I. General introduction

I.1 Introduction

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

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

In the Netherlands, the effect of early agricultural activities on the composition of the vegetation, as well as the presence of cultivated crops themselves, is deduced mainly from pollen diagrams originating from large bogs (VAN ZEIST 1955a; 1955b; 1959; JANSSEN & TEN HOVE 1971; VAN GEEL 1978; CASPARIE 1992). However, the Neolithic farmers resided at a large distance from these bogs, so that the changes in the pollen rain which indicate their activity are diluted. Theoretically, small bogs, many of which are so-called pingo scars, are a much better source of information, if they are located in the vicinity of Neolithic settlements. However, in most small bogs, the so-called Neolithic Occupation Period (NOP) occurs in *Sphagnum* peat sediment. In the more recent past, this peat was often dug away to be used as fuel (*turf*). In these small bogs, below the peat sediment, often lake sediment is found, called gyttja, which could not be used as fuel and was therefore not exploited. At present, only very few pingo scars on the Drenthe Plateau are known in which the Neolithic Occupation Period is recorded in gyttja. One of these pingo scars is the Gietsenveentje, which is located near the village of Gieten in the province of Drenthe.

The pollen picture of the beginning of the Neolithic Occupation Period in the Gietsenveentje as known from preliminary studies (VAN DER KNAAP 1974; HAGEDOORN 1986), does not correspond to that described by Iversen and Troels-Smith for the Funnel Beaker Culture. Furthermore, the ^{14}C date of the first signs of human activity in the sediment, ca. 3600 cal BC (LANTING & BOTTEMA 1991), cannot be correlated with dates of the earliest agricultural settlements in the area: in the direct neighbourhood of the Gietsenveentje, there are several settlements of the Funnel Beaker Culture, which can be dated ca. 3300 cal BC. Possibly, the beginning of the Neolithic Occupation Period in the Gietsenveentje can be correlated with a late phase of the Swifterbant Culture. Several authors have already suggested a form of agriculture preceding that of the Funnel Beaker Culture in northern Germany, Denmark and southern Sweden (GÖRANSSON 1988a; 1988b; KOLSTRUP 1988; KALIS & MEURERS-BALKE 1998). The possibility of pre-TRB agriculture on the Drenthe Plateau will be considered in the present study.

I.2 Research strategy and approach

The aim of this study is to describe and explain the changes in the natural environment caused by the earliest farmers on the Drenthe Plateau, by means of a detailed palaeobotanical study of the Neolithic Occupation Period (NOP) in the sediment of the Gietsenveentje. A model of the Neolithic Occupation Period will be framed for the northern Netherlands and adjacent areas, which will be comparable to Iversen's *landnam* model for Denmark. Answers will be sought to the following questions:

- What was the natural environment like just before and during the Neolithic Occupation Period?
- What forms of interference affected the original vegetation?
- Which types of agricultural economy were practised during the Neolithic Occupation Period?
- Which cultures can be connected with the various phases of the Neolithic Occupation Period in the pollen diagrams?
- What was the role of the culture-indicator species *Rumex acetosa* (common sorrel) and *R. acetosella* (sheep's sorrel) in the vegetation during the Neolithic Occupation Period?
- What factors influence the manifestation of a land-occupation phase in a pollen diagram?

In the centre of the Gietsenveentje, a trench was dug to create an open section. It was possible to sample relatively large volumes of sediment from this section. Furthermore, a series of sequences were cored from the centre to the edges of the Gietsenveentje. The sediment samples from the open section and from the sequences were used for various types of analysis: pollen analysis, ^{14}C dating, pollen concentration and pollen influx analysis, analysis of macroscopic remains and wood, and phosphorus analysis. In order to get a very detailed chronology of the Neolithic Occupation Period, a large number of samples were ^{14}C-dated. For a study of the structure of the pingo basin, a factor which may have influenced the reflection of agricultural activities in the pollen diagrams, a large number of sequences were cored for lithological descriptions. The morphology of the culture-indicator pollen types *Rumex acetosa* and *R. acetosella* was examined in detail. For a study of the role of *Rumex acetosa* and *R. acetosella* in the Neolithic Occupation Period, vegetation plots were recorded and surface samples collected in modern vegetation types with these two *Rumex* species.

I.3 Context

This study was carried out in the framework of project group no. 2 of the Groningen Institute of Archaeology of the University of Groningen, the Netherlands. The research of this project group is focused on farming and early urban societies in the Netherlands. The project manager of the project group is Prof. Dr. H.R. Reinders.

