

VIII. Discussion and conclusions

VIII.1 A model of the Neolithic Occupation Period in Pleistocene areas near the North Sea coast

When the data collected during the present study are combined with data from literature, it may be possible to construct a model of the Neolithic Occupation Period in pollen diagrams which is valid for a larger area than only the Gietsenveentje or the Drenthe Plateau. The ultimate aim is to construct a model of the Neolithic Occupation Period which is valid for Pleistocene areas near the North Sea coast, because these areas are not only characterized by roughly similar geological and edaphic circumstances, but also by finds of the same archaeological cultures. The diagrams of the Gietsenveentje will form the basis for the model. Furthermore, other diagrams from the province of Drenthe and diagrams from northwestern Germany (*Siedlungskammer* Flögel) will be incorporated. On the basis of the simplified pollen diagrams in figs. 73-74, the Neolithic Occupation Period in the Gietsenveentje diagrams, which is subdivided into three Neolithic Occupation Phases, is correlated with the corresponding periods in the other diagrams from Drenthe and those from northwestern Germany. These diagrams include selected regional pollen types which show clear changes during the Neolithic Occupation Period. The Neolithic Occupation Phases in the Gietsenveentje diagrams (fig. 73a-c) are defined as follows:

- NOP-1: Very gradual decline of *Ulmus*; maximum values of *Tilia* and *Quercus*; increase of Non-Arboreal Pollen, particularly Gramineae and *Calluna vulgaris*; appearance of *Plantago lanceolata* and Cerealia-type; increase of *Rumex acetosa*. When the decline of *Ulmus* does not coincide with the first appearance of *Plantago lanceolata*, this phase is subdivided into phase NOP-1a (*Ulmus* decline, no *Plantago lanceolata*) and phase NOP-1b (appearance of *Plantago lanceolata*).
- NOP-2: Gradual decrease of *Tilia*; high values of *Pteridium*; relatively high values of Gramineae and *Calluna vulgaris*; maximum values of *Plantago lanceolata*, *Rumex acetosa* and Cerealia-type.

NOP-3: Decrease of *Ulmus*; decrease of Non-Arboreal Pollen; decrease of Gramineae; increase of *Calluna vulgaris*; decrease of *Plantago lanceolata*, *Rumex acetosa* and Cerealia-type.

I have been able to distinguish these Neolithic Occupation Phases also in most of the other diagrams. The similarities and differences in the pollen picture will now be briefly discussed. The locations are indicated on the map of fig. 6.

Exterveld (fig. 73d). The *Ulmus* decline occurs before the first appearance of *Plantago lanceolata*. The values of *Ulmus* and *Tilia* are lower than in the Gietsenveentje. The NOP-1b/NOP-2 transition is marked by a strong increase of Gramineae and an increase of Cerealia-type. *Plantago lanceolata* and *Rumex acetosa*-type do not increase at the beginning of NOP-2. Gramineae reach higher values, but the culture-indicator types have far lower values here than in the Gietsenveentje.

Emmererfscheidenveen V (fig. 73e). The *Tilia* maximum in NOP-1 is rather weak. Very high values of Ericaceae indicate that this pollen has a predominantly local origin. The highest values of Gramineae occur in the Atlantic. During phases NOP-1, NOP-2 and NOP-3, Gramineae values remain constant. Pollen grains of Cerealia-type are found in the Atlantic; these grains were possibly misidentified, otherwise they must originate from wild grasses, which is not very probable (a Cerealia-type curve is not included in the pollen diagram of the original publication by Van Zeist (1955b)). Values of *Rumex acetosa*-type and *Plantago lanceolata* are lower than in the Gietsenveentje. The ¹⁴C date of the NOP-1/NOP-2 boundary (ca. 2700 cal BC) is much younger than the corresponding date in the Gietsenveentje (ca. 3450 cal BC). *Quercus* reaches maximum values in NOP-3. A ¹⁴C date of the end of phase NOP-3 (ca. 1700 cal BC) indicates that this phase extends into the Bronze Age.

Bargeroosterveld (fig. 73f; fig. 8). There is no clear *Ulmus* decline. The *Tilia* maximum in phase NOP-1 is pronounced. Irregular values of *Calluna vulgaris* point to a predominantly local origin of this pollen. Gramineae reach a maximum in the Atlantic, which has to be local. The culture-indicator types occur very sporadically in this diagram. Nonetheless, the *Plantago lanceolata* maximum in NOP-2 is pronounced.

Fig. 73 (pp. 237-239). Six simplified pollen diagrams of sequences from Drenthe (the northern Netherlands). Various phases of the Neolithic Occupation Period (NOP) and corresponding ^{14}C dates are indicated. The dates in the Giet-senveentje diagrams (figs. 73 a-c) are calibrated according to Method II calibration of sub-datasets (wiggly matching) (see VI.4.2 and table 9). The dates in the other diagrams of figs. 73 and 74 are calibrated according to Method I calibration, which takes into account the fixed stratigraphical sequence of the dated samples but assumes no constant growth rate (see VI.4.2); here the 1 σ ranges of the calibrated dates are given. ^{14}C dates in *italics* are extrapolated dates.

Swienschuhle (fig. 74a). After its initial decline, *Ulmus* recovers in phase NOP-2. *Tilia* shows the same values in the Atlantic and in phase NOP-1; the decline at the end of NOP-2 is pronounced. *Quercus* shows maximum values in NOP-1 and again in NOP-3. The values of *Calluna vulgaris* and Gramineae are high to very high in NOP-2, which indicates that this pollen is for the most part local. The values of the culture-indicator types are relatively high in this diagram. The NOP phases can be correlated with the phases distinguished by Behre & Kučan (1994) in the diagrams of *Siedlungskammer Flögel*n (see II.2.6):

NOP-1: Phase 1 in Behre & Kučan

NOP-2: Phase 2 in Behre & Kučan

NOP-3: not distinguished by Behre & Kučan

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

Jagen 20 (fig. 74b). The *Ulmus* decline occurs before the first appearance of *Plantago lanceolata*. After its initial decline, *Ulmus* recovers for a short period at the end of NOP-1. *Quercus* reaches very high values in NOP-1 (up to 80% of the AP!). The *Tilia* and *Quercus* declines at the end of NOP-1b are very pronounced. *Calluna vulgaris* and Gramineae reach exceptionally high values in NOP-2, indicating that the pollen of these taxa has a largely local origin. The culture-indicator types are very poorly represented in this diagram. There is no increase, but a decrease of these types in NOP-2. The NOP-1b/NOP-2 boundary is dated at ca. 2750 cal BC, which is on the young side (BEHRE & KUČAN 1994, 106). The NOP-2/NOP-3 boundary is dated at ca. 1900 cal BC, which means that phase NOP-3 is part of the Bronze Age.

Flögelner Holz (fig. 74c). The *Ulmus* decline, which is fairly gradual here, occurs before the first appearance of *Plantago lanceolata*. *Ulmus* briefly recovers in phase NOP-2. The *Tilia* maximum in NOP-1 and the *Tilia* decline at the NOP-

1b/NOP-2 boundary are pronounced. *Quercus* reaches no maximum in NOP-1. Irregular values of *Calluna vulgaris* and Gramineae show that the pollen originates from local plants, although Gramineae reach maximum values in NOP-2. The culture-indicator types are very poorly represented in this diagram. Cerealia-type is only found in the Atlantic (!) and in phase NOP-1b. *Rumex acetosella* (sic) is not present in each sample; *Plantago lanceolata* shows a small increase in NOP-2. The beginning of phase NOP-1 is not dated. The NOP-2/NOP-3 boundary is dated at ca. 2100 cal BC, which implies that phase NOP-3 comprises the last part of the Neolithic and the first part of the Bronze Age.

Silbersee (fig. 74d). The *Ulmus* decline is very gradual. The *Tilia* and *Quercus* maxima in NOP-1 are very pronounced, but these two types decline only gradually at the end of NOP-1. High and irregular values of *Calluna vulgaris* and Gramineae point to the mainly local origin of the pollen of these taxa. Again, the culture-indicator types are poorly represented. The increase of these types at the NOP-1/NOP-2 boundary is not very clear. A few grains of *Plantago lanceolata* are found in the Atlantic. There are no dates for the NOP phases in this diagram.

Fuhrenkamp (fig. 74e). The *Ulmus* decline is very indistinct in this diagram; the first signs of a decline occur before the first appearance of *Plantago lanceolata*. There is also no clear *Tilia* decline. *Quercus* reaches higher values in NOP-2 than in NOP-1, which is different from all the other diagrams from Flögeln. Probably most of the *Calluna vulgaris* pollen in this diagram is of local origin. Gramineae increase in NOP-2. Their comparatively stable and low values point to a regional origin of the pollen. Again, the culture-indicator types show very low values throughout the diagram, but the highest values are reached in NOP-2. A few grains of *Plantago lanceolata* are found in the Atlantic. Phase NOP-3 is missing in this diagram: after phase NOP-2, Gramineae and the culture-indicator types only increase. According to an extrapolated ^{14}C date of ca. 1550 cal BC for the end of phase NOP-2, phase NOP-2 extends into the Bronze Age.

Gieten V - A
(Core location 59)

Pollensum: ΣP excl. *Betula*
Location type: pingo scar (centre)
Sediment type: gyttja
Distance to TRB settlement: 600 m

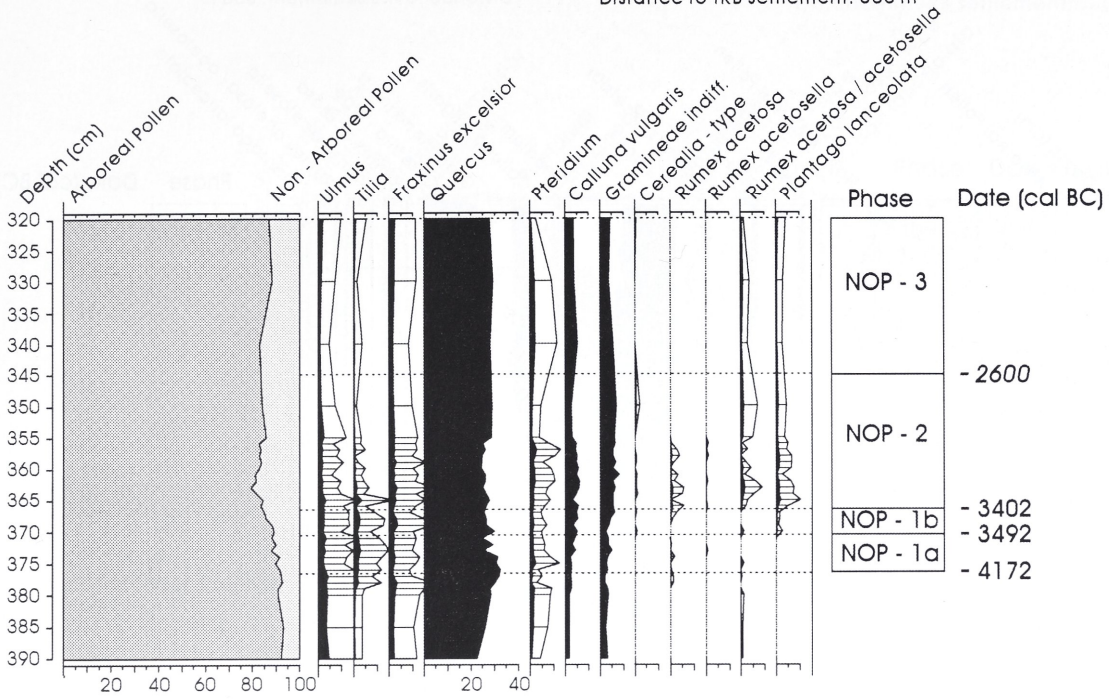


Fig. 73a.

Gieten V - D
(Core location 57)

Pollensum: ΣP excl. *Betula*
Location type: pingo scar (S edge)
Sediment type: gyttja
Distance to TRB settlement: 600 m

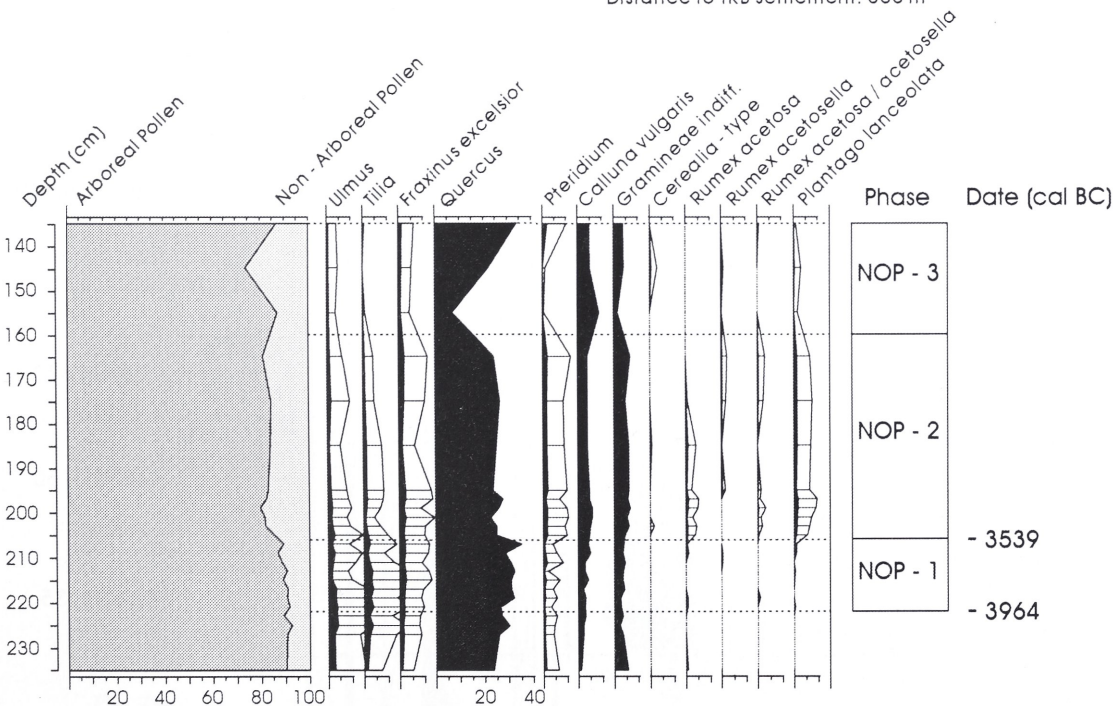


Fig. 73b.

Gieten V - B

(Core location 61)

Pollensum: ΣP excl. *Betula*
 Location type: pingo scar (N edge)
 Sediment type: peat
 Distance to TRB settlement: 600 m

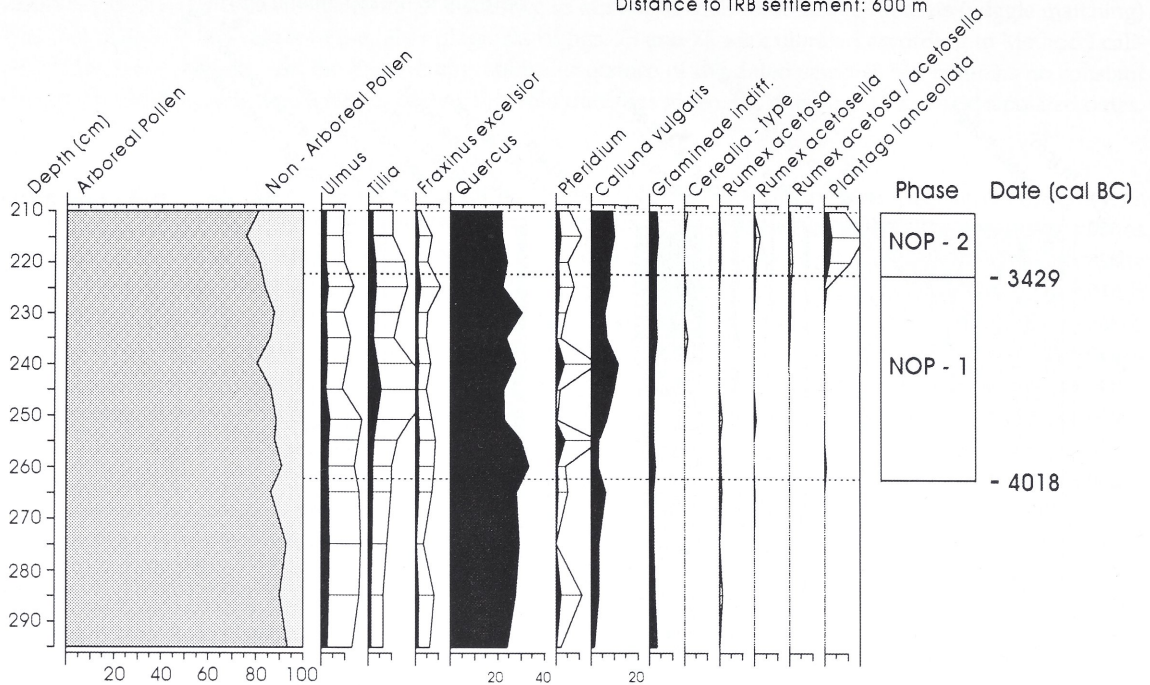


Fig. 73c.

Eexterveld

(Bakker et al. 1999)

Pollensum: ΣAP
 Location type: small pingo scar
 Sediment type: peat
 Distance to TRB settlement: < 100 m

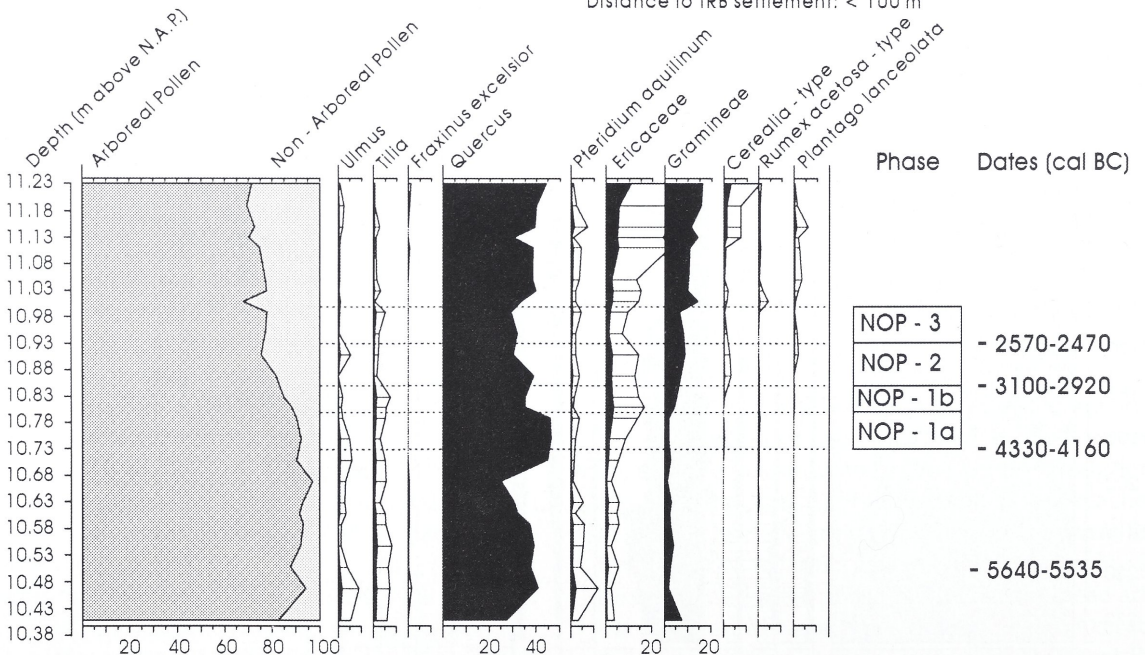


Fig. 73d.

