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STUDIES ON THE POST-BOREAL VEGETATIONAL HISTORY OF SOUTH-EASTERN DRENTHE (NETHERLANDS)

W. VAN ZEIST

(*Institute for Biological Archaeology, Groningen*)

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INTRODUCTION

In this paper the results of some palynological investigations of peat deposits in south-eastern Drenthe will be discussed. The location of the profiles to be discussed is indicated on the map of Fig. 1. This map, which is a slightly modified copy of the Geological Map (No. 17, sheets 2 and 4, No. 18, 2 and 4), gives a survey of the soils in the Emmen district.

Peat formation took place chiefly in the Hunze *Urstromtal*, which to the west is bordered by the Hondsrug, a chain of low hills. It may be noted that the greater part of the raised bog has now vanished on account of peat cutting. In the eastern part of the Hondsrug fairly fertile boulder clay reaches the surface, whereas more to the west in general the boulder clay is covered by a more or less thick deposit of cover sand. Fluvio-glacial deposits are exposed on the eastern slope of the Hondsrug.

Unfortunately, no natural forest has been left in south-eastern Drenthe. Under present conditions the climax vegetation in areas with boulder clay on or slightly below the surface would be a *Querceto-Carpinetum subatlanticum* which is rich in *Fagus*, that in the cover sand areas—dependent on the depth of the boulder clay—a *Querceto roboris-Betuletum* or a *Fageto-Quercetum petraeae* (*cf.* TÜXEN, 1955).

In contrast to the diagrams from Emmen and Zwartemeer previously published (VAN ZEIST, 1955a, 1955b, 1956b) which provide a survey of the vegetational history of the whole Emmen district, the diagrams from Bargeroosterveld and Nieuw-Dordrecht have a more local character. The latter two profiles are in the border zone of the raised bog, only a short distance from the higher soils of the Hondsrug. In these diagrams the influence of prehistoric man on vegetation comes out better than it does in those from the more central parts of the raised bog.

The profile of Nieuw-Dordrecht was sampled during the excavation of a trackway (VAN ZEIST, 1956a). This trackway consisted mostly of split tree stems, of a length of about 3 m, which were laid on the peat transversally side by side. A radiocarbon dating of a piece of wood from this trackway gave an age of 1885 ± 55 B.C. (Gro 1087).

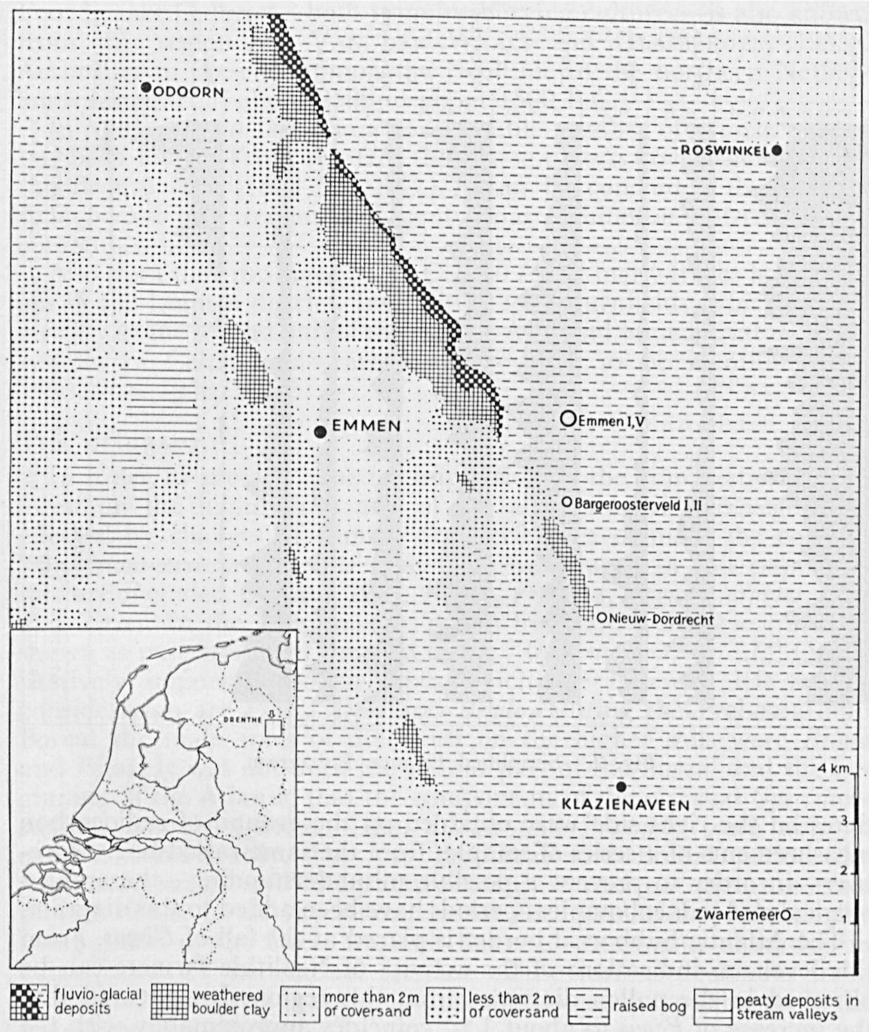


Fig. 1. Soil map of the Emmen region with location of the profiles discussed in this paper.

The samples from the Bargeroosterveld profiles were collected on the occasion of the excavation of the remains of a wooden building placed on the peat. This structure, which was surrounded by a circle of rather small stones, had undoubtedly a ritual purpose (WATERBOLK and VAN ZEIST, in preparation). The level of this building, which according to a radiocarbon measurement is to be dated at 1045 ± 65 B.C. (Gro 1552), is indicated in the Bargeroosterveld II diagram.

A summary of the results previously published gives the simplified diagram Emmen I (VAN ZEIST, 1955a, Fig. 4). The Boreal and early Atlantic part of this diagram has been omitted here (Fig. 2). The

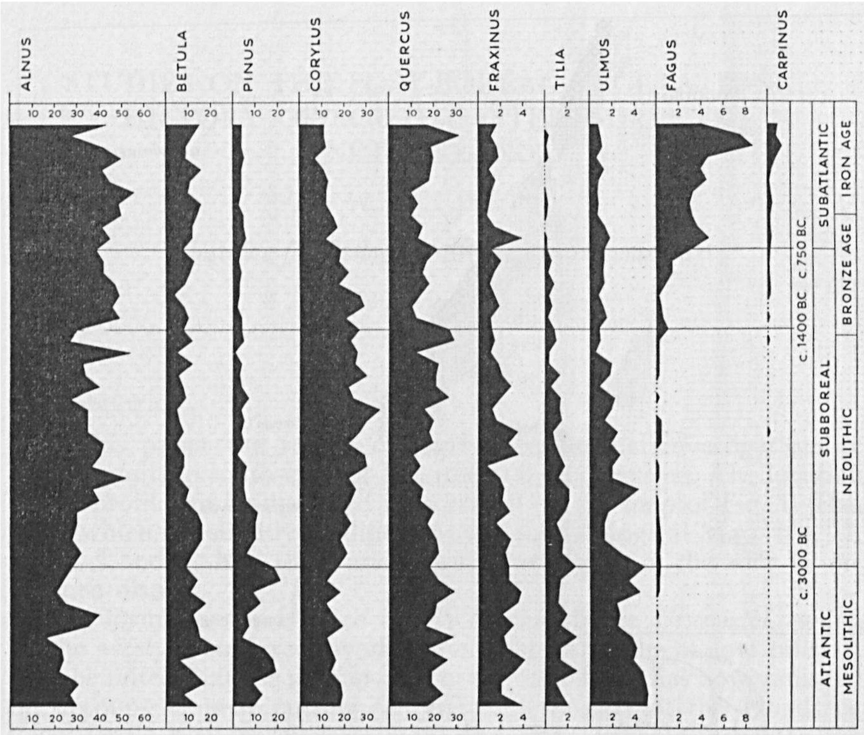


Fig. 2. Simplified Emmen I diagram.

dates on the right side were obtained on the ground of radiocarbon measurements of a series of samples from the same raised bog. Moreover—in order to prevent a possible misunderstanding—the archaeological and palaeobotanical periods have been added to this diagram.

The Atlantic/Subboreal border is placed at the fall of *Ulmus*. From this level on, indications of the activity of Neolithic farmers can be observed in the pollen diagrams from this region. It appeared that the increase of *Fagus* to about 1 % coincides approximately with the transition from the Neolithic to the Bronze Age. The Subboreal/Subatlantic border is placed at the first important increase of *Fagus* (up to about 5 %).

The prehistoric occupation of the Emmen district

As the influence of man on vegetation is to be discussed in this paper, it is necessary to summarize very briefly the prehistoric occupation of this region. The interference of man with the natural vegetation began in the Neolithic with the settling of the first farmers. In the northern Netherlands three Neolithic cultures occurred. The megalithic tombs (*hunebedden*) ,a relatively large number of which are found in the south-eastern part of the Hondsrug, attest the presence of the Funnel Beaker Culture. Pottery of the Bell Beaker and Protruding

Foot Beaker Cultures—both tumulus-burying cultures—is also known from this region (*cf.* VAN DER WAALS and GLASBERGEN, 1955). According to present opinion the Neolithic in the northern Netherlands lasted from about 2500 to about 1500 B.C.

In south-eastern Drenthe a considerable number of bronze objects has been found. From the fact that these objects cover the whole of the Bronze Age (1500–500 B.C.) it can be concluded that during that period this region had continuous habitation (BUTLER, oral communication).

Also from the Iron Age (500 B.C.–400 A.D.) many traces have been left in the Emmen district. In addition to the urnfields, which started already in the second half of the Bronze Age, and some burial mounds, systems of Celtic fields—arable plots—have to be mentioned (*cf.* WIERINGA, 1958, Fig. 5).

THE DIAGRAMS

In order to provide a better impression of the composition of the forest on the higher soils and of the alterations in the vegetation effected by changes of climate or interference of man, the concept "*Quercetum-mixtum sensu lato*" has been introduced in this paper. In this are included *Quercus*, *Tilia*, *Ulmus*, *Fraxinus*, *Fagus*, *Carpinus*, *Acer* and *Taxus*. In the diagrams the pollen frequencies of these trees are shown as percentages of the sum of the "*Quercetum-mixtum s.l.*" Quantitatively important pollen types which are herewith left out of consideration are *Pinus*, *Alnus* and *Betula*. During the Preboreal and Boreal the main trees of the forest on the higher soils were *Betula* and *Pinus*. It was not until the second part of the Boreal and the beginning of the Atlantic that the components of the classical *Quercetum-mixtum*, namely *Quercus*, *Tilia*, *Ulmus* and *Fraxinus*, were able to expand considerably. For the Preboreal and Boreal period the "*Quercetum-mixtum s.l.*" diagrams certainly would not give a correct picture of the forest vegetation. In the first part of the Atlantic the composition of the forest was still liable to continuous alteration in consequence of the gradual increase of the various deciduous trees. It was not until later in Atlantic time that a certain equilibrium in the vegetation was reached.

It is beyond doubt that in the second part of the Atlantic and in the later periods *Pinus* and *Betula* formed part of the vegetation on the poorer soils, although in general their share would not have been very important. After a forest clearing, however, *Betula* would locally have shown a considerable increase of a temporary nature (*cf.* IVERSEN, 1941). It must likewise be taken into account that *Alnus* was present in the wettest parts of the mixed oak forest. That these trees have been left out of the "*Quercetum-mixtum s.l.*" is due to the fact that locally they played an important part in the bog vegetation. Birch, alder and pine were growing on the peat, especially in the border zone and along the streams. One may assume that a great part of the pollen of *Pinus*, *Betula* and *Alnus* in the post-Boreal peat deposits from this region was produced by trees which belonged to the vegetation of the bog. Moreover, *Alnus* would have been common in the stream valleys. For *Ulmus* and *Fraxinus* these peaty valleys would certainly not have formed a suitable environment.

