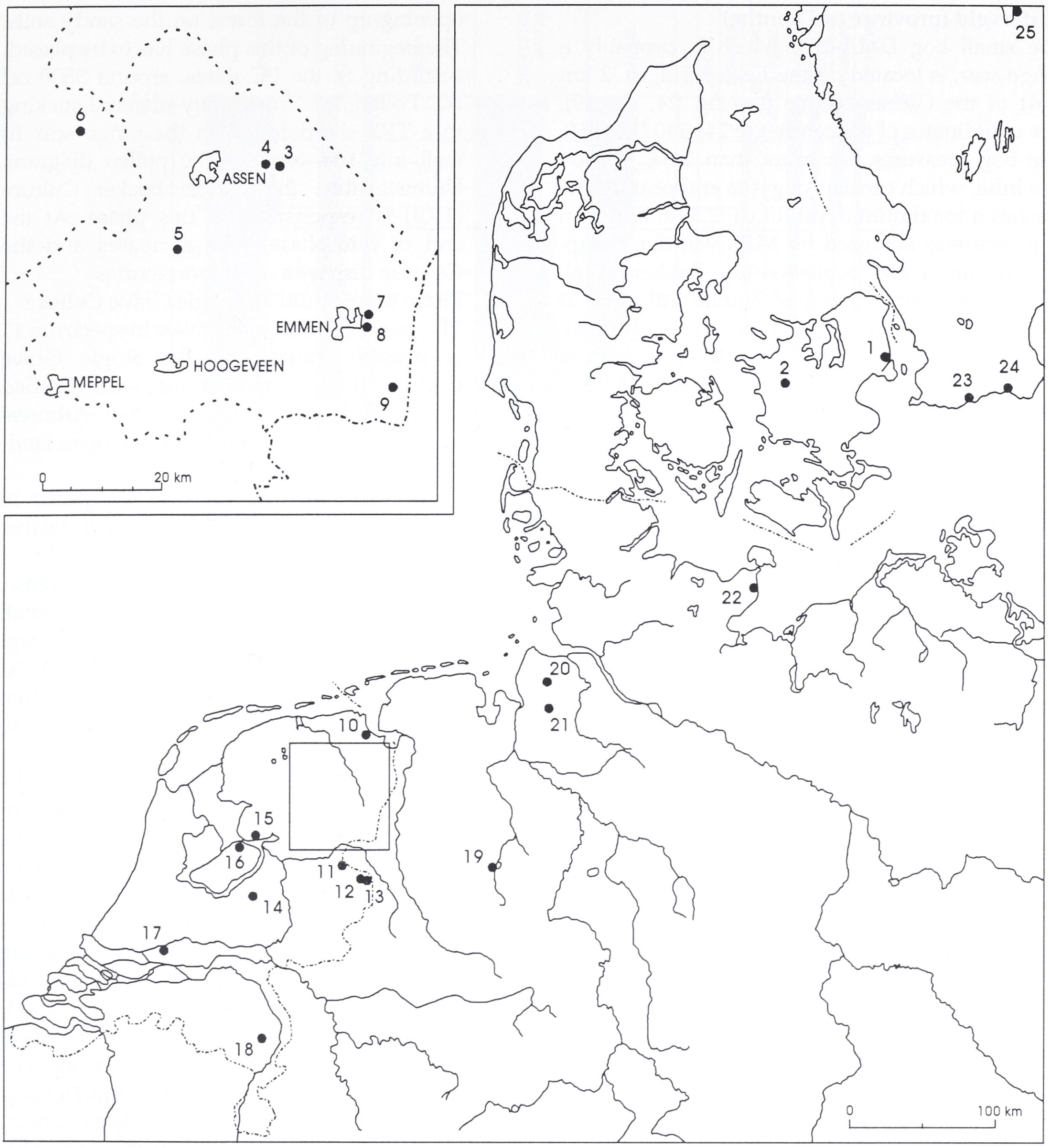

Fig. 6. Locations of pollen diagrams with occupation phases attributed to Neolithic cultures discussed in this chapter: 1. Ordrup Mose; 2. Aamosen; 3. Gietsenveentje; 4. Eexterveld; 5. Hijkermeer; 6. Wijnjewoude; 7. Emmererfscheidenveen; 8. Bargeroosterveld; 9. Meerstalblok; 10. Farmsum; 11. Engbertdijksvenen; 12. De Borchert; 13. De Klokkenberg; 14. Uddelermeer; 15. Schokland; 16. Swifterbant; 17. Hazendonk; 18. De Peel; 19. Hüde; 20. Flögeln; 21. Herrenhof; 22. Siggeneben-Süd; 23. Skateholm; 24. Ystad; 25. Alvastra.

low values. In spectrum 19, *Quercus* and especially *Tilia* decrease, while Cerealia-type appears, only occurring sporadically afterwards. In spectra 27-28, the culture-indicator types decrease again. An increase of *Fagus* to ca. 5% of the total AP in spectrum 33 seems to mark the end of the Subboreal. Generally, the Hijkermeer diagram is characterized by a lack of sudden changes in the course of the curves. During the first part of the Subboreal, the Ericaceae show relatively high values, while the Gramineae show relatively low values.

Eexterveld (province of Drenthe)

The small bog DMA-15a, which is probably a pingo scar, is located on the Eexterveld, ca. 2 km west of the Gietsenveentje (see fig. 24, no. 19). The coordinates of the centre are 244.140/558.560. The bog measures not more than 24 x 10.5 m. The infill, which consists of gyttja and peat layers, reaches a maximum depth of ca. 2.5 m. A pollen sequence was analyzed by M.D. van der Kamp. The results were published by Bakker et al. (1999). The interpretation of human influence in the pollen diagram seemed extremely difficult, because according to the ^{14}C dates the entire Neolithic is compressed into ca. 30 cm of peat, while the TRB period covers only a few spectra. Despite this, several phases of human activity could be traced in the diagram (it has to be remarked that spectrum 1 is the youngest and spectrum 20 is the oldest spectrum):

- Phase 1: spectra 17-20, date just below spectrum 16: 5394 ± 41 BP [UtC-6012]: Mesolithic.
  A decline of Quercus and Tilia and an increase of *Betula* seem to indicate the earliest phase of human activity, which is dated before 5400 BP/4200 cal BC. At this level also charcoal particles of *Quercus* were found. However, no culture-indicator pollen types were traced. These activities may be attributable to Mesolithic people.
- Phase 2: spectra 15-16: Swifterbant or pre-megalithic TRB.
  Just above the ^{14}C date of 5400 BP/4200 cal BC, the first Cerealia pollen, identified as *Triticum*-type, was found. Simultaneously, *Ulmus* and *Tilia* decrease, while the Non-Arboreal Pollen (NAP) increases, except for the Gramineae. High values of Rosaceae possibly point to the existence of a natural shrub vegetation along the forest edge. Possibly, the Swifterbant Culture or pre-megalithic TRB (Early Neolithic TRB) are responsible for this phase of human activity. The first possibility is more likely, because so far the Early Neolithic TRB Culture is not known from the northern Netherlands and northwestern Germany.
- Phase 3: spectra 12-14, date just below spectrum 12: 4410 ± 49 BP [UtC-6011]: Funnel Beaker Culture.
  This phase begins with a decline in *Quercus* and *Ulmus*, an increase in *Tilia* and the first occurrence of *Plantago lanceolata*. The Non-Arboreal Pollen, including Gramineae, and *Pteridium* increase. This points to a further opening-up of the forest on the sandy soils. The beginning of this phase has to be placed, according to the ^{14}C dates, around 3500 cal BC. Pollen data from peaty material sticking to a TRB sherd found in the pingo scar fit well into this level of the pollen diagram. Unmistakably, the Funnel Beaker Culture (TRB) is responsible for this phase. At the end of this phase, *Tilia* decreases and the Cerealia display a continuous curve.
- Phase 4: spectrum 11: Single Grave Culture.
  The peak of *Plantago lanceolata* in spectrum 11 is possibly caused by the Single Grave Culture (EGK; synonymous with Corded Ware Culture). The increase of Non-Arboreal Pollen points to a more and more open landscape.
- Phase 5: spectra 9-10, date between spectra 10 and 11: 4000 ± 37 BP [UtC-6010]: Bell Beaker Culture.
  Cerealia and *Plantago lanceolata* decrease, while *Betula*, *Quercus* and *Tilia* show small peaks. The human influence on the vegetation has become quite insignificant. A ^{14}C date of 4000 BP/2500 cal BC indicates that this level should probably be attributed to the Bell Beaker period (BB).

Bakker et al. (1999) emphasize that because of the small size of the bog, the pollen data are only of local significance and that general trends in the cultural development of the region will only be reflected in rather weak signals. Furthermore, they conclude that the Arboreal Pollen values remain extremely high in the entire diagram, compared to the spectra from TRB burial mounds (see II.2.4). This should indicate that the woodland vegetation extended towards the very edges of the bog itself throughout the period. The regular presence of pollen of *Lemna* and *Hottonia palustris* indicates the presence of eutrophic open water in the Neolithic. For this reason, the TRB remains found in the bog itself cannot be interpreted as ordinary domestic waste; they are supposed to be sacrificial.

Wijnjewoude (province of Friesland)

Near Wijnjewoude, a pingo scar was discovered almost entirely filled with peat (coordinates of the centre 205.80/563.80); the peat in the uppermost layer is level with that in the nearby Boorne valley, so that it is difficult to notice the pingo scar in the landscape. Its size is ca. 150 x 100 m. The infill reaches a maximum depth of 5.50 m. The results of the pollen analysis were published by Ploeger & Groenman-van Waateringe (1964).

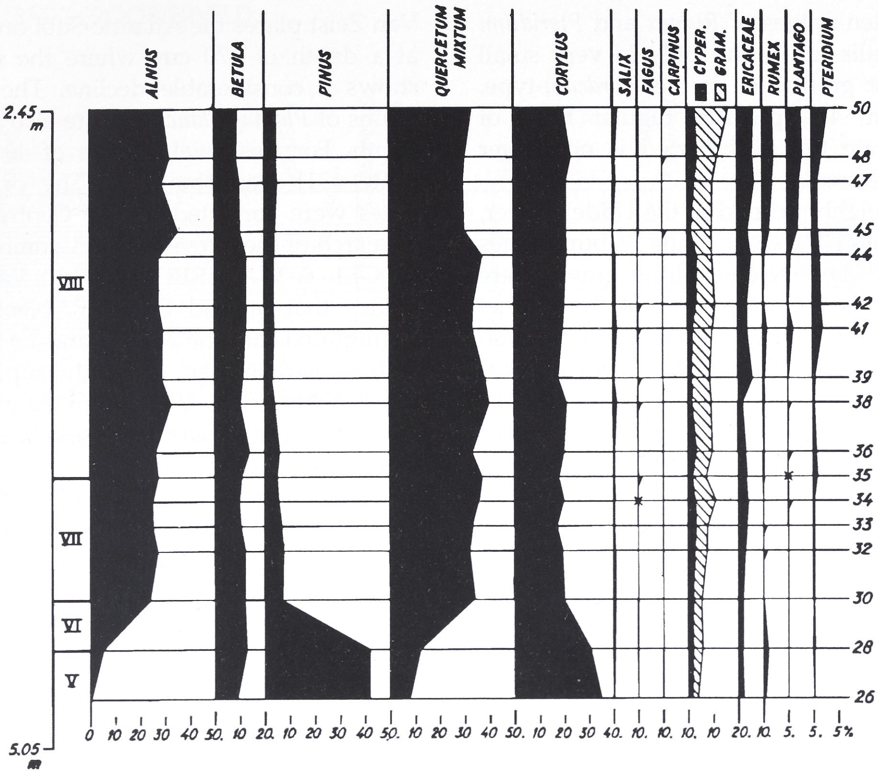

Fig. 7. Summarizing pollen diagram of the Uddelermeer (after POLAK 1959, diagram IV). Only the Arboreal Pollen is included in the pollen sum.

In the diagram, the first part of the Subboreal is compressed into the upper 75 cm. The last part of the Subboreal seems to be missing. The sediment in this part of the sequence consists of forest peat (0.75-0.50 m) and Cyperaceae peat (0.50-0 m). The *Ulmus* curve declines at 0.70 m. One pollen grain of *Plantago lanceolata* was found just above this level.

According to Ploeger & Groenman-van Waateringe, the upper five spectra (0.50-0 m) record an Iversen *landnam*: an increase is seen of Gramineae, Ericales, *Plantago lanceolata, Rumex* and Compositae. Ploeger & Groenman-van Waateringe, following Waterbolk (1956) and Van Zeist (1959, see II.2.3), conclude that this Iversen *landnam* was due to the Protuding Foot Beaker Culture (Single Grave Culture, EGK). In their opinion, the occurrence of several barrows of this culture in the district support this theory. However, also many finds of the preceding Funnel Beaker Culture (TRB) are known from the district (see FOKKENS 1990).

Uddelermeer (province of Gelderland)

The Uddelermeer, located in the Veluwe in the central Netherlands, is a very large pingo scar with a size of 420 x 260 m, which has always contained open water. The infill reaches a maximum thickness of 4.40 m, and consists of gyttja (0-245 cm) and dark brown dy (245-440 cm). Results of a pollen analysis were published by Polak (1959). A summarizing pollen diagram is shown in fig. 7.

The Subboreal, which occurs in dark brown dy, is well-represented in the diagram. The preceding period, the Atlantic, is compressed into a few spectra. In spectra 34-35, a decline of *Ulmus* is observed, while *Tilia* reaches maximum values. In the same spectra, Gramineae increase, *Plantago lanceolata* appears and also one pollen grain of *Hordeum* measuring 42 µm was found. *Plantago lanceolata* occurs only sporadically in the following spectra. Polak (1959, 564) located the Atlantic-Subboreal transition at spectrum 35; however, the *Ulmus* decline already starts in spectrum 34, so that it seems better to place this transition between spectra 33 and 34. From spectrum 41 upwards, *Plantago lanceolata* forms a continuous curve; the pollen values of *Rumex* and *Pteridium* increase. Cerealia are found only in very small numbers; most grains are of the *Hordeum*-type. From spectrum 45 upwards, regular finds of *Carpinus* indicate that this period is no longer part of the Subboreal.

In the direct neighbourhood of the Uddelermeer, dwelling pits and different kinds of burial sites have been excavated. No megalithic graves were found, but artefacts and pottery of the Funnel Beaker Culture (TRB) have been recovered within the region. Also protruding-foot beakers (belonging to the Single Grave Culture, EGK) and especially bell beakers (belonging to the Bell Beaker Culture, BB) occurred. It appears that different cultures followed each other and that the material became mixed. The bank and the surroundings of the Uddelermeer were inhabited from Early Neolithic up to Carolingian times. Human occupation is reflected in the pollen picture. However, a pronounced Iversen *landnam* is not seen. Most pollen grains of Cerealia were identified as *Hordeum*. Possibly, on the poor soils of this part of the Veluwe, *Hordeum*, which is ecologically less susceptible than the various *Triticum* species, was the most important crop during the first part of the Neolithic. According to the relatively low Ericaceae percentages, no extensive heathland was present in this part of the country during the Neolithic; probably there were open spaces covered with grasses and patches of heather.

II.2.3 Large raised bogs of southeastern Drenthe

Emmererfscheidenveen

The raised bog near Emmererfscheidenveen forms part of the formerly extensive raised bog east of the Hondsrug, the Bourtanger Moor. This raised bog lies in the primeval valley of the Hunze (fig. 14). In the lowest parts, peat formation already started in Late-Glacial times. The natural drainage of this raised bog took place by a stream called Runde which ran in a northerly direction. Peat-digging was practised in this area up to the 1950s. The only dated pollen sequence from this area is Emmererfscheidenveen V (VAN ZEIST 1955b) (coordinates 262.08/ 534.78). The sediment reaches a depth of ca. 3.40 m, and consists of a very thin layer of gyttja, followed by thick layers of mainly *Sphagnum* peat. The Subboreal, which occurs in *Sphagnum* peat, is well-represented in the diagram.

Van Zeist places the Atlantic-Subboreal transition at a depth of 170 cm, where the *Ulmus* curve shows a considerable decline. The first pollen grains of *Plantago lanceolata* are also found at this depth. For this level, a date of 4965 ± 135 BP [GRO-431] was obtained. (The original GRO-dates were corrected by the Centre for Isotope Research of the University of Groningen, see also VOGEL & WATERBOLK 1963.) Van Zeist concludes that around 5000 BP, Neolithic people immigrated into the region, and he remarks that "this is earlier than generally supposed up to now" (VAN ZEIST 1955b, 116). At a depth of 115 cm, *Plantago lanceolata* increases considerably, but reaches not more than 1% of the AP, and forms a continuous curve. For this level, a date of 4185 ± 140 BP [GRO-428] was obtained. Van Zeist compares the *Plantago lanceolata* values in this diagram with *Plantago lanceolata* values in palynological spectra from Neolithic burial monuments - megalithic tombs from TRB times and tumuli from EGK times. In contrast to spectra from megalithic tombs, the spectra from tumuli are characterized by high percentages for *Plantago lanceolata* and other herbs (see II.2.4). For this reason, Van Zeist concludes that the increase of *Plantago lanceolata* at 115 cm marks the "arrival" of the EGK people. He ascribes the rather scarce pollen grains of *Plantago lanceolata* below a depth of 120 cm to the activity of TRB people. At a depth of 62 cm, *Fagus* reaches a value of about 1%. According to Van Zeist, this level corresponds approximately with the Neolithic-Bronze Age transition. For this level, a date of 3350 ± 140 BP [GRO-424] (ca. 1660 cal BC) was obtained. By present-day standards, this date is already well into the Bronze Age, which begins ca. 1900 cal BC.