Emmererfscheidenveen V

(Van Zeist, 1955b)

Pollensum: ΣP excl. *Betula*
 Location type: large raised bog
 Sediment type: peat
 Distance to TRB settlement: > 3 km

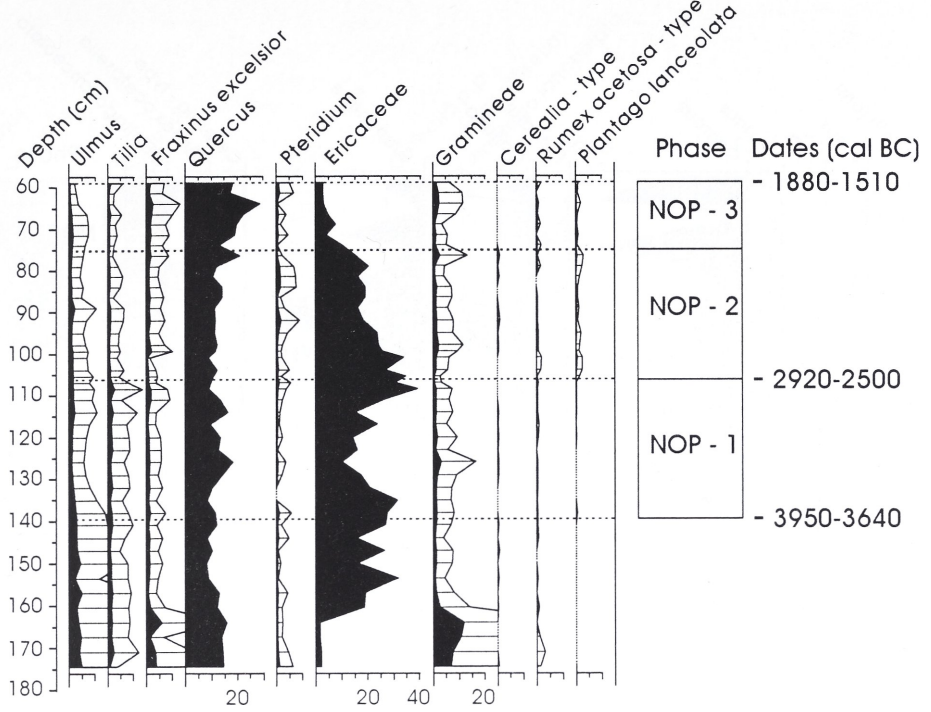


Fig. 73e.

Bargeroosterveld

(Van Zeist, 1959)

Pollensum: ΣP excl. *Betula*
 Location type: large raised bog
 Sediment type: peat
 Distance to TRB settlement: > 1 km

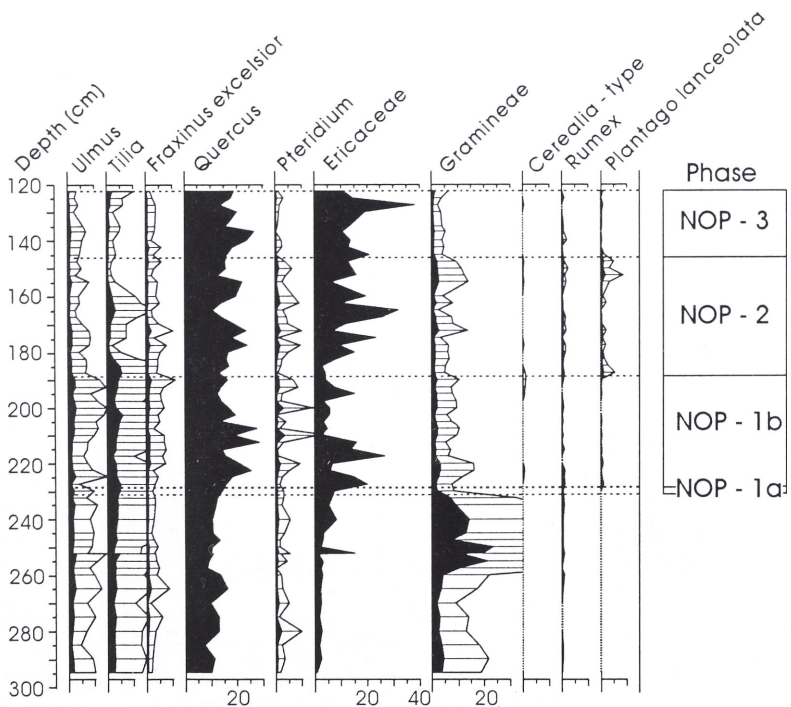


Fig. 73f.

Swienschuhle

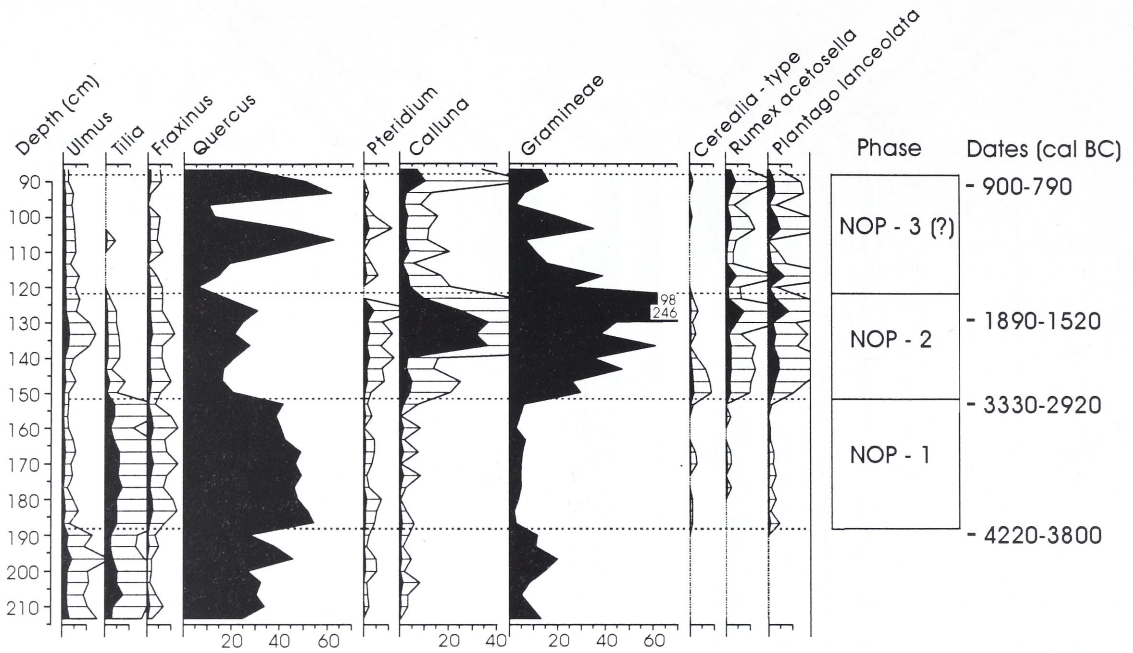
(Behre & Kučan, 1994)

Pollensum: Σ AP

Location type: small kettle-hole

Sediment type: sedge peat

Distance to TRB settlement: 2400 m



Jagen 20

(Behre & Kučan, 1994)

Pollensum: Σ AP

Location type: peat bog

Sediment type: *Sphagnum* peat

Distance to TRB settlement: 2750 m

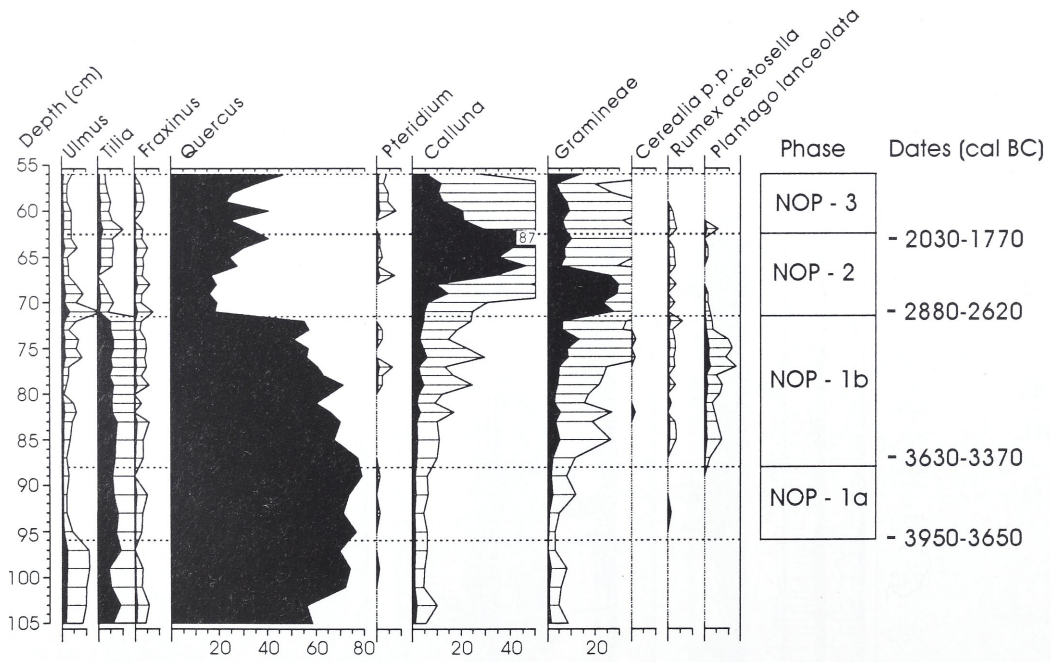


Fig. 74 (pp. 240-242). Six simplified pollen diagrams of sequences from *Siedlungskammer* Flügeln (northwestern Germany). Various phases of the Neolithic Occupation Period (NOP) and corresponding ^{14}C dates are indicated.

Flögelner Holz

(Behre & Kučan 1994)

Pollensum: Σ AP
 Location type: kettle-hole
 Sediment type: *Sphagnum* peat
 Distance to TRB settlement: 1600 m

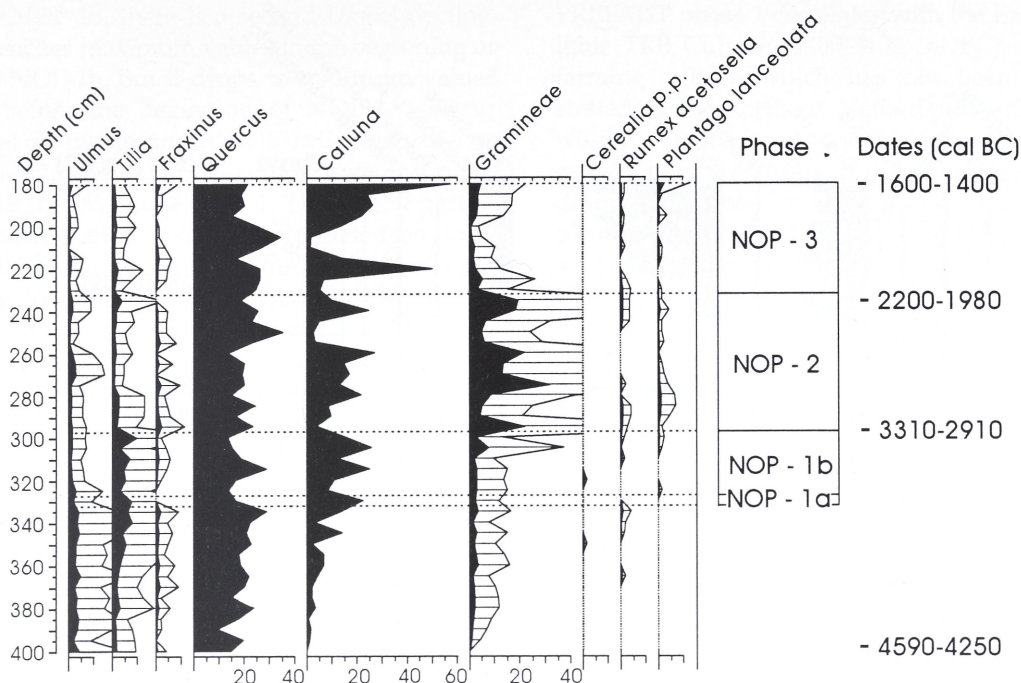


Fig. 74c.

Silbersee

(Behre & Kučan 1994)

Pollensum: Σ AP
 Location type: kettle-hole
 Sediment type: *Sphagnum* peat
 Distance to TRB settlement: 2100 m

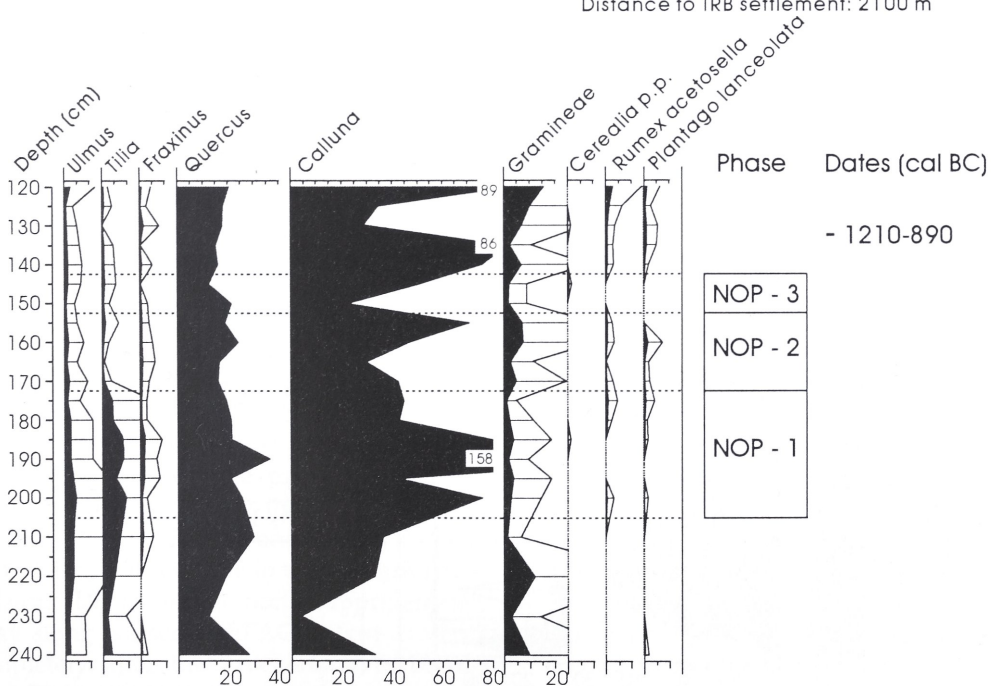


Fig. 74d.

Fuhrenkamp

(Behre & Kučan 1994)

Pollensum: Σ AP

Location type: kettle-hole

Sediment type: *Sphagnum* peat

Distance to TRB settlement: 2000 m

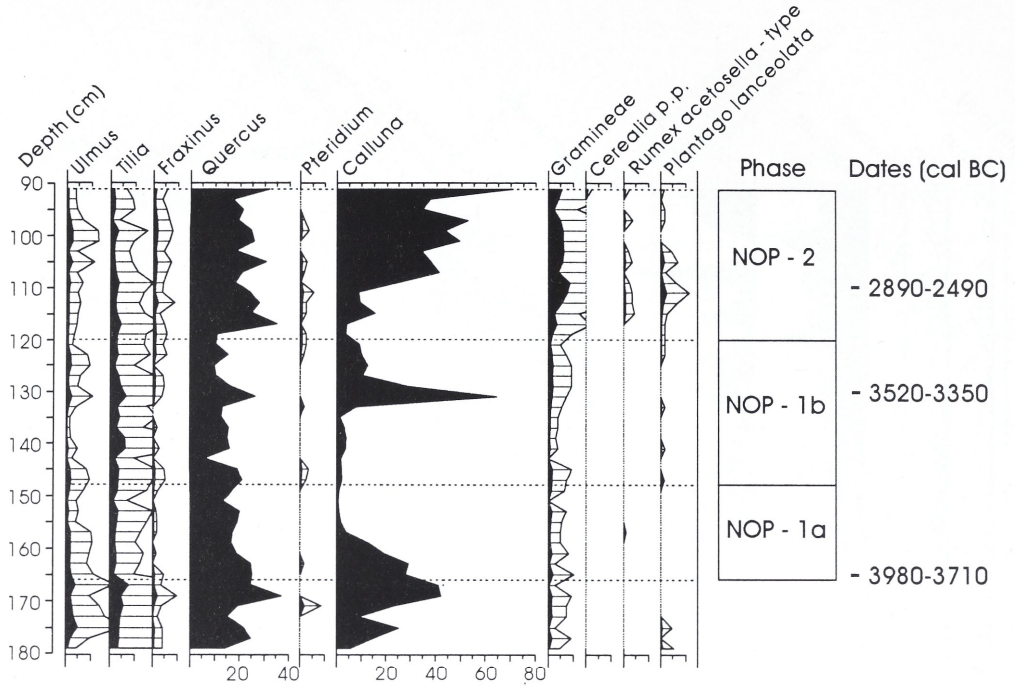


Fig. 74e.

Flögelin V

(Behre & Kučan 1994)

Pollensum: Σ AP

Location type: large raised bog

Sediment type: *Sphagnum* peat

Distance to TRB settlement: 600 m

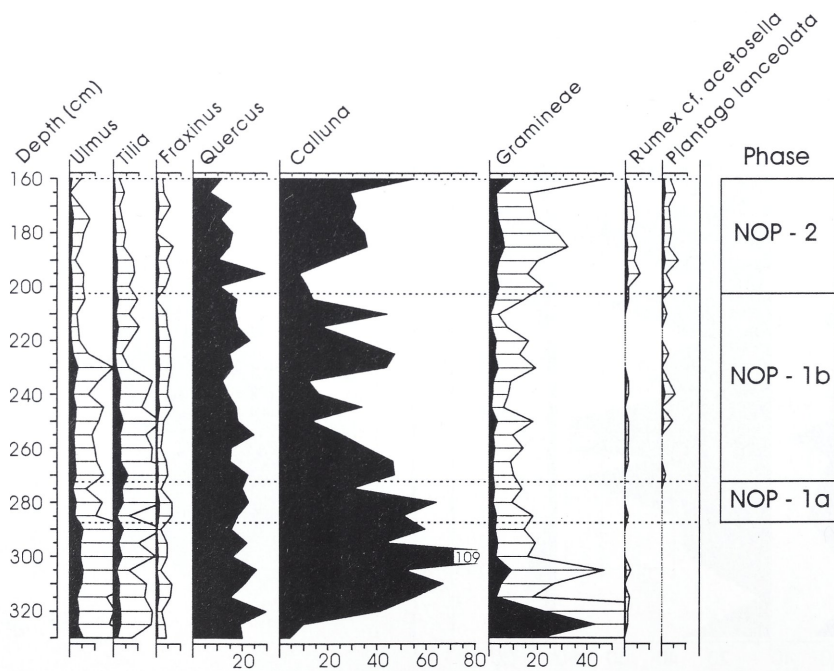


Fig. 74f.

Flögeln V (fig. 74f). The *Ulmus* decline, which occurs before the first appearance of *Plantago lanceolata*, is quite pronounced. In the course of phase NOP-1b, there is a second *Ulmus* decline. *Tilia* reaches maximum values in the beginning of phase NOP-1b, but it drops to minimum values even before the beginning of NOP-2. *Quercus* reaches no maximum in NOP-1. *Calluna vulgaris* and Gramineae attain their highest values in the Atlantic, before phase NOP-1. The largest part of the pollen of these taxa must originate from local plants. The values of the culture-indicator types remain low in the entire diagram; however, in phase NOP-2 there is a clear increase of *Plantago lanceolata* and *Rumex cf. acetosella*. Cerealia-type pollen grains are not found at all in the Neolithic Occupation Period. There are no dates of this part of the diagram. Phase NOP-3 seems to be completely absent; after NOP-2, Gramineae and the culture-indicator types only increase. According to Behre & Kučan (1994, 132), the entire phase NOP-2 falls in the Bronze Age. Yet it is possible that phase NOP-2 already begins at the *Tilia* decline of 230 cm, and that it ends at 200 cm. Then the part above 200 cm would belong to the Bronze Age. However, if this is true, there is no increase of Gramineae and culture-indicator types in phase NOP-2.

The Neolithic Occupation Phases as defined above will now be compared with the Iversen and Troels-Smith occupation phases which are distinguished by Kalis & Meurers-Balke (1998; 2001) for the western Baltic. In fig. 75, simplified versions of the original pollen diagrams by Iversen and Troels-Smith are shown, with updated phase indications and (extrapolated) dates added by Kalis & Meurers-Balke (see figs. 4-5). In the diagram of Aamosen, the first phase of human activity, Troels-Smith-PREFACT phase A, begins as early as 5000 cal BC, which is approximately 1000 years before the "classic" *Ulmus* decline. Phase NOP-1 in diagrams of Pleistocene areas near the North Sea coast has some affinity with the Troels-Smith-PREFACT phases and with Iversen-PREFACT phase 1 in diagrams of the western Baltic. However, a major difference is that in Pleistocene areas near the North Sea coast, the "classic" *Ulmus* decline occurs at the beginning of phase NOP-1, while in the western Baltic, the "classic" *Ulmus* decline occurs approximately halfway along Iversen-PREFACT phase 1, which is completely after the Troels-Smith-PREFACT phases. These various phases were caused by completely different cultures: phase NOP-1 is

attributed to the Swifterbant Culture; the Troels-Smith-PREFACT phases are correlated with the Ertebølle Culture (5100-4100 cal BC), and Iversen-PREFACT phase 1 correlates with the Early Neolithic TRB Culture (4100-3400 cal BC), an early farming culture which has not been demonstrated in the northern Netherlands and north-western Germany. A conclusion must be that quite different cultures in different areas and in different periods may cause similar pollen pictures. In spite of the difference in cultures, the *Ulmus* decline occurs contemporaneously both in Pleistocene areas near the North Sea coast and in the western Baltic, namely around 4000 cal BC (see fig. 10).