The pollen frequencies of the herbs represented in the diagrams are expressed as percentages of the sum of the components of the "*Quercetum-mixtum s.l.*" It would perhaps have been better to use as the basis of calculation the pollen sum of the "*Quercetum-mixtum s.l.*" and these herbs. This, however, encountered the difficulty that in certain parts of the profiles from Bargeroosterveld and Nieuw-Dordrecht a considerable amount of Gramineous pollen has to be attributed to a local production. Generally no curves are given here for those pollen types which for the greater part would have been produced by plants which formed part of the bog vegetation.

The *Corylus* pollen frequencies are shown as percentages of the sum the "*Quercetum-mixtum s.l.*" and *Corylus*.

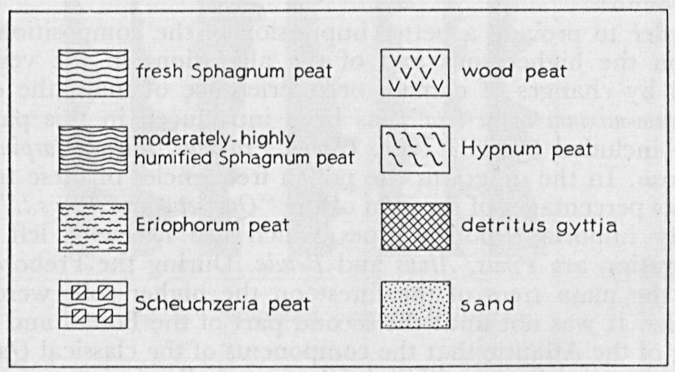


Fig. 3. Key to the symbols employed in the pollen diagrams.

As this manner of representing the results differs from the usual one, new diagrams have been drawn for the profiles from Zwartemeer and Emmen (Figs. 6, 7 and 10). For practical reasons nearly all herbs have been omitted in these diagrams, whereas from the profiles Emmen I and V the lower part, comprising the early Atlantic and older periods, has not been given. From the Bargeroosterveld and Nieuw-Dordrecht profiles also a traditional tree pollen diagram (*Corylus* included in the Σ AP) is published here (Figs. 4, 8 and 12). These diagrams have been simplified in that the components of the "*Quercetum-mixtum s.l.*" have been taken together here.

The fall of Ulmus and the first farmers

A striking feature in the pollen diagrams from western and north-western Europe is the fall of *Ulmus*. This decline of the *Ulmus* curve is generally accepted as a criterion for defining the border between the Atlantic (zone VII in Denmark and Norway, zone VIIa in England and Ireland, zone VI and VII according to Firbas, 1949) and the Subboreal (zones VIII, VIIb and VIII respectively).

In the diagrams from Denmark published by IVERSEN (1941) the recession of *Ulmus* coincides with an important decrease of *Hedera*. As this behaviour of *Hedera* is ascribed to a deterioration of climate after the post-glacial optimum (IVERSEN, 1941, 1944), it may be supposed that the decrease of *Ulmus* was due to the same factor. Also the circumstance that this phenomenon can be observed in so many diagrams would be in favour of a climatological cause. This the more as a number of radiocarbon datings suggests that in a large area the fall of *Ulmus* was a more or less synchronous phenomenon that can be dated at about 3000 B.C. (see Table I).

However, a climatological explanation for the decrease of *Ulmus* encounters difficulties. In the Danish diagrams *Fraxinus* shows a not unimportant increase simultaneously with the fall of *Ulmus*. For that reason Iversen supposes that it was *Ulmus carpinifolia* which as a consequence of the change in climate disappeared partly or wholly from Denmark. *Ulmus carpinifolia*, whose northern limit lies in Schleswig-Holstein, shows in ecological respect much resemblance with *Fraxinus excelsior*. The latter, however, ranges farther to the north-east, indicating that this tree can bear a more raw climate than *Ulmus carpinifolia*.

A serious drawback in the study on the behaviour of *Ulmus* in prehistoric times is that it has hitherto been impossible to separate the pollen of the various elm species. For that reason the palynological investigation cannot show the share of each *Ulmus* species in the pollen rain.

Concerning Norway, where undoubtedly only *Ulmus glabra* is the elm species in question (*cf.* HAFSTEN, 1956, p. 79), the diagrams from the relatively continental Oslo Fjord area show a descent of *Ulmus* that is also accompanied by an increase of *Fraxinus*. In northern and north-eastern Europe *Ulmus glabra* exceeds the limit of *Fraxinus excelsior*. For that reason it is difficult to imagine that *Fraxinus* would have been able to expand during a deterioration of climate of a nature that could cause a decline of *Ulmus glabra*.

In extremely oceanic western Norway the fall of *Ulmus* is even coupled with an increase of *Tilia* and *Hedera* (FAEGRI, 1940, 1944a, 1944b). In the post-glacial pollen diagrams from Ireland—where probably also only *Ulmus glabra* has to be considered—a marked decrease of *Ulmus* can be observed (MITCHELL, 1951, 1956), although *Hedera* does not show a decline at the same time (GODWIN, 1956, Fig. 50). Also in the Emmen district the fall of *Ulmus* is not attended by a decrease of *Hedera* (*cf.* Fig. 14).

Thus, in the diagrams from various regions one observes a descent of *Ulmus*, but no decrease of *Hedera*. In view of the present distribution of *Ulmus glabra* and *Hedera* it is not likely that a deterioration of climate could cause a recession of this elm species without effecting ivy. Consequently, in the regions, where there can only be a question of *Ulmus glabra*, a climatological factor can hardly be held responsible for the fall in the *Ulmus* curve if there is no decline of *Hedera*.

GODWIN (1956) put forward the suggestion that it could have been

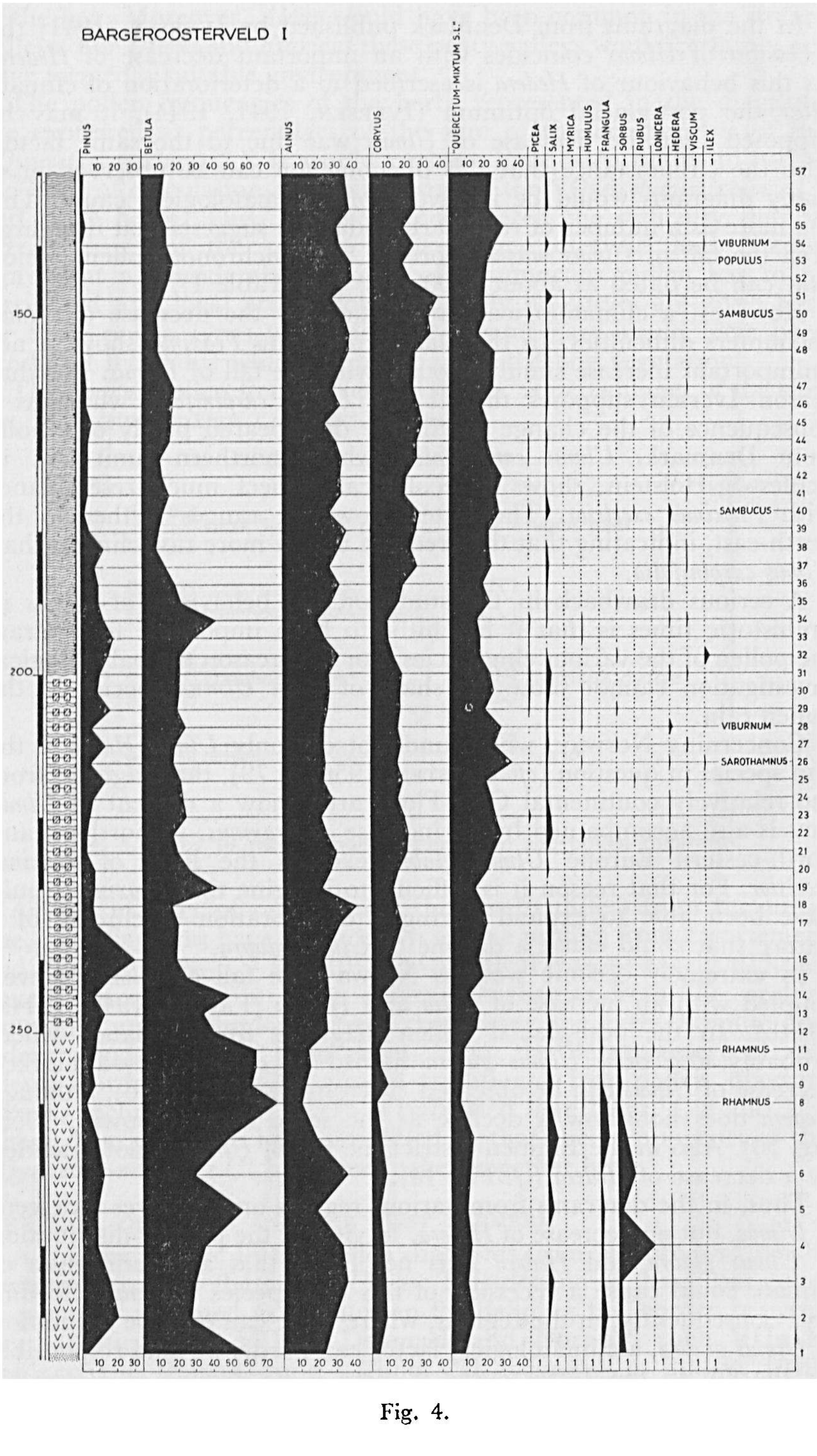

BARGEROOSTERVELD I
PINUS
BETULA
ALNUS
CORYLUS
"QUERCETUM-MIXTUM S.L."
PICEA
SALIX
MYRICA
HUMULUS
FRANGULA
SORBUS
RUBUS
LONICERA
HEDERA
VISCUM
ILEX
VIBURNUM
POPULUS
SAMBUCUS
SAMBUCUS
VIBURNUM
SAROTHAMNUS
RHAMNUS
RHAMNUS
150
200
250

Fig. 4.