I.4 Definition of the most important terms and concepts

I.4.1 Stratigraphical classification

Most data used in this study were obtained from various sediment cores of the Gietsenveentje. One of the tools for classifying these data is stratigraphy, by which layers of the sediment can be compared with similar deposits elsewhere (JANSSEN 1980). There are various types of stratigraphical classification. Here two types of biostratigraphical classification will be used, in which zones are defined on the basis of differences in the pollen content of the sediment:

A. Blytt/Sernander classification.
Periods: **Atlantic** and **Subboreal**.
The terms Atlantic and Subboreal were originally defined in the climatostratigraphic classification of Blytt (1876) and Sernander (1908) as warm and humid, and warm and dry periods, respectively. In later times, when the climatic typifications of these periods were no longer tenable, they were defined biostratigraphically, viz. on the basis of the pollen record (see, for example, FIRBAS 1949; VAN ZEIST 1955a, 8). When biostratigraphical definitions are used, the Atlantic-Subboreal transition does not occur synchronously everywhere.

B. Anthropo-stratigraphical classification.
This classification subdivides the sediment into zones on the basis of traces of human presence, as seen in the pollen picture.
Period: **Neolithic Occupation Period (NOP)**, subdivided into three Neolithic Occupation Phases.
The beginning of the Neolithic Occupation Period (NOP) is defined palynologically as a decrease of tree pollen, especially *Ulmus*, and an increase of herb pollen, especially the culture-indicator pollen types (see I.4.2). The Neolithic Occupation Period is subdivided into three Neolithic Occupation Phases, which

are roughly defined as follows:

NOP-1: still high percentages of tree pollen, low percentages of culture-indicator types;

NOP-2: lower percentages of tree pollen, high percentages of culture-indicator types;

NOP-3: stabilization of tree pollen percentages, somewhat lower percentages of culture-indicator types.

As already mentioned, these phenomena or at least some of them in pollen diagrams are often summarized by the term ***landnam***. This term was first used by Iversen (1941; see II.1.2), because he saw a parallel between the immigration and land reclamation of the Neolithic people and the immigration of Viking settlers into Iceland and Greenland, which was traditionally referred to by the Old-Icelandic word *landnam*. Since then, the term *landnam* has been adopted by many palynologists to describe palynological phenomena connected with the first appearance of agriculture. Unfortunately, in the course of time, the original meaning of the term *landnam* almost disappeared from sight. The term was defined definitively by another famous Danish palynologist, Jørgen Troels-Smith (1942, 207): "We may speak of a *landnam*, when the course of the curves reflects large-scale forest clearances, undertaken by a newly immigrated people making use of agriculture, to create the facilities for practising arable farming and stock keeping." In the opinion of Iversen and Troels-Smith, the various phases of a *landnam* (see II.1.2) only represented a relatively short-lasting, local cycle of clearance, agriculture and forest regeneration. However, when for the first time large numbers of ^{14}C dates became available, it became clear that the phases of the *landnam* represented long-lasting, regional phenomena, which were found in many pollen diagrams of northwestern Europe (see for example ROWLEY-CONWY 1982; GÖRANSSON 1988c, 34; MADSEN 1990, 29; KALIS & MEURERS-BALKE 1998). For this reason, the "charged" term *landnam* will not be used in this study, but it will be replaced by the term Neolithic Occupation Period (NOP) (see also KALIS & MEURERS-BALKE 1998, 5).

On the basis of several series of ^{14}C dates, the aim is to obtain an absolute chronology of the Neolithic Occupation Period and its phases as seen in the Gietsenveentje pollen diagrams. The Gietsenveentje ^{14}C dates will be compared with dates of archaeological finds, in order to correlate the Neolithic Occupation Period and its phases as seen in the Gietsenveentje pollen diagrams with cultural periods or even cultures in archaeology. As the name already indicates, the Neolithic Occupation Period as observed in the pollen diagrams is expected to coincide with the Neolithic as it is known from archaeological finds. The beginning of the **Neolithic**, or New Stone Age, is conventionally defined as the appearance of the first domestic crops and livestock. The period is also marked by the first widespread use of pottery and ground stone tools, by a substantial increase in the number of settlement sites and the quantity of material remains and by the first field monuments (FAGAN 1996, 215). It has to be emphasized that in different areas, the beginning of the Neolithic does not occur synchronously (see II.5).