Bargeroosterveld

A few years after the collection of the Emmererfscheidenveen sequence, a sequence was collected at another location in the Bourtanger Moor near Emmen: Bargeroosterveld (coordinates 262.11/533.31) (VAN ZEIST 1959; 1967). This location is in the border zone of the raised bog, only a short distance from the higher ground of the Hondsrug. Van Zeist expected that in pollen diagrams from this site the influence of prehistoric man on the vegetation would appear more clearly than it would in diagrams from the more central parts of the raised bog. The Bargeroosterveld sequence reaches a maximum depth of ca. 3 m, and consists of layers of wood peat, *Scheuchzeria* peat and *Sphagnum* peat. A sum-

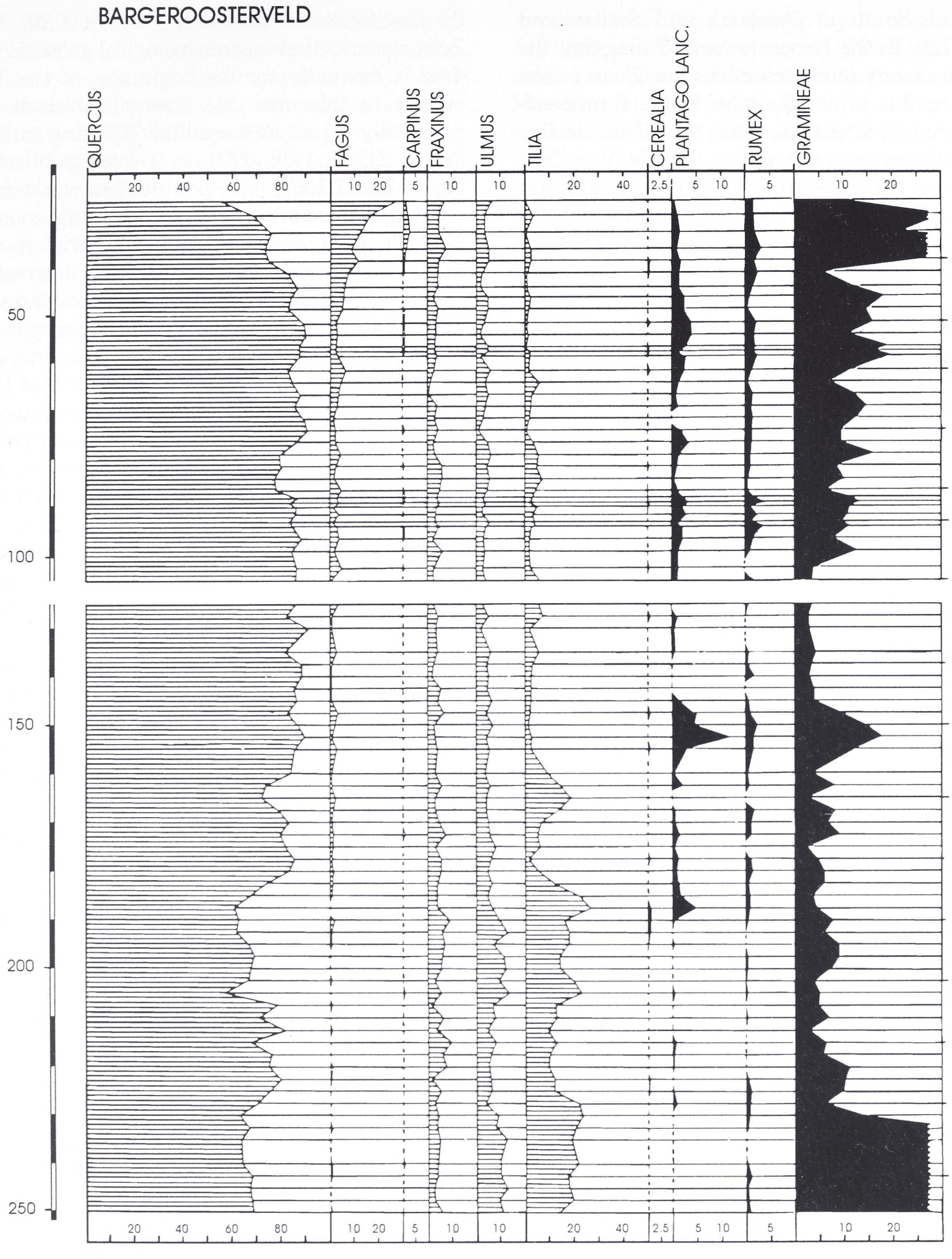

Fig. 8. Pollen diagram of Bargeroosterveld (after VAN ZEIST 1967, fig. 4). Only the pollen types with hatched curves are included in the pollen sum.

marizing pollen diagram is shown in fig. 8.
In spectrum 19, a pollen grain of *Plantago major* was found. Between spectra 20 and 35, *Plantago lanceolata* is very scarce, whereas the pollen of Cerealia-type is present. Simultaneously with the appearance of these culture indicators, the *Ulmus* curve declines. According to Van Zeist, these phenomena were caused by the first farmers in Drenthe, whose agricultural practices would have shown a great similarity to those described

by Troels-Smith in Denmark and Switzerland (see II.1.3). In the Bargeroosterveld diagram, the *Tilia* curve very much resembles the *Ulmus* curve; however, this is not the case in the Emmererf-scheidenveen diagrams: there, the *Ulmus* decline is not attended by a recession of *Tilia*. Van Zeist (following TROELS-SMITH 1954) explains this in the following way: *Tilia* flowers again about 4 years after the cutting of the leafy branches for fodder, while *Ulmus* is unable to produce flower buds within 7 or 8 years. Van Zeist assumes that before flowering, they would mostly be cut again. He reaches the conclusion that in conesquence of the cutting of leafy branches by prehistoric man, the share of *Ulmus* in the pollen rain would decrease considerably more than that of the other trees.

According to Van Zeist (1959, 169), the high value of *Plantago lanceolata* in spectrum 36 and upwards represents the *landnam* type described by Iversen (see II.1.2): rather large areas were cleared with the help of axe and fire. He believed a small part of the clearings to have been used for cereal cultivation, while the larger part was used as grazing for the numerous livestock. In contrast to the farmers of the preceding period, Van Zeist considers these "new immigrants" to be herdsmen. *Rumex* shows an increase together with *Plantago lanceolata*. Also an increase of Gramineae might be expected; but no such change is seen in the diagram, possibly because it is masked by pollen of Gramineae growing on the peat. According to Van Zeist, *Tilia* shows a clear response to the *landnam*: he interprets the *Tilia* declines around spectrum 37 and spectrum 46 as "waves of large-scale forest clearance". When the third wave struck the area, around spectrum 48, *Tilia* had not yet recovered, so that there was no third decline (VAN ZEIST 1959, 169). Van Zeist therefore distinguishes two Neolithic *landnam* types in the Bargeroosterveld diagram: below, that of a farming culture; above, that of herdsmen. By comparing the Bargeroosterveld diagram with the results of palynological investigations of Neolithic burial monuments (see II.2.4) - as he did in his 1955 article (VAN ZEIST 1955b) - he reaches the conclusion that the first *landnam*, which is characterized by low values of *Plantago lanceolata* (spectra 20-35), has to be attributed to farmers of the Funnel Beaker Culture (TRB), while the second *landnam*, which is characterized by relatively high values of *Plantago lanceolata* (spectra 36-52), has to be attributed to farmers of the Single Grave Culture (EGK). According to the date of the *Ulmus* decline in the Emmen region, the first farmers settled here about 5000 BP. Van Zeist remarks that on archaeological grounds this date is too early for the beginning of the TRB culture in this area. He does not exclude the possibility of a pre-megalithic farming culture (VAN ZEIST 1959, 173). In a later publication (VAN ZEIST 1967), Van Zeist further worked out a detailed comparison between the Bargeroosterveld diagram and spectra from burial monuments in Drenthe. He draws some interesting conclusions about the EGK culture, which in his opinion caused the Iversen *landnam* (spectra 36-52) in the Bargeroosterveld diagram. This diagram, and other diagrams too, show that Iversen's *landnam* phase lasted 200-300 years, suggesting that for at least 8 to 10 generations people stayed in a restricted area. Consequently, it is likely that the EGK people were sedentary to a large extent. Farming practice differed from that of the Funnel Beaker and Bell Beaker Cultures in that the EGK farmers made large clearings to provide their livestock with sufficient grazing (VAN ZEIST 1967, 59).

According to Casparie & Groenman-van Waateringe (1980, 58), the "considerable decline" in *Ulmus* and *Tilia* taking place at the beginning of the Troels-Smith occupation phase (spectra 20-35) suggests that this phase of Neolithic intervention was already quite extensive, which is not what one would expect with a Troels-Smith type of occupation phase. The TRB people, who in the opinion of Casparie & Groenman-van Waateringe caused the Troels-Smith occupation phase, probably cleared mainly *Ulmus*- and *Tilia*-rich forests on the weathered till ridge. The open spaces made by the TRB farmers were not extremely small. However, in the regenerating forest and in the open spaces lying fallow, *Plantago lanceolata* was not able to expand because the soil conditions were not favourable for this plant: in compact soils like till, *Plantago lanceolata* germinates poorly and with difficulty (BLOM 1974).

During the Iversen *landnam* (spectra 36-52), forest was cleared also on coversand soils. On these soils, *Plantago lanceolata* was able to expand considerably. This marked expansion, well represented in the Emmererfscheidenveen V diagram and the Bargeroosterveld diagram, is not accompanied by a corresponding expansion of other light-demanding herbs of open vegetation types.

Casparie & Groenman-van Waateringe (1980, 59) conclude that the characteristic features of Neolithic activity in pollen diagrams are much more indicative of the type of forest cleared and the condition of the soil occupied (rich or poor in nutrients, compact or less compact, wet or dry) than of cultural or economic differences between the TRB and EGK cultures. The Bargeroosterveld diagram shows that the herb vegetation did not expand considerably after the reclamation of the forest at the beginning of the Iversen *landnam* (spectrum 36). Perhaps the forest floor in many places received so much light that no large-scale systematic reclamation was necessary to create clearings suitable for cultivation and grazing. In the opinion of Casparie & Groenman-van Waateringe (1980, 59), a *landnam* of the Iversen type - with the aid of fire - would have had a more pronounced effect on the herb composition than is shown by the pollen diagrams.

The Troels-Smith occupation phase and the Iversen *landnam* are seen by Casparie & Groenman-van Waateringe as two extreme forms of agricultural systems. It seems more likely that prehistoric man largely adapted his methods of reclamation to the available opportunities, possibly in such a way that no culturally-linked pattern is evident (CASPARIE & GROENMAN-VAN WAATERINGE 1980, 62).

Meerstalblok

Dupont (1986) carried out pollen analysis on peat sections from Meerstalblok, one of the last remnants of the formerly extensive Bourtanger Moor (coordinates 266.75/523.98). Meerstalblok is located far from the Hondsrug ridge and consequently far from prehistoric occupation. Hence the signals in the pollen diagrams pointing to human activity are expected to be rather weak. The infill reaches a maximum depth of ca. 3 m, and mainly consists of thick layers of *Sphagnum* peat. Apart from a pollen percentage diagram, also a pollen influx diagram was constructed, which is based on only a few ^{14}C dates: two of the Atlantic period and three of the Subboreal. Peat spectra of only 1 cm thick were dated.

Between 6000 and 4500 BP, the total arboreal influx increases. Possibly the earliest, modest human activities caused a more open structure of the forest, favouring increased pollen production. After 4500 BP, increasing human influence reduced the forest area to such an extent that the overall pollen production began to decline. The increased anthropogenic influence can be observed in the curve of the total pollen influx of indicators of human influence (DUPONT 1986, fig. 7).

At a depth of 225 cm (ca. 5000 BP), *Rumex* appears, 1 cm later followed by *Plantago lanceolata*. In the percentage diagram, the classic *Ulmus* decline is observed at exactly the same depth. However, at this level in the influx diagram, no decline of *Ulmus* can be observed; the *Ulmus* decline in the percentage diagram is attributable to the increased absolute representation of other trees, especially *Quercus* and *Corylus*. The increase of *Quercus* and *Corylus* may well be the result of enhanced pollen production due to a more open structure of the forest, probably caused by small-scale human activities, but *Ulmus* flowering apparently did not benefit from this (DUPONT 1986, 100). Following Van Zeist (1967) and Casparie & Groenman-van Waateringe (1980), Dupont ascribes this phase to activities of the Funnel Beaker Culture (TRB). At a depth of 209 cm (ca. 4250 BP), *Ulmus*, *Quercus* and *Betula* decrease sharply in the influx diagram. According to Dupont, this decrease is caused by increasing human disturbance. However, the total pollen influx of indicators of human influence does not increase at this level. Dupont ascribes this phase to activities of the Single Grave Culture (EGK).

II.2.4 Barrow spectra from the northern and central Netherlands

In the Netherlands, there is a strong tradition in the study of pollen spectra from burial mounds. In the 1950s already, the first studies about this subject were published (WATERBOLK 1954; 1956; VAN ZEIST 1955a). Later, more extensive studies were published by Van Zeist (1967) and Casparie & Groenman-van Waateringe (1980). In palynological studies of funerary monuments, samples from the upper 1-2 cm of the fossil soil (both from the old surface under the monument and from the sods used for the construction of the mound) are analyzed. It is assumed that these samples reflect the local and regional vegetation of the period just before the construction of the monument (VAN ZEIST 1967, 49-50). Two important points have to be kept in mind when barrow spectra are compared with spectra from lake deposits: a. the pollen frequencies in the upper part of the buried soil profile may have changed as a consequence of selective corrosion and selective outwash; b. the pollen picture of barrow spectra to a large extent reflects the local vegetation, which may lead to strongly fluctuating frequencies especially for herb pollen (NAP) and *Betula*. For this reason, *Betula* and the NAP

were left out of the pollen sum (ΣP) in barrow spectra (VAN ZEIST 1967, 53-54).
Casparie & Groenman-van Waateringe (1980) summarize the results of the analysis of pollen spectra from burial monuments of three Neolithic cultures in the northern Netherlands (the Drenthe Plateau): the Funnel Beaker Culture (TRB), the Single Grave Culture (EGK) and the Bell Beaker Culture (BB). The pollen picture of these barrow spectra is shown in fig. 9. Compared to pollen diagrams from lake deposits, all spectra are characterized by high to very high percentages of especially *Calluna*, *Succisa* and Compositae. According to Casparie & Groenman-van Waateringe (1980, 60) the phenomenon that TRB and BB barrow spectra have on average lower herb values than EGK spectra, especially lower values of *Plantago lanceolata*, *Rumex* and Gramineae, cannot be ascribed merely to different methods of reclamation; within each culture, also considerable differences in pollen values are observed. Apparently, even during the TRB period different types of open space could be chosen for burial of the dead. The pollen picture of the Neolithic barrow samples points to arable land abandoned for varying lengths of time, to grazing, to expansion of heath and - to a far lesser extent - to regeneration of the forest. In most cases, the burial monuments seem to have been erected on abandoned fields, which could no longer be used because of the exhausted soil. In some barrow samples, many charcoal particles are found. Here the local vegetation was destroyed by fire shortly before the barrow was constructed. The environment in the immediate vicinity of a barrow varied from only slightly degraded forest to extremely degraded, heath-rich vegetation types, with all possible intermediate stages. It seems difficult to demonstrate differences in methods of reclamation, in use of open spaces and in the production of animal fodder on the basis of barrow spectra. It is difficult even to demonstrate with certainty the cultivation of grain or the use of land as pasture. The general picture obtained from the barrow spectra is that in general the pressure of man on the environment continually increased from the TRB period, throughout the EGK and BB periods, into the Bronze Age, resulting in progressive degradation of the natural forest (CASPARIE & GROENMAN-VAN WAATERINGE 1980, 61).
In pollen spectra from barrows of the sandy areas of the central Netherlands (the Veluwe, the Gooi and the Utrechtse Heuvelrug), almost no evidence for arable and stock farming was found. This suggests that large open areas, cleared by man, did not yet occur during the Neolithic in the central Netherlands. The same picture emerges from pollen diagrams of various locations on the Veluwe, published by Polak (1959; 1967; see II.2.2) and Maarleveld & De Lange (1977). In none of these diagrams can a *landnam* type as described by Iversen be observed. Casparie & Groenman-van Waateringe (1980) assume that the original vegetation was already rather open woodland, on account of activities in these woods for several thousand years. In the Neolithic, the forests became increasingly open as a result of grazing; however, this seems to have been a gradual process, without the use of burning. The high values of *Tilia* in the barrow spectra are interpreted by Casparie & Groenman-van Waateringe as a further indication of the openness of the forest, because *Tilia*, especially under favourable light conditions, is a great pollen producer. When *Tilia* grows in dense forest, however, flowering is greatly reduced (IVERSEN 1960, note 11). The influence of Neolithic man on the vegetation led to impoverishment of the soils and of the vegetation. This resulted in an expansion of taxa which were strong enough to resist long-term human interference: Gramineae and Ericaceae.