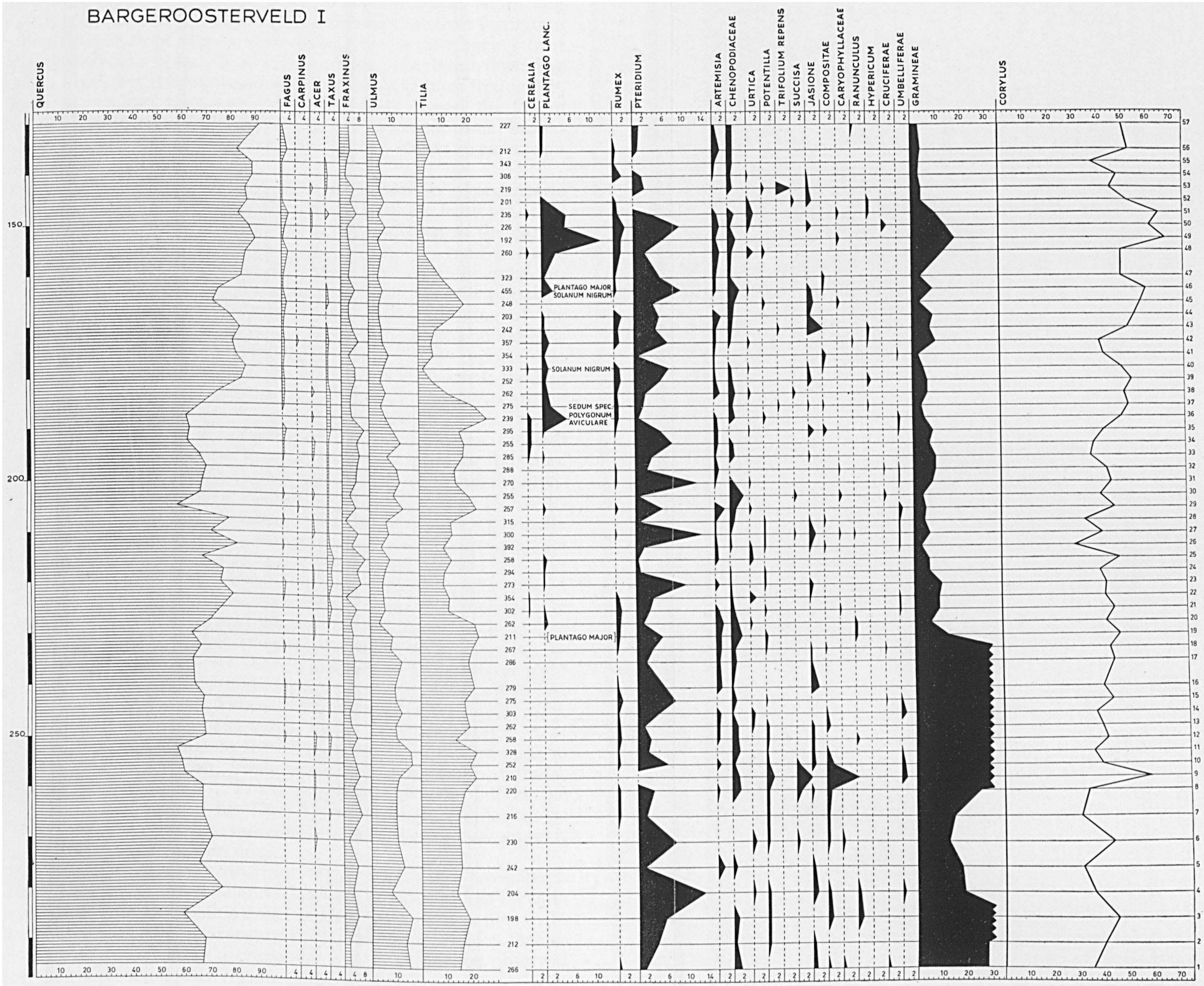

BARGEROOSTERVELD I
QUERCUS
FAGUS
CARPINUS
ACER
TAXUS
FRAXINUS
ULMUS
TILIA
CEREALIA
PLANTAGO LANC.
RUMEX
PTERIDIUM
ARTEMISIA
CHENOPODIACEAE
URTICA
POTENTILLA
TRIFOLIUM REPENS
SUCCISA
JASIONE
COMPOSITAE
CARYOPHYLLACEAE
RANUNCULUS
HYPERICUM
CRUCIFERAE
UMBELLIFERAE
GRAMINEAE
CORYLUS
PLANTAGO MAJOR
SOLANUM NIGRUM
SEDUM SPEC.
POLYGONUM AVICULARE
150
200
250

Fig. 5.

an increase of late spring frost that caused the fall of *Ulmus*. According to this author MELVILLE was able to demonstrate that fruit formation in the British species of elm is very susceptible to late spring frost once the flowers are open. It is *Ulmus glabra*, the latest-flowering British elm, which appears to escape late frost damage most frequently. This, however, cannot have been the factor that caused the fall of *Ulmus* at the beginning of the Subboreal, as at the same time *Fraxinus* —which is also very susceptible to late spring frost—shows an expansion in various areas.

FAEGRI (1944b) has pointed to the effect of the activity of prehistoric man on the production of *Ulmus* pollen. Especially the leafy branches of the elms would have been cut in order to give them to the cattle. Until recently the foliage of various kinds of trees was used as cattle fodder in mountainous regions with a serious shortage of grass. In remote areas, among others in Norway, this custom is still practised (*cf.* VE, 1930; BROCKMANN-JEROSCH, 1918). Heavy pruning of the trees promotes the sprouting of new shoots, which can then be harvested again after some years. BROCKMANN-JEROSCH (1918) reports that the foliage of *Ulmus* and *Fraxinus* is the most suitable for cattle fodder; in second place comes that of *Quercus*, *Acer*, *Tilia* and others. According to this author many kinds of trees can be utilized as cattle fodder. VE (1930) mentions that in Springtime in Norway even the still leafless twigs of the elm were cut in order to serve as food for the cows.

TROELS-SMITH (1953, 1955) carried out extremely detailed palynological investigations of the first farmers both in Switzerland (Michelsberg and Early Cortaillod Culture) and in Denmark (Ertebølle Culture). On the basis of the very low percentages of *Plantago lanceolata* this author arrives at the conclusion that little or no pasture land was available for the cattle. The domestic animals would have been kept in stalls or at least within an enclosure. For feeding the cattle people depended to a high degree on the foliage of various trees. Confirmation of this hypothesis is provided by the results of archaeological investigations in Switzerland. At the excavation of a settlement near Robenhausen, leaves of deciduous trees and twigs of the silver fir, likewise very suitable as cattle fodder, were met with (HEER, 1865, p. 7). The investigation of the settlement from Thayngen-Weier near Schaffhausen, which belongs to the Michelsberg Culture, brought to light the leafy shoots of elm, birch, oak, lime and maple (GUYAN, 1955, p. 262). Consequently, Troels-Smith ascribes the fall in the *Ulmus* curve, which both in his Danish and Swiss diagrams can be seen at the level where the first indications of a farmer culture appear, to the interference of Neolithic man.

In the Bargeroosterveld I diagram (Fig. 5) *Plantago lanceolata* is very scarce between samples 20 and 35, whereas the pollen of cerealia is present. In sample 19 a pollen grain of *Plantago major* was met with. Simultaneously with the appearance of these indicators of a farmer culture the elm curve shows a recession. The same can be observed in other diagrams from this region (Figs. 6 and 7).

Undoubtedly the agricultural practices of the first farmers in

Drenthe would have shown a great similarity to those in Denmark and Switzerland described by Troels–Smith. In order to obtain arable land people had to make a forest clearing. The size of the fields would have been relatively small. When, after some time, the soil became exhausted, another part of the forest was cleared, whereas on the abandoned field the wood could regenerate. The probably not very numerous livestock would have been allowed to graze on the open places around the settlement—as the abandoned fields—and perhaps also in the forest. An important cattle fodder was constituted by the leafy branches of various deciduous trees.

From the fact that in the Bargeroosterveld I diagram the *Ulmus* percentages again attain their original value between samples 29 and 35, it may perhaps be concluded that at that time these surroundings were unused or at least less intensively utilized.

In the part of the Bargeroosterveld I diagram discussed up to now the course of the curve for *Tilia* shows much resemblance to that for *Ulmus*. For that reason one will ask whether this is to be ascribed to the cutting of the branches of the lime. It has already been noted that in the diagrams Emmen I and V, which provide a general picture of the vegetational history of the whole Emmen district, a marked decrease of *Ulmus* can be seen at the appearance of the first pollen grains of *Plantago lanceolata*. However, in neither of these diagrams is the decline of *Ulmus* attended by a recession of *Tilia*. The fact that generally one observes only a fall of *Ulmus* can perhaps be explained in the following manner. VE (1930) reports that *Fraxinus* flowers again 2 to 3 years after the cutting of the leafy branches, and that after 4 years this tree shows an abundant fruit formation. New shoots of the lime flower after about 4 years. Those of the elm, on the other hand, are unable to produce flower buds in less than 7 or 8 years, and before that time they are mostly cut again. Concerning the other deciduous trees in this respect the present writer has no data at his disposal. If, however, the new shoots of these trees are able to flower after about 4 years, it would be understandable that in consequence of the cutting of leafy branches by prehistoric man the share of *Ulmus* in the pollen rain would decrease considerably more than that of the other trees.

As already mentioned, the Bargeroosterveld I diagram does show a reaction of *Tilia* to the activity of the first farmers. From the fact that in the lower part of this diagram the *Tilia* percentages are about twice as high as those in the corresponding part of the diagrams Emmen I and V it can be concluded that in Atlantic time the forest within a short distance of the Bargeroosterveld profile was particularly rich in lime. It is not impossible that in this forest type lime was the dominant tree.

The course of the curve for *Tilia* could point to a certain predilection of the first farmers for this lime-rich forest, that their settlement was situated within it. The making of clearances in this local forest type can to a certain extent be held responsible for the temporary decrease of *Tilia*. Herewith it has to be considered that the cultivated

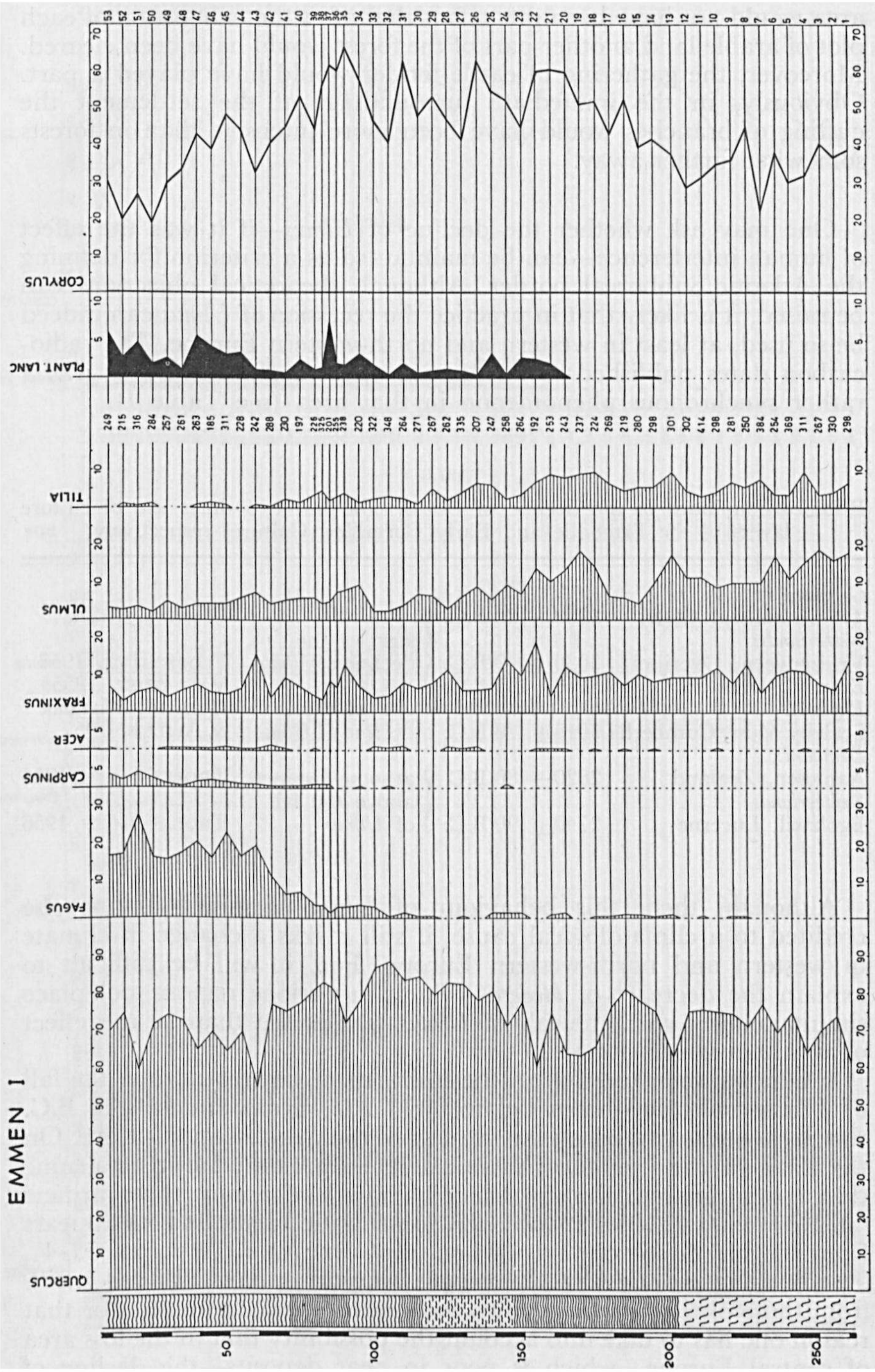

EMMEN I
QUERCUS
FAGUS
CARPINUS
ACER
FRAXINUS
ULMUS
TILIA
PLANT. LANC.
CORYLUS

Fig. 6.

area would not have been great, but that after the exhaustion of each plot of arable land another part of the forest would have been cleared. Moreover, the gathering of cattle fodder would have played a part. Obviously, in the immediate surroundings of the settlement the cutting of branches would have been more intensive than in forests somewhat further away.