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

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

Factors influencing the manifestation of the NOP in pollen diagrams

The manifestation of the Neolithic Occupation Period in the various pollen diagrams can be severely affected by local conditions. In my view, the following four factors are the most important

Ordруп Mose

(Iversen 1949; Kalis & Meurers - Balke 1998; 2001)

Pollensum: ΣP excl. Gramineae
 Location type: terrestrialized bay
 Sediment type: gyttja
 Distance to TRB settlement: unknown

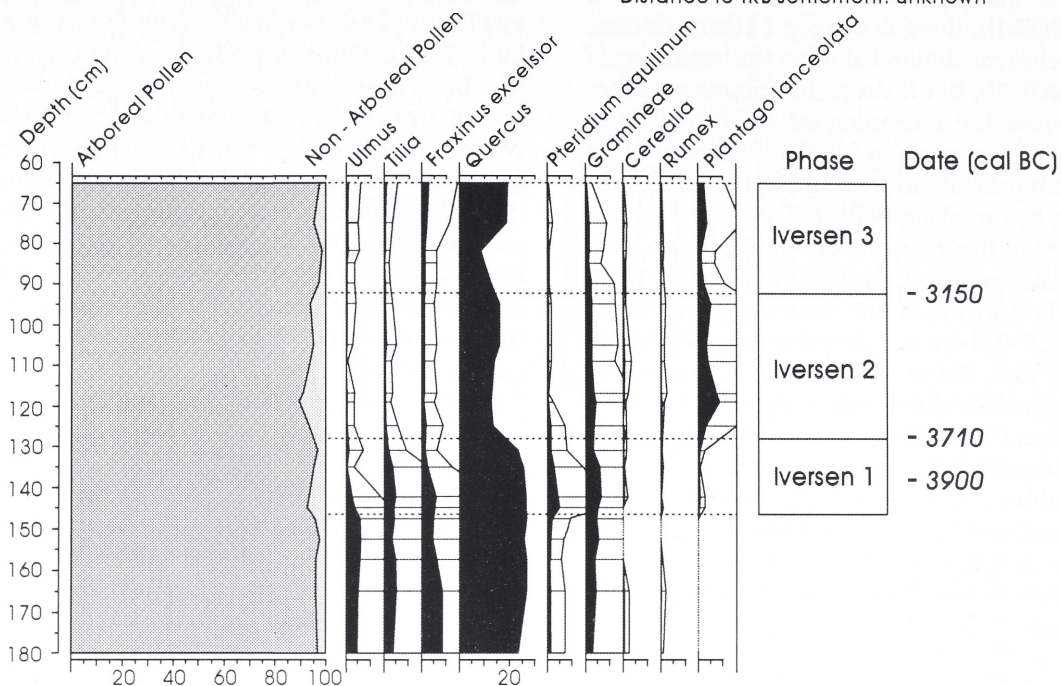


Fig. 75a.

Aamosen

(Troels-Smith 1960; 1961;
 Kalis & Meurers - Balke 1998; 2001)

Pollensum: *Hedera* + *Viscum* + *Ulmus* +
Tilia + *Fraxinus* + *Quercus* + *Corylus*
 Location type: large raised bog
 Sediment type: peat
 Distance to TRB settlement: unknown

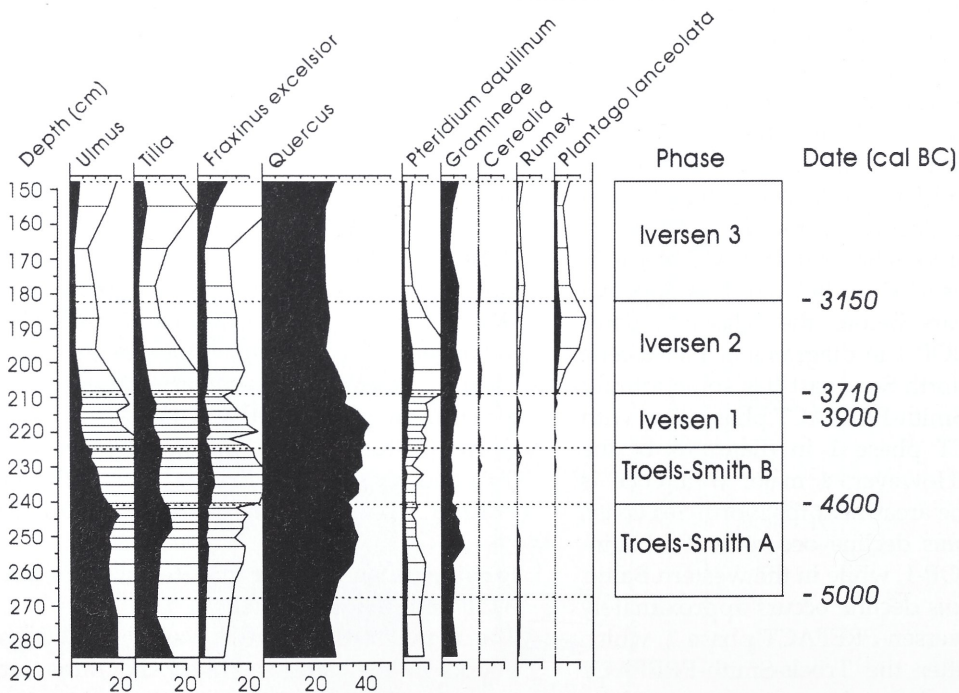


Fig. 75b.

Fig. 75 (left). Two simplified pollen diagrams of the original Danish sequences used by Iversen and Troels-Smith for the construction of their respective models of Neolithic occupation. Various Iversen and Troels-Smith occupation phases, distinguished by Kalis & Meurers-Balke (1998), and corresponding ^{14}C dates are indicated. The ^{14}C dates are all extrapolated dates from dated pollen sequences from eastern Holstein (see KALIS & MEURERS-BALKE 2001).

ones influencing human-induced changes in pollen curves in the NOP: location type, sediment type, location within the basin and distance to the settlement and/or agricultural land. Hereafter some examples will be briefly discussed, demonstrating the possible influence of these factors.

Location type:

In small and medium-sized basins (up to circa 250 m across), the local component of the pollen rain is expected to prevail (TAUBER 1965; J.A. BAKKER et al. 1999). Signals from events at a greater distance will be reflected only weakly. The smallest basin discussed in this section is the bog on the Eexterveld (24 x 10 m). When the pollen values of this pingo scar are compared with those of the medium-sized basin of the Gietsenveentje, which is located at a distance of only 2 kilometres (see fig. 24), it can be seen that in the Neolithic Occupation Period, the values of *Ulmus*, *Tilia*, *Quercus*, *Corylus* and the culture-indicator types are lower, while the values of *Betula*, *Alnus* and Gramineae are higher than in the Gietsenveentje. Most probably, *Betula*, *Alnus* and certain Gramineae grew on the edge or even within the pingo scar. Because the pollen of these taxa dominated the pollen rain, the pollen of regional taxa became relatively less important. A different situation is found in the two smallest basins of *Siedlungskammer* Flögeln, Swienskuhle (42 x 27 m) and Jagen 20 (170 x 54 m): especially in phase NOP-1 of the corresponding pollen diagrams, high to very high values of *Quercus* are found. Evidently, oak trees in this period grew almost at the edge of these small basins.

In large basins (diameter larger than circa 250 m), the regional component of the pollen rain is expected to have a more clear-cut expression because not much pollen-producing vegetation would grow inside the basin. The three diagrams from large raised-bog areas discussed here, Emmererfscheidenveen V, Bargerosterveld and Flögeln V, have remarkably many characteristics in common, although these diagrams are from locations hundreds of kilometres apart. The values of *Ulmus*, *Tilia*, *Quercus*, Gramineae and the culture-indicator types are lower, while the values of *Alnus*, *Pinus* and *Calluna vulgaris* are higher than in most diagrams from small basins.

The low values of *Ulmus*, *Tilia*, *Quercus*, Gramineae and the culture-indicator types are explained by the larger distance from the rich forests and human activities in these forests. The high values of *Calluna vulgaris* and *Alnus* are caused by plants or trees growing on the raised bog itself and at the edges. Most pollen of *Pinus* is believed to originate from long-distance transport, because of the good distribution capacity of the *Pinus* pollen grains (BIRKS & BIRKS 1980, 180). Therefore the high values of *Pinus* are explained by an increased importance of regional pollen.

Summarizing, it can be stated that it is difficult to demonstrate differences in the pollen rain due to basin size for the purpose of distinguishing small and medium-sized basins. The pollen rain in large basins, however, shows several characteristics which are clearly caused by basin size.

Sediment type:

The sedimentation of the same pollen rain in different sediment types may result in different pollen pictures. The Gietsenveentje sequences offer an excellent opportunity to compare the Neolithic Occupation Period as recorded in gyttja and in *Sphagnum* peat: in sequences Gieten V-A and V-D, the NOP occurs in gyttja, while in Gieten V-B, it occurs in *Sphagnum* peat (fig. 45). For several reasons the pollen content of peat sediment is generally considered to be more reliable than the pollen content of gyttja sediment. First, the sedimentation rate of *Sphagnum* peat is higher than that of gyttja: in the Gietsenveentje, the mean sedimentation rate of the *Sphagnum* peat is 0.99 mm/year, while the mean sedimentation rate of the gyttja is 0.55 mm/year (see VI.5.2). Because of the higher sedimentation rate, the resolution of events recorded in the pollen rain is higher in *Sphagnum* peat. Secondly, compared to gyttja, the horizontal and vertical movement of pollen in *Sphagnum* peat is very limited. The compaction of *Sphagnum* at lower levels restricts vertical movements of pollen. The compact layer is formed in 5-10 years (CLYMO 1973). In lakes, horizontal and vertical redistribution of pollen will often occur. In the Gietsenveentje lake, horizontal movement of pollen may have been caused by wind; vertical movement almost

certainly occurred when water turbulence mixed the upper, loose sediment layer and through the activities of burrowing animals, such as midge larvae and worms. These creatures can redistribute pollen over a vertical distance of up to 15 cm, although most disturbance is within 3-4 cm (R.B. DAVIS 1967; 1974). In the gyttja sediment of the Gietsenveentje, 3-4 cm on average represent 55-75 years, which is less than the confidence limits of the ^{14}C dates (see table 9). In pollen diagrams from gyttja sediment, the mixing activities of animals result in smoothed curves.

When the diagrams of Gieten V-A and V-D, in which the NOP occurs in gyttja, and Gieten V-B, in which the NOP occurs in peat, are compared, it is found not only that the curves of the first two diagrams are clearly more smoothed, but also that in diagram Gieten V-B, phase NOP-1 is represented by a considerably longer piece of sediment core than in diagrams Gieten V-A and V-D (table 21).

In spite of the different process of pollen sedimentation in gyttja and *Sphagnum* peat, the reflection of the Neolithic Occupation Period in the gyttja diagrams Gieten V-A and V-D and the peat diagram Gieten V-B is more or less the same: both the palynological characteristics and the ^{14}C dates of the various NOP phases correspond remarkably well. According to these observations, the influence of sediment type on the course of the pollen curves in the case of the Gietsenveentje seems to be limited.

Location within the basin:

Generally, sequences for pollen analysis are cored in the centre of a basin. However, the larger the basin, the greater the differences in pollen values between sequences from the centre and the edges. In only very few published studies are several pollen cores from one basin compared (for example SØNSTEGAARD & MANGERUD 1977). In the case of the Gietsenveentje, nine pollen sequences were cored at various locations within the pingo scar. It has already been outlined in VIII.1 that there are indeed differences in pollen values between diagrams from the centre and diagrams from the edges, although these differences are not fundamental. Possibly, the still fairly small basin size of the Gietsenveentje (200 x 170 m) explains the relatively minor differences in pollen content between sequences cored in different parts of the basin.

Distance to the settlement and/or agricultural land:

When the human influence on the vegetation in the Neolithic Occupation Period is studied on the basis of pollen and macroscopic-remains sequences, two important questions are: What was the nature of the human activities, and: At what distance did these human activities take place? It may be very difficult to separate these two factors. Small-scale human activities in the direct neighbourhood of a core location might cause the same changes in the pollen picture as large-scale activities at a larger distance. Archaeology can help us to resolve this problem. When there are archaeological traces of a certain culture in the direct vicinity of a core location, it is expected that this culture also left traces in the pollen diagram of that core. When the relationship between palynology and archaeology is studied, as is done in this study, core locations are selected in an area with a large density of archaeological finds from the period in which the researcher is interested; preferably, the core location is as close to the archaeological findspots as possible. The researcher hopes to find some kind of relationship between the pollen values of especially the culture-indicator types and the distance of the archaeological finds from the core location. Unfortunately, this relationship is often not very clear, sometimes even completely unclear. A few examples from the diagrams discussed in this section and in II.2 may illustrate this.

In the bog on the Eexterveld, sherds of TRB pots were found; within 200 m, there are several other TRB findspots (J.A. BAKKER et al. 1999). The TRB findspot closest to the Gietsenveentje lies at a distance of 600 m (see fig. 24). Still, the pollen values of the culture-indicator types in the Gietsenveentje diagrams are considerably higher than in the diagram of Eexterveld.

In the *Siedlungskammer* Flögeln, a TRB settlement with house plans was excavated (ZIMMERMANN 1980). Remarkably enough, the pollen sequences farthest from the TRB settlement, Swienschuhle and Jagen 20, produced the highest values of Gramineae and culture-indicator types, while in the pollen sequence Flögeln V, which is located only 600 m from the TRB settlement, only very low values of Gramineae and the culture-indicator types were observed! However, the location type of Flögeln V may also be partly responsible for the low values of Gramineae and culture-indicator types: the sequence Flögeln V was cored not far from the edge of a large raised-bog area.

Another example are two peat sequences cored near a settlement of the Vlaardingse Culture (present in the western and southern Netherlands more or less simultaneously with the TRB Culture) near Leidschendam, province of Zuid-Holland. In both pollen diagrams, only very low values of the culture-indicator types were found; in the sequence cored 40 m from the settlement, the pollen values of the culture-indicator types were lower than in the sequence cored 200 m from the settlement (GROENMAN-VAN WAATERINGE et al. 1968).

At Siggeneben-Süd in northeastern Germany, a pollen sequence was cored only 10 m from a settlement dated to the Early Neolithic Funnel Beaker Culture (MEURERS-BALKE 1983; KALIS & MEURERS-BALKE 1998; see II.2.9). In the pollen diagram, the Early Neolithic TRB is represented by Iversen-PREFACT phases 1a, 1b and 2a (KALIS & MEURERS-BALKE 1998, 7). However, the culture-indicator types in these phases show very low values. The values of *Plantago lanceolata* are even higher in Troels-Smith PREFACT phase B, which represents the Ellerbek Group (Ertebølle/Ellerbek Culture)!

These examples indicate that there is often no direct relation between pollen values of culture-indicator types and the distance of archaeological finds to the core location. This makes the interpretation of pollen values of culture-indicator types in terms of human influence on the landscape extremely difficult. Pollen diagrams in the first place reflect agricultural activities and not activities which took place in a settlement. For convenience, it is assumed that agricultural activities took place in the direct vicinity of settlements. For this reason it is believed that when core locations of pollen sequences are located in the neighbourhood of settlements, high values of culture-indicator types will be found. In practice, this seems far from true. High values of culture-indicator types more probably point to the close presence of agricultural land. The problem is, however, that it is often difficult to demonstrate the presence of agricultural land archaeologically. Direct archaeological evidence for agricultural land, like ard marks or Celtic fields, is mostly dated to the Late Neolithic or later (DRENTH & LANTING 1997; BRONGERS 1976).

In a recent study, Bakels (2000) palynologically studied a peat core at a distance of 10 m from a field or rather a series of superimposed fields

with ard marks near Haarlem, the Netherlands. A few sherds showed that the fields dated from the Middle and Late Bronze Age (1500-800 cal BC). In the entire pollen diagram, the values of the culture-indicator types are low. In the period which represents the Middle and Late Bronze Age (phase 4), only one grain of Cerealia-type was found. The values of *Rumex acetosa*-type and *Plantago lanceolata* hardly exceed 1%. Of course it is possible that the period when the fields were tilled is not represented in the pollen diagram because it falls between two samples. The sedimentation rate of the peat in phase 4 of the pollen diagram, which represents the period of the fields, is ca. 1 cm in 15 years; the pollen samples were taken every 5 cm, which means that the time between the individual samples is ca. 75 years. It seems unlikely that the well-developed agricultural layers, consisting of several superimposed plough soil horizons, represent a period of less than 75 years. Assuming that the period of the fields is represented in the pollen diagram, this example demonstrates that even when fields were present in the direct vicinity of a core location, it is possible that their presence is not reflected in a pollen diagram from that core.

In the Gietsenveentje, Swienschuhle and Jagen 20, locations which are all at relatively large distances from the nearest archaeological finds pointing to a settlement (see table 1), relatively high pollen values of culture-indicator types are found in the Neolithic Occupation Period. Apparently, arable fields and/or pastures were located in the direct neighbourhood of these circular depressions. Possibly the accompanying settlements simply have not yet been found. Otherwise, these results indicate the possibility that the arable fields and grazing land for the livestock were located one or two kilometres from the settlement.

Length in the sediment and dates of the phases

Now that I have distinguished the Neolithic Occupation Phases in a number of diagrams from the northern Netherlands and northwestern Germany on the basis of changes in the pollen curves, it is interesting to compare some characteristics of these phases, namely the length of the core section in the sediment, ¹⁴C dates of the boundaries and the duration in calendar years of the three phases (table 21 and fig. 76). The similarities and differences are discussed below.

| NOP-1 | | | | |
|------------------------|-----------------------------------------------|-------------------------|--------------------------------|------------------------------|
| Location | Type of sediment | Length in sediment (cm) | ¹⁴ C dates (cal BC) | Duration in calibrated years |
| Gieten V-A | fine gyttja | 10 | 4172-3402 | 770 |
| Gieten V-B | fine <i>Sphagnum</i> peat | 40 | 4018-3429 | 589 |
| Gieten V-D | gyttja | 16 | 3964-3539 | 425 |
| Eexterveld | peat | 12 | 4245-3010 | 1235 |
| Emmererfscheidenveen V | <i>Sphagnum</i> peat | 35 | 3795-2710 | 1085 |
| Bargeroosterveld | <i>Scheuchzeria</i> / <i>Sphagnum</i> peat | 44 | ? | ? |
| Swienschuhle | sedge peat | 36 | 4010-3125 | 885 |
| Jagen 20 | <i>Sphagnum</i> peat | 24 | 3800-2750 | 1050 |
| Flögelner Holz | <i>Sphagnum</i> peat | 40 | 3561-3110 | 451 |
| Silbersee | <i>Sphagnum</i> peat | 32 | ? | ? |
| Fuhrenkamp | <i>Sphagnum</i> peat | 46 | 3845-3062 | 783 |
| Flögel V | <i>Sphagnum</i> peat | 86 | ? | ? |

| NOP-2 | | | | |
|------------------------|------------------------------|-------------------------|--------------------------------|------------------------------|
| Location | Type of sediment | Length in sediment (cm) | ¹⁴ C dates (cal BC) | Duration in calibrated years |
| Gieten V-A | fine/coarse gyttja | 21.5 | 3402-2600 | 802 |
| Gieten V-B | fine <i>Sphagnum</i> peat | 17.5 (incompl.) | 3429-? | ? |
| Gieten V-D | gyttja/ <i>Sphagnum</i> peat | 46 | 3539-? | ? |
| Eexterveld | peat | 8 | 3010-2520 | 490 |
| Emmererfscheidenveen V | <i>Sphagnum</i> peat | 30 | 2710-2015 | 695 |
| Bargeroosterveld | <i>Sphagnum</i> peat | 33 | ? | ? |
| Swienschuhle | sedge peat | 30 | 3125-1540 | 1585 |
| Jagen 20 | <i>Sphagnum</i> peat | 10 | 2750-1900 | 850 |
| Flögelner Holz | <i>Sphagnum</i> peat | 66 | 3110-2090 | 1020 |
| Silbersee | <i>Sphagnum</i> peat | 32 | ? | ? |
| Fuhrenkamp | <i>Sphagnum</i> peat | 30 | 3062-1571 | 1491 |
| Flögel V | <i>Sphagnum</i> peat | 40 | ? | ? |

Table 21. Characteristics of the three phases of the Neolithic Occupation Period in pollen diagrams discussed in this section. The Gietsenveentje dates are calibrated according to Method II calibration of sub-datasets (wiggle matching) (see VI.4.2 and table 9). The other dates are calibrated according to Method I calibration, which takes into account the fixed stratigraphical sequence of the dated samples but assumes no constant growth rate (see VI.4.2); here the middle points of the 1 σ range of the calibrated dates are given. ¹⁴C dates in *italics* are extrapolated dates. Durations in *italics* are durations based on extrapolated dates.

| NOP-3 | | | | |
|------------------------|-----------------------------|-------------------------|--------------------------------|------------------------------|
| Location | Type of sediment | Length in sediment (cm) | ¹⁴ C dates (cal BC) | Duration in calibrated years |
| Gieten V-A | coarse gyttja | 60 | 2600-1769 | 831 |
| Gieten V-D | coarse <i>Sphagnum</i> peat | 25 (incompl.?) | ? | ? |
| Eexterveld | peat | 8 | 2520-? | ? |
| Emmererfscheidenveen V | <i>Sphagnum</i> peat | 16 | 2015-1661 | 354 |
| Bargeroosterveld | <i>Sphagnum</i> peat | 23 | ? | ? |
| Swienschuhle | sedge peat | 50 | 1540-644 | 896 |
| Jagen 20 | <i>Sphagnum</i> peat | 6 | 1900-1306 | 594 |
| Flögelner Holz | <i>Sphagnum</i> peat | 50 | 2090-1500 | 590 |
| Silbersee | <i>Sphagnum</i> peat | 10 | ? | ? |

Table 21 (continued).