II.2.5 The eastern Netherlands

De Klokkenberg (province of Overijssel)
Van der Hammen (1965) studied deposits in a small gully below plaggen-soil layers at De Klokkenberg near Denekamp palynologically. Only four spectra in the diagram of section P_1 seemed to represent the Atlantic and the first part of the Subboreal. The sediment of spectra 2, 3 and 5 consisted of dark grey humic sand; the sediment of spectrum 4, which contained no pollen, consisted of light grey humic sand.
In spectra 2 and 3, dated to 6810 ± 60 BP [GrN-2813], which is in the Atlantic, Cerealia pollen and large quantities of charcoal seem to reflect human activity. However, the other culture-indicator types are not present or do not show an increase. According to Van der Hammen (1965, 130), we have to be careful drawing conclusions, because there is a possibility of illuviation from above or the selective destruction of pollen grains. In spectrum 5, dated to 4405 ± 55 BP [GrN-2814], which is in the Subboreal, the values of *Tilia* and *Ulmus* are lower than in spectra 2 and 3. The Gramineae reach relatively high values.

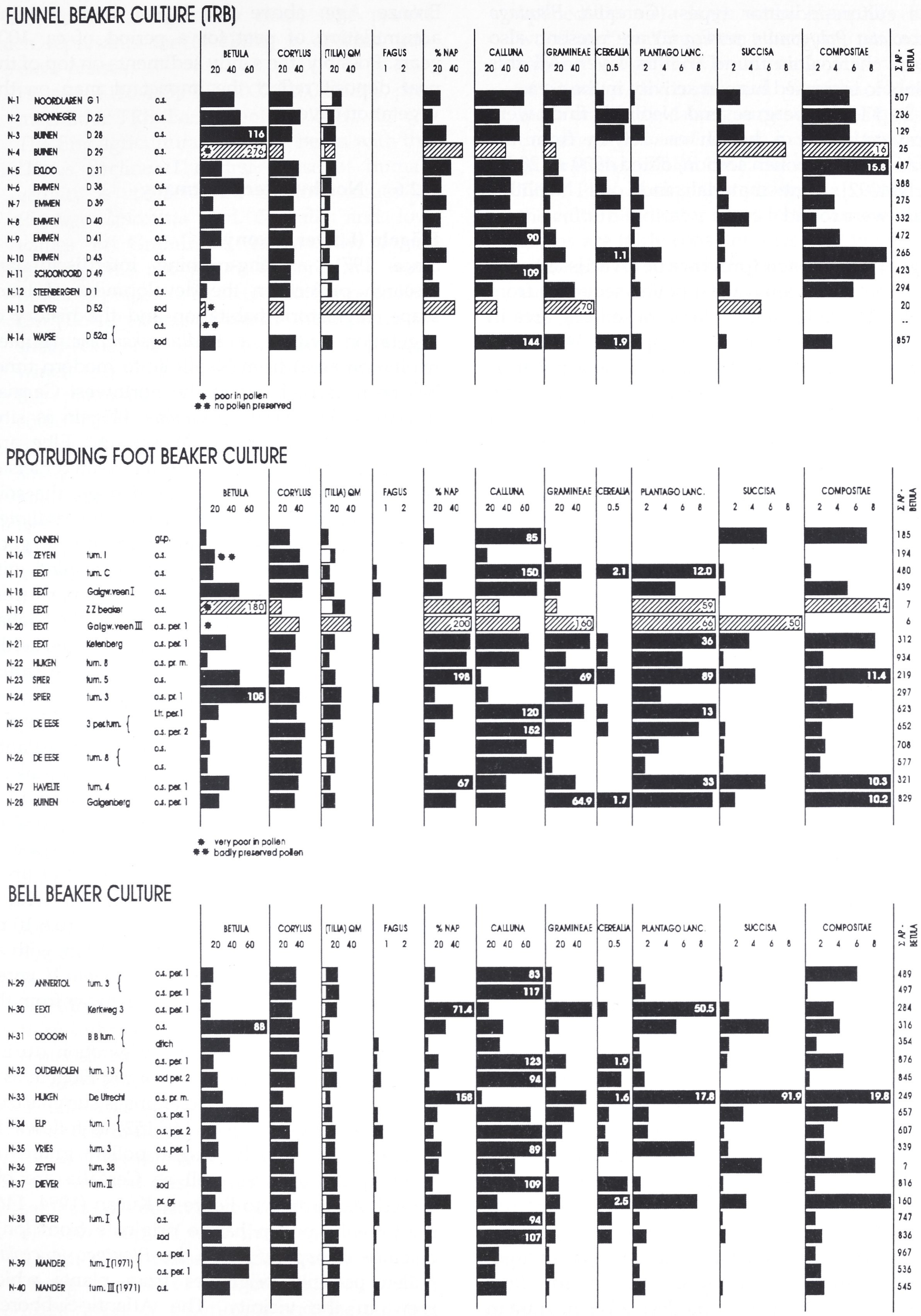

Fig. 9. Barrow spectra of the TRB, EGK and BB periods (north of the river IJssel) (after CASPARIE & GROENMAN-VAN WAATERINGE 1980, figs. 2-4).

The culture-indicator types (Cerealia, *Plantago lanceolata, Polygonum persicaria*) are present; also much charcoal is found in this layer. All this points to increased human activity in the area.
At De Klokkenberg, several Neolithic finds were excavated: near a hearth ca. 100 m from the location of the pollen section, dated 4930 ± 120 BP [GrN-4092], flint material and one Neolithic sherd were found.

Engbertdijksvenen (province of Overijssel)
Van Geel (1978) analyzed a pollen sequence from the Engbertdijksvenen, a large raised-bog area in the province of Overijssel. In spectra 34 and 40, which are of late Atlantic age, Cerealia pollen is found. The Atlantic-Subboreal transition, which is located at spectrum 47, is characterized by a decline of *Ulmus* and *Tilia* (date of spectrum 47: 4815 ± 40 BP [GrN-6815]). From spectrum 47 upwards, Cerealia are regularly observed in low frequencies. *Plantago lanceolata* appears in spectrum 50. According to Van Geel (1978, 8), the presence of pollen of *Plantago lanceolata* is not necessarily indicative of human activity, but may sometimes reflect an unstable climate. The local vegetation succession in the ENG-I section supports this idea for the early Subboreal period. During the entire Subboreal, the percentages of the culture-indicator types remain relatively low (less than 1%). Possibly this means that the location was situated far from prehistoric settlements.

De Borchert (province of Overijssel)
Van Geel et al. (1981) studied a peat section from a filled-in river branch at De Borchert near Denekamp in the province of Overijssel. The exact position of the Atlantic-Subboreal transition is uncertain, because there are no clear declines of *Ulmus* and *Tilia*. In spectrum 253, an increase of Gramineae is observed. Only in spectrum 263 does pollen of *Plantago lanceolata* and Cerealia appear; at the same point, the *Rumex* curve becomes continuous. The estimated age of the sediment at this depth is ca. 3900 BP. If the dates are correct, the pollen diagram reflects no human activity in the neighbourhood of this location in the first part of the Neolithic, between 5000 and 3900 BP. During the second part of the Neolithic and also during the Bronze Age, the percentages of the culture-indicator types are very low (less than 1%), pointing to a modest level of human activity or activities at a large distance. The top of the amorphic Subboreal layer is dated 3425 ± 25 BP [GrN-7915], which indicates that it is already Bronze Age; above this layer, there was no accumulation of peat for a period of ca. 1000 years. Possibly, the sandy sediments on top of the peat deposit reflect the impact of man on the vegetation cover.

II.2.6 Northwestern Germany

Flögeln (Lower Saxony)
Since 1971, a long-running interdisciplinary research project on the development of landscape, prehistoric habitation and the history of vegetation within a *Siedlungskammer* (limited habitation area) from Neolithic to modern times has been carried out in the northwest German lowlands. The *Siedlungskammer* Flögeln is situated between the rivers Weser and Elbe and comprises about 23.5 km^2. It is an isolated Pleistocene area surrounded by raised bogs, the soils mainly consisting of poor sands. The *Siedlungskammer* Flögeln is characterized by a good number of kettleholes, most of them filled with peat. Some of these kettleholes originate from pools formed by falling meltwater in the Saalian (BEHRE & KUČAN 1994, 15; 94). From the kettleholes as well as from the margins of the surrounding raised bogs, 13 pollen diagrams were compiled (BEHRE & KUČAN 1994). In the following six sequences, the last part of the Atlantic and the Subboreal are present: Swienskuhle, a small kettlehole of 42.6 x 27.5 m with an infill of up to 2.37 m; Jagen 20, a peat bog of 170 x 54 m, with an infill of up to 2.60 m; Silbersee, a kettlehole of 190 x 110 m, with an infill of up to 4.16 m; Flögelner Holz, a kettlehole with a diameter of 270 m, with an infill of up to 6.10 m; Fuhrenkamp, a kettlehole of 180 x 110 m, with an infill of up to 3.41 m; and finally Flögeln V, cored in the large raised-bog area, 280 m away from the Pleistocene sand.
The human influence on the vegetation during the Neolithic in the *Siedlungskammer* Flögeln as it is reflected in the pollen diagrams is summarized by Behre & Kučan (1994, 146-152) as follows. In the Atlantic, already single pollen grains of *Plantago lanceolata* as well as Cerealia are observed. According to Behre & Kučan (1994, 146), the Cerealia pollen has to originate from long-distance transport, while the *Plantago lanceolata* pollen possibly originates from plants which grew in the vicinity. The Atlantic-Subboreal transition, which here coincides with the beginning of the Neolithic (BEHRE & KUČAN 1994, Abb. 40), is located at the decline of *Ulmus*

(which is not always very clear). The period which represents the Neolithic is divided into two clear phases:

- Phase 1: 5150-4450 BP/4000-3100 cal BC, pre-megalithic TRB (Early Neolithic TRB).
  The first agricultural activities begin with the *Ulmus* decline. The first phase of human activity is characterized by low values of *Plantago lanceolata* and Cerealia and low values of Gramineae. Apparently, forest grazing was not practised here, nor were pastures present. According to Behre & Kučan (1994), *Plantago lanceolata* here points to small-scale arable farming: because a plough which turns the soil was not yet invented, this perennial species with its long roots could easily persist in the fields. In this period, the forests were cleared only on a small scale. This points to the type of occupation phase first described by Troels-Smith (see II.1.3): probably, the livestock were fed on leaf fodder, especially of *Ulmus*. The leaf-fodder economy was practised especially in the western part of the *Siedlungskammer* (Swienskuhle, Jagen 20). Sequences in the eastern part (Flögelner Holz, Fuhrenkamp) must have been located at the edge of the area used by these farmers. Unfortunately, there are no archaeological remains of the people who caused this phase in northern Lower Saxony. Behre & Kučan (1994, 151) ascribe this phase to the pre-megalithic TRB, which is equivalent to the Danish Early Neolithic TRB. However, so far there is no evidence at all that this culture ever established itself in northwestern Germany and the northern Netherlands (LANTING & VAN DER PLICHT 1999/2000).
- Phase 2: 4450-? BP/3100-? cal BC, Middle Neolithic TRB Culture.
  Very suddenly, the leaf-fodder economy was replaced by a new type of economy: the *landnam* phase as described by Iversen (see II.1.2). This phase also is most clearly observed in diagrams of the western part of the *Siedlungskammer* (Swienskuhle, Jagen 20). Evidently, at this time the most important settlements must have been located here. However, up till now these have not been found. This phase is characterized by a strong decrease of *Tilia* and *Quercus*, and by high values of Gramineae and the culture-indicator types. Cultivation of crops must have taken place in the direct vicinity of especially Swienskuhle. The forests were opened up on a large scale, especially for woodland grazing; here, there are no indications of clearance by burning. The curves of *Plantago lanceolata* and Cerealia follow more or less the same course, which suggests that *Plantago lanceolata* is an indicator for crop cultivation (BEHRE 1981; BEHRE & KUČAN 1994, 149). During this phase, the values of the culture-indicator types in the various diagrams are fairly constant: probably the fields were not shifted much, perhaps they were even more or less permanent. At the end of this phase, a regeneration of the *Quercus* forests is observed; *Fagus* partly took the place of *Tilia* in these forests. The *Tilia* decline, which marks the beginning of this phase, does not occur synchronously at various locations. In the *Siedlungskammer* Flögeln it occurs between 4650 and 4150 BP; at other locations in northwestern Germany, it occurs between 4700 and 3700 BP (BEHRE & KUČAN 1994, 150). The duration of the Iversen *landnam* phase varies in the various diagrams of *Siedlungskammer* Flögeln, but it can last more than 1000 years; sometimes it reaches into the Bronze Age. Clearly, no shifting of the settlement took place (BEHRE & KUČAN 1994, 151). The Iversen *landnam* phase can be clearly connected with the Middle Neolithic TRB Culture. By comparing their dates for the beginning of this phase with dates from Denmark (MADSEN 1990) and the Netherlands (VAN ZEIST 1959; 1967), Behre & Kučan (1994) conclude that this type of economy developed in Denmark (earliest date: 4800 BP/3500 cal BC) and spread from there to the west. In the *Siedlungskammer*, apart from several megalithic tombs, also three houses of the TRB culture were excavated (ZIMMERMANN 1980). However, the sequences located nearest to these houses (Flögeln V, Fuhrenkamp) do not show a very clear *landnam* phase.

It has to be remarked that the situation in the *Siedlungskammer* Flögeln closely resembles the situation in Drenthe: both are Pleistocene areas with predominantly poor sandy soils, bordered by large raised bogs, located not far from the coast; in both areas, many small circular depressions are found, formed during the Saalian or Weichselian Ice Ages; in both areas, the same archaeological cultures are found. For these reasons, a model which describes the Neolithic as represented in pollen diagrams in Drenthe may be also valid for northwestern Germany.

Herrenhof (Lower Saxony)

Dörfler (1989) analyzed a pollen sequence from the small peat bog Herrenhof in the centre of the Elbe-Weser triangle (northern Lower Saxony). The diameter of the bog is ca. 70 m, while the infill reaches a maximum depth of 9.20 m. The zone representing the Neolithic occurs in *Sphagnum/ Equisetum* peat. In earlier times, a rampart surrounded the bog, which indicates that it is most probably a pingo scar.

At 656 cm, a decline of *Ulmus* is observed; *Tilia* and *Quercus* reach relatively high values; *Plantago lanceolata* appears for the first time (date of 677-667 cm: 4870 ± 80 BP [KI-2727.672]). Cerealia-type pollen is first found at a depth of 612 cm. Around 606 cm, *Tilia* decreases strongly, while *Plantago lanceolata, Rumex acetosa/acetosella,* Cerealia-type and Gramineae increase considerably (date of 610-600 cm: 4670 ± 90 BP [KI-2727.605]). However, already at 592 cm, these types decrease again. From 560 cm upwards, *Tilia* reaches the same values as before its decrease of 612-600 cm, pointing to an almost complete regeneration of this tree in the forests in the neighbourhood. *Corylus* reaches relatively high values. The culture-indicator types are almost absent in this phase, while Gramineae remain more or less constant.

The *Ulmus* decline at 656 cm is only very weak in Herrenhof. For this reason, Dörfler does not think that this decline was caused by human intervention in the vegetation. He sees no evidence of an occupation phase as described by Troels-Smith for Denmark and Switzerland. The *Tilia* decline around 606 cm is clearly caused by human intervention. Because *Tilia* grows on the better soils, clearance of these areas for agriculture is a good explanation for the abrupt decline of its values. Leaf foddering to livestock is another explanation. Dörfler did not find any evidence of clearance by burning in this phase. Apart from the absence of evidence for burning, the phase between 606 and 568 cm in the Herrenhof diagram resembles the occupation phase described by Iversen for Denmark (DÖRFLER 1989, 37). At a distance of 4.5 km from the Herrenhof bog, megalithic tombs from TRB times occur, pointing to the presence of TRB people in the area.