One may ask whether the decline of *Ulmus*—if it was the effect of human interference—can be maintained as a criterion for defining the Atlantic/Subboreal border. Although theoretical objections can be raised, it is likely that in practice the recession of *Ulmus* can indeed be so used, at least in western and north-western Europe. The radiocarbon dates published so far suggest that the fall of *Ulmus* was a rather synchronous phenomenon in that area (see Table I).

TABLE I

Radiocarbon dates of the decline of *Ulmus*. The last two dates are of culture layers of the Ertebølle and Early Cortaillod Cultures respectively.

Germany:			
Tannenhausen, Ostfr.	3030±120 B.C.		GROHNE, 1957*a*
Netherlands:		start of the	
Vriezenveen, Overijsel	3030±140 B.C.	decline of *Ulmus*	FLORSCHÜTZ, 1957
Emmen, Drenthe	3010±135 B.C.		VAN ZEIST, 1955*b*
England:		end of the	GODWIN, WALKER
Scaleby Moss, Cumberl.	3015± 70 B.C.	decline of *Ulmus*	& WILLIS, 1957
Denmark:			
Aamosen, Zealand	2620± 80 B.C.	at some distance	TROELS-SMITH, 1956
Switzerland:		above the fall	
Egolzwil, Lucerne	2740± 90 B.C.	of *Ulmus*	TROELS-SMITH, 1956

Although, then, this behaviour of *Ulmus* seemingly cannot be credited to a climatological cause, it still marks a change in climate in western and north-western Europe. For, it will be difficult to explain the decrease of *Hedera*—which in various regions took place simultaneously with the fall of *Ulmus*—otherwise than as the effect of an alteration of climate.

It is not impossible that in the löss area of central Europe the fall of *Ulmus* took place even before 3000 B.C. From about 4000 B.C. this area was occupied by the farmers of the *Bandkeramik* Culture. On the basis of the results of botanical investigations one may assume that agriculture had already reached a high level among these farmers (*cf.* ROTHMALER, 1956). Moreover, some cattle was raised, as appears from the rather scarce finds of bones (*cf.* BUTTLER, 1938, pp. 53–4). The farming practices of this people would not have differed much from those of the first farmers in Switzerland and Denmark. For that reason one has to take into account the possibility that in the löss area of central Europe—which is poor in peat deposits—the decline of *Ulmus* may have taken place before 3000 B.C.

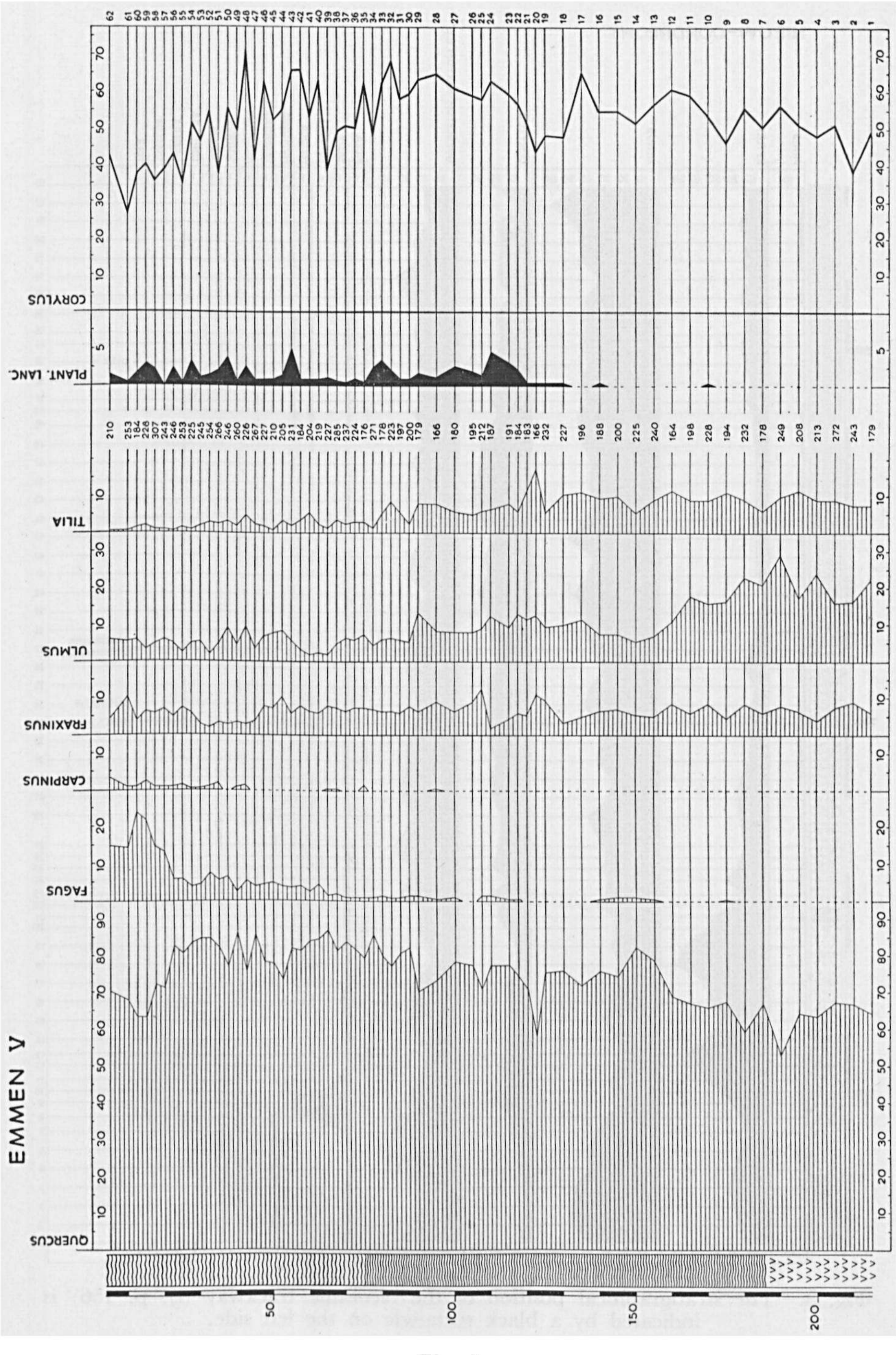

EMMEN V
QUERCUS
FAGUS
CARPINUS
FRAXINUS
ULMUS
TILIA
PLANT. LANC.
CORYLUS

Fig. 7.

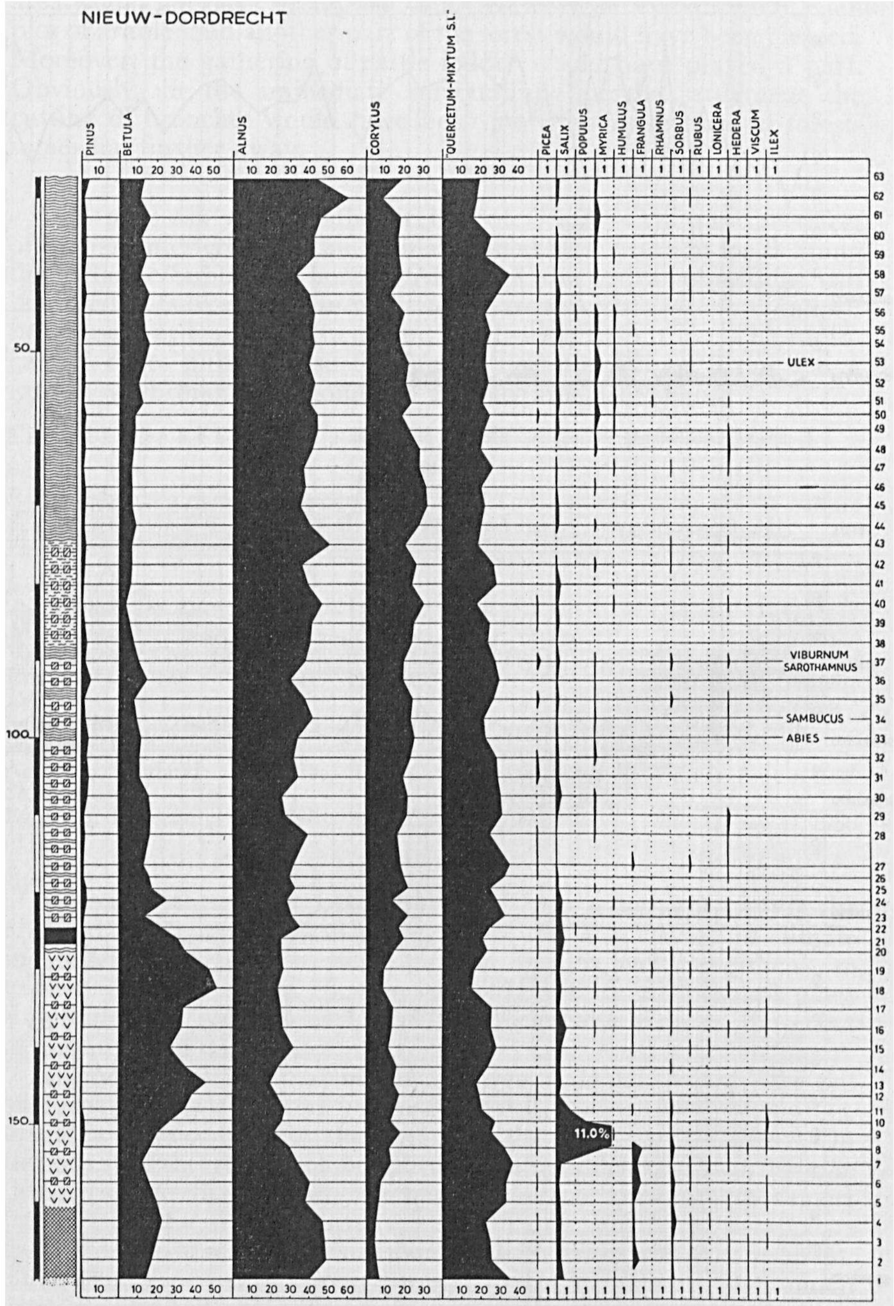
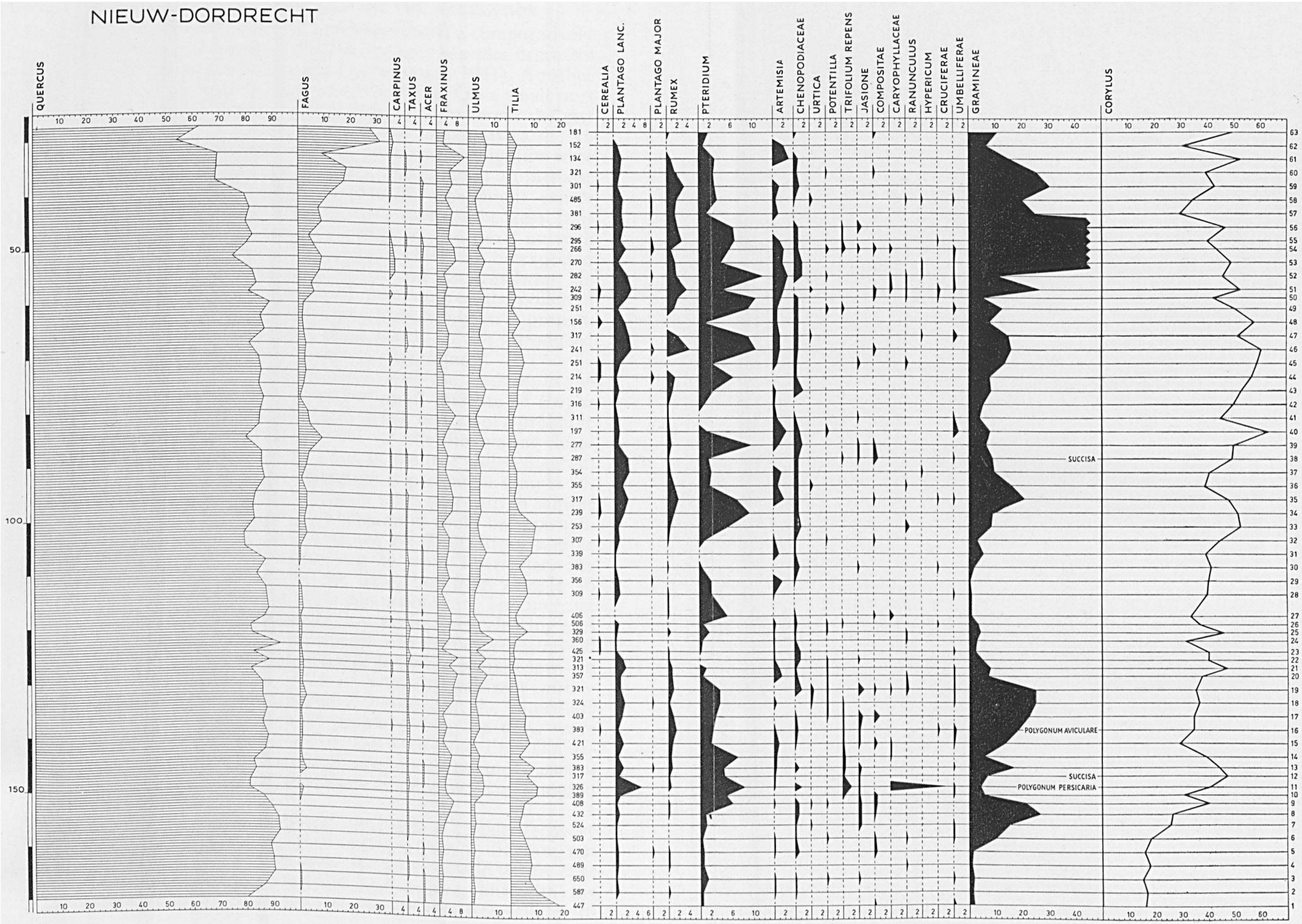