NOP-1: As expected, the core length of this phase in gyttja is shorter than in peat (except for the very small bog on the Eexterveld). The average length in gyttja is 13 cm; the average length in peat is ca. 40 cm. The ¹⁴C dates of the beginning and end of this phase correspond quite well. The average date of the beginning in the Gietsenveentje and Eexterveld is ca. 4100 cal BC; in Emmererfscheidenveen V and the diagrams from *Siedlungskammer* Flögel, the phase begins on average ca. 3800 cal BC. In the Gietsenveentje diagrams, the phase ends ca. 3450 cal BC; in the other diagrams, it ends on average ca. 3000 cal BC. The duration of this phase in the Gietsenveentje is on average ca. 600 years; in all diagrams, the duration is on average ca. 800 years.

In all diagrams, this phase starts hundreds of years before the beginning of the TRB Culture (fig. 76), which means that it has to be attributed to the Swifterbant Culture.

NOP-2: This phase occurs entirely in gyttja only in diagram Gieten V-A; there the core length in the sediment is 21.5 cm. The core length of this phase in the diagrams from southeastern Drenthe and *Siedlungskammer* Flögel is on average ca. 35 cm. The ¹⁴C dates of the end of this phase are not unambiguous: in the Gietsenveentje and Eexterveld, they are on aver-

age ca. 2550 cal BC, while in *Siedlungskammer* Flögel, they are on average ca. 1825 cal BC. Because the date of the end of this phase varies considerably between the diagrams, the duration of this phase also varies significantly, between 500 and 1600 years. On average, the duration of this phase is ca. 1000 years.

In the Gietsenveentje diagrams, phase NOP-2 covers the entire TRB period and a small part of the EGK/BB period; in the Eexterveld diagram, it covers the last third part of the TRB period and a small part of the EGK/BB period; in the Emmererfscheidenveen and Jagen 20 diagrams, it falls entirely in the EGK/BB period; in the three other diagrams from Flögel, it begins a few centuries after the beginning of the TRB period, and also covers the entire EGK/BB period. In Swienschuhle and Fuhrenkamp, phase NOP-2 even extends into the Bronze Age (fig. 76).

NOP-3: This phase could not be identified in diagram Gieten V-B because of disturbed sediment. In two diagrams from *Siedlungskammer* Flögel, Fuhrenkamp and Flögel V, this phase is entirely absent. The core length of this phase in the sediment varies considerably: in the gyttja sediment of Gieten V-A, it has a length of 60 cm, while in peat sediment, it has an average length of just ca. 25 cm! The

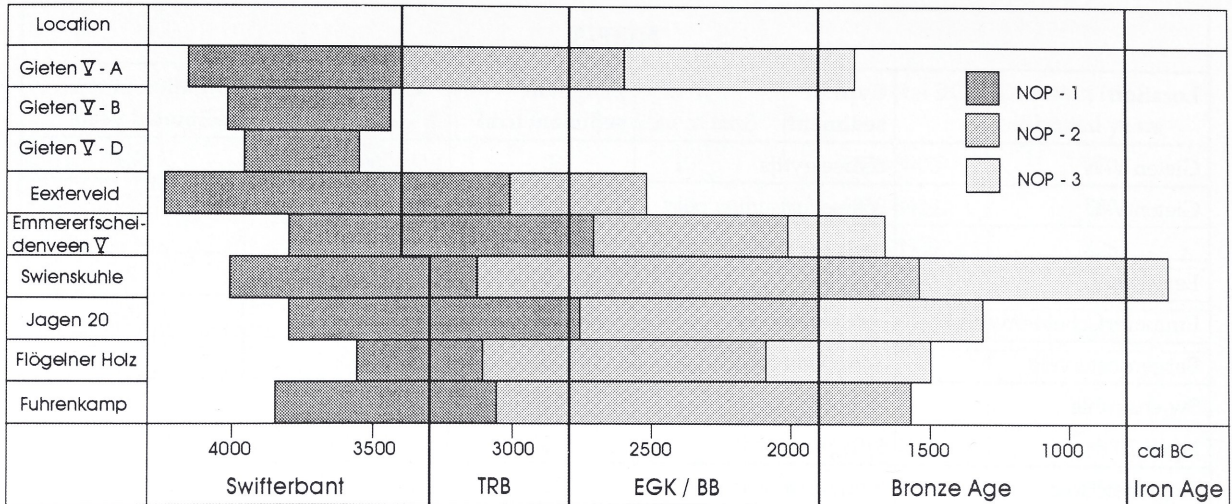


Fig. 76. Duration of the three phases of the Neolithic Occupation Period (as far as they are present) in calendar years in the pollen diagrams of figs. 73 and 74, compared to the periods of the cultures present on the Pleistocene soils near the North Sea coast. The dates are taken from table 21.

dates of the end of this phase also vary considerably, between ca. 1800 cal BC in the Gietsenveentje and as late as ca. 650 cal BC in Swienschuhle. On average, the duration of this phase is ca. 800 years.

In the Gietsenveentje, phase NOP-3 covers almost the entire EGK/BB period; in Emmererfsheldenveen and in three diagrams from Flögel, it begins in the last phase of the EGK/BB period and extends into the Bronze Age (fig. 76).

It is remarkable that the dates of the zone boundaries, especially of the zone boundaries NOP-2/NOP-3 and NOP-3/zone 4b, differ so much. Part of these differences can be explained by uncertainties in the ^{14}C dates: all phase boundaries at all locations except for the Gietsenveentje are based on individual ^{14}C dates, most dates even on extrapolations of individual ^{14}C dates. It was already indicated in VI.4.2 that because of irregularities in the calibration curve caused by changes in the ^{14}C content of the atmosphere, an individual date often corresponds to a relatively long period in real calendar years, which makes such a date suitable only for a global period indication. But even when this is kept in mind, the differences in the dates of the boundaries of phase NOP-3 in particular seem too large. This raises the question whether this phase in the various diagrams is really the same and caused by the same type of human interference in the veg-

etation. At the moment, there are too few accurate dates of the boundaries of this phase to answer this question. This study has concentrated mainly on the dating of phase NOP-1 and the beginning of phase NOP-2. Since in the Gietsenveentje all zone boundaries except for NOP-2/NOP-3 are defined by series of at least three dates, the Gietsenveentje dates of the zone boundaries will be taken as a starting point for drawing up a model for the Neolithic Occupation Period in Pleistocene areas near the North Sea coast.

A model of the NOP in Pleistocene areas near the North Sea coast

On the basis of the simplified pollen diagrams of figs. 73-74, a generalized and idealized model is constructed which describes the course of selected pollen curves in the Neolithic Occupation Period. Especially those pollen types are included which are expected to have been most strongly influenced by human interference in the vegetation. Compared to the simplified pollen diagrams of figs. 73-74, two pollen types are omitted: *Fraxinus excelsior* and *Calluna vulgaris*. The changes in the pollen values of *Fraxinus excelsior* during the NOP are so slight that it is useless to include this pollen type in the model. *Calluna vulgaris*, clearly a regional pollen type in the diagrams of the Gietsenveentje and Eexterveld, shows very high and irregular values in the dia-

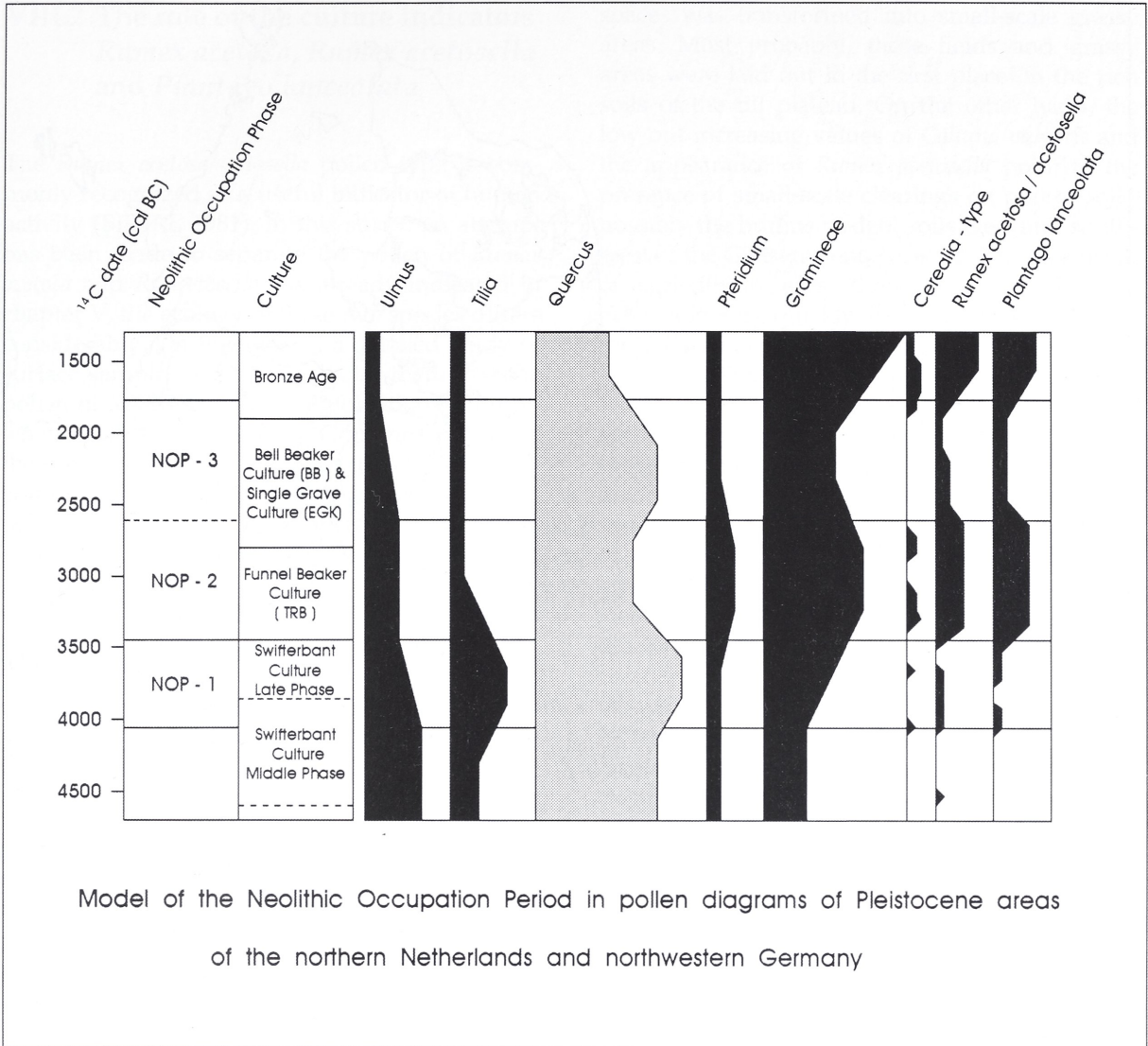


Fig. 77. Model of the Neolithic Occupation Period. The grey curve is a five times magnification of the black curves.

grams of the large raised bogs of southeastern Drenthe and in most diagrams of *Siedlungskammer* Flögeln, indicating that at these locations it is a local pollen type.

With the help of a large number of ¹⁴C dates, especially from the Gietsenveentje, the various phases of the NOP are connected with archaeological cultures. The model is shown in fig. 77. It is evident from this figure that the boundaries of the Neolithic Occupation Phases do not always coincide with those of the cultures. Yet it is noteworthy that the boundary which is most accurately dated in the Gietsenveentje, namely NOP-1/NOP-2, almost exactly coincides with the

Swifterbant/TRB transition. The beginning of NOP-1 is also dated quite accurately, but this date seems not to coincide with any boundary between phases of the Swifterbant Culture. As already indicated above, the NOP-2/NOP-3 and NOP-3/zone 4b boundaries are dated far less closely. It is most probable that in the northern Netherlands, phase NOP-3 coincides with the EGK/BB period. In northwestern Germany, phase NOP-2 also seems to cover the largest part of the EGK/BB period, while phase NOP-3 does not start until the end of the EGK/BB period and extends into the Bronze Age (fig. 76). As already stated, more ¹⁴C dates are needed to determine



Fig. 78. Indication of the area for which the model of the Neolithic Occupation Period is valid.

the boundaries of phase NOP-3 and the correlation of this phase with archaeological cultures. The area to which the model of fig. 77 applies, is indicated in fig. 78. Of course when any given diagram from this area is considered, deviations from the model will always be found. Often these deviations will be caused by one of the four fac-

tors discussed above. But in general, the trends as described in the model can be recognized in almost every diagram from the area of fig. 78. The archaeological implications of the model, i.e. the nature of the human interference in the vegetation in the various phases, will be discussed in VIII.4.

VIII.2 The role of the culture indicators *Rumex acetosa*, *Rumex acetosella* and *Plantago lanceolata*

The *Rumex acetosa/acetosella* pollen type is commonly recognized as a useful indicator of human activity (BEHRE 1981). In this study, an attempt has been made to separate the pollen of *Rumex acetosa* and *R. acetosella*. As already indicated in chapter V, the ecology of these two species differs considerably. On the basis of a detailed study of surface samples, it was concluded there that the pollen of *Rumex acetosa* in combination with pollen of *Plantago lanceolata* and Gramineae points to the presence of grass-rich vegetation with a moderate to high availability of nutrients, while the pollen of *Rumex acetosella*, often in combination with pollen of *Calluna vulgaris*, points to forest clearance, *Secale* fields or former arable land. This knowledge was used for the global description of the vegetation in the Neolithic Occupation Period. Here the specific role of the two *Rumex* species in the vegetation of the Neolithic Occupation period and later will be explored in more detail.

In fig. 79, the curves of *Rumex acetosa*, *R. acetosella* and a selection of other pollen types in diagram Gieten V-A are shown for the first part of the Neolithic Occupation Period and for the period from the late Middle Ages up till the present day. (In the intervening period, the pollen of *Rumex acetosa* and *R. acetosella* was not separated.)

In pollen zone 3b, which represents the Atlantic, only pollen of *Rumex acetosa* is found and no pollen of *Rumex acetosella*. Most probably, this pollen originates from *Rumex acetosa* growing in its natural biotope: brooksides and light spots in the forest (WEEDA et al. 1985). Because *Rumex acetosa* prefers relatively nutrient-rich soils, small quantities most probably occurred on lighter spots in the rich forests on the till plateau near the Gietsenveentje during the Atlantic (fig. 67).

In phase NOP-1, which represents the Swifterbant Culture, *Rumex acetosa* slightly increases; small increases of Gramineae and *Calluna vulgaris* are observed. *Plantago lanceolata* and Cerealia-type appear. Also a few grains of *Rumex acetosella* are found. Most probably, people of the Swifterbant Culture created small clearings in the forest. The finds of Cerealia-type pollen indicate that some of these open spaces were used for small-scale cereal cultivation; the low but increasing values of Gramineae, *Rumex acetosa* and *Plantago lanceolata* indicate that another part of these open

spaces was transformed into small-scale grassy areas. Most probably, these fields and grassy areas were laid out in the first place on the rich soils of the till plateau. On the other hand, the low but increasing values of *Calluna vulgaris* and the appearance of *Rumex acetosella* point to the presence of small-scale clearings on poorer soils, possibly the humus-podzol soils west and southwest of the Gietsenveentje (see fig. 20). As a result of agricultural uses, these poor soils became exhausted very quickly, creating ideal conditions for *Calluna vulgaris* and *Rumex acetosella*.

In phase NOP-2, which represents the Funnel Beaker Culture, considerable increases are observed in the values of *Rumex acetosa*, *Plantago lanceolata* and Gramineae. *Rumex acetosella*, *Calluna vulgaris* and Cerealia-type increase to a much smaller extent. TRB people cleared larger pieces of forest than did their predecessors; given the remarkably increased values of *Rumex acetosa*, *Plantago lanceolata* and Gramineae, the new open spaces were used almost exclusively for the creation of pasture. In view of the still very low values of Cerealia-type, the use of cereals barely increased in this phase. Possibly, the slightly increased values of *Rumex acetosella* and *Calluna vulgaris* point to expanding areas of abandoned, exhausted arable fields. When arable fields were laid out on the poorer soils south and southwest of the Gietsenveentje, they were of course exhausted much sooner than those on the till plateau. The agricultural activities reflected in the pollen picture of phases NOP-1 and NOP-2 must have taken place not far from the Gietsenveentje: *Rumex acetosa* reaches values of more than 1%, which according to the surface-sample study in chapter V points to considerable amounts of *Rumex* plants within a distance of 25 m. Furthermore, the major part of the area around the Gietsenveentje was still covered with dense forest; because of the finds of pollen grains reflecting agricultural activities among the vast amount of tree pollen, these agricultural activities must have taken place in the direct vicinity of the core location.