Hüde (Lake Dümmer)

The area around Lake Dümmer in southern Lower Saxony was inhabited intensively in the Mesolithic as well as the Neolithic. The most important findspot in the area is Hüde I. This site, which was excavated between 1961 and 1967, is situated at the southern edge of the lake, directly east of the place where the river Hunte enters the lake. In the Neolithic, the findspot was surrounded by watercourses, reed and sedge swamps and carr forests (SCHÜTRUMPF 1988). Because the Hüde pottery has many characteristics in common with Swifterbant pottery, it seems justified to classify Swifterbant and Hüde pottery in one supra-regional group: the Hüde-Swifterbant Group (TEN ANSCHER, cited in GEHASSE 1995, 199). The zonation of Hüde I is problematic, because of disturbances in the cultural layers and the occurrence of very gradual transitions in the pottery characteristics (TEN ANSCHER, cited in GEHASSE 1995). Still, Kampffmeyer (1988, 241; 284; Abb. 250; see also STAPEL 1991, 15 for a more or less comparable division) distinguished four occupation phases:

1. Hüde-Swifterbant horizon (6100-5900 BP); pottery characterized by Ertebølle/Ellerbek elements and Rössen imports; separated by a hiatus from the next horizon; this phase can be correlated with phase SW-1 of the Swifterbant Culture (GEHASSE 1995, 210; see III.7.3);
2. Rössen-Bischheim horizon (5600-5500 BP); the most intensive habitation occurred in this period; finds of Rössen pottery and Bischheim variants; gradually transforming into the next horizon;
3. early TRB horizon (5500-5200 BP); earliest and early TRB pottery (of Rosenhof and Satrup type); according to Lanting & Van der Plicht (1999/2000), Kampffmeyer's "Early Neolithic TRB pottery" is in fact Swifterbant pottery; this horizon transforms with an interruption into the next horizon; phases 2 and 3 together can be correlated with phases SW-2/3/4 of the Swifterbant Culture (GEHASSE 1995, 210; see III.7.3);
4. TRB West Group (Middle Neolithic) horizon (4950-4750 BP); Drouwen A-C pottery.

Kampffmeyer rejects dates based on charred food remains, since the content of a pot may be considerably younger than the pot itself. By eliminating these dates, he is able to distinguish the above-mentioned four occupation phases, the first and the last of which are separated by hiatuses from the second and third occupation phases. However, even if a ^{14}C date is not related to the manufacture of a specific pot, the date is still an indication of activity at a certain time and therefore may bridge a presumed hiatus. As a result, Raemaekers (1999, 73) does not consider Kampffmeyer's hiatuses as relevant. With the chronological resolution provided by the pottery and ^{14}C dates, no gaps in the occupation history need be postulated. According to Raemaekers (1999, 74), this means that the potential of the Hüde I site in establishing rather than illustrating developments in subsistence and material culture is limited. The ^{14}C dates of Hüde I were examined critically by Lanting & Van der Plicht (1999/2000). They reject most of the dates, for differing reasons. Finally, only 20 Neolithic dates seem to be reliable. These dates can be divided into three groups: two of 5875 ± 100 and 5860 ± 70 BP, fourteen between 5615 ± 95 and 5170 ± 90 BP and four between 4920 ± 100 and 4735 ± 75 BP. According to Lanting & Van der Plicht (1999/2000), there is a possibility that these three phases represent three settlement phases of the Swifterbant Culture: the Early, Middle and Late Phases. In Kampffmeyer's phase 2, impressions of cereal grains in sherds and quernstones have been found. According to Kampffmeyer (1988), these finds only indicate that the inhabitants of that period had cereals at their disposal, but they do not demonstrate the cultivation of cereals. Given the wet local environment, any cultivation of cereals on the site is unlikely. Because of the large numbers of bones of hunted deer, fishes and birds, the absence of local cereal cultivation, the wet conditions and the relatively small horizontal distribution of finds, phases 2-4 of Hüde I are interpreted as a hunting camp which was used repeatedly, and which was visited in late summer and autumn. However, there are some indications that the camp may sometimes have been used in winter.

A palynological study of Hüde was published by Schütrumpf (1988). The most important event, which can be recognized in almost all Hüde diagrams, is the *Ulmus* decline. On the basis of analysis of pollen spectra associated with archaeological finds from known periods, Schütrumpf concludes that this decline occurs between the "cultural horizons" K_2 (which comprises the above-mentioned phases 2 and 3) and K_1 (which comprises the above-mentioned phase 4). Schütrumpf (1988, 19) mentions a ^{14}C date of 5300 ± 165 BP for the K_2 horizon. On the basis of this date, Kampffmeyer (1988, 328) estimates the *Ulmus* decline to have taken place between 5300 and 5100 BP. When the data of Schütrumpf and Kampffmeyer are combined, the conclusion has to be drawn that the early TRB horizon (the above-mentioned phase 3) already occurs before the *Ulmus* decline.

In several diagrams, pollen grains of *Plantago lanceolata* are found before the *Ulmus* decline (SCHÜTRUMPF 1988, Abb. 4; 7; 9; 11; 12); in one small diagram (SCHÜTRUMPF 1988, Abb. 7), a few grains of Cerealia are found before the *Ulmus* decline. Nowhere is an increase of Gramineae observed. After the *Ulmus* decline, the situation does not change very much: still, the culture-indicator types are observed very sporadically or not at all. To my mind, this observation confirms that Hüde was inhabited only seasonally, because the inhabitants of a seasonal camp leave fewer traces in the landscape than inhabitants of permanent settlements.

II.2.7 The low-lying parts of the Netherlands

Farmsum (province of Groningen)

Jelgersma (1960) analyzed pollen sequences from the so-called basal peat layer between Meedhuizen and Farmsum, just south of Delfzijl. According to ^{14}C dates, the basal peat layer in this area was formed on the Pleistocene sands between the Middle Atlantic and the Late Subboreal. In the Subatlantic, a transgression ended the peat growth and effected the sedimentation of a thick layer of clay. At the time of Jelgersma's study, almost nothing was known about Neolithic habitation of this area. In the 1980s, during the excavation of the *terp* of Heveskesklooster, which is located a few kilometres from the core locations of the pollen sequences, a megalithic tomb and a stone cist from the Funnel Beaker Culture (TRB) were discovered in the Pleistocene subsoil (BOERSMA 1988; J.A. BAKKER 1992; CAPPERS 1994). Apparently, the TRB people inhabited the small sandy outcrops between Groningen and Delfzijl, even in the time when as a result of a rising sea level and water table, the largest part of this area became overgrown by peat.

In Jelgersma's pollen diagrams, no real occupation phases can be recognized. In diagram Farmsum A, Cerealia-type is found near a ^{14}C date of 4995 ± 120 BP [GRO-655]; in diagram Farmsum B, *Plantago lanceolata* is found at a ^{14}C date of 5250 ± 170 BP [GRO-637]. (The original GRO-dates were corrected by the Centre for Isotope Research of the University of Groningen, see VOGEL & WATERBOLK 1963.) In the diagrams Farmsum A and B, an *Ulmus* decline is observed around 5000 BP. In diagram Farmsum A, a continuous curve of *Plantago lanceolata* occurs from ca. 4250 BP upwards. Possibly, the sporadic early finds of Cerealia-type and *Plantago*

lanceolata pollen point to the presence of people of the Swifterbant Culture in the Delfzijl area. No archaeological remains of this culture are known from this area.
Recent excavations in the Wetsingermaar, ca. 10 km north of the city of Groningen, have revealed not only TRB sherds but possibly also sherds of the Late Phase of the Swifterbant Culture (FEIKEN et al. 2001). Charcoal from the occupation layer was dated 4700 ± 40 BP [GrA-16659] (ca. 3500 cal BC). This suggests that Swifterbant people were also present in the coastal areas of the northern Netherlands.

Schokland (province of Flevoland)
During excavations at site P14, situated near the former island of Schokland in the present-day Noordoostpolder, several pollen sequences were sampled (GEHASSE 1995, 6-7). The findspot lies on the edge of a till ridge, covered by sand, and directly adjacent to a former course of the river Vecht. The site was inhabited between 4900 and 1700 cal BC by people of, successively, the Swifterbant Culture, the Funnel Beaker Culture (TRB), the Single Grave Culture (EGK), the Bell Beaker Culture (BB) and the Bronze Age. The pollen sequences were taken in clayey and peaty deposits on the flanks of the ridge.
No clear occupation phases can be distinguished in the pollen diagrams, although P14 is regarded as a permanent, year-round settlement (GEHASSE 1995, 271). Because in this area mixed oak forest was only present on the higher ridges, possible forest clearances must have taken place on a far smaller scale than in the Pleistocene sandy areas, which were for the larger part covered with mixed oak forests. Furthermore, the influence of local vegetation (alder carr, sedge marshes) is far more important here than in the Pleistocene sandy areas. Possibly, the local pollen partly obscures the effect of the first agricultural activities on the pollen picture. However, the frequent occurrence of Cerealia-type pollen even before 3700 cal BC (for example in phase sp200 of diagram wp89-17 (GEHASSE 1995, diagram II)) demonstrates that the people of at least the Late Phase of the Swifterbant Culture cultivated cereals locally.

Swifterbant (province of Flevoland)
Near Swifterbant, in the East Flevoland polder, Mesolithic and early Neolithic dwelling-places were excavated in the 1970s. The culture responsible for the early Neolithic occupation layers was named after this site: the Swifterbant Culture (see III.7.3). Near the site, there are a few peat deposits, which were used for the coring of pollen sequences (CASPARIE et al. 1977). The sequence H 46 was sampled in a dammed-up gully, 4 km east of site S_3; the sequence G 43 was sampled in the upper part of a filled-up creek, site S_5, next to S_3. The base of the peat layer of H 46 was dated to 5610 ± 60 BP [GrN-5067]; the base of the peat layer of G 43 was dated to 4955 ± 35 BP [GrN-7505]. This indicates that most of the peat formation at H 46 took place shortly before the occupation of the site S_3 (dated about 5300 BP), whereas the peat deposition at G 43 must be dated some time after the Neolithic habitation (CASPARIE et al. 1977, 30). No effects of agricultural activities can be traced in either of the pollen diagrams: no culture-indicator types are found. Nor is any decline of *Ulmus* observed around 5000 BP. The values of *Ulmus* in both diagrams are always below 5%. The conclusion must be that the scale of any agricultural activities in the neighbourhood of the sites of the Swifterbant Culture was too small for detection in the pollen diagrams. Furthermore, possible traces of agriculture in the pollen diagrams may have been obscured by large quantities of local pollen from the nearby *Alnus* carr and sedge marshes.

Hazendonk (province of Zuid-Holland)
Louwe Kooijmans (1974) and Van der Wiel (1982) published pollen diagrams of core locations at the foot of the river dune Hazendonk near Molenaarsgraaf (province of Zuid-Holland). Between 5250 and 3650 BP/4200 and 2000 cal BC, human settlements were repeatedly established on the Hazendonk, the river dune being one of the few dry places in a marshy river valley. Louwe Kooijmans distinguishes several phases of anthropogenic influence. In phase HAZ-1 (pollen zone 2), dated ca. 5300 BP [GrN-6215], one Cerealia grain was found, while *Plantago lanceolata* appears for the first time. It is believed that in this zone occupation at some distance is reflected. Louwe Kooijmans assumed that the activities in this zone were attributable to a culture related to the Swifterbant Culture. Later on, phase HAZ-1 was found to be contemporary and strongly related to phase SW-3 of the Swifterbant Culture (GEHASSE 1995, 202; see III.7.3).
In phase HAZ-3 (pollen zone 3), dated ca. 4900 BP [GrN-6214], pollen of *Plantago lanceolata* and Cerealia is present in very low values; *Urtica* and *Artemisia* reach high values; *Quercus* and *Fraxinus* decrease. According to Louwe Kooijmans, this proves occupation in the immediate vicinity of

the core location of the diagram. In Van der Wiel's opinion, the beginning of the HAZ-3 phase coincides with the Atlantic-Subboreal transition and is defined by a *Tilia* fall. Van der Wiel remarks that in the western Netherlands, this transition is seldom characterized by an *Ulmus* decline. At the time of Louwe Kooijmans' publication (1974), no comparable archaeological finds were known from that period; he labels this phase as the "Hazendonk pottery" phase. In later times, it was discovered that the HAZ-2 and HAZ-3 phases form a northwestern outlier of the Michelsberg Culture (LOUWE KOOIJMANS 1998). Above the HAZ phases, a cultural phase occurs attributable to the Vlaardingen Culture, VL-1b (dated ca. 4500 BP [GrN-5175,GrN-6213]). Still, the culture-indicator types do not reach very high values. The Vlaardingen Culture, which is found in the Holocene delta and the higher sandy regions south of the large rivers between ca. 4700 and 4100 BP (see VAN REGTEREN ALTENA et al. 1963), is more or less contemporary with the Funnel Beaker Culture in the northern and central Netherlands.

II.2.8 The southern Netherlands

The Peel raised bogs (province of Noord-Brabant)

Janssen & Ten Hove (1971) studied three cores from the Peel bogs, a large raised bog complex in southeastern Noord-Brabant, comparable to the Bourtanger Moor in the northern Netherlands. They located the Atlantic-Subboreal transition at a minimum of the *Ulmus* curve; at this level, *Plantago lanceolata* and Cerealia appear, while *Pteridium* rises. A ^{14}C date of the *Pteridium* maximum, which occurs just above the first appearance of *Plantago lanceolata*, is 4510 ± 85 BP [GrN-5619]. *Ulmus* thus starts to decline even before that date. Janssen & Ten Hove conclude from this that this decline of *Ulmus* may not be connected with human interference. In the Subboreal, the *Ulmus* curve shows three maxima. There is a correlation between *Pteridium-Rumex acetosella* (sic)-Cerealia and *Ulmus*; however, there is no correlation between *Plantago lanceolata* and *Ulmus*; *Plantago lanceolata* remains low throughout the Subboreal. Janssen & Ten Hove conclude that apparently three land-occupation phases are connected with a decline of *Ulmus* (or two in the case of an overlap, because a ^{14}C date just above the second *Ulmus* decline yielded a result of 4470 ± 30 BP [GrN-5163]). The low *Plantago lanceolata* values suggest a type of occupation phase as described by Troels-Smith. According to Janssen & Ten Hove, these low *Plantago lanceolata* values in the Subboreal are also found in small bogs in brook valleys west of the Peel region and in adjacent Belgium and Germany. A striking feature in the diagrams of Janssen & Ten Hove is that after the first land occupation phase, there is almost complete regeneration of *Ulmus*. The *Fraxinus* and *Tilia* curves display a faintly similar trend to the *Ulmus* curve. This may indicate a connection with the land-occupation phases. *Corylus* reaches relatively high values in the Subboreal. Generally *Corylus* rises markedly in pollen diagrams that show land-occupation phases of the Iversen type. Shifting agriculture, responsible for the Iversen type of *landnam*, apparently was not practised during the Subboreal in Brabant. One would therefore expect smaller percentages of *Corylus* (JANSSEN & TEN HOVE 1971, 49). The date of ca. 4500 BP for the first occupation phase most probably points to the Stein Group, which is strongly related to the Vlaardingen Culture. The second occupation phase is probably attributable to the Single Grave Culture (EGK); the third one falls in the Bronze Age (JOOSTEN & BAKKER 1987, 25).
Evidently, the occupation phases caused by the Vlaardingen Culture in pollen diagrams of the Pleistocene sandy areas south of the large rivers as well as the low western part of the Netherlands, are of the Troels-Smith type. This is in contrast with the occupation phases from roughly the same period attributed to the Funnel Beaker Culture in pollen diagrams of the Pleistocene sandy areas in the northern and central Netherlands, which are of the Iversen type.