Fig. 8. The stratigraphical position of the Neolithic trackway (*cf.* p. 156) is indicated by a black rectangle on the left side.



NIEUW-DORDRECHT
QUERCUS
FAGUS
CARPINUS
TAXUS
ACER
FRAXINUS
ULMUS
TILIA
CEREALIA
PLANTAGO LANC.
PLANTAGO MAJOR
RUMEX
PTERIDIUM
ARTEMISIA
CHENOPODIACEAE
URTICA
POTENTILLA
TRIFOLIUM REPENS
JASIONE
COMPOSITAE
CARYOPHYLLACEAE
RANUNCULUS
HYPERICUM
CRUCIFERAE
UMBELLIFERAE
GRAMINEAE
CORYLUS
SUCCISA
POLYGONUM AVICULARE
SUCCISA
POLYGONUM PERSICARIA

Fig. 9.

THE INFLUENCE OF NEOLITHIC HERDSMEN ON THE VEGETATION

Sample 36 in the Bargeroosterveld I diagram shows a comparatively high value for *Plantago lanceolata*, which in the next samples decreases again. This is the *landnam* type described by IVERSEN (1941). A rather large area was cleared with the help of axe and fire. On a small part of the clearing cereals would have been cultivated, whereas the rest would have been used as grazing land for the numerous cattle. In contrast to the farmers described on p. 160, these new immigrants were herdsmen. In addition to *Plantago lanceolata*, *Rumex* shows an increase in the Bargeroosterveld I diagram. Reasonably one might expect an increase of Gramineous pollen; in fact, perhaps because it is masked by the pollen of the grasses growing on the peat, no such reaction can be seen at this level. Other plants which can be expected in grassland as *Ranunculus*, *Compositae*, *Succisa* and *Caryophyllaceae*, do not show an increase. On the other hand, from now on the pollen of *Trifolium repens*, *Hypericum cf. perforatum* and *Solanum nigrum* is present. *Trifolium repens* is a typical grassland plant which—if not introduced by these herdsmen—at any rate was able to expand now.

Concerning the regeneration of the forest after the *landnam*, in the Bargeroosterveld I diagram only a rather small increase of *Corylus* can be observed in samples 36 to 40. Nothing can be seen of a probable reaction of *Betula*, certainly on account of the fluctuating local production of the pollen of this tree. Thus, in the tree pollen diagram from this profile (Fig. 4) a *Betula* maximum is present in sample 34. From that level a gradual decline of *Betula* takes place up to sample 38, whereas directly above sample 35 a maximum could be expected.

A clear reaction to this *landnam* is shown by *Tilia*. From sample 37 a steep decline in the *Tilia* curve can be seen. Thereafter, one observes a gradual regeneration of the lime, but from sample 46 onwards the pollen frequencies of *Tilia* again decrease. The increase of *Corylus* in samples 43 to 46 indicates that again forest clearing and subsequent regeneration of the forest took place in the Bargeroosterveld area. The fact that the values for *Plantago lanceolata* remain low—in sample 45 not a single pollen grain of plantain was met with—suggests that the herdsmen did not attack the wood in the immediate surroundings of the Bargeroosterveld profile. When the third wave of large-scale forest clearance blew over this area—this time characterized by a marked increase of *Corylus*, *Plantago lanceolata* and *Gramineae*—lime had not yet recovered, so that there could now be no question of a decline of this tree.

After the period of successive forest clearings, a certain recovery of *Tilia* took place in this area. This appears from a diagram not published here which joins that from Bargeroosterveld I. In that diagram *Tilia* again reaches relatively high values, but with the increase of human activity the percentages for this tree fall to insignificance.

The reaction of *Tilia* to the interference of man is very clearly shown in the diagram from Nieuw-Dordrecht (Fig. 9). In samples 11 to 22 the values for *Plantago lanceolata* are relatively high. This indicates that there was a continuous activity of the herdsmen already mentioned on the boulder clay ridge at the southern point of which the samples for the diagram from Nieuw-Dordrecht were collected. The high value for *Plantago lanceolata* in sample 11, which among other things is accompanied by a relatively high percentage for *Trifolium repens*, suggests that at that time the immediate vicinity of this peat profile was cleared. Just above the level of the trackway (*cf.* p. 156) the values for plantain fall considerably. The share of *Tilia* in the forest vegetation on this boulder clay ridge had diminished regularly from sample 11 onwards. In samples 21 and 22 the percentages for lime show a minimum. After that *Tilia* again increases and relatively high percentages can be observed in samples 31 to 33. From sample 34 *Plantago lanceolata* shows a new rise, and at the same time a marked fall in *Tilia* takes place. Between samples 39 and 45, with comparatively low values for *Plantago lanceolata*, lime is recovering in some degree, only to decline again at the next increase of plantain.

The diagram from Nieuw-Dordrecht once more shows clearly that at least in Subboreal time it was man who first of all must be held responsible for the decline of *Tilia* in this region.

On the basis of his investigations in the raised bog of Gifhorn in central Germany, OVERBECK (1952) arrives at the conclusion that there is a correlation between the humidity and the behaviour of *Tilia*. In the diagrams from Gifhorn, *Tilia* shows a fall during the hygroclinous phase in Overbeck's zone IX. In the xeroclinous first part of zone X this tree again increases, to reach finally low values in the next hygroclinous phase. Concerning the Emmen district the following can be remarked in this connection. In the unpublished diagram from Bargeroosterveld mentioned above, *Tilia* attains relatively high values at the beginning of the last part of the Subboreal. That is the part in which *Fagus* shows somewhat higher values (*cf.* Fig. 6, samples 33 to 41). Just at that time the rainfall must have increased (*cf.* p. 176). But in spite of the increased humidity *Tilia* was able to show a certain recovery, so that, at least in this region, there are no direct indications for a correlation between the degree of humidity and the behaviour of lime. If there was such a relation, it was absolutely overshadowed by the influence of man.

During the Subatlantic the *Tilia* percentages show a further decline. The curve becomes discontinuous even if a comparatively large number of pollen grains is counted in each sample (Fig. 10). It is difficult to decide what was the share of man and of climate in the virtual disappearance of *Tilia* from this region. Although at the moment the temperature conditions are still amply sufficient for *Tilia cordata*, it is possible that the decrease of temperature together with the leaching of the soil has effected a recession of lime.

COMPARISON WITH SPECTRA FROM NEOLITHIC GRAVE MONUMENTS

Thus, in the Bargeroosterveld I diagram two Neolithic *landnam* types can be observed; below, that of a farmer culture; above, that of herdsmen. It is interesting to compare these results with those

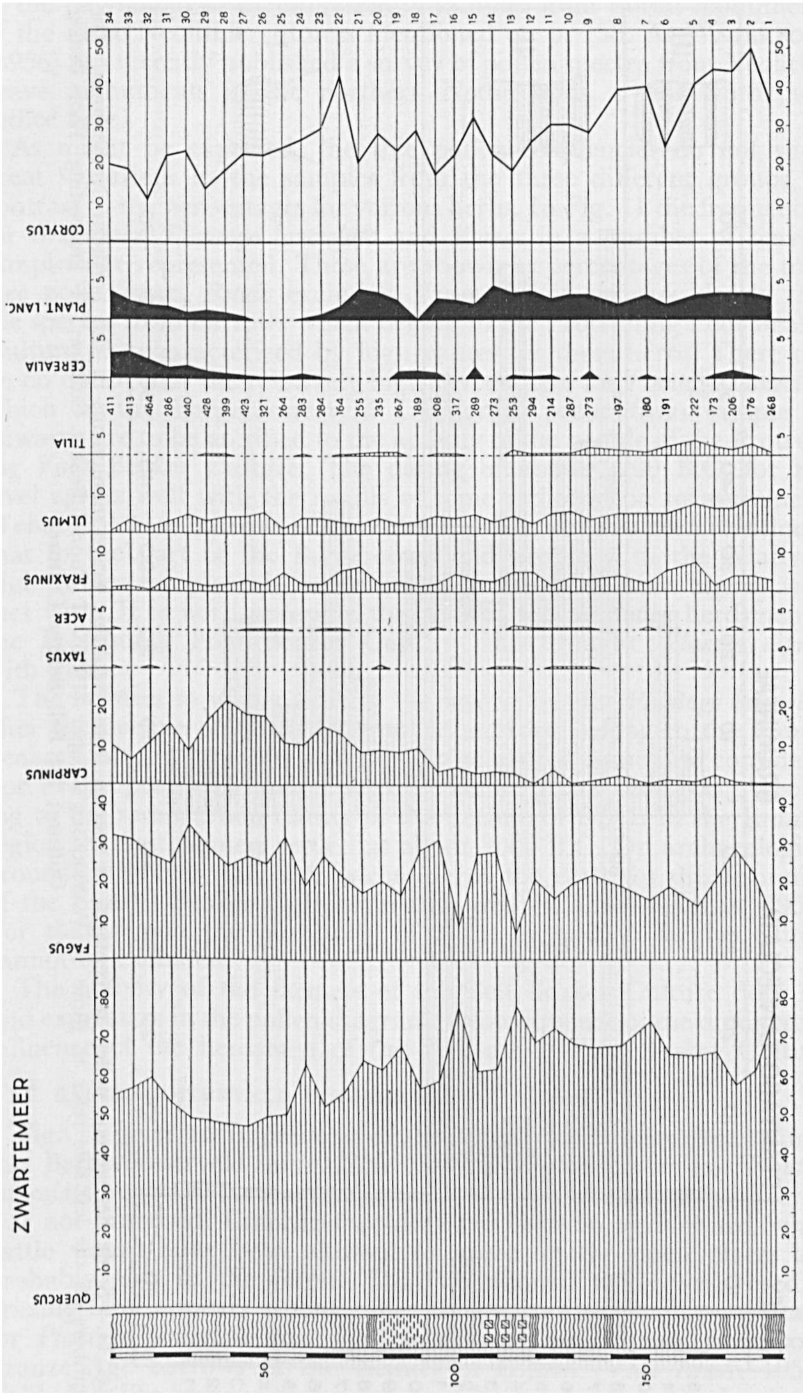

ZWARTEMEER
QUERCUS
FAGUS
CARPINUS
TAXUS
ACER
FRAXINUS
ULMUS
TILIA
CEREALIA
PLANT. LANC.
CORYLUS

Fig. 10.