After phase NOP-2, the diagram of fig. 79 continues with the last part of zone 5a, which represents the last part of the Middle Ages. Compared to the Neolithic Occupation Period, the values of *Rumex acetosa*, *Plantago lanceolata* and Gramineae are more or less the same, while the values of Cerealia-type (note the different pollen percentage scales!), *Rumex acetosella* and *Calluna vulgaris* have increased spectacularly. The landscape around the Gietsenveentje had an ut-

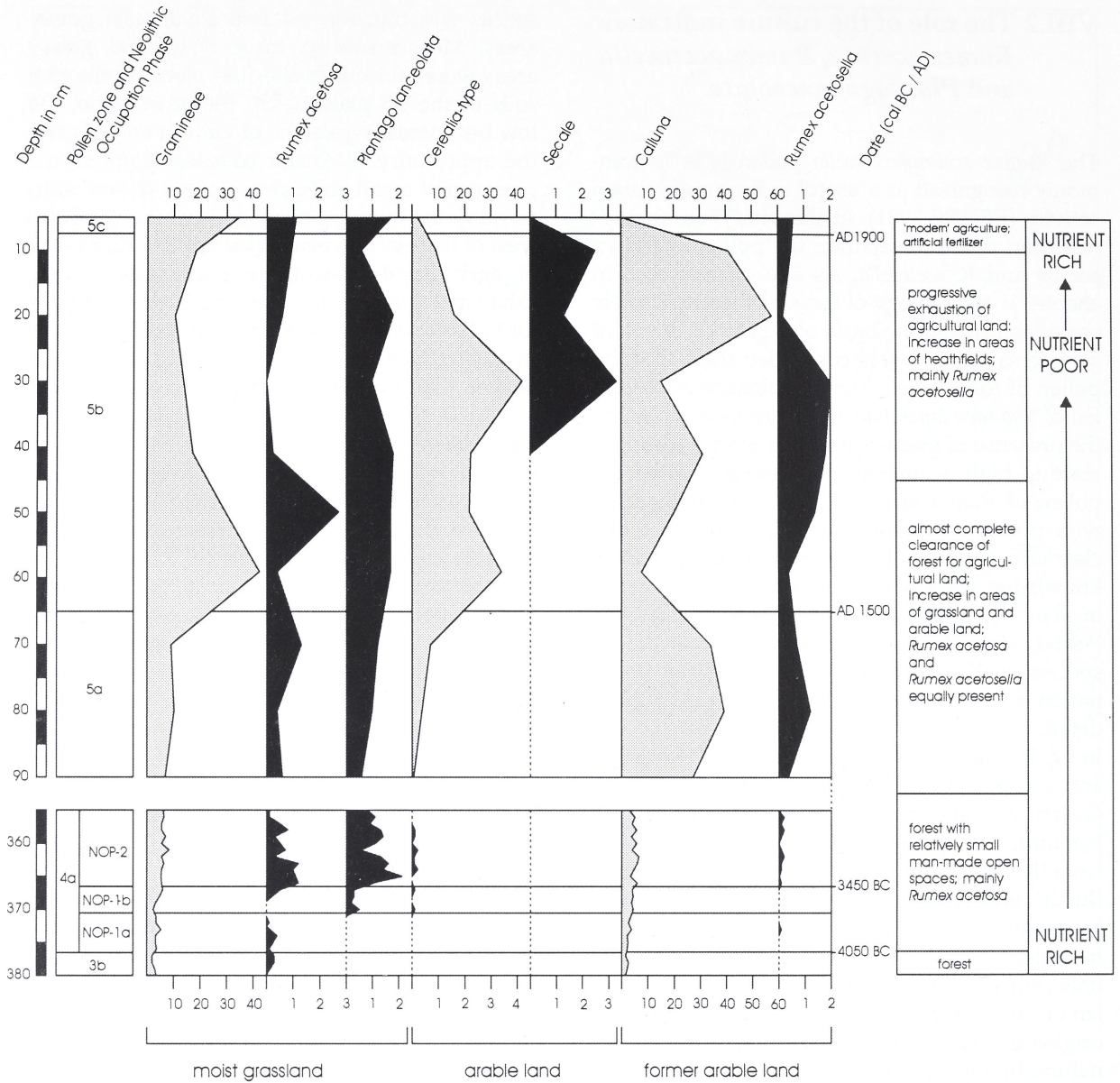


Fig. 79. Simplified pollen diagram of sequence Gieten V-A, showing the curves of *Rumex acetosa*, *R. acetosella* and a selection of other pollen types. At the right, events in the vegetation and the availability of nutrients in the soils are indicated.

terly different appearance: in the course of thousands of years, the dense primeval forests had been cleared almost completely. The cleared areas were intensively used for agricultural purposes. At the end of the Middle Ages, the area of arable land was much larger than in the Neolithic; however, the area of grass-rich vegetation had not expanded. After thousands of years of intensive agricultural use, the soils in many places were completely exhausted. These poor soils were an ideal biotope for *Rumex acetosella*

and *Calluna vulgaris*. As a result, the landscape in this period was dominated by extensive heathfields with patches of *Rumex acetosella* on the somewhat less poor soils.

In the first part of zone 5b, which in total represents the period between ca. AD 1500 and ca. AD 1900, peaks are observed of *Rumex acetosa*, *Plantago lanceolata*, Gramineae and Cerealia-type, while *Calluna vulgaris* and *Rumex acetosella* reach minimum values. Obviously, in this period the area of heathfields was pushed back by ex-

panding grassland and arable land. In the second part of zone 5b, a decrease of *Rumex acetosa*, *Plantago lanceolata* and Gramineae is observed, while the values of *Rumex acetosella* and *Calluna vulgaris* increase again. *Rumex acetosella* reaches its highest values, almost 2%. These values of more than 1% indicate that in this period *Rumex acetosella* must have grown not far from the edge of the pingo scar (see V.4). The values of Cerealia-type remain very high; pollen of *Secale* appears for the first time in percentages of 1-3%. Apparently, the area of heathfields increased at the expense of grassland, while the area of arable fields remained more or less constant. There is also a possibility that in this period *Rumex acetosella* grew as a weed in *Secale* fields (BEHRE 1981); however, since the *Rumex acetosella* curve more or less follows the same pattern as the *Calluna vulgaris* curve, it seems more likely that this species occurred mainly on former arable land in combination with *Calluna vulgaris*.

Finally, in zone 5c, which represents roughly the twentieth century, the values of *Rumex acetosa*, *Plantago lanceolata* and Gramineae increase, while the values of Cerealia-type and *Calluna vulgaris* fall considerably. The values of *Rumex acetosella* remain relatively low. As a result of the introduction of artificial fertilizer, soils were markedly enriched: the areas with *Calluna vulgaris* and *Rumex acetosella* could be transformed into farmland. Given the increased values of *Rumex acetosa*, *Plantago lanceolata* and Gramineae, the heathfields near the Gietsenveentje were transformed predominantly into pastures.

It can be concluded that in the Gieten V-A diagram the *Rumex acetosa* curve generally follows the same pattern as the *Plantago lanceolata* and Gramineae curves, while the *Rumex acetosella* curve follows the same pattern as the *Calluna vulgaris* curve. When this information is compared with the results of the surface-sample study in chapter V, it is confirmed that *Rumex acetosa* is generally an indicator type for moist grass vegetation with a moderate to high availability of nutrients, while *Rumex acetosella* is an indicator type for former arable land with a low to moderate availability of nutrients.

Now that the indicator value of *Rumex acetosa* and *Rumex acetosella* is explained, the same may attempted for *Plantago lanceolata*. Generally, *Plantago lanceolata* is regarded as an indicator type for

pasture (see I.4.2). However, Groenman-van Waateringe (1986, 200) considers the possibility that *Plantago lanceolata* grew as a weed in arable fields. *Plantago lanceolata* nowadays occurs both in pastures and meadows, but prefers meadows where no grazing or trampling takes place, on more nutrient-rich, humid, not compressed, untrodden soil (WEEDA et al. 1988). These meadows must be mown once a year in July/August, when the seeds of *Plantago lanceolata* are fully ripened. Under these circumstances, robust plants with long spikes will develop. On more nutrient-poor, little grazed or trampled vegetation types which remain low, another form of *Plantago lanceolata* is found: low-growing plants with short spikes. *Plantago lanceolata* is hampered, more than *Plantago major* or *P. media*, by trampling and grazing (WEEDA et al. 1988). Nowadays, hay meadows are the ideal biotope for *Plantago lanceolata*. Because hay meadows are improbable in the Neolithic, at least some of the *Plantago lanceolata* could have belonged to the arable weeds, because the dynamic system of an arable field with summer cereals is much the same as that of a meadow mown once a year in late summer, especially if the preparation of the field is only done with an ard and not with a plough (GROENMAN-VAN WAATERINGE 1986). Groenman-van Waateringe (1986, 200) names three points of possible evidence for *Plantago lanceolata* being an arable weed, which will be briefly discussed:

1. Iron Age barrows (sic!) with *Plantago lanceolata* values of 200-300% lie on old arable.

These figures originate from two samples of old arable below tumulus 5 and tumulus 6 of the barrow cemetery of Hijken, province of Drenthe, the Netherlands, which are dated to the Bronze Age (VAN ZEIST 1955a, 35), and not to the Iron Age, as stated by Groenman-van Waateringe. Very distinct ard marks indicated that the barrows were constructed on old arable. However, the pollen in the samples was poorly preserved, and as a result the pollen sums were very low (total AP minus *Betula* 205 and 135). Van Zeist (1955a, 76) concludes that the poor state of preservation favoured the pollen of *Plantago lanceolata*. Indeed, it is conspicuous that high values of *Plantago lanceolata* in the barrow samples nearly always coincide with low to very low pollen sums.

2. *Neolithic barrows with high values for Plantago lanceolata, at least in the central part of the Netherlands, possess sherds in their subsoil, an indication for the fields being manured with domestic waste.*

In the old surface below two EGK barrows at Vaassen and Putten in the Veluwe region, the central Netherlands, EGK sherds were found (CASPARIE & GROENMAN-VAN WAATERINGE 1980, S-2; S-12). Casparie & Groenman-van Waateringe (1980, 50) believe that these barrows were constructed on old settlement sites. Pollen samples of these old surfaces showed relatively high values of *Plantago lanceolata* (10-20%) and Gramineae (30-80%). *Rumex acetosa*-type (sic) shows higher values here than it does in most other barrow samples. However, only a few grains of Cerealia-type were found. The values of *Calluna vulgaris* are low to very low. Apparently, the soil of these old settlement sites was still too rich in nutrients for *Calluna vulgaris*. As we have seen, the combination of high values of *Plantago lanceolata*, *Rumex acetosa* (from which the *Rumex acetosa*-type pollen most probably originates) and Gramineae generally points to the presence of grass-rich vegetation. If these abandoned settlement sites had been used as arable land until a short time before the construction of the barrow, higher values of Cerealia-type would be found. It is more likely that these sites were left alone and used as grazing areas for the livestock.

3. *Charred grains of cereals are often found together with charred remains of Plantago lanceolata, especially in settlements on poor sandy soils.*

In the excavation of a medieval settlement near Gasselte, province of Drenthe, the Netherlands, charred seed samples were collected (VAN ZEIST & PALFENIER-VEGTER 1979). In three samples, one charred seed of *Plantago lanceolata* was found among thousands of cereal grains. The other species which were found in these samples are certainly not all rated among the arable weeds, for example charred seeds of *Galium palustre* and *Carex* sp.. In charred seed samples from the excavation of medieval Dorestad (Wijk bij Duurstede, the central Netherlands; VAN ZEIST 1969) a few seeds of *Plantago lanceolata* were found among the cereals, but here also other species than arable weeds were found. Furthermore, in the Middle Ages the plough which turns the soil had been in use for a long time. When this plough is used, it is

very difficult for the perennial *Plantago lanceolata* to maintain itself in a field.

In my opinion, these three examples constitute no compelling evidence for *Plantago lanceolata* being an arable weed. Of course, theoretically it is possible, as Behre & Kučan (1994, 148) indicated, that before the introduction of the "modern" plough which turns the soil, *Plantago lanceolata* grew as a weed in arable fields; it could maintain itself because its roots were not destroyed by the ard. But the palynological evidence presented in this study points in another direction: it appears from fig. 79 that the curve of *Plantago lanceolata* follows the same course as those of *Rumex acetosa* and Gramineae, and differs from the curve of Cerealia-type, which I believe to indicate that *Plantago lanceolata* grew predominantly in moist, grassy areas with a moderate to high availability of nutrients. My conclusion is that *Plantago lanceolata* is an indicator type for grass-rich vegetation with a moderate to high availability of nutrients.

VIII.3 The *Ulmus* decline

In the northern Netherlands and northwestern Germany, the beginning of the Neolithic Occupation Period more or less coincides with the "classic" decline of *Ulmus*, which occurs in many pollen diagrams from western and northern Europe (see II.3). The set of ¹⁴C dates which was used to date the beginning of the NOP, also provides information about the *Ulmus* decline, clarifying when exactly it took place and how long it lasted. This information will be compared with evidence from other recent studies of the *Ulmus* decline in northern and western Europe (see II.3).

Fig. 80 shows the *Ulmus* decline in four Gietsenveentje diagrams. The pollen values of *Ulmus* are plotted next to those of *Plantago lanceolata*. On the basis of these two pollen types and a few others, the boundaries of the three Neolithic Occupation Phases were defined. These phases and all calibrated ¹⁴C dates are also shown in fig. 80. The *Ulmus* decline in the Gietsenveentje diagrams appears to be very gradual and slow: the *Ulmus* percentage decreases from ca. 3.5% to ca. 1.5% over a period of several centuries. It is difficult to determine the exact beginning and end of the decline. In table 22 the approximate beginnings and endings of the *Ulmus* decline in the Gietsenveentje diagrams are shown. It is remarkable that the duration of the *Ulmus* decline varies so much between the Gietsenveentje diagrams, because

the *Ulmus* decline as reflected in the various Gietsenveentje diagrams presumably represents one and the same event in the vegetation. Since the *Ulmus* percentage is low anyhow and the decline is relatively slight, unknown random factors may have affected the *Ulmus* curve. It is certain that in diagram Gieten III the *Ulmus* decline is not completely represented because of a hiatus below the date of ca. 3650 cal BC. In the other diagrams, the *Ulmus* decline begins between 4200 and 3950 cal BC, and ends between 3400 and 2800 cal BC.

In table 22, data relating to the *Ulmus* decline in the Gietsenveentje as well as data of *Ulmus* declines from recent studies in other parts of northern and western Europe are shown (see II.3). It appears that the date of the beginning of the *Ulmus* decline in northern and western Europe lies between 4000 and 3700 cal BC. The percentage of *Ulmus* before the decline and the duration of the decline strongly vary among the various areas.

It is assumed that the *Ulmus* percentage before the decline represents the share of *Ulmus* in the Atlantic forest. From table 22 it appears that *Ulmus* reached its highest share in the Atlantic forests of Denmark and southern Sweden, and its lowest share in the Atlantic forests of the northern Netherlands. If the *Ulmus* decline were caused by elm disease, a kind of relation is expected between the share of *Ulmus* in the vegetation before the decline and the duration of the decline: the more individuals of *Ulmus* in the forest, the higher the risk of infection with the very infectious elm disease, and consequently the shorter the duration of the decline. Unfortunately, in practice this relationship is not so simple, because there are also other factors which contributed to the *Ulmus* decline. At most locations, the *Ulmus* decline can also be connected with human interference in the vegetation.

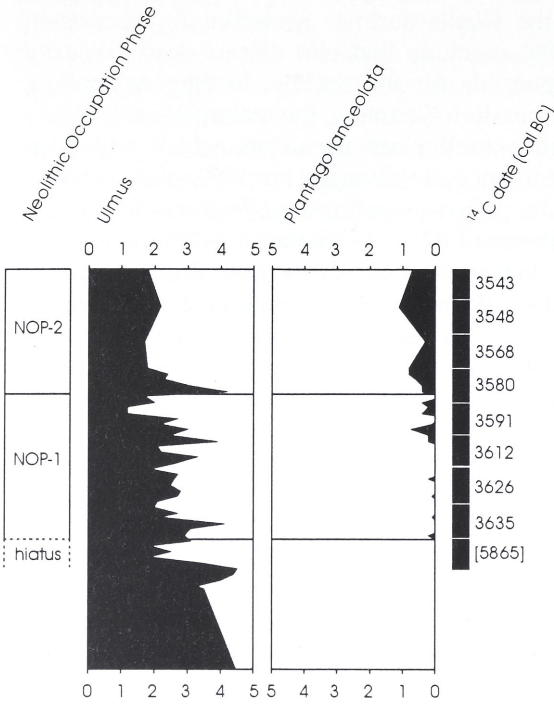
At Diss Mere, England, the *Ulmus* decline took place in only six years in woodland already disturbed by man (PEGLAR 1993). Because of the very short duration of the decline, elm disease has to be its main cause here. Possibly, regeneration of *Ulmus* was prevented by human activities like stock-grazing and fodder collection, thus accelerating the disappearance of *Ulmus*. In a pollen diagram from Kalvsjön, southern Sweden, also a very rapid *Ulmus* decline is observed (25-30 years; ANDERSEN & RASMUSSEN 1993). In this area, human interference in the vegetation appears to have been slight: almost no

culture-indicator types are observed in the period of the *Ulmus* decline. Andersen & Rasmussen (1993) conclude that elm disease was primarily responsible for the decline. In Siggeneben-Süd, northeastern Germany, the major, "classic" *Ulmus* decline took place in forests which had been disturbed quite severely for 1000 years already. In the pollen diagram, the *Ulmus* decline occurs in Iversen-PREFACT phase 1b, which represents the Siggeneben Group of the Early Neolithic Funnel Beaker Culture (KALIS & MEURERS-BALKE 1998; see II.2.9). Because the decline took ca. 300 years, it seems unlikely to have been primarily caused by elm disease: human disturbance seems to be the most important cause. Probably most *Ulmus* trees were removed by the farmers for fodder collection or grazing; as the distance between the remaining *Ulmus* trees became larger, elm disease could spread less effectively.

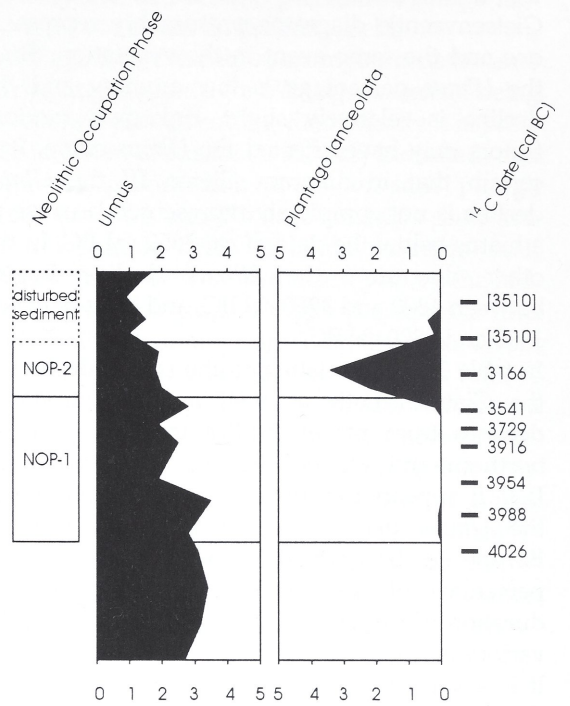
It has already been outlined that in pollen diagrams from the northern Netherlands and northwestern Germany the beginning of the *Ulmus* decline coincides with the first signs of human interference in the natural vegetation, which are reflected by the appearance of *Plantago lanceolata* and Cerealia-type and an increase of *Rumex acetosa* and Gramineae. By definition, phase NOP-1 begins at this point in time. The *Ulmus* decline persists throughout the entire phase NOP-1 and even continues into phase NOP-2. Because of the very gradual and slow decline, it seems improbable that elm disease was the primary cause of the decline. The coincidence of the decline with the appearance or increase of certain culture-indicator types instead suggests human interference in the vegetation as the most important cause of the decline. A third possible cause is a worldwide climatic change towards continentality and increased dryness which took place around 3800 cal BC (see II.4). However, such a climatic change is expected to affect not only *Ulmus* but also other trees, which is obviously not the case, given the constant values of most tree pollen types during the *Ulmus* decline.