II.2.9 Northeastern Germany

Siggeneben-Süd (Schleswig-Holstein)

Kalis & Meurers-Balke (1998) published a pollen diagram of the archaeological findspot Siggeneben-Süd, in the Dahmer Bucht, part of the Baltic area. In this area, which is near the probable area of origin of the Funnel Beaker Culture (see MIDGLEY 1992, fig. 10), there is an opportunity to study occupation phases associated with very early TRB groups. However, it has to be emphasized that the landscape differs completely from that in the northern Netherlands and northwestern Germany: the soils are richer, there is more relief and the climate is more continental.
In the Siggeneben-Süd diagram, which originates

from marine gyttja sediments, the late Atlantic and early Subboreal are well-represented. Kalis & Meurers-Balke connected events in the pollen diagram with subsequent Neolithic cultures which resided in the area, on the basis of pollen spectra associated with archaeological finds from Siggeneben-Süd and its direct vicinity (see MEURERS-BALKE 1983). In accordance with their regional *landnam* model for the western Baltic area (see II.1.6), Kalis & Meurers-Balke (1998) distinguished the following occupation phases. I have added new data and ^{14}C dates from Hartz et al. (2000) and Kalis & Meurers-Balke (2001):

- Troels-Smith-PREFACT phase A: 217.5-162.5 cm: Ellerbek Group (Ertebølle/Ellerbek Culture: 5100-4100 cal BC).
  Quercus and *Tilia* decrease, while *Corylus* and the NAP (especially *Artemisia* and *Pteridium*) increase; *Plantago major*, *Rumex* and Cerealia occur sporadically. At the neighbouring findspot Rosenhof, early Cerealia grains in a horizon with comparable pollen spectra were dated to 5780 ± 60 BP.
- Troels-Smith-PREFACT phase B: 162.5-149 cm: Ellerbek Group (Ertebølle/Ellerbek Culture).
  Fraxinus reaches high values; *Quercus* increases; grains of Cerealia are found more frequently.
- Iversen-PREFACT phase 1a: 149-141 cm: Rosenhof Group / Wangels Group (Early Neolithic Funnel Beaker Culture: 4100-3900 cal BC).
  A small decline of *Ulmus* is observed; *Corylus* reaches minimum values, while *Quercus* and *Pteridium* reach maximum values. *Plantago lanceolata* appears for the first time.
- Iversen-PREFACT phase 1b: 141-127.5 cm: Siggeneben Group (Early Neolithic Funnel Beaker Culture: 3900-3700 cal BC).
  Ulmus and *Fraxinus* decrease considerably, *Betula*, *Corylus* and *Alnus* increase; sporadic occurrence of the culture-indicator types.
- Iversen-PREFACT phase 2a: 127.5-107.5 cm: Satrup Group (Early Neolithic Funnel Beaker Culture: 3700-3400 cal BC).
  Tilia, *Quercus* and *Fraxinus* decrease markedly; *Corylus* and *Alnus* increase, while *Betula* reaches maximum values. *Plantago lanceolata* increases (but the percentage is still less than 1%) and forms a continuous curve.
- Iversen-PREFACT phase 2b: 107.5-77.5 cm: Middle Neolithic Funnel Beaker Culture II-IV (3400-3150 cal BC).
  Alnus reaches maximum values; *Quercus*, *Corylus* and *Betula* decrease; the culture-indicator types increase.
- Iversen-PREFACT phase 3a: 77.5-47.5 cm: later Middle Neolithic Funnel Beaker Culture (3150-2900 cal BC).
  Corylus reaches maximum values; *Quercus* and *Betula* reach minimum values. Cerealia reach their highest values in the diagram.
- Iversen-PREFACT phase 3b: 47.5-20 cm: end phase of Middle Neolithic Funnel Beaker Culture (from 2900 cal BC).
  Quercus and *Fraxinus* increase, while *Corylus* and the culture-indicator types decrease.

According to the pollen picture, the people of the Ertebølle/Ellerbek Culture had an economic strategy which was oriented towards large mammals (domesticated and/or wild): they created forest clearings of unknown size and used the leaves of especially *Ulmus* and *Fraxinus* as fodder. The Ertebølle/Ellerbek people must also have cultivated cereals: in eastern Holstein cereal pollen is found as early as around 5800 BP/4700 cal BC, while in southern Sweden it is found only from 4200 cal BC onwards. The pollen picture of the Ertebølle/Ellerbek Culture very much resembles that of the Rössen Culture, which was present on the loess soils between 4700 and 4300 cal BC (KALIS & MEURERS-BALKE 1988; see II.5). Connections between the two cultures are also visible in the archaeological material: the *durchlochten Breitkeile* (perforated wedges), which are adzes produced by the Rössen Culture, were found in Ertebølle/Ellerbek layers during the excavation at Rosenhof (KALIS & MEURERS-BALKE 1998, 20). In Drenthe also, several specimens of *durchlochten Breitkeile* have been found (see III.7.3). Possibly, the resemblance between the pollen pictures of the two cultures points to similar forms of agricultural economy.

With the beginning of the earliest Funnel Beaker Culture (Rosenhof Group), the relationship between man and his environment was modified: the extensive, anthropo-zoogenic use of the forest by the Ertebølle/Ellerbek people seems to be replaced by a more intensive use of certain parts of the landscape. People of the Siggeneben Group were the first to use burning to clear the forest: this is documented by high values of *Betula*, *Pteridium* and charcoal in this period (see II.1.2). The burnt areas were used to cultivate cereals and to keep livestock. Compared to the preceding period, cereal cultivation was not expanded. During the next period, when people of the Satrup and Fuchsberg Groups resided in the area, much of the natural forests with predominantly

Tilia disappeared, and were replaced by open forests with predominantly *Betula*. The use of fire was still an important method for creating open spaces. In the open forests, *Plantago lanceolata* could establish itself permanently. However, the indicators for cereal cultivation still did not increase. This seems to indicate that the newly cleared areas were predominantly used for the keeping of livestock. In this period, man for the first time changed the natural landscape on a large scale, to create completely artificial fields. In fact, the cultural landscape originates from this time (KALIS & MEURERS-BALKE 1998, 19). The cultural landscape in the next period, when people of the Middle Neolithic Funnel Beaker Culture resided in the area, was dominated by *Corylus* and *Alnus*. The role of forest burning was still important in this period. The decrease of *Pteridium* and the increase of the culture-indicator types indicate that the intervals between the fires must have been longer than in the preceding period. Given the higher values of Cerealia, the role of cereal cultivation has become more important. Kalis & Meurers-Balke conclude that the Iversen *landnam* is a more than regional phenomenon in vegetation history, which can be observed in the entire young-moraine area of the western Baltic (see II.1.6).

II.2.10 Southern Sweden

In Sweden, many palynologists have studied the problem of the beginning of agriculture in their country. Here the extensive studies by Göransson (1988a, 1988b) and Berglund (1991) will be discussed briefly. Göransson studied a series of sequences from marshes in the neighbourhood of the Alvastra pile dwelling (province of Östergötland, central Sweden) (GÖRANSSON 1988a) and sequences from the former Skateholm lagoon (province of Scania, southern Sweden) (GÖRANSSON 1988b). An impressive study edited by Berglund (1991) gives a very good description of the development of the cultural landscape in the Ystad area (province of Scania, southern Sweden), including several pollen diagrams and maps with all known archaeological finds of the area. Both Göransson and Berglund distinguish three cultural phases before the Bronze Age:

- Phase I: Mesolithic Time (MT), before 5100 BP, Ertebølle Culture?
  In this phase, the forests on high ground were dominated by *Tilia*, while *Ulmus* occurred on the moister soils; Göransson (1988a, 48) found relatively high values of charcoal and *Pteridium*, which possibly point to clearance fires. In his opinion, the Mesolithic forests were already exploited by man: by a combination of burning and girdling of trees, small clearings were created, which were used for a kind of garden cultivation of cereals. Göransson bases this conclusion on his finds of two pollen grains of *Triticum*-type in the Dags Mosse diagram (Alvastra), which were dated ca. 5400 BP (GÖRANSSON 1988a, 85). In the diagram of Kragehölmssjön (Ystad area), also Cerealia pollen grains were found in this phase: one *Hordeum*-type grain and one *Triticum*-type grain (BERGLUND 1991, 223). In the diagram of Kurarp (also Ystad area), Kolstrup (1990) found a few grains of *Plantago lanceolata* and *P. major/media* in this phase. In her opinion, this points to grazing, trampling and/or woodland clearance (KOLSTRUP 1990, 253). According to Göransson (1988a, 49), burning and girdling also created patches of coppice wood in this phase. Archaeological evidence to the effect that cereals were known during the late Atlantic period is provided by impressions in sherds from the Löddesborg site in western Scania (BERGLUND 1991, 315).
- Phase II: Early Neolithic (EN), 5100-4500 BP, Early Neolithic TRB Culture: "Early Neolithic Destruction Phase" (GÖRANSSON 1988a, 53); Landnam phase (GÖRANSSON 1988a, 48).
  This phase is characterized by low values of *Ulmus*, *Tilia* and *Fraxinus*, and increasing values of *Betula*, *Corylus* and charcoal. This indicates that the forests became more open; probably they were partly transformed into open scrubland because of several interacting factors. According to Göransson (1988a, 49), these factors may have been both abiotic (e.g. climate), and/or biotic (e.g. disease combined with browsing). In this phase, no greater amount of Cerealia pollen is found than in the preceding phase. From this, Göransson concludes that no expansion of cultivation took place in the Early Neolithic. Possibly the most important form of livelihood was animal husbandry, although in most diagrams the Gramineae do not increase in this phase, while *Plantago lanceolata* and *Rumex* only occur sporadically. The high values of *Betula* and charcoal indicate that forest fires (clearance fires or

natural fires) were very characteristic of this phase. However, according to Berglund (1991, 168), the slash-and-burn technique was certainly not necessary for the cultivation of cereals during the Early Neolithic. The nutrient-rich soils of the south Swedish deciduous forests of the late Atlantic were of sufficient quality for early agriculture. For this reason, Berglund (1991, 168) rejects the *landnam* hypothesis as described by Iversen, involving slash-and-burn cultivation (see II.1.2). As an alternative, he proposes a system of cereal cultivation in small "wandering arable fields" in *Corylus* coppice woods. These differ from shifting arable fields in that they do not involve burn-beating.

The most conspicuous archaeological remains from this period are the huge numbers of dolmens in (adjacent) eastern Denmark (GÖRANSSON 1988b, 32). The oldest Neolithic phase in the Ystad area is characterized by a local group, the Mossby Group, which was named after a site at Mossby. At this site, which was dated around 5100 BP, also a house plan was excavated (BERGLUND 1991, 316). We are here dealing with one of the oldest sites of the TRB Culture in Scandinavia.

- Phase III: Middle Neolithic (MN), 4500-3800 BP, Middle Neolithic TRB Culture: Regeneration Phase (Alvastra Phase).

This phase is characterized by a regeneration of the forests with *Tilia*, *Ulmus* and *Quercus*; however, the curves of *Plantago lanceolata* and Cerealia do not decrease. According to Berglund (1991, 69-70) the woodland regeneration was caused by natural recovery after the earlier deforestation crisis on the one hand, and decreased human impact in inland woodland on the other. The concentration of settlement on the coast, however, meant a locally intensified human impact during this same time. According to Göransson (1988b, 32), no regression in the cultivation occurred in this phase, but the forests were utilized in a more efficient way than during the preceding period: the forest farmer transformed the regenerating forests into coppice woods, but now on a larger scale than in Phase I. The coppice wood was used as an important source of winter fodder for the livestock. As Göransson (1988a, 73) demonstrated, the wood of the Alvastra pile dwelling, which was built during this phase, originates from stumps. This proves the presence of coppice-wood groves in this period.

Many archaeological remains are known from this phase. The most impressive remains are passage graves, which are known from Scania, including the Ystad area, as well as the Falbygden area in Västergötland (GÖRANSSON 1988b, 32). Furthermore, the first signs of the ard plough begin to emerge in this phase (BERGLUND 1991, 320).

The palynological evidence for early agriculture in Sweden can be summarized in a simplified way as follows: in the Mesolithic Time (Phase I), there are very weak indications for cereal cultivation as well as animal husbandry; in the Early Neolithic (Phase II), compared to the preceding period, only an increase in animal husbandry occurred, but no increase in cereal cultivation; in the Middle Neolithic (Phase III), compared to the preceding period, only an increase in cereal cultivation occurred, but no increase in animal husbandry.

One may try to incorporate the above-mentioned phases into the regional *landnam* model for the western Baltic area (see II.1.6). The Swedish Phase I can be correlated with the Troels-Smith-PREFACT phase A. In the Swedish diagrams, the pronounced *Ulmus* decline occurring at the beginning of Phase II seems to coincide with an occupation phase which can be related to the occupation phase described by Iversen for Denmark, although Göransson and Berglund explain the pollen picture in a different way to Iversen. Apparently, Troels-Smith-PREFACT phase B and Iversen-PREFACT phase 1a are not present in the Swedish diagrams. The Swedish Phase II can be correlated with the Iversen-PREFACT phases 1b and 2; the Swedish Phase III can be correlated with the Iversen-PREFACT phase 3.

II.2.11 The British Isles

Ireland

Since the early investigations by Jessen (1949), many studies have been dedicated to the beginning of agriculture in Ireland. The early work of Mitchell (1956) especially deserves mention. He studied fifteen raised bogs in central and eastern Ireland. He was one of the first researchers who subdivided the Subboreal into several occupation phases and who attempted to connect these phases with Neolithic cultures. Mitchell's work was followed by important studies by Morrison (1959) and Smith (1964) on the same subject. Here these early studies will be briefly discussed, completed with information from more recent studies by Hirons & Edwards (1986), who examined pollen from four sites in Co. Tyrone, northern Ireland, and Molloy & O'Connell (1991) who analyzed pollen from Lough Sheeauns, a small lake in Connemara, Co. Galway, western Ireland.

Mitchell (1956) distinguished three phases of human activity in the late Atlantic and early Subboreal. These three phases can be found in many Irish pollen diagrams:

- Phase I: Late Atlantic, until ca. 5100 BP:
  Long before the classic *Ulmus* decline, the first indications for agriculture occur: grains of *Plantago lanceolata* and *P. major* were found in this phase by Mitchell (1956, 236) in his diagram of Leigh (Co. Tipperary), by Morrison (1959) and Smith (1964) in pollen diagrams of locations in northern Ireland, by Hirons and Edwards (1986) and by Molloy and O'Connell (1991). Hirons and Edwards (1986) found Cerealia pollen at a level 365 ^{14}C years prior to the classic *Ulmus* decline; Molloy and O'Connell recorded Cerealia pollen grains in spectra 3 and 5 cm below the classic *Ulmus* decline. Apparently, small woodland clearances were made to facilitate arable farming. The low values of Gramineae and *Plantago lanceolata* suggest that the openings in the wooded landscape were distinctly limited. Another possibility is that *Plantago lanceolata* at that time was primarily a coloniser of fallow ground rather than a pasture species (see GROENMAN-VAN WAATERINGE 1986). According to Morrison (1959, 190), this phase has affinities with the occupation phase described by Troels-Smith for Denmark. Groenman-van Waateringe (1983), who collected much evidence for agriculture before the classic *Ulmus* decline, states that it is incorrect to regard the *Ulmus* decline in Ireland as marking the start of farming activities. Owing to the mechanics of dispersal, the presence of the culture indicators is only seldom recorded. A direct consequence of the opening up of the forest due to the disappearance of *Ulmus* (most probably as a result of disease) is improved representation of low-growing herb pollen in the diagrams. Although the amount of pollen from arable and meadow vegetation has indeed increased in the deposit, the increase of this pollen at the same time as the *Ulmus* decline spuriously suggests an increase in agricultural activity (GROENMAN-VAN WAATERINGE 1983, 223).
  According to Mitchell (1956, 241), the agricultural activities described above may be attributable to people of the "Bann Culture". Nowadays, this "Bann Culture" is considered to be part of the late Mesolithic Larnian Phase.
- Phase II: Neolithic *landnam*/Iversen occupation phase, ca. 5100-4500 BP.
  The beginning of this phase is characterized by the start of a sustained fall in *Ulmus* pollen frequencies: this is the classic *Ulmus* decline. Mitchell locates the Atlantic-Subboreal transition at this *Ulmus* decline. In many Irish diagrams, simultaneously with the *Ulmus* decline (MITCHELL 1956) or a short time later (MOLLOY & O'CONNELL 1991) an occupation phase of the Iversen type is observed: *Plantago lanceolata* and Cerealia-type occur more regularly, Gramineae increase. According to Hirons & Edwards (1986, 145), the record at the *Ulmus* decline represents a radical change in the scale of farming: apparently the tree canopy was opened more extensively than before (cf. the above-cited quite opposite opinion of Groenman-van Waateringe (1983)). Hirons & Edwards (1986, 146) dated the periods of open canopy in this phase: they were open for periods of around 70 to 365 ^{14}C years. Hirons & Edwards suggest that the diagrams possibly represent a composite record produced by multiple events, each single *landnam* possibly lasting between 50 and 100 years, as suggested by Iversen (see GÖRANSSON 1988c, 34). At the end of this phase, an almost complete regeneration of *Ulmus* and also other trees occurs. Hirons & Edwards (1986) put the duration of the recovery of the *Ulmus* percentages at 150-560 ^{14}C years. During the regeneration phase, evidence for human activities, including possible cereal cultivation, remains present. An explanation for this could be that agriculture during and after *Ulmus* recovery continued at a similar intensity to that during the period of low *Ulmus* percentages.
  Pilcher et al. (1971; see also SMITH 1975) have ^{14}C-dated the three stages of the Iversen occupation phase at three sites in northeastern Ireland. Stage A is the "clearance and farming type 1" phase, characterized by increased amounts of Gramineae pollen and

sporadic occurrence of pollen of *Plantago lanceolata* and Cerealia; it seems likely that the emphasis was on arable agriculture. Stage B is the "farming type 2" phase, characterized by relatively high values of *Plantago lanceolata*, while Cerealia pollen is absent; emphasis seems to have shifted to pastoral farming. Stage C is the regeneration phase, characterized by increasing AP values. Pilcher et al. (1971) obtained the following durations of the stages at the three sites (the boundaries of the stages are dated from deposition-rate graphs and must not be taken as fixed points):

Ballynagilly, Co. Tyrone:
- Stage A 5200-4775 BP: 425 years
- Stage B 4775-4600 BP: 175 years
- Stage C 4600-4500 BP: 100 years
- Total duration of the Iversen occupation phase: 700 years

Beaghmore, Co. Tyrone:
- Stage A 5150-4850 BP: 300 years
- Stage B 4850-4700 BP: 150 years
- Stage C 4700-4650 BP: 50 years
- Total duration of the Iversen occupation phase: 500 years

Ballyscullion, Co. Antrim:
- Stage A 5050-4975 BP: 75 years
- Stage B 4975-4750 BP: 225 years
- Stage C 4750-4650 BP: 100 years
- Total duration of the Iversen occupation phase: 400 years

Molloy & O'Connell (1991) put the duration of the Iversen occupation phase at ca. 340 calendar years: an intensive part of 150 years and a less intensive part of 190 years.