In fig. 1, the relevant periods of the two types of biostratigraphical classification are put next to the corresponding cultural periods known from archaeology. On the basis of this figure, the following question can be asked: were the beginning of the Neolithic, the Atlantic-Subboreal transition and the beginning of the Neolithic Occupation Period synchronous events in the part of Drenthe where the Gietsenveentje is located? An answer to this question will be sought with the help of high-resolution ^{14}C dating of sediments from the Gietsenveentje.

I.4.2 The detection of the beginning of the Neolithic Occupation Period in pollen diagrams

Apart from its localization in time, there is the problem of how the beginning of the Neolithic Occupation Period (NOP) manifests itself in pollen diagrams. This problem will be analyzed in two steps. The first step is to consider the question how an agricultural economy affects the vegetation. Many cultivated plants are domesticated steppe plants from the Near East (see II.5); to grow these plants in northwestern Europe, it is necessary to create and maintain open areas in the forest. In these new biotopes, next to the cultivated plants, a flora of heliophytes can develop, the so-called synanthropic species. A result of the keeping of animals is that natural biotopes are changed, because generally more individuals per area are kept than the natural forests would support. Because of the need for fodder, this inevitably leads to the creation and preservation

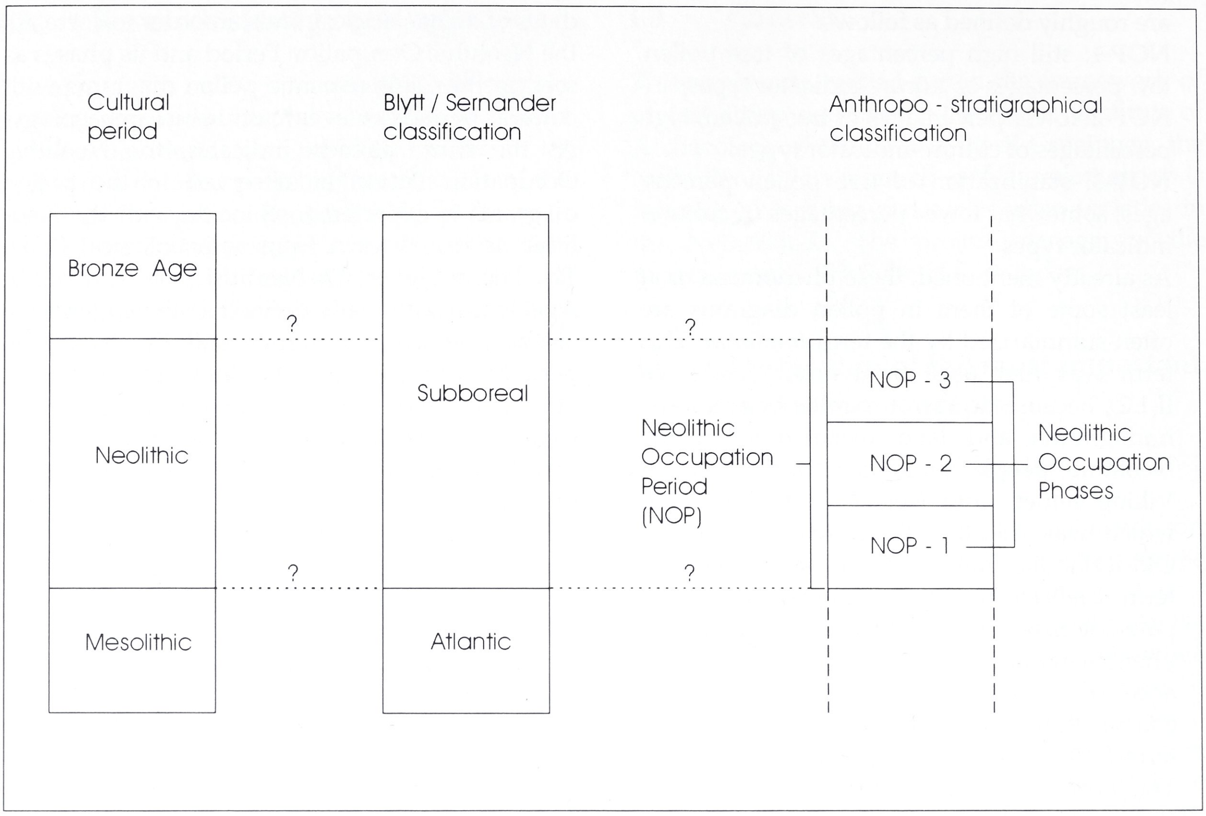

Fig. 1. Periods used in this study of two types of biostratigraphical classification and the corresponding cultural periods known from archaeology.