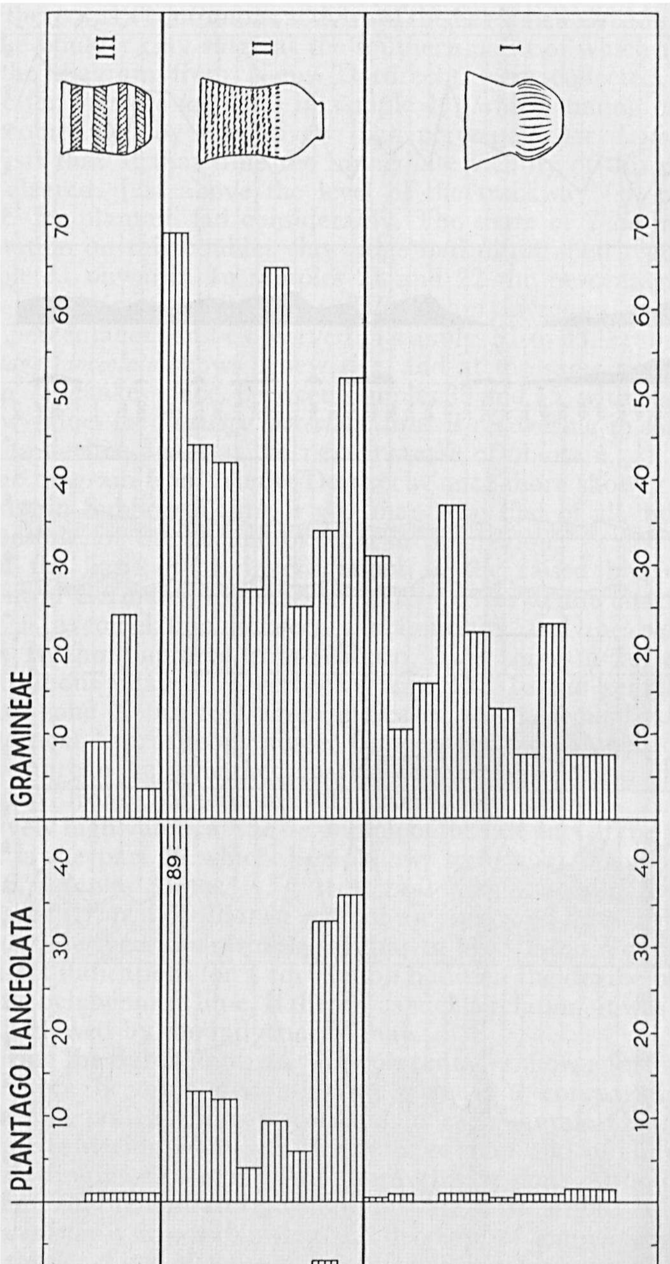


Fig. 11. Some herbaceous pollen percentages in spectra from Neolithic grave monuments in the northern Netherlands. The numbers on the left side refer to those in WATERBOLK's paper (1956). I Funnel Beaker Culture; II Protruding Foot Beaker Culture; III Bell Beaker Culture.

of the palynological investigation of samples from burial monuments of the three Neolithic cultures mentioned on p. 158. As WATERBOLK (1956) has recently published a survey of pollen spectra from Neolithic grave monuments in the northern Netherlands, a few words will suffice here.

As might be expected, the tree pollen frequencies do not show great variations in the samples from the three different groups, in contrast to the percentages for various herbs. In Fig. 11 the frequencies for *Gramineae*, *Plantago lanceolata* and *Rumex* in a number of barrow samples are represented. These are shown as percentages of the total tree pollen sum, *Betula* excluded. From this it appears clearly that the spectra from barrows which belong to the Protruding Foot Beaker Culture are characterized by high values for these herbs. There can be no doubt that the relatively high percentages for *Plantago lanceolata* which in the Bargeroosterveld I diagram occur from sample 36 onwards are to be ascribed to the activity of the people of the Protruding Foot Beaker Culture. The dating of about 2200 B.C. for this level agrees well with the results of some radiocarbon measurements of charcoal from barrows of this culture. It has already been mentioned that in the part of the Bargeroosterveld profile with the relatively high values for plantain some pollen grains of *Solanum nigrum* were met with. It is not impossible that it was the nomadic herdsmen of the Protruding Foot Beaker Culture who brought *Solanum nigrum* with them.

The farmers to whose activity the low values for *Plantago lanceolata* after the decline of *Ulmus* have to be ascribed belong to the Funnel Beaker Culture. The Bell Beaker Culture cannot come into consideration as this people did not arrive here before about 2200 B.C. According to the radiocarbon dating of the decline of *Ulmus* in the Emmen region the first farmers settled at about 3000 B.C. On archaeological grounds, however, this date is considered too early for the beginning of the Funnel Beaker Culture in this area (LÜÜDIK–KAELAS, 1955). For that reason the possibility of a pre-megalithic farmer culture cannot be excluded.

The activity of the farmers of the Bell Beaker Culture does not find expression in the pollen diagram in consequence of the dominating influence of the herdsmen of the Protruding Foot Beaker Culture.

THE BARGEROOSTERVELD II DIAGRAM

Fig. 13 gives an impression of the activity of Bronze Age man in the Bargeroosterveld area. The course of the curve for *Plantago lanceolata* suggests that a *landnam* of the type described by Iversen was not practised. Emphasis would have been on agriculture, whilst cattle would have been allowed to graze on the open places and probably also in the forest. That abandoned fields were used as grazing land appears among other things from the high percentages for *Plantago lanceolata* met with in old surface samples from some Bronze Age barrows in the vicinity of Hijken (VAN ZEIST, 1955a, Table II). The barrows concerned were built on old arable. In view of

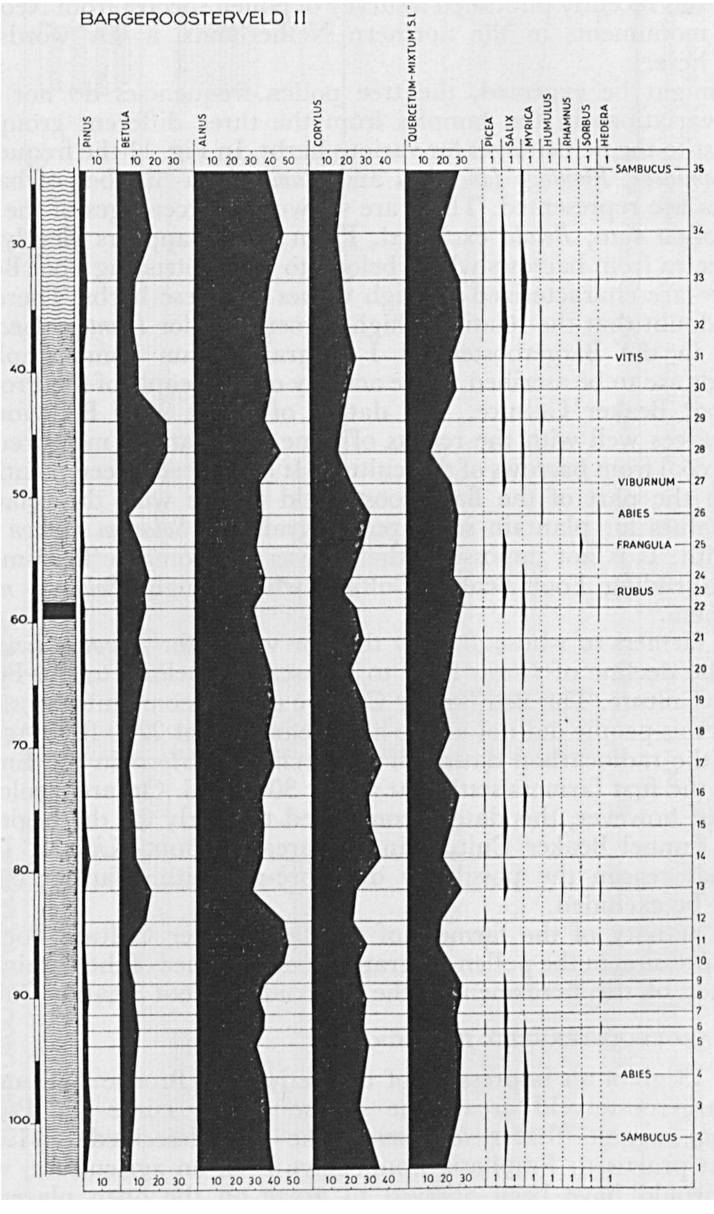


Fig. 12. The stratigraphical position of the wooden structure (*cf.* p. 157) is indicated by a black rectangle on the left side.