Mitchell (1956) ascribed this phase to people of the Western Neolithic Culture. Molloy & O'Connell (1991, 104) connect this phase with several megalithic tombs found less than a kilometre from their core location, which were dated to the early Neolithic (5200-4500 BP, see HARBISON 1988, 51-52).

- Phase III: Late Neolithic/Early Bronze Age, after ca. 4500 BP.

  A second decline of *Ulmus* marks the beginning of this phase. This decline, which is dated 4500-4300 BP, is more or less similarly dated in Ireland and Britain (HIRONS & EDWARDS 1986, 149).

England

To a certain extent, the beginning of the Iversen occupation phase as reflected in English pollen diagrams resembles the same event in Irish diagrams. However, there are also some remarkable differences. On the basis of ten pollen sites in the Lake District (northwestern England), Pennington (1975) made a detailed study of the *Ulmus* decline and the Iversen occupation phase. In several diagrams, the presence of *Plantago lanceolata* and a small increase of Gramineae between 5700 and 5100 BP points to small forest clearings before the classic *Ulmus* decline. At all of Pennington's sites, there is evidence of increased run-off from the catchments and of a rising water table, coinciding almost exactly with the steep fall in *Ulmus* pollen. The *Ulmus* decline is observed also in absolute pollen diagrams, indicating that it is a real decrease. The presence of *Plantago lanceolata* at all sites in this period can be fairly reliably attributed to the presence of man, but the pollen evidence cannot indicate whether the *Ulmus* decline is a direct effect of a leaf-foddering economy (PENNINGTON 1975, 84). Following Pilcher et al. (1971), Pennington distinguishes three stages of cultural activity after the *Ulmus* decline: Stage A is the period of declining *Ulmus*; Stage B is the period of continuous *Plantago lanceolata*, and Stage C is the forest regeneration phase. At two sites, these phases were also ^{14}C-dated:

Blea Tarn:
- Stage A 5260-5050 BP: 210 years
- Stage B 5050-4750 BP: 300 years
- Stage C: no ^{14}C dates
- Total duration of the occupation phase: more than 500 years

Ennerdale:
- Stage A 5250-5100 BP: 150 years
- Stage B 5100-4900 BP: 200 years
- Stage C 4900-4800 BP: 100 years
- Total duration of the occupation phase: 450 years

In my opinion, it can be questioned whether the three stages of the Iversen occupation phase distinguished by Pilcher et al. (1971) in northern Ireland, can be correlated with the three stages distinguished by Pennington in northwestern England. As described above, in Ireland the *Ulmus* decline more or less coincides with the beginning of the Iversen occupation phase. An increase of indicators for pastoralism, especially Gramineae, points to an Iversen occupation phase (see II.1.2). However, Oldfield has demonstrated (1963, 28) that in northwestern England the *Ulmus* decline and the beginning of the Iversen occupation phase do not coincide, but are even separated by a short regeneration phase. During the *Ulmus* decline, there is no increase in

weed pollen percentages, and only in some diagrams an increase of Gramineae. Possibly, an occupation phase with affinity to that described by Troels-Smith for Denmark, which starts at or even before the *Ulmus* decline, precedes the Iversen occupation phase in northwestern England. Because Pennington's stage A starts at the *Ulmus* decline, it is possible that a "Troels-Smith occupation phase" forms the first part of this stage. There are indications for this in Pennington's pollen diagrams: in most of her diagrams, the Gramineae do not increase exactly at the level of the *Ulmus* decline, but only some time later (see for example PENNINGTON 1975, fig. 8).
Greig (1996) presents an overview of more than thirty pollen diagrams from all parts of England. Only at very few sites has he demonstrated possible evidence for early Neolithic activity before the *Ulmus* decline by changes in some pollen values, charred layers or isolated finds of Cerealia pollen grains (see also EDWARDS 1989). In England the classic *Ulmus* decline is dated between 5600 BP (southern England) and 4500 BP; most dates are around 5100-5000 BP. Evidence of human impact around the *Ulmus* decline is often rather slight, consisting of a decline in AP, particularly *Quercus* and *Tilia*, and involving only few culture-indicator types, like *Plantago lanceolata*, *Rumex* and *Artemisia*. Cerealia-type pollen at this point only appears in a few pollen diagrams. Cerealia-type records often seem to reflect the closeness of the pollen site to the occupied landscape (GREIG 1996, 71). At only three sites is a second *Ulmus* decline observed, but this second *Ulmus* decline is far less pronounced than in Ireland: after its initial fall, *Ulmus* never fully recovered.
In most English diagrams, also a clear decline of *Tilia* is observed. In most cases, this *Tilia* decline is associated with increases in frequencies of Gramineae, *Plantago lanceolata*, *Rumex* and *Pteridium*. According to Turner (1962, 338), it is quite clear that human interference in woodland was the immediate cause of the *Tilia* decline. Turner (1962, 339) summarized the (then available) ^{14}C dates of the *Tilia* decline: in southern England, it occurs in the Late Neolithic, between 4015 and 3920 BP; in central England, it occurs in the Middle/Late Bronze Age, between 3440 and 2971 BP. According to Turner, this shows that the *Tilia* decline was not a single synchronous event throughout Britain and must indeed be attributed to people of several prehistoric cultures. In the pollen sites discussed by Greig (1996), a *Tilia* decline sometimes occurs together with the classic (first) *Ulmus* decline, at ca. 5500-5000 BP, and sometimes at ca. 3800-3700 BP, where it seems to represent an extensive clearance phase in the Late Neolithic/Early Bronze Age (GREIG 1996, 69).

II.2.12 Synthesis

In the preceding sections, the Neolithic as it is observed in pollen diagrams of many different locations has been discussed. In most cases, several occupation phases could be observed in the Neolithic. When also ^{14}C dates were available, it was possible to connect these occupation phases with archaeological cultures.
In fig. 10, all dated occupation phases in pollen diagrams which have been discussed in the preceding sections are put together. Table 1 lists data of occupation phases in pollen diagrams of many of the locations discussed in the preceding sections. In both fig. 10 and table 1, a simplified picture of the various occupation phases is given: they are all reduced either to an occupation phase as first described by Iversen for Denmark (see II.1.2), or to an occupation phase as first described by Troels-Smith for Denmark and Switzerland (see II.1.3). Put in a simplified way, the Iversen occupation phase is characterized by a considerable reduction of tree pollen values and high values of *Plantago lanceolata*, *Rumex* and Gramineae, pointing to large-scale clearance, while the Troels-Smith occupation phase is characterized by a modest reduction of the tree pollen values and low values of *Plantago lanceolata*, *Rumex* and Gramineae, pointing to small-scale clearings. Of course it might be dangerous to use these simplified definitions: the models of Iversen and Troels-Smith were framed for the Danish young-moraine landscape, and it may not be appropriate to use them for other types of landscape and other archaeological cultures (KALIS & MEURERS-BALKE 1998, 5). Furthermore, not much is known about the factors which create an Iversen or a Troels-Smith occupation phase in pollen diagrams. It is assumed that the most important factor is the agricultural methods used by the archaeological culture concerned. However, also the type of the basin, the type of sediment in which the pollen occurs, the location within the basin and the distance from the core location to the ancient settlements or fields may have influenced the pollen picture of an occupation phase. Apart from the location within the basin, which in most studies is not indicated,

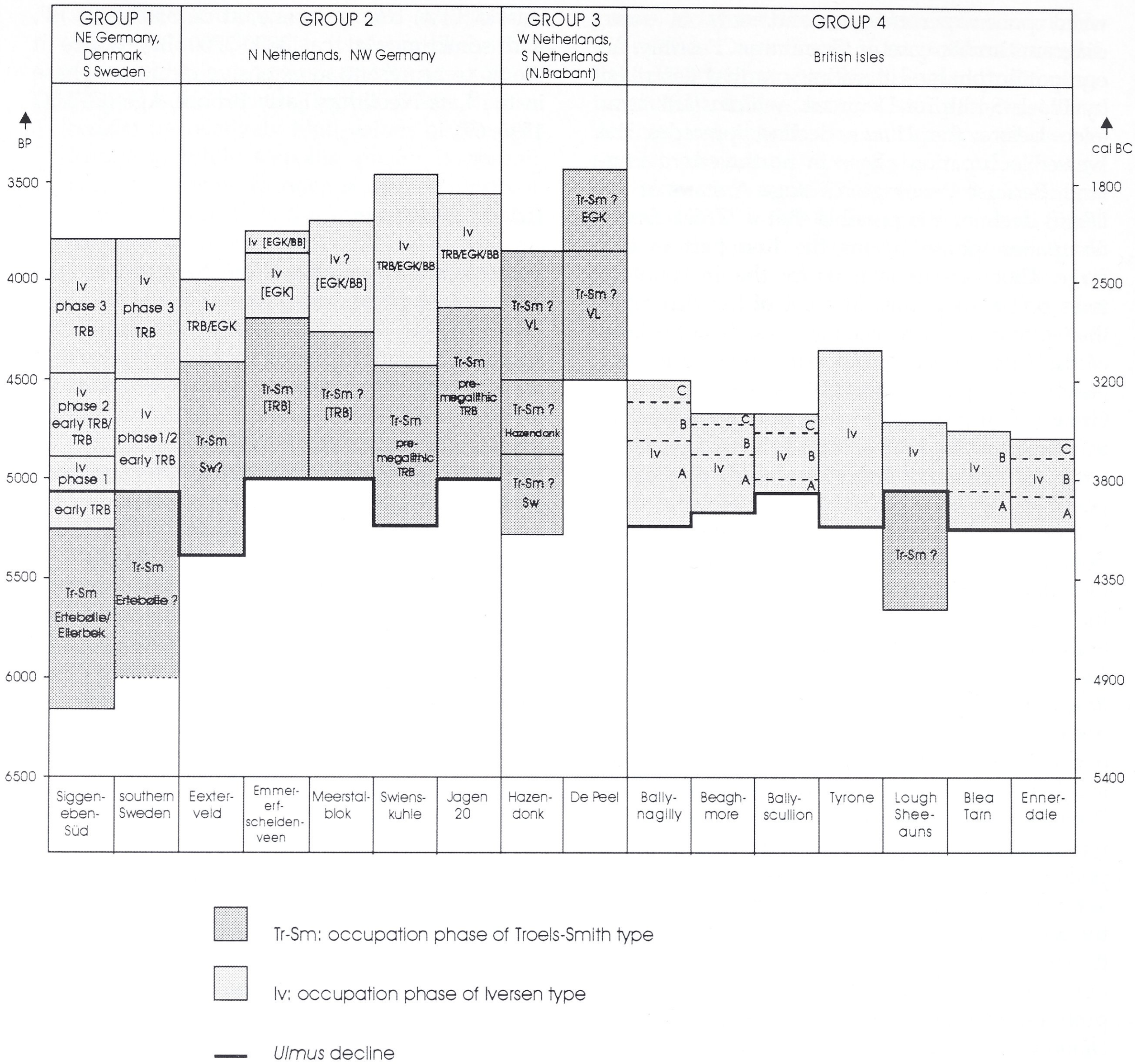

Fig. 10. Dated occupation phases of the Neolithic in pollen diagrams from various parts of Europe.

these factors are also mentioned in table 1. In spite of these objections, it does seem justified to use the above-mentioned simplified definitions, if only to obtain an overview of the global course of the Neolithic as observed in pollen diagrams from various areas. Because the classic *Ulmus* decline (see also II.3) seems in many cases connected with the beginning of occupation phases, this *Ulmus* decline (as far as it occurs in the pollen diagrams) is also shown in fig. 10.

On the basis of similarity of landscape, the discussed locations are divided into four groups, which feature in fig. 10 and table 1. On the map of fig. 11, the geographical position of each of these groups is indicated:

Group 1: areas near the coast of the western Baltic: northeastern Germany, Denmark, southern Sweden.

The classic *Ulmus* decline more or less coincides with the beginning of the Iversen occupation phase (5200-5100 BP); however, smaller declines of *Ulmus* are already detected from the beginning of the Troels-Smith occupation phase (ca. 6000 BP) onwards. A very

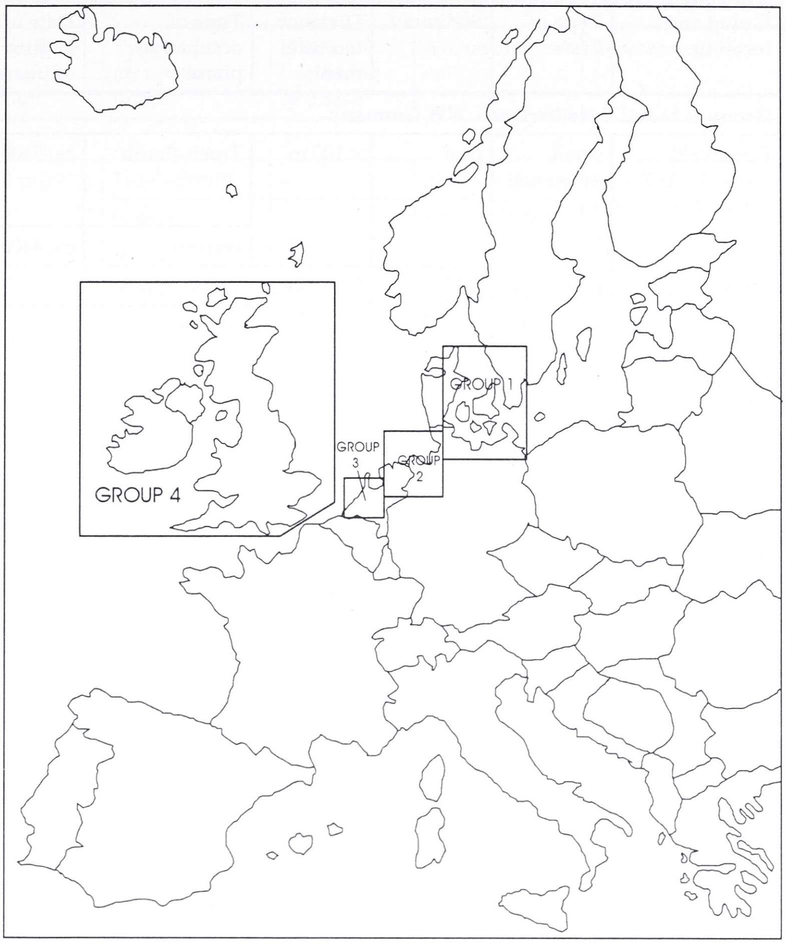

Fig. 11. Map of Europe indicating the various groups with approximately corresponding occupation phases in the Neolithic as represented in pollen diagrams (see fig. 10 and table 1).

good model describing the various Neolithic occupation phases in the western Baltic area has been constructed by Kalis & Meurers-Balke (1998, see II.1.6).

Group 2: Pleistocene areas near the North Sea coast: the northern and eastern Netherlands, northwestern Germany.

The *Ulmus* decline coincides with the beginning of the Troels-Smith occupation phase (5400-5000 BP). The Iversen occupation phase begins between 4700 and 4200 BP. Some authors connect the Troels-Smith occupation phase with the TRB Culture and the Iversen occupation phase with the EGK Culture, but in more recent publications, the Troels-Smith occupation phase is connected with the Swifterbant Culture or with the Early Neolithic TRB Culture, while the Iversen occupation phase is connected with the Middle Neolithic TRB Culture and subsequent cultures. Because the Gietsenveentje also belongs to this group, it is hoped that this problem will be resolved as a result of this study.

Group 3: the Holocene delta and the higher sandy grounds south of the large rivers in the Netherlands: western Netherlands, southern Netherlands (Noord-Brabant).

No clear *Ulmus* decline is observed in these areas. All occupation phases of the Neolithic have closest affinity with the Troels-Smith type; large-scale clearances do not occur before the Bronze Age.

Group 4: the British Isles (Ireland and England).

The classic *Ulmus* decline occurs between 5300 and 5000 BP. In many diagrams, occasional grains of culture-indicator types are found much earlier. It is not clear whether these occasional grains represent real occupation phases. In diagrams from Lough Sheeauns (western Ireland) and Tyrone (northern Ireland), a cultural phase can be recognized before 5000 BP which has a weak affinity with a Troels-Smith occupation phase. In all diagrams, an occupation phase of the Iversen type is observed immediately or shortly after the *Ulmus* decline.