of plant communities with a large biomass production (KALIS & MEURERS-BALKE 1998).
The second step concerns the question how the man-made changes in the vegetation are observed in subfossil pollen diagrams. Generally, phenomena observed in subfossil pollen diagrams are interpreted on the basis of the "modern analogue" approach. The basic assumption of this method is that the situation of the present can be used to reconstruct the situation of the past. Within this method, two approaches are possible (BIRKS & BIRKS 1980, 231):

A. the indicator-species approach: this approach involves the application backwards in time of known ecological and sociological preferences of taxa. Those with a well-defined, narrow ecological tolerance can be used as indicator species.
B. the comparative approach: this approach involves the characterization of a range of modern vegetation types by means of contemporary pollen spectra (usually from surface samples), and then the comparison of these spectra with subfossil pollen assemblages.

In this study, these two approaches are used especially with respect to the reconstruction of man-made vegetation types. The indicator-species approach involves the use of culture-indicator pollen types, also called anthropogenic indicator pollen types (BEHRE 1981; 1986); the comparative approach involves the use of modern pollen/land-use relationships for the reconstruction of past land-uses and cultural landscapes (GAILLARD et al. 1992). The use of these two approaches in this study will now be explained in greater detail.

Use of culture-indicator pollen types

Culture-indicator pollen types are pollen types which may indicate human activity. Of course, the best culture-indicator pollen types are those of cultivated plants, the so-called primary indicators. In the Neolithic of northwestern Europe, the only identified pollen types of cultivated plants are *Hordeum* (barley), *Triticum* (wheat) and *Linum* (flax). Somewhat later, in the Iron Age, *Secale* (rye) was first cultivated in northwestern Europe (BEHRE 1992a). *Hordeum* and *Triticum* are autogamous cereals, producing pollen which for the larger part remains in the hulls and hence is poorly dispersed. As a result, *Hordeum* and *Triticum* may occur very scarcely or not at all in peat or gyttja sequences cored even in close proximity to prehistoric cultivation areas. In contrast, *Secale*, as an allogamous species, has high pollen productivity and good dispersal capacity and hence is among the most reliable indicators of cultivation. Apart from cultivated plants, there are several species with readily distinguishable pollen which serve as culture indicators. These so-called synanthropic species tend to occur in man-made plant communities like arable land, meadow or heath. In specific cases, it is sometimes very difficult to determine whether these species occurred in natural or man-made biotopes; the decision can only be made when several culture-indicator pollen types are found together. Another problem is that in the early stages in the development of agriculture, when mixed farming was normal practice, the weed communities of cultivation as known today had not yet developed. The occurrence of culture-indicator species is also to a large extent influenced by the agricultural implements used: in the Neolithic, only the ard was known, a plough which does not turn the soil, so that perennating organs such as roots and rhizomes are not destroyed (see for example DRENTH & LANTING 1997). This favours the spread of perennial taxa like Gramineae and *Plantago lanceolata*.

Despite the large differences between prehistoric and modern agricultural methods, the interpretation of cultural periods in pollen diagrams will be guided in the first instance by the present-day pattern of occurrence of the culture-indicator species. Behre (1981) made a list of culture-indicator pollen types and their occurrence in various farming contexts in Europe north of the Alps. This list is reproduced in fig. 2. Besides evidence from modern communities, also information gained from many palynological investigations was incorporated. Fig. 2 will be an important guide for the recognition of cultural periods in the pollen diagrams of this study. Without doubt, the most important culture-indicator pollen types, besides the pollen types of cultivated plants, are *Plantago lanceolata* and *Rumex*-type. *Plantago lanceolata* was originally considered a pure indicator of pasture land; from its abundance, the extent of stock keeping could be estimated. However, because of its high light requirement, it would not grow in grazed forests (IVERSEN 1973, 84); apart from pastures, it grows optimally in hay-meadows which are mown once a year. However, it has been argued by several authors (BEHRE 1981; BEHRE & KUČAN 1994, 148; GROENMAN-VAN WAATERINGE 1986, 200) that *Plantago lanceolata* could also have grown as an arable weed among the crops. The dynamic system of an arable field of summer cereals is much the same as that of a meadow mown once a year in late summer; if the preparation of the field was done only with an ard, as was the case in the Neolithic, *Plantago lanceolata* could easily maintain itself. A second important culture-indicator pollen type is *Rumex*-type. In the Netherlands, small grains of *Rumex*-type originate almost exclusively from *Rumex acetosa* or *Rumex acetosella*. Because their ecology differs considerably, an attempt will be made in this study to separate the pollen of these two species (see V.2). *Rumex acetosa* is considered to be an indicator of pasture land, while *Rumex acetosella* is indicative of (former) arable land (BEHRE 1981, 236). The ecology of these two *Rumex* species and their significance for the interpretation of cultural periods in the pollen diagrams will be treated in sections V.3 and V.4.