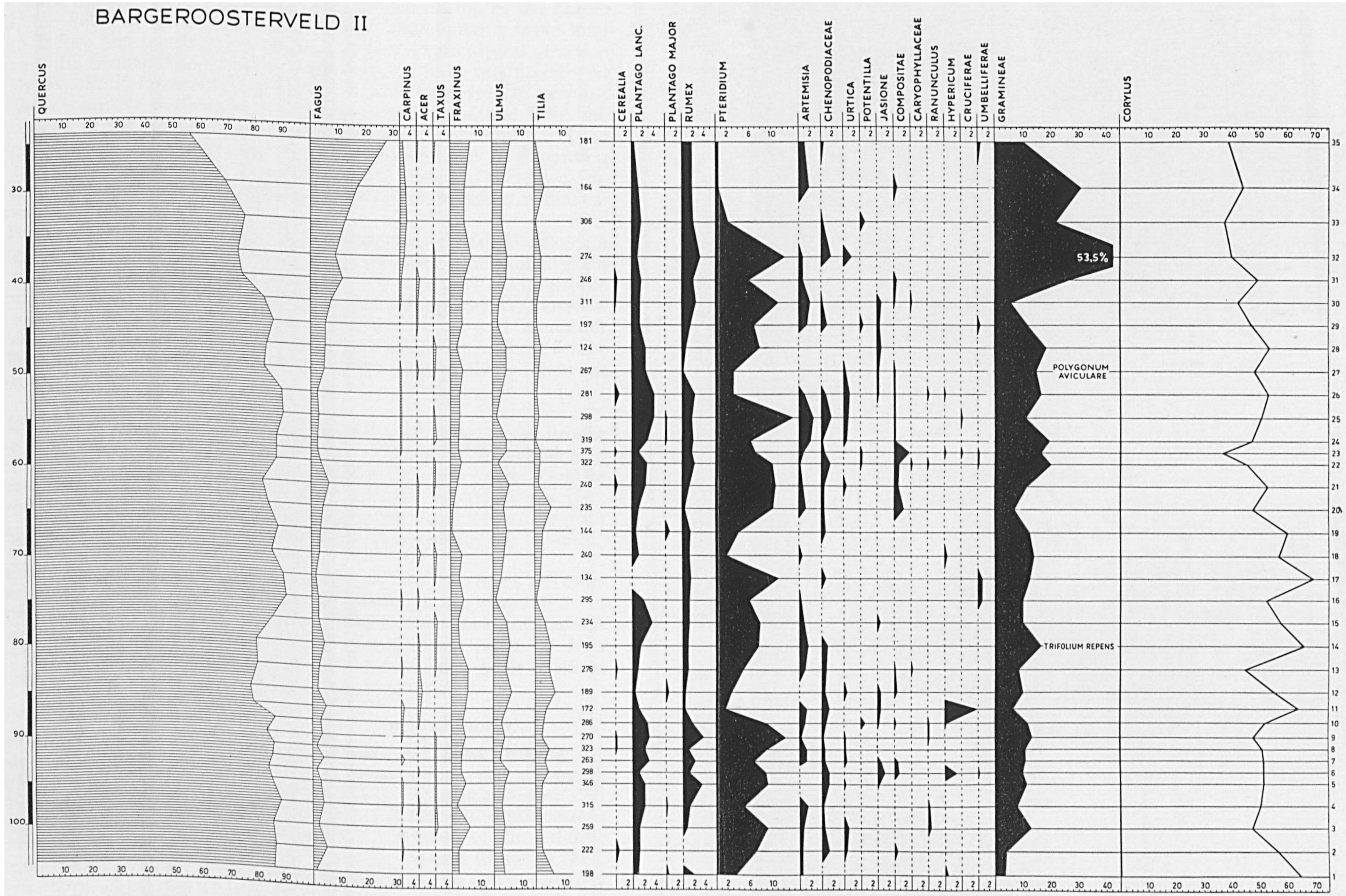

BARGEROOSTERVELD II
QUERCUS
FAGUS
CARPINUS
ACER
TAXUS
FRAXINUS
ULMUS
TILIA
CEREALIA
PLANTAGO LANC.
PLANTAGO MAJOR
RUMEX
PTERIDIUM
ARTEMISIA
CHENOPODIACEAE
URTICA
POTENTILLA
JASIONE
COMPOSITAE
CARYOPHYLLACEAE
RANUNCULUS
HYPERICUM
CRUCIFERAE
UMBELLIFERAE
GRAMINEAE
CORYLUS
53,5%
POLYGONUM AVICULARE
TRIFOLIUM REPENS

Fig. 13.

the dark humous layer which had been formed on top of the arable soil, the fields in question must have been abandoned a fairly long time before the construction of the barrows. Agricultural practice during the Bronze Age would in many respects have resembled that of the Neolithic farmers of the Funnel Beaker Culture. On account of the exhaustive cultivation which was already practised from the beginning of the Neolithic, the conditions for the regeneration of the forest became more unfavourable. In the Bronze Age an expansion of the heather took place. For the present, however, there was no question of large heath lands, which did not originate before mediaeval time.

In the late Subboreal part of the Bargeroosterveld II diagram (Fig. 12, sample 31) a *Vitis* pollen was met with. One pollen grain of *Vitis* could be counted also in the Bronze Age part of the profile from Bargeroosterveld not published here. Moreover, WATERBOLK discovered a pollen grain of *Vitis* in the late-Subboreal part of another profile from the same raised bog (oral communication). These scarce pollen finds of *Vitis* suggest that the grape was cultivated here at least during the Bonze Age.

In the Iron Age and perhaps already in the later part of the Bronze Age more or less permanent arable plots, "Celtic fields", came into use. The increase of the values for *Plantago lanceolata* in the topmost part of the Emmen I diagram (Fig. 6) and the comparatively high percentages for this plant in the lower part of the Zwartemeer diagram (Fig. 10) suggest a more dense population than during the Neolithic and the Bronze Age.

From the investigation of the content of the intestines of some peat burials (HELBAEK, 1950; BRANDT, 1950) it appeared that in addition to cereals, various herbs as *Polygonum aviculare* and *lapathifolium*, *Chenopodium album* and *Spergula arvensis* were eaten by Iron Age man. Besides, during that time the oil-containing seeds of *Linum usitatissimum* and *Camelina sativa* served as food for man.

THE BEHAVIOUR OF FAGUS IN RELATION TO THE HUMIDITY

In the foregoing the behaviour of *Tilia* and *Ulmus* during the second part of the post-glacial in the Emmen area was discussed. We may now consider the other trees of the "*Quercetum-mixtum s.l.*" Concerning the immigration and expansion of *Fagus* in south-eastern Drenthe the following can be remarked. At the end of the Atlantic the first pollen grains of beech appear in peat deposits from this area. During the greater part of the Subboreal, pollen of this tree is regularly met with, provided that a comparatively large number of tree pollen is counted in each sample. As in general the pollen of *Fagus* is not transported over a long distance and, moreover, this tree is underrepresented in the pollen spectrum, it can be assumed that during the first part of the Subboreal the beech was really present in the northern Netherlands, although for a long time it remained rare. Apparently at that time the climate was not very favourable for the beech, so that this tree remained confined to those spots which in edaphic respect were most suited.

A first, but still small expansion of the beech took place in the last part of the Subboreal. In the diagrams in which all trees are included in the tree pollen sum, this increase of *Fagus* is from about 0.3 to 1 %. This level corresponds with the beginning of the continuous *Fagus* curve in most diagrams from north-western Germany. It is notable that this increase of *Fagus* coincided with an increase of precipitation in this area. From the level where *Fagus* shows the increase mentioned above, the formation of slightly humified *Sphagnum cuspidatum* peat (*Vorlaufstorf*) started at various places in the raised bog from south-eastern Drenthe. The *Sphagnum cuspidatum* peat does not form a continuous layer over the whole raised bog, but was deposited in more or less lens-shaped layers. This indicates that the formation of this type of peat took place in pools or at least on very wet spots of various sizes. The only reasonable explanation for this phenomenon is an increase in precipitation, on account of which the conditions for the growth of *Sphagnum cuspidatum* became favourable in the depressions on the surfase of the bog.

A further indication for an increase of precipitation can be seen in the development of a podzol profile under a heather vegetation. In spite of the sometimes fairly high *Calluna* percentages a heather podzol is only exceptionally met with below Neolithic grave monuments. As such exceptions can be mentioned a megalithic tomb near Dötlingen in Oldenburg (PÄTZOLD, 1956) and a Neolithic tumulus (with a Bell Beaker and a *Grand Pressigny* flint dagger) near Witrijt, province of Noord-Brabant (BEEX, 1957). On the other hand, below grave monuments from the Bronze and Iron Age a heather podzol is generally present even if the *Calluna* percentages are sometimes rather low. In this connection it has to be remembered that the increase of *Fagus* we are now discussing coincided approximately with the transition from the Neolithic to the Bronze Age.

A further increase of *Fagus* was preceded by another indication of a changing climate. Just before the rise of *Fagus* in the raised bog of south-eastern Drenthe the conditions for the formation of fresh *Sphagnum imbricatum* and *papillosum* peat became favourable. Especially the expansion of *Sphagnum imbricatum* suggests that at that time the moisture of the peat was very high. It is not unlikely that it was not so much a further increase of precipitation as a fall of the temperature which effected an increase of humidity. However that may be, the reaction of *Fagus* to the increased humidity was a considerable expansion. Yet it was not until later that this tree reached its maximal values. This can be seen in the Zwartemeer diagram (Fig. 10), in the upper part of which the percentages for *Fagus* are generally higher than in the lower part. It is probable that it was a further increase of humidity which again effected this last increase of *Fagus*. This may perhaps be concluded from the fact that now the formation of fresh *Sphagnum* peat was in full swing even in the very small raised bogs (*cf.* WATERBOLK, 1950). In this respect it must be noted that in consequence of the relatively good drainage the edaphic conditions for the formation of fresh *Sphagnum* peat are not very favourable in these small bogs.

The possibility that beech was also enabled to expand in consequence of the activity of prehistoric man has to be considered here. The beech might have taken advantage of forest regeneration on the abandoned fields. It is clear that in a regenerating vegetation the chances for an expanding species are greater that in a dense forest. If this had been so, a considerable increase of the beech might be expected during the presence of the herdsmen of the Protruding Foot Beaker Culture. For it was these nomads who cleared large parts of the forest, so that during the regeneration of the wood the beech would have been able to expand. This did not, however, happen, or at best very locally. It is true that in the part of the Bargeroosterveld I diagram (Fig. 5) that reflects the activity of the herdsmen of the Protruding Foot Beaker Culture—from sample 36 onwards—the *Fagus* percentages are slightly higher than previously. However, the diagrams Emmen I and V (Figs. 6 and 7) do not show a similar increase of *Fagus* at the corresponding level. Consequently, in the northern Netherlands a general increase of *Fagus* during the period that the people of the Protruding Foot Beaker Culture lived here is out of the question. The rise of *Fagus* took place in the Bronze and Iron Age, and just in these periods much smaller areas were cleared at one time. Besides, in that period a part of the abandoned fields passed into moorland.

In this region the expansion of *Fagus* was therefore certainly not the direct effect of the activity of man. Moreover, if it had been, a more gradual rise of *Fagus* could be expected, whereas the expansion of beech actually took place in a series of jumps.

Concerning the influence of prehistoric man on the living conditions of beech, it may be noted here that a considerable decline of *Fagus* in Switzerland is ascribed to the activity of Neolithic farmers (TROELS-SMITH, 1955).

Summarizing, it can be remarked that in south-eastern Drenthe there must have been a close correlation between the increase of humidity and the expansion of *Fagus*. It appears as if the increasing humidity favoured beech in a direct way. The leaching of the soil, which would have become stronger in consequence of the increase of the humidity, would certainly not have been in favour of the beech. Especially near the border of its areal, this tree makes rather high demands on the soil.

In the Emmen region the expansion of *Fagus* was not directly at the expense of *Tilia* and *Ulmus* (*cf.* FIRBAS, 1949, p. 182). The diagrams from this area show first an important decline of *Ulmus* and *Tilia* in consequence of which the share of the oak in the forest increased. At the level where *Fagus* strongly increases, the *Tilia* values are already very low, whereas during the expansion of *Fagus*, *Ulmus* maintains itself at a certain percentage or at best shows a slight decline. It was the oak at whose expense the beech expanded.

CARPINUS, TAXUS AND ACER IN THE PROFILES EXAMINED

The Zwartemeer diagram (Fig. 10) shows clearly the increase of *Carpinus* in Subatlantic time. During a rather long period, from about 1000 B.C. up to the beginning of the era, this tree was present here in relatively small numbers. After that some expansion took place, although the hornbeam never became as numerous as the beech. It seems that in western Europe the climatological conditions also became more favourable for *Carpinus* in the course of the Subatlantic.

As at first the pollen of *Taxus* was not distinguished, the time of the first appearance of this tree in the northern Netherlands is not yet known with certainty. On the basis of the Bargeroosterveld I diagram (Fig. 5), *Taxus* would have reached this area in the last part of the Atlantic. In contrast to the beech, which arrived here at about the same time, *Taxus* does not show an increase in any period. During the whole Subboreal and Subatlantic the *Taxus* percentages remain very low. However, it is not unlikely that its share in the forest vegetation was more important than the low percentages in the pollen diagram suggest. The sometimes numerous stumps of *Taxus* discovered beneath peat deposits point to this. A survey of these finds is given by FIRBAS (1949, p. 270). This author arrives at the conclusion that in north-western Germany *Taxus* was present at least at the transition from the Atlantic to the Subboreal. This is not in contradiction with the Bargeroosterveld I diagram, which shows the first pollen grains of *Taxus* in the upper part of the Atlantic.