Group and location	Type of basin	Sediment	Distance to settle-ment	Type of occupation phase	Date of beginning of phase	Archaeological culture	References
Group 1: N and E Netherlands, NW Germany							
Eexterveld	small pingo scar	peat	< 100 m	Troels-Smith	ca. 5400 BP	Swifterbant/ pre-megalithic TRB	BAKKER et al. 1999
				Iversen	ca. 4400 BP	TRB	
Wijnjewoude	pingo scar	peat	a few kms	Troels-Smith	-	?	PLOEGER & GROENMAN-VAN WAATERINGE 1964
				Iversen	-	?	
Hijkermeer	large pingo scar	gyttja	far	Iversen	-	?	ZAGWIJN 1956
Uddelermeer	large pingo scar	gyttja	< 500 m	Troels-Smith	-	?	POLAK 1959
				Iversen	-	?	
Emmererf-scheidenveen V	large raised bog	peat	> 3 km	Troels-Smith	ca. 5000 BP	[TRB]	VAN ZEIST 1955b
				Iversen	ca. 4200 BP	[EGK]	
Bargerooster-veld	large raised bog	peat	> 1 km	Troels-Smith	-	[pre-megalithic culture/TRB]	VAN ZEIST 1959
				Iversen	-	[EGK]	
Meerstalblok	large raised bog	peat	> 5 km	Troels-Smith	ca. 5000 BP	[TRB]	DUPONT 1986
				Iversen?	ca. 4000 BP	[EGK]	
De Klokkenberg	small gully	humic sand	a few 100 ms	Iversen?	ca. 4400 BP	?	VAN DER HAMMEN 1965
Engbertdijks-venen	large raised bog	peat	far	Iversen	ca. 4800 BP	?	VAN GEEL 1978
De Borchert	filled-in river branch	peat	far	Iversen?	ca. 3900 BP	?	VAN GEEL et al. 1981
Swienskuhle	kettle-hole	sedge peat	2400 m	Troels-Smith	ca. 5200 BP	pre-megalithic TRB	BEHRE & KUČAN 1994
				Iversen	ca. 4450 BP	TRB	
Jagen 20	peat bog	*Sphagnum* peat	2750 m	Troels-Smith	ca. 4700 BP	pre-megalithic TRB	BEHRE & KUČAN 1994
				Iversen	ca. 4150 BP	TRB	
Silbersee	kettle-hole	*Sphagnum* peat	2100 m	Troels-Smith?	-	?	BEHRE & KUČAN 1994
				Iversen?	-	?	
Flögelner Holz	kettle-hole	*Sphagnum* peat	1600 m	Troels-Smith	-	?	BEHRE & KUČAN 1994
				Iversen	ca. 4400 BP	?	
Fuhrenkamp	kettle-hole	*Sphagnum* peat	2000 m	Troels-Smith	ca. 5050 BP	pre-megalithic TRB	BEHRE & KUČAN 1994
				Iversen	after 4650 BP	TRB	
Flögeln V	large raised bog	*Sphagnum* peat	600 m	Troels-Smith	-	?	BEHRE & KUČAN 1994
				Iversen	-	?	
Herrenhof	small pingo scar	peat	> 1400 m	Troels-Smith?	ca. 4800 BP	?	DÖRFLER 1989
				Iversen	ca. 4650 BP	?	

Table 1. Data of occupation phases in the Neolithic as represented in pollen diagrams from north-western Europe.

Group and location	Type of basin	Sediment	Distance to settlement	Type of occupation phase	Date of beginning of phase	Archaeological culture	References
Group 2: NE Germany, Denmark, S Sweden							
Siggeneben-Süd	terrestrialized bay	marine gyttja	10 m	Troels-Smith	-	Ellerbek Group	MEURERS-BALKE 1983 ; KALIS & MEURERS-BALKE 1998 ; 2001
				Iversen	-	EN/MN TRB	
Ordrup Mose	terrestrialized bay	gyttja	?	Iversen	-	EN/MN TRB	IVERSEN 1949; KALIS & MEURERS-BALKE 1998
Aamosen	large raised bog	peat	?	Troels-Smith	-	Ertebølle	TROELS-SMITH 1960; 1961; KALIS & MEURERS-BALKE 1998
				Iversen	-	EN/MN TRB	
Group 3: W Netherlands, S Netherlands (N.Brabant)							
Hazendonk	marshy river valley	wood peat	< 50 m	Troels-Smith	ca. 5300 BP	Swifterbant	LOUWE KOOIJMANS 1974
				Troels-Smith	ca. 4900 BP	Hazendonk	
				Troels-Smith	ca. 4500 BP	Vlaardingen	
De Peel	large raised bog	peat	far	Troels-Smith	ca. 4500 BP	Vlaardingen?	JANSSEN & TEN HOVE 1971
				Troels-Smith	ca. 3850 BP	EGK	

Table 1 (continued).

II.3 The relation between occupation phases in the Neolithic and the *Ulmus* decline

In many pollen diagrams from western and northern Europe, a fairly severe and sudden decline of *Ulmus* is observed around 5000 BP/3800 cal BC. From the time of Iversen and Troels-Smith onwards, much has been written about this *Ulmus* decline and several hypotheses have been proposed to explain it (a summary of the literature about these various hypotheses is given by PEGLAR 1993). These include climatic change (see II.1.4), human activity (see II.1.3), soil deterioration and disease. Other authors have argued that a combination of factors were responsible for the decline (see II.1.4). In II.2.12, it has already been outlined that in many pollen diagrams the *Ulmus* decline could be connected with the first occupation phase or with subsequent occupation phases of the Neolithic as represented in pollen diagrams (see fig. 10). Here the results of some recent, very detailed studies on the cause, the duration and the point in time of the *Ulmus* decline (or declines) in England, Denmark, Sweden and Germany and their relation to human activities will be discussed.

Peglar (1993) sampled annually laminated sediments from a small steep-sided lake, Diss Mere, in Norfolk, England. In a section known to include the *Ulmus* decline, the laminae were sampled separately, as far as possible. At the *Ulmus* decline, *Ulmus* pollen values drop from an average of 5.8% to 1.6%, a 73% decrease, over six years. The extreme rapidity of the *Ulmus* decline strongly suggests that a pathogenic attack is responsible, most probably Dutch elm disease. Dutch elm disease is caused by the ascomycete fungus *Ceratocystis ulmi*. It is carried mainly by two bark-beetles, *Scolytus scolytus* and *Scolytus multistriatus*. The *Ulmus* decline in Diss Mere is comparable in rate and magnitude with the fall, as recorded palynologically, in *Castanea dentata* from North America known to have been caused by a pathogen early in the 20th century, with the mid-Holocene *Tsuga canadensis* decline also attributed to a pathogen, and with the present-day *Ulmus* decline caused by Dutch elm disease in Scords Wood, England. This supports the hypothesis of a pathogenic attack having caused the *Ulmus* decline at Diss Mere. Peglar (1993, 11) reaches the conclusion that the *Ulmus* decline was caused by a combination of disease and human activity, a virulent attack taking place in disturbed woodland, where the *Ulmus* trees had already been disturbed by human activity for at least 160 years. Grazing, fodder collection and related activities may have prevented regeneration of the *Ulmus* population after the pathogenic outbreak.

Andersen & Rasmussen (1993) studied *Ulmus* declines in a pollen diagram from Hassing Huse Mose, a small lake in northwestern Denmark. Four *Ulmus* declines were found. By applying the method of "wiggle matching" (see VI.4), a reservoir effect of 120 years was found, and dates for the four *Ulmus* declines of 4530, 4130, 3870 and 3410 cal BC were obtained. The start of the third *Ulmus* decline at Hassing Huse Mose (3870 cal BC) is likely to correspond to the start of the principal (classic) *Ulmus* decline. The first two *Ulmus* declines are accompanied by slight increases of Gramineae and *Rumex acetosella*, while also a few grains of *Triticum*-type are found. However, the evidence for vegetation disturbance and agricultural activity at this site before the major *Ulmus* decline is weak. The third (classic) *Ulmus* decline coincides with the beginning of the Early Neolithic Funnel Beaker Culture. Gramineae and *Rumex acetosella* increase, *Plantago lanceolata* appears, there is a single *Hordeum*-type pollen grain, and charcoal dust increases conspicuously. Hence there is some evidence of agricultural activity. The beginning of the fourth (very weak) *Ulmus* decline coincides with the transition from the Early to the Middle Neolithic Funnel Beaker Culture. *Ulmus* and *Tilia* are now low, *Betula* decreases and *Corylus* increases. Gramineae and *Plantago lanceolata* increase slightly. As causes of the first three *Ulmus* declines, Andersen & Rasmussen, following Peglar (1993), suggest outbreaks of elm disease provoked by stress from human activity. It is difficult to explain why only *Ulmus* was affected by man during the first three *Ulmus* declines. Selective exploitation of *Ulmus* woodland may have been due to the establishment of fields on particular (fertile) soils or to the promotion of pig pannage. Curiously, Andersen & Rasmussen nowhere mention the term Iversen occupation phase or *landnam*, nor the term Troels-Smith occupation phase. In my opinion, the first two *Ulmus* declines represent occupation phases of the Troels-Smith type (Troels-Smith-PREFACT phases A and B in the model of Kalis & Meurers-Balke, see II.1.6 and II.2.9), while the third *Ulmus* decline represents an occupation phase of the Iversen type (Iversen-PREFACT phases 1b and 2 in the model of Kalis & Meurers-Balke).

Skog & Regnéll (1995) sampled a *Sphagnum*-peat sequence from Ageröds Mosse in southernmost Sweden. Pollen samples were analyzed at 1 cm intervals. The *Ulmus* decline is very distinct in the pollen diagram: the *Ulmus* percentage falls from 9 to 2%, amounting to a 78% decrease in a time span corresponding to 2 cm of sediment at most. The peat accumulation rate for this interval was estimated to be ca. 0.5 mm/year. The 2 cm interval of the two samples at the *Ulmus* decline accordingly corresponds to ca. 40 years, which is a maximum value for the duration of the decline, as closer pollen sampling may reveal an even narrower interval. On the basis of the pollen analysis, nine peat samples were picked out for ^{14}C analysis. The width of each sample was 2 cm. By applying the method of "wiggle matching" (see VI.4) it was found that the *Ulmus* decline in Ageröds Mosse occurred within a few decades at ca. 3770 cal BC. This date is in agreement with that of the principal *Ulmus* decline found by Andersen & Rasmussen (1993), which suggests that at this location the *Ulmus* decline likewise coincides with the beginning of the Early Neolithic Funnel Beaker Culture (TRB) (see II.2.10).

Digerfeldt (1997) analyzed a sequence from Lake Kalvsjön in southern Sweden (province of Scania). Here the *Ulmus* decline occurs in a gyttja layer between two sedge-peat layers. *Ulmus* declines abruptly, the percentage representation decreasing from about 5% to 1% within a sample interval of 2.5 cm. There are only two dates of the sedge peat layers below and above the gyttja layer (5190 ± 80 BP and 4780 ± 80 BP, respectively). Based on these two dates, the average rate of gyttja accumulation is estimated to be 0.9 mm/year. Thus the decline in *Ulmus* may have occurred within less than 25-30 years. The rapidity of the *Ulmus* decline here strongly suggests a pathogenic attack to be primarily responsible for the decline. At the level of the decline, *Plantago lanceolata* appears, but Gramineae do not increase, indicating that human activity was still insignificant (DIGERFELDT 1997, 12). Human interference and climate-induced palaeohydrological change probably interacted by disturbing the forests, and consequently increasing the susceptibility of *Ulmus* to pathogenic attack. According to Digerfeldt, the climate-induced disturbance in the Lake Kalvsjön area is more severe and accordingly more conductive to the outbreak of elm disease than any human interference.

Kalis & Meurers-Balke (1998) also discuss the possible causes of *Ulmus* declines in the Neolithic. The decline of *Ulmus* most probably attributable to the Ertebølle Culture (Troels-Smith-PREFACT phase A/B, see II.1.6 and II.2.9) lasts for a few centuries, which makes it unlikely that this was caused by a pathogenic attack. Nor is climatic change a plausible cause of this *Ulmus* decline, because in the western Baltic area the *Ulmus* species concerned do not occur near the climatically determined limit of their distribution area (KALIS & MEURERS-BALKE 1998, 16). According to Kalis & Meurers-Balke, an anthropo-zoogenic cause seems more plausible. An increase of large leaf-eating mammals, which preferred the nutritious and tasty leaves of *Ulmus* and *Fraxinus*, must have had a differential effect on the numbers of these trees: *Ulmus* decreased, while the pioneer tree *Fraxinus* increased, taking advantage of the opening up of the forest. In the zone in the pollen diagrams which reflects the beginning of the Early Neolithic Funnel Beaker Culture (Iversen-PREFACT phase 1a), the *Ulmus* curve continues to decline. According to Kalis & Meurers-Balke (1998, 17), this decline is not caused by a pathogenic attack either, because the disappearance of complete *Ulmus* stands would have led to the development of substituting communities with *Corylus*, *Alnus* and *Hedera*. However, the pollen diagrams record not an increase, but a decrease of these three taxa. An anthropogenic cause of this *Ulmus* decline is more probable: apparently, the TRB people particularly exploited the rich soils on which *Ulmus* preferably grew. The "classic" *Ulmus* decline in northeastern Germany coincides with the presence of the Siggeneben Group of the Early Neolithic Funnel Beaker Culture (Iversen-PREFACT phase 1b). It is possible that elm disease played a role in the decrease of *Ulmus* in this period; because of the already quite severe human disturbance of the forests, the remaining *Ulmus* trees became more susceptible to pathogenic attack (KALIS & MEURERS-BALKE 1998, 18).

In summary, it can be stated that a widely held opinion nowadays is that the *Ulmus* decline is best explained by an interaction between human impact and the spread of elm disease, i.e. a pathogenic attack on forests disturbed by human interference (DIGERFELDT 1997). In some areas, a rapid *Ulmus* decline is recorded, indicating that a pathogenic attack must have been involved (for example, PEGLAR 1993; SKOG & REGNÉLL 1995); however, in other areas a slow and progressive decline is recorded, which has been explained by human impact, climatic or edaphic change or interactions between such factors (for example, GÖRANSSON 1988a; BERGLUND 1991; KALIS & MEURERS-BALKE 1998). Probably there is no universal explanation, and the decline may demand explanations specific to each region (SMITH 1961; PENNINGTON 1979). Climatic and edaphic change, human activity and elm disease may have been responsible for the decline, but the importance of each of these factors is likely to have varied from region to region (DIGERFELDT 1997).

II.4 The relation between the beginning of the Neolithic in pollen diagrams and climatic change

The possibility of a climatic change more or less coinciding with the Atlantic-Subboreal transition and consequently also with the beginning of the Neolithic in northwestern Europe as represented in pollen diagrams (see I.4.1) was already suggested by Iversen (1944). In the opinion of several authors, the classic *Ulmus* decline was caused primarily by a change of climate around the Atlantic-Subboreal transition (for example NILSSON 1948; 1961; see II.1.4). It is now generally accepted, however, that any plausible, universal climatic explanation of the classic *Ulmus* decline cannot be found. Yet climate in different combinations of interactions may have contributed to the decline (DIGERFELDT 1997). Iversen used three indicator species to demonstrate climatic change: *Hedera helix*, *Viscum album* and *Ilex aquifolium*. Because in northwestern Europe these species occur near the limit of their area of distribution, they are very sensitive to climatic change in this area. *Hedera* and *Ilex* are oceanic species, sensitive to winter frost; *Viscum* is a continental element, requiring warm summers (IVERSEN 1944). At the Atlantic-Subboreal transition, the relative amount of *Hedera* and *Viscum* decreased. From this, Iversen concluded that in wide parts of central Europe not only did the winters become cooler, but also summer temperatures may have been lowered. In his opinion, and in the opinion of numerous subsequent investigators, the climate changed towards increased continentality and increased dryness around 5000 BP/3800 cal BC (DIGERFELDT 1997). Although at the end of the Atlantic

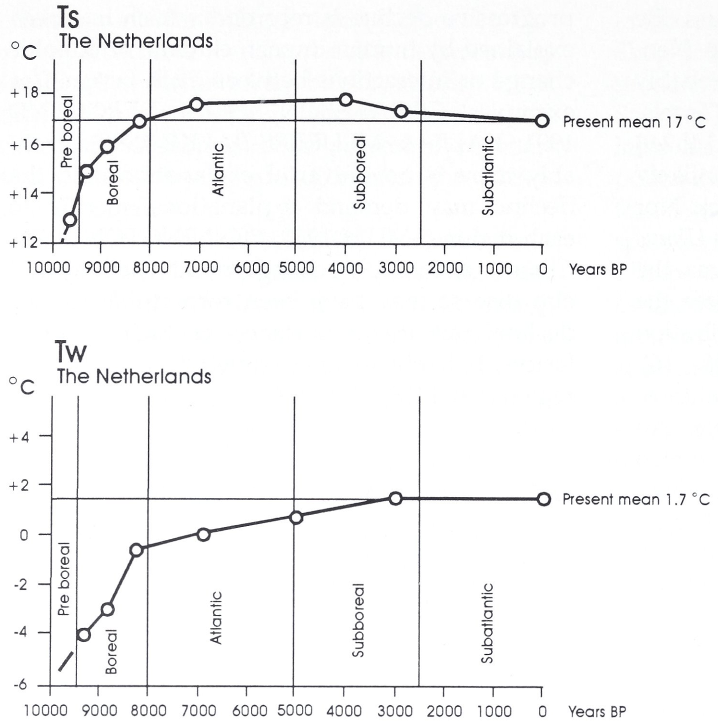

Fig. 12. Hypothetical temperature curves of mean summer and winter temperatures in the area of Amsterdam, the Netherlands, since the Preboreal (after ZAGWIJN 1994, adapted). Ts: mean summer temperature; Tw: mean winter temperature.

the significance of the three named species decreased, they were still part of the central and northwest European flora. From this, Frenzel (1966) concludes that if climate indeed changed at the Atlantic-Subboreal transition, then this change cannot have been very great.