Most probably, *Ulmus* occurred predominantly in the rich forest vegetation of the till plateau north and east of the Gietsenveentje and of the moist till plateau south of the Gietsenveentje (see fig. 67), in forest types of the *Fago-Quercetum* and *Stellario-Carpinetum* plant communities (STORTELDER et al. 1999). At the beginning of phase NOP-1, people of the Swifterbant Culture cleared a small part of the forests of the till plateau and moist till

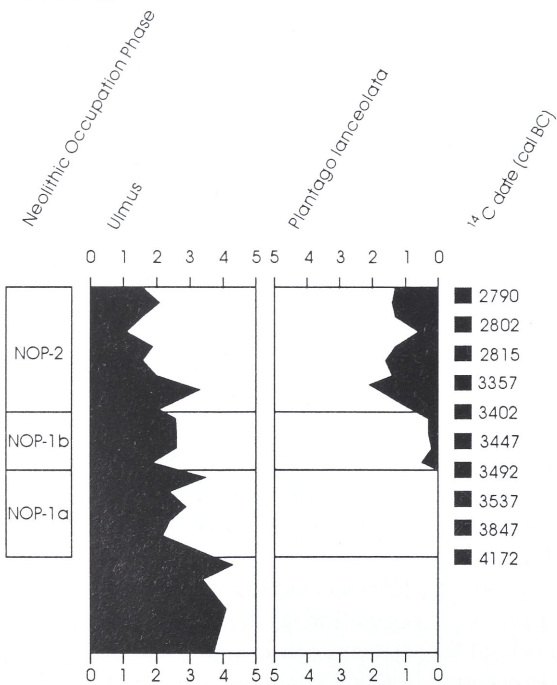
GIETEN III



GIETEN V - B



GIETEN V - A



GIETEN V - D

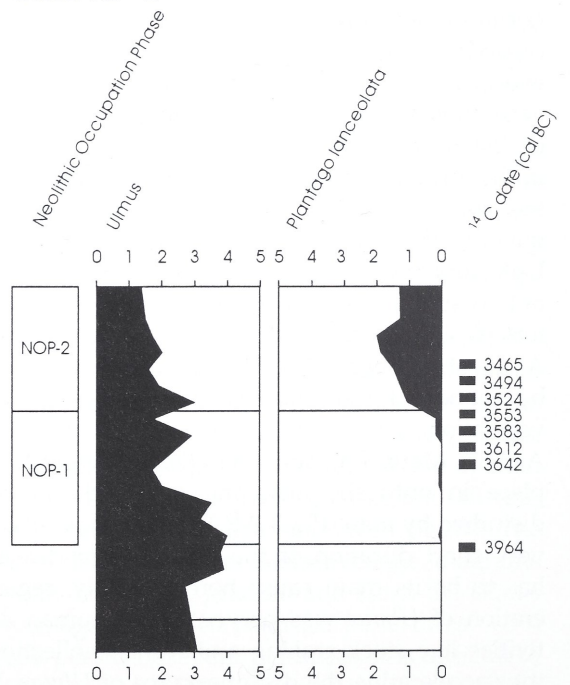


Fig. 80. The *Ulmus* decline and the first appearance of *Plantago lanceolata* in four Gietsenveentje pollen diagrams.

| Country and location | <i>Ulmus</i> values before and after decline (between brackets: composition of ΣP) | ^{14}C dates of beginning and end of decline | Duration of decline | Possible causes |
|---------------------------------|---------------------------------------------------------------------------------------------|------------------------------------------------|---------------------|---------------------------------------------------------------------------------|
| Great Britain | | | | |
| Diss Mere | 5.8% → 1.6% (AP+NAP) | ? | 6 years | elm disease, human activity |
| southern Sweden | | | | |
| Ageröds Mosse | 9% → 2% (AP) | ca. 3770 cal BC | max. 40 years | ? |
| Lake Kalvsjön | 5% → 1% (AP+NAP) | ca. 3870 cal BC | ca. 25-30 years | elm disease; weak human interference; climate-induced palaeohydrological change |
| Denmark | | | | |
| Hassing Huse Mose | 11% → 2% (AP+NAP) | 3870-3700 cal BC | 170 years | agricultural activity in combination with elm disease |
| northeastern Germany | | | | |
| Siggeneben-Süd | 7.5% → 2% (AP+NAP excl. Gramineae) | ca. 4000-3700 cal BC | 300 years | forests were already severely disturbed by man; elm disease (?) |
| Belauer See | 9.5% → 1.7% (AP) | 3818-3573 cal BC | 245 years | interaction between elm disease and human interference |
| the northern Netherlands | | | | |
| Gieten III | 3% → 2% (AP+NAP excl. <i>Betula</i>) | 3650-3550 cal BC | 100 years | human disturbance, possibly in combination with elm disease |
| Gieten V-A | 4% → 1.5% (AP+NAP excl. <i>Betula</i>) | 4200-2800 cal BC | 1400 years | |
| Gieten V-B | 3% → 2% (AP+NAP excl. <i>Betula</i>) | 4000-3400 cal BC | 600 years | |
| Gieten V-D | 4% → 1.5% (AP+NAP excl. <i>Betula</i>) | 3950-3400 cal BC | 550 years | |

Table 22. Characteristics of the *Ulmus* decline in northern and northwestern Europe. The data are from Peglar (1993), Skog & Regnéll (1995), Digerfeldt (1997), Andersen & Rasmussen (1993), Wiethold (1998), Kalis & Meurers-Balke (1998) and the present study.

plateau, to create open spaces for small-scale arable fields and, to a lesser extent, pastures. The rich soils of the till plateau and moist till plateau were very suitable for agriculture. It is also possible that *Ulmus* trees were felled selectively, because the nutritious branches and leaves make excellent fodder (HEYBROEK 1963). Given the low pollen values in the Atlantic, *Ulmus* never was a very common tree in the forests on the

richer soils of the Drenthe Plateau. Because of the limited appearance of *Ulmus* in these forests, any epidemic of elm disease that swept across Europe around 3800 cal BC would have had only a limited influence on the elm stands of the Drenthe Plateau.

My conclusion is that the *Ulmus* decline in the northern Netherlands was in the first place

caused by activities of the first farmers. It cannot be excluded that elm disease also played a role, but no direct palynological evidence to support this hypothesis is found in the Gietsenveentje diagrams. The only possible, but circumstantial evidence might be that ^{14}C dates of the beginning of the *Ulmus* decline in the Gietsenveentje closely correspond to ^{14}C dates of the *Ulmus* decline in other parts of northern and western Europe (table 22). As the *Ulmus* decline seems to occur everywhere at more or less the same time, this might be an argument in favour of elm disease as the primary cause of the *Ulmus* decline. However, in many areas including the northern Netherlands also human interference in the vegetation contributed to the *Ulmus* decline.

VIII.4 Interpretation of the Neolithic Occupation Period in terms of archaeology

VIII.4.1 Introduction

In section VIII.1, a model was presented which describes the courses of some selected pollen curves during the Neolithic Occupation Period (NOP). This model was constructed by comparing the pollen diagrams of the Gietsenveentje with a number of other pollen diagrams from Pleistocene areas near the North Sea coast.

Now it is time for an interpretation of the changes in the pollen curves during the NOP. As a starting point, this section describes the situation before the beginning of the NOP, when the Drenthe Plateau was covered by primeval forests. This is followed by a description of the events in the vegetation which could have been responsible for the beginning and the various phases of the NOP. It is assumed that in this period most changes in the vegetation were caused by human interference. Attempts will be made to define the nature of this interference as well as the agricultural economy practised by the people who lived on the Pleistocene soils near the North Sea coast.

VIII.4.2 The Atlantic forests

According to the master diagram of Gieten V-A the highest percentages of total Arboreal Pollen (AP) were found in the Atlantic. These high AP values were interpreted as the Drenthe Plateau being entirely covered with relatively dense

forests. On the fertile till plateau, rich forests with *Quercus*, *Ulmus*, *Tilia* and *Fraxinus* occurred, while the coversand areas carried less rich forests with *Quercus* and *Betula* (see VII.1). In the opinion of Iversen and most other palynologists, these Atlantic forests must have been so dense that there was almost no undergrowth (IVERSEN 1973, 72). However, in a recent publication, Vera (1997) opposes this opinion. He believes that the Atlantic forests were park-like in appearance, maintained thus by large wild herbivores (VERA 1997, 72 ff.). In his opinion, such a relatively open landscape better explains the high values of *Quercus* and *Corylus* in the Atlantic pollen diagrams than would dense forests. According to forestry data, *Quercus* does not regenerate in closed forest, while *Corylus* will not flower below the forest canopy and consequently fails to produce any pollen (VERA 1997, 82). The high pollen values of *Corylus* in the Atlantic can be explained by the presence of *Corylus* in the following biotopes:

- a. shores and edges of lakes, rivers and bogs;
- b. *Corylus* woodland;
- c. (grazed) park-like landscapes

Vera (1997, 77) considers the appearance of *Corylus* woodland in prehistory improbable, nor does he believe that the presence of *Corylus* was limited to shores and edges of lakes, rivers and bogs. Furthermore, Vera attributes the (very scarce) finds of *Plantago lanceolata* and *Plantago major* in the Atlantic to the presence of grassy areas, maintained by wild herbivores. However, the very low values of Gramineae in almost all Atlantic diagrams argue against Vera's theory. Because the Atlantic is very well represented in all Gietsenveentje pollen diagrams, the Gietsenveentje data may contribute to the solution of this problem. I consider the following facts as strong arguments in favour of the presence in the Atlantic of a fairly dense, closed forest in the vicinity of the Gietsenveentje:

- a. The Gramineae percentage in the Atlantic is very low in all Gietsenveentje diagrams (ca. 3%). It appears from fig. 71 that, in the Atlantic, the Gramineae percentages are highest near the edges of the pingo scar (diagrams Gieten V-C and Gieten V-D), which points to a predominantly local origin of the pollen.
- b. Not one pollen grain of *Plantago lanceolata* is found in the Atlantic of the Gietsenveentje diagrams.
- c. Indeed, in the Atlantic, relatively high percentages of *Corylus* are found in all Gietsenveentje diagrams (ca. 20%). However, it

appears from fig. 71, that in the Atlantic, the highest *Corylus* percentages are found near the northern edge of the pingo scar (diagram Gieten V-C). This points to the presence of *Corylus* in the mantle vegetation near the northern edge of the pingo scar. In phases NOP-1 and NOP-2, the *Corylus* percentage remains more or less constant. In my opinion, this still mainly reflects *Corylus* from the mantle vegetation directly around the pingo scar.

- d. At the beginning of phase NOP-1, *Quercus* and *Tilia* increase in almost all Gietsenveentje diagrams (see figs. 73a-c). This can be explained by the theory which Vera uses to reconstruct a park-like landscape in the Atlantic: because of the creation of small-scale open spaces (in the case of phase NOP-1, by the first farmers), a landscape was formed with free-standing trees or groups of trees. Especially *Quercus* and *Tilia* took advantage of this new situation: they could flower more abundantly than they did in the Atlantic forests and consequently they produced more pollen (VERA 1997, 79).
- e. Almost no Mesolithic finds are known of the Drenthe Plateau which are dated to the last part of the Atlantic (WATERBOLK 1985b; LANTING & VAN DER PLICHT 1997/1998). Apparently, living conditions on the Drenthe Plateau in this period became very unfavourable for the Mesolithic people. Most probably, the forests on the Drenthe Plateau had become too dense for large herbivores and subsequently for the Mesolithic hunters to live in; the only activities took place in more open landscapes like lake and river banks or coastal areas.

Concluding, it can be stated that the Atlantic forests near the Gietsenveentje must have been fairly dense. There are no signs at all pointing to the presence of natural areas of grass-rich vegetation, maintained by large wild herbivores. It has already been outlined that the extensive forests which covered the Drenthe Plateau in the Atlantic were certainly not uniform: a kind of mosaic vegetation must have occurred, with more dense and rich forests on the till plateau and on the coversand more open and poor forests.

VIII.4.3 Combination of the pollen data with other types of archaeological evidence

As we have seen, two cultures are involved in the emergence and the early development of agriculture on the Drenthe Plateau: the Swifterbant Culture and the Funnel Beaker Culture (TRB). In the last part of the Neolithic, the EGK and BB Cultures flourished in this area.

It is obviously impossible to deduce the agricultural economies of these cultures only from pollen data. In the first place, it is far from certain that we can speak of "the" agricultural economy of for example the TRB Culture; it is plausible that this economy was strongly dependent on the local conditions and possibilities, for example with regard to soil and geomorphology. In the second place, many additional, more specifically archaeological types of evidence are necessary to obtain a reasonably clear picture of the agricultural economies of the Neolithic cultures in a certain area. For these reasons, the Gietsenveentje pollen data will be combined with three types of data: archaeological finds directly pointing to agriculture, and macroscopic remains and pollen from archaeological contexts.

Archaeological finds directly pointing to agriculture

a. ard marks

At five locations in the northern Netherlands, Neolithic ard marks have been found: Bornwird (province of Friesland; FOKKENS 1982), Emmershout (province of Drenthe; DRENTHE & LANTING 1997), site P14 near Schokland (province of Flevoland; DRENTHE & LANTING 1997), and two sites in the city of Groningen (province of Groningen): Winschoterdiep (KORTEKAAS 1987) and Oostersingel (KORTEKAAS 2002). From P14-Schokland and Groningen-Winschoterdiep, also pollen samples are available (see II.2.7 and below). The exact dating of the fields is problematical, but most probably they can all be attributed to the Single Grave Culture (EGK). Although ard marks were discovered below TRB barrows in Poland and Denmark (MIDGLEY 1992), so far no ard marks have been found in Dutch TRB contexts. According to Fokkens (1990), the ard was introduced in the Netherlands only in the Late Neolithic by the Single Grave Culture. Gehasse (1995) argues that in the Netherlands, people of the Swifterbant and Funnel Beaker Cultures possibly worked the land with hoe-like implements. At the P14 site, a worked piece of red-deer antler was found in a

Swifterbant context, which may be interpreted as a kind of hoe (GEHASSE 1995, 60). According to Drenth & Lanting (1997, 62), it is not possible to say when the ard was introduced in the Netherlands nor when it became widespread, but they conclude that it is likely that ard agriculture was already common at an early stage of the TRB West Group.

b. cattle locks

Southeast of Anloo (province of Drenthe), only 4 km from the Gietsenveentje, a two-period TRB settlement was excavated (see III.7.4; WATERBOLK 1960; HARSEMA 1982; JAGER 1985). In the second period, which can be attributed to the Early Havelte E2 phase, the settlement was surrounded by two enclosures. Given the presence of cattle locks in the outer enclosure, one of the functions of this enclosure might have been to keep the cattle within or outside the settlement area.

Macroscopic remains from archaeological contexts

a. remains of crop plants and domesticated animals of the Swifterbant Culture

At one of the most representative sites of the Middle Phase of the Swifterbant Culture, S3 near Swifterbant (province of Flevoland), which was inhabited between 4200 and 4000 cal BC, macroscopic remains of three cereals were found: predominantly *Hordeum vulgare* var. *nudum*, but also *Triticum dicoccon* and *T. aestivum*. Of *Hordeum*, also threshing waste was found (CASPARIE et al. 1977; VAN ZEIST & PALFENIER-VEGTER 1981). However, in the pollen diagrams, no cereal pollen was found; moreover, no cultural influences could be distinguished at all (see II.2.7; CASPARIE et al. 1977). For this reason, Gehasse (1995, 202) believes that cereals were not cultivated locally at this site, or at most on a very small scale. At another site of the Swifterbant Culture, P14 near Schokland, only very few macroscopic remains of cereals were found (GEHASSE 1995, 59). However, because also threshing waste and cereal pollen were found at this site, Gehasse (1995, 208) assumes that at P14, cereals were probably cultivated locally in the period of the Swifterbant Culture. Because the stratigraphy of P14 is not very clear, it is quite difficult to date the introduction of crop plants at this site. It can only be estimated to have taken place between 4900 and 4100 cal BC.

At several recently excavated sites of the Early Phase of the Swifterbant Culture (Hoge Vaart,

Hardinxveld-Giessendam and Brandwijk-Het Kerkhof, which can be dated between ca. 4900 and 4500 cal BC), no remains of crop plants were found. This prompts the tentative conclusion that the incorporation of crop plants into the subsistence strategy of the Swifterbant Culture did not occur before ca. 4200 cal BC, which is halfway through the Middle Phase (RAEMAEKERS 1999, 186; BRINKKEMPER et al. 1999, 82). Domesticated cattle, however, is known from Swifterbant contexts from as early as ca. 4750 cal BC, which is in the Early Phase (RAEMAEKERS 1999, 186). In Swifterbant contexts, the ratio of domesticated to wild animals generally ranges from 30/70% to 40/60% (RAEMAEKERS 1999, 114).

b. remains of crop plants and domesticated animals of the TRB Culture

In the Netherlands, very few organic remains have been found in TRB contexts, because of the small number of excavated findspots and the poor conservation conditions in the sandy soils, the most important areas of habitation of the TRB people (GEHASSE 1995, 218). For this reason, most evidence about the subsistence economy of the TRB comes from Germany, Denmark and Poland. The most important cereal crops cultivated by TRB people were *Triticum dicoccon* and *Hordeum vulgare* and to a lesser extent *Triticum monococcum*. A ratio of domesticated to wild animals ranging from 80/20% to 90/10% points to the important share of domesticated animals, particularly cattle, but also pig and sheep/goat (MIDGLEY 1992, 370).

c. wood

At the Swifterbant site S3, a bundle of *Ulmus* twigs was found. The twigs are mostly three to four years old. Possibly, these twigs were carried in as fodder. This would imply that at least occasionally animals were fed in the settlement (CASPARIE et al. 1977, 54).

Near Nieuw-Dordrecht (province of Drenthe), a wooden trackway was discovered, which runs from a till ridge into a large raised-bog area (CASPARIE 1982; 1992). The trackway, which could be followed over a length of about 1 km, is dendrochronologically dated to 2552 cal BC, which means that it was constructed by EGK people. There is a remarkable variety in the used wood species. In the part located nearest to the till ridge, the westernmost part, primarily *Betula* was used, trees with diameters of 15-20 cm, ca. 20-40 years old. According to Casparie, this wood

originates from secondary forests, regenerating on former cultivated fields (CASPARIE 1992, 122). In the next part of the trackway, especially *Quercus* and also some *Tilia* were used (CASPARIE 1982, trench 2 G-J). A large part of the *Quercus* logs consisted of cleft wood and many had very narrow annual rings, indicating relatively slow growth, typical of trees from fairly dense forest stands. The thickness of the *Quercus* logs varied between 15 and 25 cm, coming from trees 50-70 years old. The *Quercus* and *Tilia* logs most probably originate from the richer forests on the till ridge. According to Casparie, by this time these forests were already for the larger part secondary (CASPARIE 1982, 147). However, it can be argued on the basis of the same arguments that these relatively dense stands of full-grown *Quercus* and *Tilia* trees still represent natural, virgin forest. The easternmost part of the trackway, located farthest from the till ridge, almost exclusively consisted of *Alnus* logs, originating from *Alnus* trees growing locally in bog-margin forests.

Madsen (1990) has studied timber constructions of the Early and Middle Neolithic TRB in Denmark. During the first part of the Early Neolithic TRB (Iversen-PREFACT phase 1, as defined by KALIS & MEURERS-BALKE 1998), normally huge trunks with diameters up to one metre were used in the timber constructions of the long barrows. In the later part of the Early Neolithic TRB and in the Middle Neolithic TRB (Iversen-PREFACT phase 2, as defined by KALIS & MEURERS-BALKE 1998), timber with diameters of 20-40 cm was used for the construction of mortuary houses and palisades of causewayed enclosures, suggesting a forest of comparatively young trees. Moreover, in this period rather slender pieces of wood were found, some of which definitely come from coppiced trees (MADSEN 1990, 30).

Pollen from archaeological contexts

Pollen directly originating from archaeological contexts far better reflects human activities than pollen from bogs and lakes. However, pollen samples from archaeological contexts are in most cases pollen samples from soils, and some serious disadvantages stick to the analysis of soil pollen samples (VAN ZEIST 1967, see II.2.4). Certain pollen types, such as *Tilia*, *Plantago lanceolata* and *Dryopteris*, seem to survive the mostly poor conservation conditions better than others, which results in a probably distorted pollen picture (VAN ZEIST 1955a). Furthermore, it is not known how

much time is represented by a 1 cm soil sample. Waterbolk (1954, 30) assumed that a 1 cm sample of the humic layer underneath a barrow has a pollen content representing several decades. Groenman-van Waateringe (1986, 197) showed on the basis of correlations between cover percentages and the pollen content of litter samples that 1 cm samples are more likely to represent only a few years. On the other hand, Bottema (1995) found that pollen spectra from surface samples, collected in moss polsters and the upper part of plaggen soils, represented a vegetation of at least hundred years old. The samples even seemed to give more information about the old vegetation than about the recent vegetation! These contradictory results make the interpretation of subfossil soil pollen samples even more difficult. We have to be very careful in comparing soil pollen samples with pollen diagrams from bogs and lakes. Evidence is available from soil pollen samples from two types of archaeological context:

a. pollen samples from ard mark layers

Mook-Kamps & Van Zeist (1987) collected soil pollen samples in and just above a layer with ard marks, excavated near the Winschoterdiep canal in the city of Groningen, on the northernmost and narrowest part of the Hondsrug ridge. According to ¹⁴C dates, the ard marks can be dated between 4550 and 3850 BP (between 3250 and 2300 cal BC); most probably, they were made by people of the Single Grave Culture (EGK). In the pollen samples taken from the ard marks, which are thought to represent the arable phase, high values of *Tilia* and very low values of *Ulmus* were found; a forest rich in *Tilia* must have grown on the richer soils in the neighbourhood. Although we have to assume that predominantly cereals were cultivated in the field, remarkably enough only one grain of *Triticum* type was found in all samples. Gramineae reach values of 5-10%, *Plantago lanceolata* occurs with values of 2-5%. These taxa might have grown in the field during the fallow periods.

Pollen samples taken just above the ard marks show a different pollen picture: Ericaceae, Gramineae and *Plantago lanceolata* reach considerably higher values than in the samples from the ard marks. This indicates that after the abandonment of the field, the area was used as grazing land for livestock; otherwise, the vegetation would have reverted to forest. Of course, a large part of the pollen originates from a far wider area than the field alone. It is impossible to say whether the

abandoned fields were already so exhausted that only Ericaceae could grow there, or that the soil was exhausted to a lesser extent so that Gramineae and *Plantago lanceolata* could colonize the abandoned fields. The overall pollen picture demonstrates ongoing deforestation in the area. A layer of driftsand which was deposited on the ard-mark layers, indicates that after a long and intensive use for agriculture, the soils in the area were completely exhausted, finally resulting in driftsand. The drifting of sand most probably started in frequently used cattle tracks. After the abandonment of exhausted soils by the farmers and their livestock, the driftsand could progressively expand. The sand originates from higher parts of the Hondsrug ridge, but it is impossible to estimate the extent of the deforested areas on the Hondsrug in this period.

b. pollen samples from barrows

Since the 1950s, soil pollen samples have been analyzed from below burial mounds in the Netherlands (see II.2.4), Germany, Denmark and Poland. An attempt is made to discover a culture-related pattern in the pollen content of these barrow samples, revealing for example that the pollen content of samples below TRB mounds differs structurally from that of samples below EGK mounds. But first some characteristics which all barrow samples have in common will be briefly reviewed.