Use of modern pollen/land-use relationships for the reconstruction of past land-uses and cultural landscapes

Up till now, the indicator-species approach has been the common method used for interpretation of pollen diagrams in terms of past land-uses (see BEHRE 1986). However, in recent years several large-scale studies have been carried out using the comparative approach for the reconstruction of past human-influenced plant communities and vegetation-landscape units (GAILLARD et al. 1992; BROSTRÖM et al. 1998). In this study, the comparative approach is used in combination with the indicator-species approach for a reconstruction of the landscape in the Neolithic Occupation Period. Because the two culture-indicator species *Rumex acetosa* and *Rumex acetosella* are clear indicators of two different types of agriculture, they have been used for a small-scale modern pollen/land-use study: recent human-influenced and natural plant communities in which these two species play an important role have been studied (see V.3). The results will be used for interpreting the course of the pollen curves at the beginning of, and during the Neolithic Occupation Period.

		Life form	Winter cereals	Summer cereals and coppice cultures	Fallow land	Moist grass vegetation	Dry grass vegetation and heaths	Grazed forest	Footpath and ruderal communities
Primary indicators									
Ce	*Secale*	T	◯	+	+				
	Hordeum	T	o	O	+				
	Triticum	T	∘	O	+				
	Avena	T		◯	+				
	Zea	T		◯	+				
Cu	*Fagopyrum*	T		O	+				
	Linum (usitatissimum)	T		O	+				
	Vicia faba	T		o	+				
	Cannabis (type)	T		o	+				
Secondary indicators									
Ad	*Centaurea cyanus*	T	o	+	+				
	Lychnis/Agrostemma (type)	T	o	+	+	∘			
	Scleranthus annuus	T	o	+	+		+		
	Spergula arvensis	T	∘	o	∘				+
	Polygonum convolvulus	T	o	∘	∘				∘
	Polygonum aviculare	T	o	o	o	∘		∘	o
	Polygonum persicaria (type)	T	∘	o	o			+	∘
	Plantago lanceolata	H			∘	O	+	+	+
	Plantago major/media	H		+	∘	o	∘	∘	◯
Ap	*Rumex acetosella*	H	O	∘	o	+	o	∘	∘
	Rumex acetosa	H			∘	o		∘	+
	Trifolium repens	H	+	∘	∘	o	+	o	o
	Succisa pratensis	H				o	∘		
	Jasione/Campanula (type)	H			∘	+	o	∘	
	Urtica	H		∘	∘			∘	◯
	Artemisia (vulgaris)	H			∘			∘	O
	Melampyrum (pratense)	T					∘	O	
	Pteridium aquilinum	G			+	∘	∘	O	
	Polypodium vulgare	Ch					∘	∘	
	Calluna vulgaris	Ch					◯	∘	
	Juniperus communis	P					O	∘	
Fa	Gramineae		o	o	O	◯	O	O	∘
	Cyperaceae				∘	O	∘	∘	
	Caryophyllaceae p.p.		∘	∘	∘	∘	+	+	∘
	Cruciferae		∘	o	o	∘	+	∘	o
	Ranunculaceae		+	+	∘	O		∘	o
	Umbelliferae				∘	o	+	o	∘
	Chenopodiaceae			o	o				O
	Compositae		∘	∘	o	o	∘	∘	o

Fig. 2. Culture-indicator pollen types and their occurrence in various farming contexts in Europe north of the Alps (after BEHRE 1981 and LANG 1994). A five-part scale is used, from a plus (weak indicator for the biotope concerned) to a large circle (strong indicator for the biotope concerned). Ce: cereals. Cu: dicotylous culture plants. Ad: adventive plants. Ap: apophytes. Fa: apophytic plant families. T: therophytes. H: hemicryptophytes. G: geophytes. Ch: chamaephytes. P: phanerophytes (terminology: see LANG 1994, 227-229 and LANJOUW et al. 1968, 11).