On the basis of distribution maps showing the first pollen occurrences in the Holocene of the climate indicators *Hedera, Ilex* and *Viscum* as well as data for *Corylus*, Zagwijn (1994) constructed a series of maps that show summer and winter isotherms at various points in time during the Holocene. On the basis of these maps, climate curves for Amsterdam (the Netherlands) were compiled, which are shown in fig. 12. The mid-Holocene climatic optimum occurs between 7000 and 4000 BP, when the mean temperature in July reaches 18°C (1°C more than nowadays). However, the mean temperature in January continues to increase until it reaches its maximum value of 1.7°C at 3000 BP. Between 3000 BP and now, the mean temperature in January has remained constant. From Zagwijn's climate curves it can be seen that around 5000 BP the mean temperature in July was not changing, while the mean temperature in January was still rising. Zagwijn (1994, fig. 23) concludes that seasonality was stronger at the beginning of the Holocene, the climate being more continental. Later, seasonality decreased and the climate became more oceanic.

Apart from palynological evidence, many additional types of evidence can be used to demonstrate a climatic change at the Atlantic-Subboreal transition. In mountainous regions, the effects of a climatic change will be visible more clearly than in lowlands, where a more stable equilibrium between various plant communities is reached and where human impact on the vegetation is much stronger. Here the results of some studies from the Swiss Alps and Norway will be discussed. Just before 5000 BP, a short-term climatic oscillation towards cold climate could be demonstrated in Switzerland, the so-called Piora oscillation (FRENZEL 1966, 103). However, Frenzel emphasizes that the Piora oscillation was only a minor oscillation, which only slightly modified the general trend in the post-Glacial evolution of climate, i.e. from cold and dry phases of late-Glacial times to the post-Glacial warm period and again to cooler and moister conditions (FRENZEL 1966, 106). In a more recent study in the Swiss Alps, Gamper (1993) found increased geomorphological activity setting in around 5000 BP. Whereas geomorphological activity was very slight around 8000-5000 BP, the following period, lasting from 5000 BP up to the present, has been characterized by a rapid succession of brief soil development phases and phases of geomorphological activity. According to Gamper (1993), the change in geomorphological activity around 5000 BP probably reflects a change of climate from more oceanic to increasingly continental. Unfortunately, he could not answer the question of how much this change was also due to human impact. Veit (1993) found a comparable phase of increasing geomorphological activity setting in around 5000 BP in the Austrian Alps. Burga (1993) gives an outline of the Swiss alpine Holocene palaeoclimate, mainly using palynological data. He concludes that the Piora oscillation in the pollen diagrams, which is dated between 5200 and 4200 BP, coincides with glacier advances and intensified solifluction phases. In conclusion, the studies by Gamper, Veit and Burga all point to a climatic change to a colder (more continental) climate around 5000 BP in the Alps. A study in the mountain-foot zones in western Norway demonstrated glacier advances from 5200 BP onwards and increasing avalanche activity from 4600 BP onwards, also pointing to the setting in of a colder climate after 5000 BP (BLIKRA & NEMEC 1993).

Very recently, several articles were published which present evidence for a world-wide cold period between ca. 5200 and 4400 BP (O'BRIEN et al. 1995, fig. 2; STEIG 1999; SANDWEISS et al. 1999). This can be seen most clearly in the polar regions: in an ice core from Summit, Greenland, the GISP 2 ice core, increased concentrations of sea salt and terrestrial dusts were found during five periods since the Younger Dryas (O'BRIEN et al. 1995). One of these periods is the period between 5200 and 4400 BP (4100-3000 cal BC). During these periods, temperatures in the mid to high northern latitudes were potentially the coldest since the Younger Dryas event. Between 5200 and 4400 BP, most tropical and subtropical land areas either cooled or became more arid, or both; at temperate latitudes, some areas experienced a mid-Holocene dry period followed by increasingly cool and wet conditions. In addition to these changes in land air temperatures and precipitation, the period between 5200 and 4400 BP also saw substantial change in atmospheric and ocean circulation patterns (STEIG 1999; SANDWEISS et al. 1999). Sandweiss et al. (1999) correlate climatic change and cultural change in the mid-Holocene (7100-2800 BP/6000-1000 cal BC) in various parts of the world. They conclude that the presented evidence confirms that the mid-Holocene was a time of increasing climatic variability and cultural change in many parts of the world, but that climatic and cultural trends were neither global nor synchronous. In general, climate was warmer and less variable for several millennia before 5000 BP/3800 cal BC than in the immediately following period. Cultural complexity generally increased where climate change was most apparent. Faced with change, humans have the capacity to alter their behaviour, not all of which leads in the same direction or is equally successful.

Concluding, it can be stated that there is evidence from multiple disciplines and many locations that a climatic change took place around 5000 BP. The scale and duration of this change are still under discussion, but it is most probable that a change towards continentality and increased dryness took place in this period. Only the results of a study by Zagwijn (1994) point to decreasing continentality after 5000 BP. When the human influence on the vegetation around 5000 BP is studied, a date which more or less marks the beginning of the Neolithic in northwestern Europe as represented in pollen diagrams, it always has to be remembered that a climatic change in this period may have caused at least part of the changes in the vegetation. However, climate-induced changes in the vegetation are unlikely to have a very sudden character: it is more probable that these changes took place over a period of hundreds of years.

II.5 Archaeology of the Neolithic in the Netherlands and the process of Neolithization

In the preceding sections it has been outlined that in many pollen diagrams, several occupation phases representing the Neolithic could be correlated with archaeological cultures, usually on the basis of ^{14}C dates. 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). In this section, the archaeology of the Neolithic in the Netherlands will be discussed, with an emphasis on these two cultures; furthermore, some general remarks will be made concerning the process of Neolithization in the Netherlands.

In the course of the first part of the Holocene, approximately between 10,000 and 5,000 BP, farming cultures with permanent settlements, arable farming and stock keeping spread from the Near East and southeastern Europe all over Europe. The transition from a nomadic subsistence of hunting and gathering to a sedentary subsistence of farming is one of the largest steps forward in human history, so that it is justified to speak of the "Neolithic Revolution" (CHILDE 1951), although by this term not a catastrophic, but rather a gradual event in the sense of an "Evolution" is designated. The progressive expansion of Neolithic cultures throughout Europe results in varying starting dates for the Neolithic, dependent on geographical position: it starts in the southeast, and eventually reaches the northwest and north (fig. 13). The origin of Neolithic cultures has to be sought in the Near East, more precisely in the so-called Fertile Crescent (fig. 13). Here, the transition from hunting and gathering to farming took place around 9400 cal BC. Even before the later confirmation by archaeological finds, it was assumed that the origins of arable farming and stock keeping lay in the Fertile Crescent, because the natural habitat of wild ancestors of several domesticates, plants as well as animals, is found in that area. Examples are *Triticum dicoccoides* (wild emmer), *Triticum boeoticum* (wild einkorn), *Hordeum spontaneum* (wild barley), *Pisum humile* (wild pea), *Lens orientalis* (wild lentil) and *Capra aegagrus* (wild goat) and *Ovis orientalis* (wild sheep) (UERPMANN 1983).

The first real farming culture in the Netherlands was the Linear Pottery Culture (LBK). This culture colonized the loess areas of Central Europe (fig. 13), where it replaced local Mesolithic groups. According to Zvelebil (1998), the spread of the LBK is a classical example of farming colonization and replacement of local foragers. However, in recent years, also the possibility of Neolithization of the Mesolithic society is considered with respect to the Linear Pottery Culture (LANTING & VAN DER PLICHT 1999/2000). 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 this moment onwards, 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 contacts between the Rössen Culture on the loess soils and the Mesolithic foragers must have been fairly intensive, because Rössen-type adzes have been found frequently in the eastern and northern Netherlands (VAN DER WAALS 1972; RAEMAEKERS 1999); from Drenthe, ca. 200 km from the nearest Rössen settlement, also some 15 Rössen-type adzes are known (see III.7.3). Lanting & Van der Plicht (1999/2000) suggest the possibility that these Rössen-type adzes were produced locally by people of the Swifterbant Culture. As a result of long-term interaction, pottery production and animal husbandry may have become less alien concepts to the Mesolithic foragers.

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 areas, 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 residential sites among a series of resource patches (LOUWE KOOIJMANS 1998; RAEMAEKERS 1999). Cultural groups like the Swifterbant Culture in the Netherlands, the Dümmer-Hüde

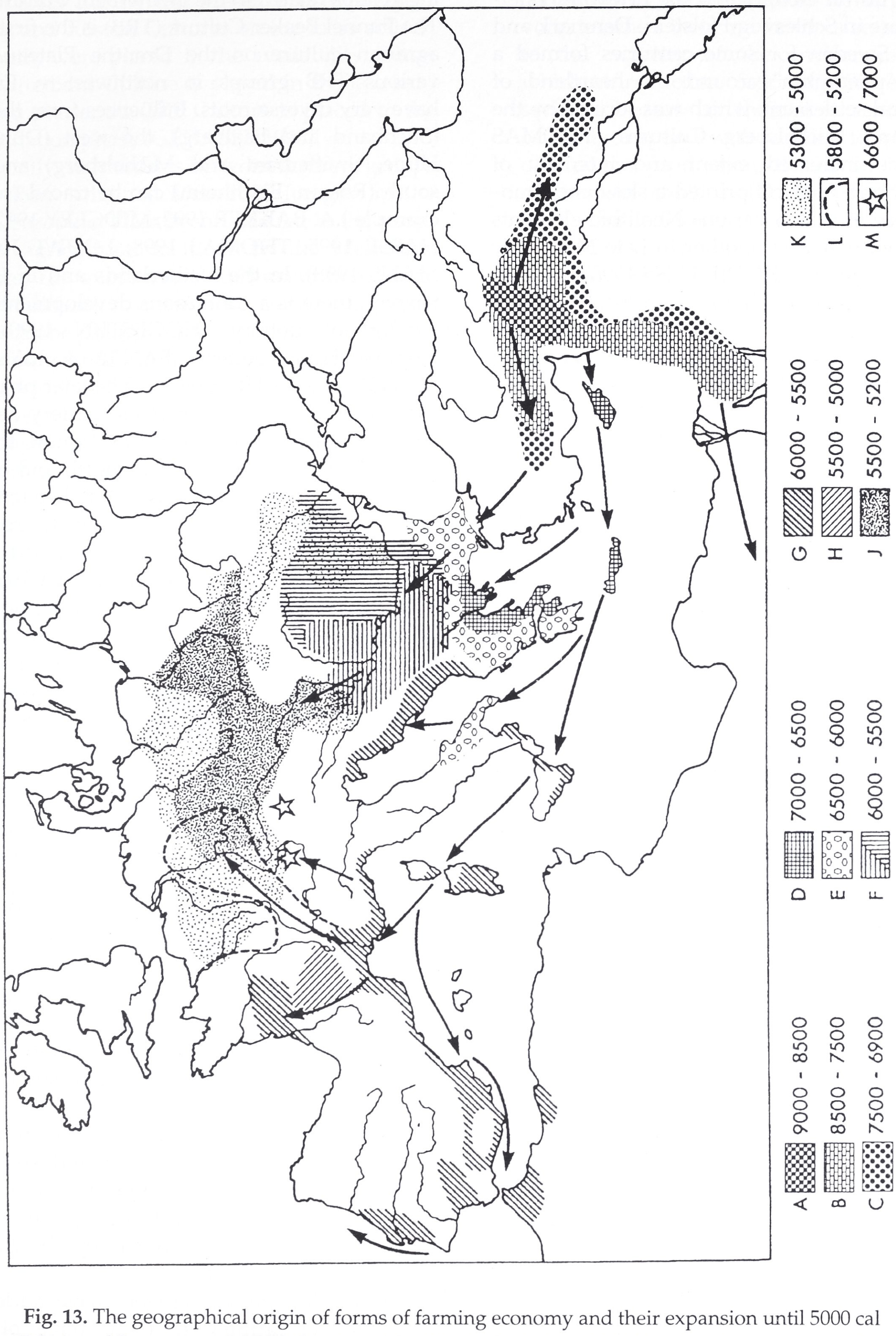

Fig. 13. The geographical origin of forms of farming economy and their expansion until 5000 cal BC. A and B: preceramic Neolithic A and B (PPN A/B); C: Late PPN B and early ceramic; D: first expansion to Europe (eastern Greece) and to mediterranean islands (Cyprus, Crete); E: western and northern Greece, Bulgaria, southeastern Italy; F: Starčevo-Körös-Criš; G: Impressa and Cardial; H: Roucadourien; I: oldest Linear Pottery Culture (LBK); K: old to young Linear Pottery Culture (LBK); L: La Hoguette (northern and eastern border); M: Late Mesolithic cereal cultivation. All dates are expressed in cal BC (after LÜNING 2000).

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. According to them, these finds probably are 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 not inhabited at all (FOKKENS 1990). However, a few scattered finds (see III.7.3) 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.

The Funnel Beaker Culture (TRB) is 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, 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 large 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).

Zvelebil & Rowley-Conwy (1984; see also ZVELEBIL 1986) formulated a three-phase model for the transition to agriculture: the availability model. In the view of these authors, the process towards the adoption of farming passes through several "frontier" situations, which may occur simultaneously in geographical space. The entire zone of foraging-farming interaction is regarded as a frontier, rather than merely the line of forager-farmer contact. In the availability model, the following three phases are distinguished (ZVELEBIL 1986):

1. availability phase: farming is known to the foraging groups in question and some exchange of materials and information goes on between farming and foraging settlements, yet farming is not adopted by the hunter-gatherer communities.
2. substitution phase: foragers have added elements of farming to their range of subsistence strategies.
3. consolidation phase: arable farming and stock keeping become dominant over hunting and gathering.

In terms of the Dutch situation, the foragers living in the central and northern parts of the

Netherlands during the presence of the Linear Pottery and Rössen Cultures on the loess soils in the south, were placed in the availability phase; the Swifterbant Culture is placed in the late substitution phase; the TRB Culture is placed in the consolidation phase (GEHASSE 1995).

Apparently, the contacts between farming groups of the loess soils and Mesolithic foragers of the North European Plain eventually led to the adoption of agricultural methods by the Mesolithic foragers. The question *why* this event took place, is as yet difficult to answer. Three types of explanation can be put forward:

1. environmental reasons: Potential environmental factors that might have affected the balance between people and available food include changes in climate, sea level, marine resources, usable land area and vegetation (PRICE et al. 1995).
2. social reasons: Cereals and livestock might have been introduced into Mesolithic societies as prestige goods. Gradually, their importance increased until they became dominant in the food economy. Parallel to this slow development, an adaptation of the social structure of the society occurred (JENNBERT 1985).
3. combination of environmental and social reasons: After the withdrawal of the ice cap, the biomass of the primary producers steadily increased, followed by those of the primary consumers, like the large herbivores. Because of the abundance of food, the social inhibition mechanism on population growth was switched off and group size increased. At a certain time, the populations of large herbivores reached their maximum size in relation to the capacity of the environment, after which a reduction followed. Since human societies because of their slow reproduction can only respond with a delay to a decrease of biomass production, the social inhibition mechanism could not be applied immediately. This led to overpopulation, food shortages and social stress. Solutions to this situation were a partial migration of the population to other areas or the transition to farming (GROENMAN-VAN WAATERINGE 1988).

For the Dutch situation, a combination of environmental and social reasons seems the best explanation (GEHASSE 1995, 193). Concluding, it can be stated that in the Netherlands, the incorporation of arable farming and stock keeping into subsistence economies formerly based on hunting and gathering did not follow a fixed and straightforward course. Instead, it was a strongly fluctuating process, in which sometimes arable farming and stock keeping, sometimes hunting and gathering were more important, dependent on environmental and social factors (GEHASSE 1995). In the Netherlands, interaction, exchange, adoption and acculturation are sufficient to explain the transformation from hunting-gathering to farming. Apart from the initial Neolithic (the Linear Pottery Culture), no migrations or physical expansions are needed. There is enough positive evidence for demographic continuity (LOUWE KOOIJMANS 1998).