First, the pollen values of barrow samples often fluctuate very strongly, which is partly caused by the different and often poor conservation conditions. For this reason, we have to be very careful about the interpretation of the pollen content of barrow samples.

Secondly, the pollen picture of barrow samples points to a high diversity of landscapes around the mounds. Apparently, the burial monuments were erected in all kinds of open landscapes. In many cases, they were erected in open areas which had been used as arable fields for a long time, as a result of which the soils had become exhausted and therefore useless for crop cultivation. However, also other open areas were utilized, like old settlement sites (CASPARIE & GROENMAN-VAN WAATERINGE 1980). It seems probable that abandoned settlement sites, which were very rich in nutrients, were first used for agriculture and only in a later stage for the erection of a burial mound.

Thirdly, nearly always high to very high values

of Ericaceae are found in barrow samples. This indicates that the soils on which the burial monuments were erected, were relatively poor in nutrients (BAKKER & GROENMAN-VAN WAATERINGE 1988). Furthermore, grazing of some kind must have taken place in the direct neighbourhood of the burial monuments, otherwise the heathfields would have changed into forest (GROENMAN-VAN WAATERINGE 1986). The very low Ericaceae values in the barrow samples from eastern Denmark (S.T. ANDERSEN 1992a) must be due to the naturally rich soils in that area, which are a less suitable biotope for Ericaceae.

In Drenthe, pollen spectra collected from beneath barrows of four different cultures yielded the following results (see also fig. 9; WATERBOLK 1954; 1956; VAN ZEIST 1955a; 1967; CASPARIE & GROENMAN-VAN WAATERINGE 1980):

TRB: high values of *Tilia*, low values of Gramineae, *Plantago lanceolata* and *Rumex*;

EGK: lower values of *Tilia*, higher values of Gramineae, *Plantago lanceolata* and *Rumex*;

BB: fluctuating values of *Plantago lanceolata*, low values of Gramineae and *Rumex*;

Early Bronze Age: fluctuating values of *Plantago lanceolata*, lower values of Gramineae.

In the Veluwe region (central Netherlands), the pollen spectra collected beneath barrows of EGK, BB and Early Bronze Age are quite uniform: no decline of *Quercus* and *Tilia* is observed, and the values of the culture-indicator types remain low (CASPARIE & GROENMAN-VAN WAATERINGE 1980).

In Germany, pollen analysis by Groenman-van Waateringe (1979a) of samples collected beneath barrows of three different cultures yielded the following results:

TRB: Oldendorf a.d. Luhe (northwestern Germany): very high values of *Tilia*, very low values of *Quercus*, low values of Gramineae, *Plantago lanceolata* and *Rumex*;

Deinste (northwestern Germany): very low values of *Tilia*, high values of *Quercus*, higher values of Gramineae and *Plantago lanceolata*;

EGK: Ahsen (Westfalen, central western Germany): high values of *Tilia*, low values of Gramineae, *Plantago lanceolata* and *Rumex*;

BB: Altenrath (Nordrhein, central western Germany): very high values of *Tilia*, very low values of Gramineae, *Plantago lanceolata* and *Rumex*.

In eastern Denmark, S.T. Andersen (1992a; 1992b) analyzed barrow samples collected from beneath Early Neolithic and Middle Neolithic TRB barrows, obtaining the following results:

Early Neolithic TRB: high values of *Tilia*; high values of Gramineae and *Plantago lanceolata*;

Middle Neolithic TRB: lower values of *Tilia*, lower values of Gramineae and *Plantago lanceolata*.

Finally, in Poland, pollen samples from below a TRB barrow near Sarnowo and from a contemporary settlement, located only 100 m from the barrow, were analyzed (DĄBROWSKI 1971; MIDGLEY 1992, 359-360). In the barrow samples, only 20% AP was found; Gramineae, *Plantago lanceolata* and *Rumex* were common, and Cerealia reach very high values (4.6%). In the settlement samples, 60% AP was found, low values of *Plantago lanceolata* and *Rumex*, but relatively high values of Cerealia.

From this small overview it becomes clear that in pollen samples below barrows of the same culture, certainly not always the same pollen picture is found, not even approximately: it is not possible to demonstrate a culturally linked pattern. The barrow samples too strongly reflect the (very) local conditions to offer a reliable picture of "the" agricultural economy of a culture. The picture which emerges from the barrow samples is that Neolithic activities reflected in these samples are more strongly determined by the type of forest and the condition of the soil than by qualities of the culture concerned (CASPARIE & GROENMAN-VAN WAATERINGE 1980).

Now let us turn to the sometimes remarkable differences between barrow samples and samples from bogs and lakes from the same period. As we saw in II.2.3, Van Zeist (1959; 1967) attributed the first Neolithic phase with low values of Gramineae and *Plantago lanceolata* in regional pollen diagrams from southeastern Drenthe, which is equivalent to phase NOP-1 in this study, to the TRB Culture. The next phase, with high values of Gramineae and *Plantago lanceolata*, which is equivalent to phase NOP-2, he attributed to the EGK Culture. He reached this conclusion by correlating the results from regional pollen diagrams with the spectra from barrow samples referred to above. However, the very appropriate ¹⁴C dates obtained during the present study demonstrate unquestionably that phase NOP-1 reflects a pre-TRB culture, namely the Swifterbant Culture, of

which no barrows are known, and that phase NOP-2 must be attributed to the TRB Culture. These results leave us with a discrepancy between the pollen spectra of the barrow samples and the regional diagrams in the TRB and the EGK periods (table 23).

There are two explanations for this discrepancy. For the first solution, it is assumed that the pollen samples taken just below the burial mounds represent a period of only a few years (GROENMAN-VAN WAATERINGE 1986). The situation in the northern Netherlands can be compared with the situation in eastern Denmark, where S.T. Andersen (1992a; 1992b) has also tried to correlate the results from barrow samples with regional diagrams. He analyzed pollen samples from below barrows of the Early Neolithic TRB, a culture which did not occur in the Netherlands, and the Middle Neolithic TRB. Remarkably, in the Middle Neolithic TRB period he found the same discrepancy between barrow samples and regional diagrams as is observed in the northern Netherlands: in the barrow samples, the Gramineae and *Plantago lanceolata* values are low, while in the regional diagrams they are relatively high. In the Early Neolithic TRB period, he found the opposite: high values of Gramineae and *Plantago lanceolata* in the barrow samples and low values of these taxa in the regional diagrams (table 23). S.T. Andersen (1992a, 167-171) explains these apparent discrepancies as follows: in the Early Neolithic TRB period, *Tilia* forest was cleared and used for intensively grazed pasture in the direct vicinity of the barrows; however, these pastures were of small extent. In the Middle Neolithic TRB period, mixed woodlands with *Tilia*, *Corylus* and *Alnus* were cleared by burning. The areas with treeless vegetation were larger than in the preceding period, but the open areas were less intensively grazed. Possibly this explanation, of course only with regard to the Middle Neolithic TRB, is also valid for the situation in the northern Netherlands. The pollen picture of the EGK period in the northern Netherlands resembles that of the Early Neolithic TRB period in eastern Denmark: high values of Gramineae and *Plantago lanceolata* in the barrow samples and low values of these taxa in the regional diagrams (table 23). Possibly, the Dutch EGK period, like the Danish Early Neolithic TRB period, was characterized by intensively grazed pastures which covered a smaller area than in the Middle Neolithic TRB period.

| | Early Neolithic TRB | Middle Neolithic TRB | EGK |
|----------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------|------------------------------------------------------|
| barrow samples, eastern Denmark | Gramineae and <i>Plantago lanceolata</i> high | Gramineae and <i>Plantago lanceolata</i> low | ? |
| regional pollen diagrams, eastern Denmark | Gramineae and <i>Plantago lanceolata</i> low | Gramineae and <i>Plantago lanceolata</i> high | ? |
| barrow samples, the northern Netherlands | - | Gramineae and <i>Plantago lanceolata</i> low | Gramineae and <i>Plantago lanceolata</i> high |
| regional pollen diagrams, the northern Netherlands | - | Gramineae and <i>Plantago lanceolata</i> high | Gramineae and <i>Plantago lanceolata</i> low |
| explanation | intensively grazed grass-rich areas of small extent | extensively grazed grass-rich areas of large extent | intensively grazed grass-rich areas of small extent? |

Table 23. Comparison between the pollen values of Gramineae and *Plantago lanceolata* in barrow samples and regional pollen diagrams covering three Neolithic cultures and in two areas: eastern Denmark (S.T. ANDERSEN 1992a; 1992b) and the northern Netherlands (CASPARIE & GROENMAN-VAN WAATERINGE 1980; this study). The Early Neolithic TRB did not occur in the Netherlands.

| | Swifterbant | Middle Neolithic TRB | EGK |
|-----------------------------------------------------------------------------------|----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| barrow samples, the northern Netherlands | - | Gramineae and <i>Plantago lanceolata</i> low | Gramineae and <i>Plantago lanceolata</i> high |
| barrow samples, the northern Netherlands, when representing the preceding culture | Gramineae and <i>Plantago lanceolata</i> low | Gramineae and <i>Plantago lanceolata</i> high | Gramineae and <i>Plantago lanceolata</i> low* |
| regional pollen diagrams, the northern Netherlands | Gramineae and <i>Plantago lanceolata</i> low | Gramineae and <i>Plantago lanceolata</i> high | Gramineae and <i>Plantago lanceolata</i> low |

Table 24. Comparison between the pollen values of Gramineae and *Plantago lanceolata* in barrow samples and regional pollen diagrams covering three Neolithic cultures in the northern Netherlands (CASPARIE & GROENMAN-VAN WAATERINGE 1980; this study). In the second row, it is assumed that the barrow samples taken below burial mounds represent a period of more than a hundred years; as a result they represent the culture which preceded the culture that erected the burial mound. * pollen content of samples taken below burial mounds of the Bell Beaker Culture (BB).

For the second solution, it is assumed that the pollen samples taken just below the burial mounds represent a period of more than a hundred years (BOTTEMA 1995). As a result, there is a possibility that these pollen samples represent the culture preceding that which erected the burial mound. In this case, the low values of Gramineae and *Plantago lanceolata* be-

low TRB burial mounds would have been caused by the Swifterbant Culture, and the high values of Gramineae and *Plantago lanceolata* below EGK burial mounds would have been caused by the TRB Culture. When this assumption is made, the results of the barrow samples coincide with those of the regional pollen diagrams (table 24).

VIII.4.4 The agricultural economies of the Neolithic cultures on the Drenthe Plateau

Combining the model of the Neolithic Occupation Period proposed in VIII.1 with data more directly related to archaeology, discussed in the preceding section, may finally lead us to a more complete picture of the agricultural economies of the first farming cultures on the Drenthe Plateau. As already indicated, it is not justified to speak of "the" agricultural economy of the Swifterbant Culture or the TRB Culture. The concluding remarks in the following in the first place apply to the Drenthe Plateau, and most probably also to areas with comparable geomorphological and edaphic conditions in northwestern Germany (see fig. 78), but, for example, not to the entire distribution area of the TRB Culture. For each phase of the Neolithic Occupation Period, observed phenomena will be interpreted in terms of archaeology. Finally, there is a brief discussion of the problem of quantifying human interference in the Neolithic landscape.

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

On the Drenthe Plateau, the first signs pointing to agriculture appear in the pollen diagrams around 4050 cal BC. Apparently, agriculture was introduced on the Drenthe Plateau by people of the Swifterbant Culture.

The pollen picture has some affinity with the occupation phase as described by Troels-Smith for Denmark and Switzerland (see II.1.3). Troels-Smith explained his occupation phase by the leaf-foddering theory. He linked stable feeding with the use of leaves as fodder for livestock. The possibility of leaf foddering and possibly stable feeding has to be considered for the Drenthe Plateau.

Not many changes are observed in the regional tree pollen values in this period, except for a gradual decline of *Ulmus* and an increase of *Tilia* and *Quercus*. As already put forward in VIII.3, the *Ulmus* decline in this area was most probably in the first place caused by human interference in the vegetation. Because most other tree percentages remain constant, it looks as if *Ulmus* trees were used selectively by the first farmers. It is possible that the trees were pollarded, and that the leaves and branches were fed to the cattle. Another possibility is that the cattle, which was allowed to roam freely, predominantly consumed the tasty young shoots of *Ulmus* in the natural

and man-made open spaces, thus preventing the regeneration of this tree. In my opinion, the increase of *Tilia* in this phase can also be attributed to activities of the first farmers. It has already been noted by several authors (VAN ZEIST 1959; GROENMAN-VAN WAATERINGE 1992; KALIS & MEURERS-BALKE 1998) that different tree species react differently to the practice of pollarding. *Ulmus* would suffer most severely, while *Fraxinus* and *Tilia* would take advantage of the situation: when it is assumed that the branches were cut every 3-4 years, *Ulmus* would not be able to flower in the intervening period, in contrast to *Fraxinus* and *Tilia*, species which regenerate much faster than *Ulmus*. In the pollen diagrams of the northern Netherlands and northwestern Germany, a pronounced maximum of *Tilia* is found in this phase, while *Fraxinus* remains more or less constant (figs. 73-74).

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

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

Troels-Smith (1954; 1960) explained his occupation phase by assuming that the cattle were fed exclusively on leaves. Low values of Gramineae and *Plantago lanceolata* in his opinion pointed to the absence of pastures. As argued by Groenman-van Waateringe (1986; 1992) it is very unlikely that cattle were fed exclusively on leaf fodder:

cattle are grazers and not browsers. This means that cattle must have their major food intake from grass. Leaves can only be used as a major food source for shorter periods of time, or be a minor supplement to the staple fodder. These facts make Troels-Smith's explanation for his occupation phase at least improbable. In his own diagram from Aamosen, a clear increase of Gramineae is observed in the Troels-Smith occupation phase (see fig. 75); in many diagrams from the northern Netherlands and northwestern Germany, increasing values of Gramineae and *Plantago lanceolata* are observed during phase NOP-1, which is characterized by a pollen picture strongly resembling the Troels-Smith occupation phase. These observations suggest that in these areas, this phase did see a kind of grass-rich vegetation, most probably woodland pasture. This situation can be compared to that in Switzerland, where Troels-Smith (1984) and Rasmussen (1990; 1993) convincingly demonstrated on the basis of macroscopic analysis that foddering took place in the Neolithic. The animals were held inside the settlements, in some kind of byre, during the winter. The fodder consisted of twigs and leaves. However, in contrast to northwestern and northern Europe, where in the Neolithic NAP values of more than 10% are often reached, in Switzerland the values of NAP and particularly Gramineae remain below 10% throughout the Neolithic (RASMUSSEN 1990, 76). In the Swiss Neolithic, the open areas with grass must have been very limited. Apparently, leaf foddering was practised on a far larger scale here than in northwestern and northern Europe. This is in agreement with the observation by Burrichter & Pott (1983) that in mountain districts there is more need for leaf foddering in winter than in maritime districts, because of the shorter growing season and the longer and heavier snow cover.

It must have been very difficult to harvest leaves of *Ulmus* and *Tilia* selectively in the dense Atlantic forests, because most leaves grew in the tops of the trees, and the trees lacked lateral branches. Therefore I assume that if the technique of leaf foddering was applied in phase NOP-1 by people of the Swifterbant Culture, this was done only in combination with small-scale woodland pastures. Especially leaves and twigs of *Ulmus* and *Tilia* must have been harvested; a recovered bundle of *Ulmus* twigs at the Swifterbant site S3, probably intended as fodder, supports this theory (CASPARIE et al. 1977, 54). Possibly, the woodland pastures were created by the felling of

trees which were not used for pollarding. There is no indication at all that burning was used in this phase to create open spaces in the forest.

In pollen diagrams from Pleistocene areas near the North Sea coast, Cerealia-type pollen grains are first found at the very beginning of phase NOP-1, which is ca. 4050 cal BC (Eexterveld, Swienschuhle, Flögelner Holz, see figs. 73-74). In the Gietsenveentje diagrams, grains of Cerealia-type first appear only around 3500 cal BC. *Triticum* sp. and *Hordeum* group are more or less equally represented (table 8). Apart from the role of cereals in the human food supply, the remains of these plants were possibly used as winter fodder beside leaves and twigs. The date of 4050 cal BC has to be considered as a *terminus ante quem* for the introduction of cereal crops in Pleistocene areas near the North Sea coast. The date is more or less in agreement with the data published by Brinkkemper et al. (1999), who deemed the incorporation of crop plants into the subsistence strategy of the Swifterbant Culture to have taken place not before ca. 4200 cal BC.

As already indicated, the pollen picture of phase NOP-1 displays similarities both with Troels-Smith-PREFACT phases A and B, associated with the Ertebølle Culture, and with Iversen-PREFACT phase 1, caused by the Early Neolithic TRB, in northeastern Germany and Denmark (KALIS & MEURERS-BALKE 1998). In archaeological terms, the Ertebølle Culture and the (early) Swifterbant Culture do not show many similarities, but certain parallels in their pottery show that there is indeed a relationship of some kind between the Early Neolithic TRB and the (late) Swifterbant Culture (RAEMAEEKERS 1999, 166). Madsen (1990) described the agricultural economy of the Early Neolithic TRB in Denmark as adaptive to the environment, resulting in only minor interference with nature; it was a system that required a dispersed and mobile society. I believe the same description also applies to the Swifterbant Culture in the northern Netherlands and northwestern Germany.

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

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

Germany. The TRB Culture can be considered the first fully agrarian culture on the Drenthe Plateau.

In the pollen picture, a clear decline of *Tilia* attracts attention. This *Tilia* decline is particularly pronounced in the diagrams from northwestern Germany (fig. 74); it is often accompanied by a decline of *Quercus*. Behre & Kučan (1994) interpreted these phenomena as large-scale forest clearings, especially for the purpose of forest grazing. S.T. Andersen (1988; 1992a) also found a *Tilia* decline at the beginning of the Middle Neolithic TRB in eastern Denmark. According to S.T. Andersen, leaf lopping of *Tilia* was discontinued and the tree was suppressed to remove its shade (S.T. ANDERSEN 1988, 402). The forests with *Tilia* were replaced by open, secondary forests dominated by *Corylus*, which were maintained by the farmers for browsing and grazing by cattle or sheep. In the northern Netherlands and northwestern Germany, however, no evidence for such secondary forests is found in the TRB period. Here, more intensive clearances may well have been responsible for the *Tilia* decline: it seems that the cattle were now for the larger part fed on grass instead of leaves. The possibly freestanding *Tilia* trees, which had been used for pollarding or shredding, might have been cleared by the TRB farmers to eliminate their shade.

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

forest in order to create agricultural land was not commonly used in the TRB period in Drenthe. It is more likely that the forest was cleared by felling and/or girdling.

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

On fertile loess and clay soils, fields could have been cultivated for fairly long periods without interruption. It was demonstrated by experiments by Meurers-Balke & Lüning (1990) on loess soils in Germany, that even on permanently cultivated fields, a heavy weed flora could develop among the cereals; very intensive weed control seemed to be necessary. This weed flora consisted especially of weed species of the forest and of the forest edge. On the sandy, less fertile soils of the Drenthe Plateau, however, different conditions prevailed: after 3-5 years of cultivation, the soil was already exhausted, and a fallow period of 10-15 years was necessary before the field could be used again. During such a long fallow period, the ground became penetrated by roots of weeds to such an extent, that an ard could not break up the soil (FOKKENS 1982). Probably, it was easier to clear a new plot of forest for creating new fields, than to try to remove the roots of weeds from the former fields: the undergrowth of the Atlantic forests was composed of shrubs and especially herbs which rooted only shallowly in the loose forest soil, so that it must have been easy to remove them with an ard after felling and maybe burning the trees (GROENMAN-VAN WAATERINGE 1979b). In the experiments of Meurers-Balke & Lüning (1990) in *Stellario-Carpinetum* forests on loess soils, it seemed quite difficult to plough the forest soil with an ard, because the ard often caught on thick tree roots. However, when the ploughing was regularly repeated, it became increasingly easy, because the root network was progressively destroyed. In the opinion of Groenman-van Waateringe (1979b), no specific arable weed associations could develop when newly

created fields were used only for a period of 2-3 years. However, the results of the experiments by Meurers-Balke & Lüning (1990, 88) point in another direction: after harvesting, the fields became totally overgrown by weeds within a few weeks (!). It is clear that with the present state of knowledge, it cannot be decided whether the fields in the Neolithic were cultivated only once or on a more permanent basis. This study has demonstrated that in TRB times the larger part of the Drenthe Plateau was still covered by a relatively dense forest (see fig. 69). Without deciding between shifting cultivation or permanent fields, it can only be remarked that there was enough forest left for the TRB farmers to practise shifting cultivation for hundreds of years, even if they preferred to clear the forests on the more fertile soils of the till ridges (BAKKER & GROENMAN-VAN WAATERINGE 1988). Behre & Kučan (1994, 149) conclude from the fairly constant values of pollen types pointing to arable farming in the pollen diagrams of *Siedlungskammer* Flögel during the TRB period, that the fields were shifted only slightly, or possibly even were permanent.

The small decrease of AP and the increase of Gramineae, Ericaceae and the culture-indicator types demonstrate the presence of more open areas than in the preceding phase. Since Cerealia-type displays a far smaller increase than Gramineae, *Plantago lanceolata* and *Rumex acetosa*, it is probable that most of the newly created treeless areas were used to keep livestock. The increased importance of stock keeping in the Middle Neolithic TRB period was already emphasized by several authors (IVERSEN 1941; VAN ZEIST 1959; MADSEN 1990; KALIS & MEURERS-BALKE 1998). The wooden fence with cattle locks excavated near Anloo shows that the TRB farmers separated the settlement and arable land from areas where the livestock were allowed to graze (WATERBOLK 1960; HARSEMA 1982; JAGER 1985). On the basis of the comparison between barrow samples and regional pollen diagrams from Drenthe, it was already suggested that the pastures in the TRB period might have been extensive and of relatively large extent, compared to the following phase. In the barrow samples from Drenthe, the Ericaceae far exceed the Gramineae; the Gramineae percentage lies mostly below 10%. Groenman-van Waateringe (1986, 198) concludes from this that in the neighbourhood of the burial mounds, the opportunities for grazing were extremely restricted and certainly would not allow grazing throughout the year. Groenman-

van Waateringe indicates the possibility of winter grazing on the dry sandy soils. She believes that maybe the summer pastures are not to be found here, but more probably in the river valleys. But can the high Ericaceae values in the barrow samples not be explained simply by the fact that barrows were constructed only in open areas which had become useless for agriculture because the soils were exhausted? We should imagine the open spaces in the Atlantic forests created by the TRB farmers as a mosaic of arable fields in use, abandoned arable fields which served as (winter?) pasture and permanent grazing.

The pastures were probably in part woodland pastures. However, there is a clear link between canopy cover and grass yields: only with a reduction of canopy cover to less than 50% the grass yields will increase significantly (GROENMAN-VAN WAATERINGE 1986; 1993). Therefore, the increasing Gramineae values in the pollen diagrams of this phase in my view point either to treeless pastures or to very open woodland pastures. Given the relatively small increase of Cerealia-type compared to phase NOP-1, the use of cereals in the food economy had not much increased. Finds of macroscopic remains in north-western Germany suggest that *Hordeum* was the commonest cereal in the TRB West Group (HOPF 1961). *Hordeum* is well suited to cultivation on the varied lowland soils and is more resistant to cold than *Triticum*. These are the most likely reasons for its increased popularity during the later TRB (MIDGLEY 1992, 366). However, this is not confirmed by the finds of Cerealia-type pollen in the Gietsenveentje diagrams: *Hordeum* and *Triticum* are more or less equally represented in the TRB period (table 8).

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

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

The TRB Culture was followed by the EGK and BB Cultures. The phase in the pollen diagrams which represents these two cultures is characterized by a temporarily decreased pressure on the vegetation, which is especially evident from the constant or even slightly decreasing NAP

values. This phase has affinity with the "regeneration phase" in pollen diagrams from northeastern Germany, eastern Denmark and southern Sweden. In these areas, the "regeneration phase" is often dominated by *Corylus*. Generally this is explained as the presence of coppice woods with predominantly *Corylus* (GÖRANSSON 1988b). The following use of the coppice woods can be imagined: leaves and twigs were cut as winter fodder for the livestock, hazelnuts were gathered for human consumption and larger twigs were used for wattle. According to Göransson (1988b) this so-called "regeneration phase" does not really represent a decreasing influence of the farmers on the vegetation, but rather a more efficient use of the landscape, with a more intensive use of smaller areas.

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

- a. a *Corylus* increase on sandy soils generally points to a decreasing human influence on the vegetation: in periods poor in settlements, its former biotopes became available again, and it could increase considerably, because for this pioneer species the growing conditions were much better than in a closed forest;
- b. a *Corylus* increase on moist, loamy soils generally points to an increasing human influence on the vegetation: when these soils, which were not suitable for arable farming, were not too intensively used for woodland pasture, *Corylus* could increase considerably because of the favourable light conditions.

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

too slight to reflect a change to a woodland management based on coppicing.

In the Gietsenveentje diagrams, a small decrease is observed in the values of Gramineae and the culture-indicator types. As we have seen, this is generally explained in terms of a decreased pressure of man on the vegetation. However, Groenman-van Waateringe (1993) has demonstrated, on the basis of grazing experiments and surface samples, that continuous, intensive grazing results in a decrease of grass pollen production and a pollen picture which appears to reflect a closed forest cover! Following this reasoning, there is a possibility that the decreasing Gramineae values in this phase point to (locally?) increased grazing pressure. This fits in with the first hypothesis that was proposed to explain the difference in pollen content between barrow samples and regional pollen diagrams from the EGK period: the Dutch EGK period was characterized by intensively grazed pastures which, however, covered a smaller area than in the preceding phase (table 23). Unfortunately, nothing is known about the density of habitation of the TRB, EGK and BB Cultures in Drenthe; there seems to be a tendency towards a more concentrated habitation in the EGK/BB period (oral comm. J.N. Lanting). This is in agreement with the generally accepted interpretation of the pollen picture of the EGK and BB periods, which assumes a decreased pressure of man on the vegetation compared to the TRB period. Wiethold (1998, 267) attributed the decrease of NAP, especially Gramineae and culture-indicator types, in the EGK phase in pollen diagrams from eastern Schleswig-Holstein (northeastern Germany) to a marked population decrease and the end of the economic system of the TRB Culture.

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

It has already been remarked in VIII.1 that phase NOP-3 does not appear very clearly in the pollen diagrams from northwestern Germany (table 21). In some diagrams (Fuhrenkamp, Flögeln V, see fig. 74) a regeneration phase is completely absent: Gramineae and the culture-indicator types only increase higher up in the diagrams. In most pollen diagrams from Drenthe, phase NOP-3 does occur clearly and consistently (fig. 73). This situation can again be compared with the situation in Denmark, where two types of pollen diagram occur with regard to occupation history (S.T. ANDERSEN 1992b). In the first type, which is found in eastern Denmark, human occupation was abandoned in the Late Neolithic, while in the second type, which is found in northwestern Denmark, a continuous expansion of human occupation from the Neolithic to the present day is observable (ODGAARD 1988). S.T. Andersen (1992b, 6) infers a fundamental difference in the history of occupation in eastern and western Denmark. Probably this difference is linked to the difference in soil fertility between the poor sandy soils of western Jutland and the more fertile soils of the young moraine landscape in eastern Denmark. Possibly, the sandy soils in western Denmark were already so exhausted by the end of the TRB period, that forest regeneration was seriously hampered. In northwestern Germany, a comparable situation seems to have existed. Additional evidence for this hypothesis is provided by the very high values of *Calluna vulgaris* in the pollen diagrams of both areas (BEHRE & KUČAN 1994; ODGAARD 1988). In this case it is assumed that not all *Calluna vulgaris* pollen in the diagrams from northwestern Germany has a local origin. In diagrams from Drenthe, the *Calluna vulgaris* values are considerably lower; in diagrams from the Veluwe (the central Netherlands), where also relatively poor sandy soils are found, the *Calluna vulgaris* values are lower yet. According to Casparie & Groenman-van Waateringe (1980, 60-61) the higher values of *Calluna vulgaris* in Drenthe compared to the Veluwe are caused by the more rapid exhaustion of the much wetter and more acid soils in Drenthe. By comparing the situation in the Netherlands, northwestern Germany and Denmark, the following relationship between the three named factors can be determined: the higher the soil fertility, the lower the *Calluna vulgaris* values and the higher the degree of regeneration of the forest in the Late Neolithic. In conclusion, there is a possibility that the weak presence of phase NOP-3 in diagrams from northwestern Germany compared to

diagrams from Drenthe can be explained by less fertile soils in the former area.

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

The above-mentioned characteristics of the agricultural economies of Neolithic cultures on the Drenthe Plateau are summarized in table 25.

So far, this study has only offered qualitative descriptions of the agricultural economies of the Neolithic cultures on the Drenthe Plateau. It would be interesting to see if the extent of human influence on the vegetation could also be quantified. As several authors have pointed out (GROENMAN-VAN WAATERINGE 1992; LÜNING & KALIS 1992), this is certainly not possible on the basis of pollen data alone. The maps in figs. 67-70 show rough estimations of the extent of the open areas around the Gietsenveentje at the time of the various Neolithic cultures. Besides palaeobotanical data, edaphic and archaeological data were used for these estimates. Several authors have tried to calculate the extent of open areas in the Neolithic of northwestern Europe (see FRENZEL 1992). Lüning & Kalis (1992, 43) estimate that LBK people cleared at most 8-9% of the woodlands of the loess areas. Groenman-van Waateringe (1992, 22) made some calculations with regard to the open areas needed for grain production and grazing in the Middle Neolithic, with all the basic assumptions taken as unfavourably as possible. The result was that ca. 80 km² was needed for grain production and ca. 1000 km² for grazing. This is less than 10% of the Pleistocene sandy areas at the end of the Atlantic. Behre (1992b, 157) arrived at roughly the same percentage of open areas in Germany in the Neolithic. Yet Casparie (1992, 126) found that in the Emmen region (southeastern Drenthe) 85-90% of the area was deforested in the Middle Neolithic. Casparie believes that these results also hold for other parts of Drenthe. My results indicate that the estimates of Groenman-van Waateringe and Behre better quantify the Neolithic de-

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

Table 25. Characteristics of the agricultural economies of Neolithic cultures on the Drenthe Plateau.

forested areas in the northern Netherlands and northwestern Germany than those of Casparie: neither in the pollen percentage diagrams nor in the pollen influx diagrams was there any evidence of large-scale deforestations in the Neolithic. On the contrary, all the evidence points to only relatively small deforested areas throughout the Neolithic; the major part of the primeval forests seems to have remained untouched, even by the Late Neolithic (figs. 67-70). The first indications of large-scale deforestations on the Drenthe Plateau are not found until the Bronze Age.

VIII.4.5 Subsistence strategies of inland vs. coastal communities

This study has revealed evidence of agricultural activities on the Drenthe Plateau from at least 4050 cal BC onwards. In all probability, these activities can be attributed to people of the Swifterbant Culture. This means that the Swifterbant people apparently colonized two entirely different types of landscape: the wetland areas near the coast and the upland areas on the Pleistocene sandy soils. Because of several large-scale excavations (see III.7.3), much is known about the subsistence strategy of the Swifterbant people in the wetland areas. By contrast, almost nothing is known about their presence, let alone their subsistence strategy in the upland areas. An interesting question is whether the Swifterbant people practised the same type of subsistence strategy in the upland areas as in the wetland region. This question was already tackled by Raemaekers (1999, 121-122). He considers three possibilities:

- a. the subsistence data of the wetland sites are representative for the upland subsistence base as well;
- b. the wetland subsistence strategies are an adaptation to the specific natural environment, in which wild animals and plants are the major resources; the unknown upland communities would to a larger extent rely on domestic animals and crop cultivation;
- c. a settlement and subsistence system in which the wetland and upland areas both play a part.

At present, it cannot be decided on the basis of the archaeological material which of these possibilities is the right one. In the opinion of Raemaekers (1999, 123), the similarities in the subsistence data of the sites of the Swifter-

bant Culture in different environmental settings suggest that this strategy is not specifically a wetland adaptation, but instead may be seen as representative of Swifterbant occupation in a larger area, including the Pleistocene areas bordering the wetlands. Maybe the results of this study can help to resolve the question which of the above-mentioned possibilities is the right one. But first let us briefly look at comparisons of coastal and inland sites of two other cultures: the Ertebølle Culture and the Funnel Beaker Culture (TRB).

In Schleswig-Holstein (northern Germany), a good picture of the subsistence strategies of coastal and inland populations of the Ertebølle and TRB Cultures is obtained on the basis of many finds of macroscopic remains and pollen diagrams (KALIS & MEURERS-BALKE 1998; 2001; WIETHOLD 1998; HARTZ et al. 2000). In the period of the Ertebølle Culture (5100-4100 cal BC), pollen of *Cerealia*-type and heliophilous plants was found in the coastal areas: the oldest finds of *Cerealia*-type pollen are dated to 4770 cal BC (KALIS & MEURERS-BALKE 1988). In the inland areas however, no pollen of *Cerealia*-type and culture-indicator types was found in this period; also no indications of stock keeping were obtained (HARTZ et al. 2000). From 4100 cal BC onwards, when the Early Neolithic TRB occurred for the first time, the differences between coastal and inland areas became greater: in the coastal pollen diagrams, pollen of *Cerealia*-type and *Plantago lanceolata* regularly appears, while in the inland diagrams there are still no indications for human activity. Apparently, the coastal area of eastern Holstein (western Baltic) had a lead in time over the inland areas with regard to the adoption of arable farming (WIETHOLD 1998).

According to Midgley (1992, 402), the dichotomy between coastal and inland settlement patterns and the resulting different economic adaptations of Ertebølle and TRB has always been overemphasized. Midgley argues that the coastal communities were less experienced in the manipulation of natural resources than their inland neighbours, because coastal resources simply do not lend themselves easily to human interference and management. For this reason some people suggest that in Denmark, the inland population took a leading and dominant role at the onset of the Neolithic in Denmark. Midgley (1992, 403) cannot regard the environmental changes along the Danish coast as a primary cause for the introduction of farming. It is clear that the opinion of Midgley, who assumes that the process of

Neolithization started inland, is not in accordance with the above-mentioned studies from Schleswig-Holstein, which demonstrate that the process of Neolithization definitely started in the coastal areas.

Now let us return to the Swifterbant Culture. When we want to compare the subsistence strategies of the wetland and the upland communities, macroscopic-remains and pollen data from both areas are needed. As we have seen, there are macroscopic-remains data only from the wetland areas (CASPARIE et al. 1977; VAN ZEIST & PALFENIER-VEGTER 1981; GEHASSE 1995; BRINKKEMPER et al. 1999). This study has presented a number of pollen diagrams from Pleistocene sandy areas in which an occupation phase associated with Swifterbant people is visible (fig. 77). However, in pollen diagrams from Swifterbant sites in the wetland zone, no occupation phases are observed at all (LOUWE KOOIJMANS 1974; CASPARIE et al. 1977; VAN DER WIEL 1982; GEHASSE 1995; see II.2.7). This is in contrast with the situation in northeastern Germany and Denmark, where occupation phases attributed to the Ertebølle Culture can be recognized in pollen diagrams from both coastal and inland areas (the Troels-Smith occupation phase, see II.1.3). Thus we have only macroscopic-remains data from the wetland sites and only pollen data from the upland sites to document the Swifterbant Culture. My conclusion is that on the basis of this incomplete picture, it is impossible to draw any conclusion about differences in subsistence strategies between wetland and upland communities of the Swifterbant Culture.

VIII.4.6 The spread of agriculture

The occupation phase associated with the Swifterbant Culture in pollen diagrams of the northern Netherlands and northwestern Germany (phase NOP-1) not only resembles the occupation phases of the Ertebølle Culture and the subsequent Early Neolithic TRB in pollen diagrams of northeastern Germany, Denmark and Sweden (Troels-Smith-PREFACT phases A/B, Iversen-PREFACT phase 1), but also the occupation phase of the Rössen Culture in pollen diagrams of the loess zone (KALIS & MEURERS-BALKE 1988; 1998). The finds of Rössen-type adzes in both Swifterbant and Ertebølle contexts are evidence for the presence of fairly intensive contacts between the Rössen Culture and these two cul-

tures. At the same time also the knowledge about agricultural methods seems to have spread, which initiated the process of Neolithization in the north (KALIS & MEURERS-BALKE 1998, 20). It is interesting to compare the spread of agriculture, in space as well as in time, by the Swifterbant Culture and the Ertebølle Culture. They obtained their knowledge from the same source: the Rössen Culture of the loess areas, but the process of diffusion seems to be somewhat different. Let us first consider the Ertebølle Culture. In Denmark and southern Sweden, no macroscopic remains from Ertebølle contexts pointed to cereal cultivation or stock keeping (S.H. ANDERSEN 1998); in pollen diagrams from these areas, the Troels-Smith occupation phase clearly points to small-scale agriculture in Ertebølle time (KOLSTRUP 1988; GÖRANSSON 1988b; KALIS & MEURERS-BALKE 1998). In eastern Holstein, cattle bones were found which were dated to ca. 4850 cal BC, which is definitely within the Ertebølle period (HARTZ et al. 2000, 136). This date more or less tallies with dates of the beginning of the Troels-Smith occupation phase in the pollen diagrams (KALIS & MEURERS-BALKE 1998). This evidence shows that agriculture spread from the loess zone to the north, first reaching eastern Holstein around 4850 cal BC, then Denmark and finally Sweden. Because the situation in Denmark and Sweden is still not entirely clear, it is not possible to say how long it took for agriculture to spread from the loess zone to Sweden.

This study and some other very recent studies (e.g. GEHASSE 1995; RAEMAEEKERS 1999; BRINKKEMPER et al. 1999) have shed new light on the spread of agriculture in the small country of the Netherlands. As we have seen, ¹⁴C dating of macroscopic remains from the wetland sites in the western and central Netherlands has put the earliest evidence for stock keeping at ca. 4750 cal BC and the earliest evidence for crop cultivation at ca. 4200 cal BC (RAEMAEEKERS 1999, fig. 5.1). The beginning of phase NOP-1 in pollen diagrams from the Pleistocene sandy areas in the northern Netherlands is dated to ca. 4050 cal BC. In phase NOP-1, evidence for crop cultivation as well as stock keeping was found. This seems to indicate that agriculture was adopted somewhat earlier by the wetland communities than by the upland communities. It is not possible to draw definitive conclusions on this point until upland sites of the Swifterbant Culture are found with macroscopic remains. However, it is quite plausible that, as in the case of the Ertebølle Culture, the use of agriculture spread from the Rössen

Culture on the loess soils first to the nearby wetland areas in the western and central Netherlands, and only in a later stage to the upland areas in the northern Netherlands, which are at a greater distance.

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

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

VIII.4.7 The relation between occupation phases in pollen diagrams and archaeological cultures

At first sight, it seems strange that the activities of three entirely different cultures, living in three entirely different types of landscape - the Ertebølle Culture, the Swifterbant Culture and the Rössen Culture - have yielded a more or less similar type of occupation phase in the pollen diagrams. Still it is obvious to assume purely on the basis of the pollen data that these three cultures used more or less similar agricultural methods. As already indicated, it is very likely that the knowledge of these methods was disseminated by the Rössen Culture to the Ertebølle and Swifterbant Cultures.

On the other hand, it is also possible that a single culture caused different types of occupation phase in pollen diagrams from different areas. One example may illustrate this: in Denmark, the Early Neolithic TRB Culture is connected with phase 1 and the beginning of phase 2 of the Iversen occupation phase (Iversen-PREFACT phases 1 and 2a as defined by KALIS & MEURERS-BALKE 1998; 2001), while in southern Sweden this culture is connected with a *landnam* phase which has affinity to phase 2 of the Iversen occupation phase in Denmark (GÖRANSSON 1988a; 1988b).

The type of occupation phase occurring in a pollen diagram apparently is conditioned not only by cultural factors but also to a large extent by the nature of the environment itself (CASPARIE & GROENMAN-VAN WAATERINGE 1980; MIDGLEY 1992, 392). Because of these differing environmental conditions, it is not possible to assign a particular type of occupation phase always to a particular culture. A model describing a sequence of Neolithic occupation phases in pollen diagrams is therefore valid only in an area defined by a specific type of landscape, and certainly not outside that area. Furthermore, we have to take into consideration that even within such a limited area the appearance of a certain occupation phase in different pollen diagrams may differ considerably as a result of other factors, such as location type, sediment type, location within the basin and distance to the settlement and/or agricultural land (see VIII.1). In spite of these limitations, it is possible to determine certain general trends in pollen diagrams from such a limited area, which can be used to define a sequence of occupation phases palynologically. With the help of accurate ¹⁴C dates, it is possible to connect these occupation phases with archaeological cultures. Following Kalis & Meurers-Balke (1998), whose model of Neolithic occupation phases in pollen diagrams from the western Baltic is a major achievement, this study has been aimed at framing a model of Neolithic occupation phases in pollen diagrams from Pleistocene areas near the North Sea coast. I hope that this model will contribute to resolving the complex problem of the emergence of agriculture in the Netherlands.