Prehistoric man knew the excellent qualities of *Taxus* wood, as is shown by the shaft for an adze discovered at the excavation of the trackway of Nieuw-Dordrecht (*cf.* p. 156). Radiocarbon measurement of a sample of wood from this trackway dates this object to about 1885 B.C.

Pollen of *Acer* appears in the first part of the Atlantic. Of the three *Acer* species now found in western and north-western Europe, *Acer campestre* is indigenous in the Netherlands, whereas *Acer pseudo-platanus* seems to be native at least in a part of the country. The western limit of *Acer platanoides* lies to the east of the eastern border of the Netherlands (*cf.* GAMS, 1924). As it has thus far appeared impossible to separate the pollen of the various *Acer* species, palynological investigation cannot show which species of this genus grew here in earlier times. It must, however, be noted that under the remains of a house of the 6th to 7th century B.C. near Jemgum, 5 km to the north-west of Leer, a piece of wood of *Acer pseudo-platanus* was found by GROHNE (1957b). From this it may be concluded that at that time *Acer pseudo-platanus* would have occurred likewise in the northern Netherlands. As with *Taxus* the *Acer* percentages remain very low.

Acer platanoides is a subcontinental species (FIRBAS, 1949, p. 185), so that it is likely that at least during the post-glacial this tree did not occur in the Netherlands, assuming that the Subboreal did not have a comparatively continental character (see below).

HEDERA, VISCUM AND ILEX IN THE EMMEN DISTRICT

Finally, the occurrence of *Hedera*, *Viscum* and *Ilex* in the pollen diagrams presented in this paper will be discussed. On the basis of the present distribution of *Hedera*, *Viscum* and *Ilex* and the temperature data of a number of meteorological stations relevant to this purpose, IVERSEN (1944) was able to construct thermal correlation diagrams for each of these plants. Therewith it was assumed that the mean temperature for the warmest and coldest months provides a good idea of the course of the temperature during the whole year. Iversen could demonstrate that the northern and eastern limit of these plants is determined by the temperature. The occurrence of *Viscum* appears especially to be dependent on the mean temperature during the warmest month. This plant can endure fairly much cold during the winter. This in contrast to *Ilex* and *Hedera*, for which the mean temperature of the coldest month rather quickly becomes a limiting factor. On the other hand, these plants are able to thrive at lower summer temperatures than *Viscum*.

From the frequencies of *Hedera*, *Viscum* and *Ilex* in the material studied by him, Iversen concluded that during the Atlantic the mean January and July temperatures were 0.5° and 2° C higher than nowadays. During the Subboreal the mean January temperature would have been 1° C lower and the mean July temperature 2° C higher than at present. Consequently, the Subboreal climate would have had a more continental character than that of the Atlantic and Subatlantic. The greater part of the material studied by Iversen was collected in Djursland, in eastern Jutland, with mean January and July temperatures of 0° and 16° C respectively.

However, the results of HAFSTEN (1956, 1957) in the rather continental Oslo Fjord area could point to a somewhat different course of the temperature. In that area the temperature conditions are such that at present *Hedera* and *Viscum* cannot grow there. In the Atlantic and also in the Subboreal, *Hedera* and *Viscum* were present in the Oslo Fjord area, although for the latter period the percentages are considerably lower. Hafsten arrives at the conclusion that at present the mean January temperature must be at least 2° C lower than during the Atlantic and the Subboreal. A more continental Subboreal, compared with the present climate, can hardly have been the case in the Oslo Fjord area. The behaviour of *Hedera* and *Viscum* in that area can only be explained by assuming a more or less gradual decrease both in the summer and the winter temperature.

Now, Iversen's "continental" Subboreal is mainly based on the fact that in his material *Ilex* is totally lacking. He assumes that in the Atlantic this plant did not yet reach Djursland, whereas during the Subboreal the climate, that is to say the winter temperature, would have been too unfavourable for *Ilex*. The fact that *Ilex* pollen was not found in the Subatlantic material is ascribed by Iversen to the relatively small number of pollen grains counted from this period. In this connection it has to be remembered that nowadays *Ilex* is present in Denmark.

On the other hand, one has to take into account the possibility that the absence of *Ilex* was not so much due to climatological as to ecological factors; that this tree did not get the chance to establish itself in the dense forests on the fertile moraine soils of Djursland. If a gradual fall in both the summer and the winter temperature is also assumed for Denmark, the considerable decline of *Viscum* in the course of the Subboreal can better be understood. On the ground of Iversen's hypothesis practically no decline of *Viscum* might have been expected during the Subboreal.

TABLE II

Occurrence of *Hedera*, *Viscum* and *Ilex* in the profiles discussed in this paper.

	samples	$\sum$ *Quercus Ulmus Fraxinus Tilia Fagus Carpinus*	*Hedera* no. of pollen of	*Hedera* no. of samples with	*Hedera* percentage	*Viscum* no. of pollen of	*Viscum* no. of samples with	*Viscum* percentage	*Ilex* no. of pollen of	*Ilex* no. of samples with	*Ilex* percentage
Emmen I											
Subatlantic	42–53	3085	3	3	0.10	—	—	—	—	—	—
Subboreal 2	33–41	2209	3	3	0.14	—	—	—	—	—	—
Subboreal 1	14–32	4924	20	14	0.41	2	2	0.04	3	3	0.06
Atlantic	1–13	4055	13	9	0.32	1	1	0.02	—	—	—
Emmen V											
Subboreal 2	40–56	3968	7	5	0.18	—	—	—	1	1	0.03
Subboreal 1	12–39	5733	18	13	0.31	—	—	—	—	—	—
Atlantic	1–11	2394	6	6	0.25	1	1	0.04	—	—	—
Zwartemeer											
Subatlantic	2–34	9549	5	5	0.05	1	1	0.01	2	2	0.02
Nieuw-Dordrecht											
Subboreal 2	32–57	7163	12	10	0.17	—	—	—	—	—	—
Subboreal 1	1–31	12448	19	15	0.15	4	4	0.03	16	9	0.13
Bargeroosterveld I											
Subboreal 2	61–82*	5584	7	7	0.13	—	—	—	1	1	0.02
Subboreal 1	19–60	11326	21	16	0.19	8	8	0.07	11	3	0.10
Atlantic	1–18	4494	21	9	0.47	11	5	0.24	—	—	—
	[6–18	3372	8	4	0.24]						
Bargeroosterveld II											
Subboreal 2	1–30	7581	9	9	0.12	—	—	—	—	—	—

* The upper part of the Bargeroosterveld I diagram is not published in this paper.

From the occurrence of *Emys orbicularis* (Degerbøl and Krog, 1951) and some insects as *Potosia speciosissima* (Johnsen and Krog, 1948) and *Cerambyx cerdox* (Thomsen and Krog, 1949) in Subboreal deposits from Denmark, it may be concluded that during that period the mean July temperature must have been at least 18° C there. If the hypothesis put forward above is correct, during the Atlantic the mean temperature for the warmest month in most parts of Denmark must have been still higher (*cf.* IVERSEN, 1944, Fig. 9).

Concerning the gradual fall of the temperature after the climatic optimum in the Atlantic, this "gradual" is not to be understood too literally. Undoubtedly there would have been minor oscillations, in consequence of which the general decline of the temperature might have been intensified, weakened or even totally reversed. On account of the influence of the sea, the fall of the temperature would have been of less importance in oceanic regions than in more continental areas.

The data concerning *Hedera*, *Viscum* and *Ilex* from the profiles discussed in this paper are represented in Table II. The average pollen frequencies for these plants are shown as percentages of the sum of *Quercus*, *Tilia*, *Ulmus*, *Fraxinus*, *Fagus* and *Carpinus*. The total number of tree pollen counted in this material is about 380 000. It appeared useful to divide the Subboreal into two parts. In the lower part (Subboreal 1) the *Fagus* percentages are very low, in the upper one (Subboreal 2) *Fagus* shows somewhat higher values (about 1 % in the diagrams in which all trees are included in the tree pollen sum). At present the Emmen district has mean January and July temperatures of about 1° and 16° C respectively (BRAAK, 1950).

The *Hedera* percentages in the diagrams Emmen I and V do not show great mutual differences. The graph of Fig. 14 is drawn from the data of both these diagrams, and completed with the results of the

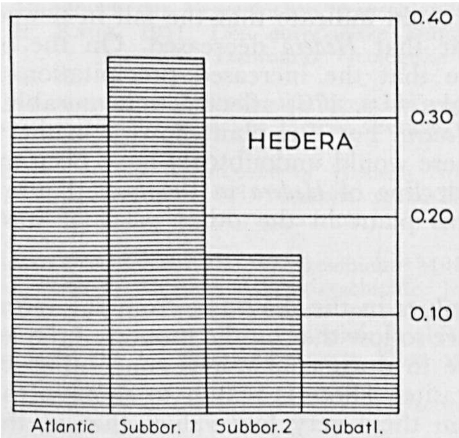


Fig. 14. Graph of the *Hedera* values in the diagrams Zwartemeer, Emmen I and V.

Zwartemeer profile for the Subatlantic. As in the first part of the Subatlantic the percentages for *Hedera* are somewhat higher than in the later phases of this period the Subatlantic part of the Emmen I diagram is not included in this graph.

In the diagrams Emmen I and V there is no question of a fall of *Hedera* at the transition from the Atlantic to the Subboreal. This is clearly shown in the graph. On the other hand, the Atlantic part of the Bargeroosterveld I diagram does show a considerably higher *Hedera* value than the next periods. However, this relatively high *Hedera* percentage is to a large extent effected by 13 pollen grains of this plant counted in the lowermost 5 samples. If these samples are left out of consideration (the values in brackets) the *Hedera* percentage in the last part of the Atlantic does not longer show a significant difference with that in the next period. Very probably the relatively high *Hedera* value in the lower samples from this profile reflects a very local occurrence of this liane. That in general the *Hedera* values in the diagrams from Bargeroosterveld and Nieuw-Dordrecht have a more local character appears also from the circumstance that in these diagrams the *Hedera* percentages in the first part of the Subboreal are considerably lower than in the diagrams Emmen I and V. Undoubtedly the Emmen diagrams give a better reflection of the behaviour of *Hedera* in the Emmen district than those of Bargeroosterveld and Nieuw-Dordrecht. In these latter diagrams little or nothing can be seen of the fall of *Hedera* which is very pronounced in the graph of Fig. 14.

That *Hedera* does not show a decline at the transition from the Atlantic to the Subboreal need not mean that here no change of climate had set in at that time. A plant will not react to a change in its environment before a critical point has been reached. Thus it is possible that at first the fall in temperature had no influence on the frequency of ivy in the northern Netherlands.

Concerning the marked decline of *Hedera* in the last part of the Subboreal, this could indicate that the fall in temperature had now proceeded so far that *Hedera* decreased. On the other hand, it is perhaps possible that the increased precipitation in the last part of the Subboreal (*cf.* p. 176) affected unfavourably the dispersal of the pollen of *Hedera*. For this plant flowers in the Autumn, during which season there would undoubtedly have been much rain.

The further decline of *Hedera* in the Subatlantic agrees with the behaviour of this plant in the other parts of western and northwestern Europe.

The *Viscum* values in the diagrams from the more central part of the raised bog are so low that on the ground of the available material it is not possible to draw conclusions concerning a possible decline of this semi-parasite. There is reason to suppose that it is not wise to conclude from these very low values that in this region *Viscum* was always an extremely rare plant. In the lower part of the Bargeroosterveld I profile *Viscum* occurs fairly regularly. In sample 13 5 pollen grains of this plant were counted. *Viscum* likewise occurs regularly in the lower part of the Buinerbrug diagram (WATERBOLK, 1954, Fig. 16). Peat deposits which were formed at a short distance from the higher soils can contain a relatively large number of *Viscum* pollen. This points to a very poor dispersal of *Viscum* pollen over distances.

As with *Viscum*, pollen of *Ilex* was in general rarely met with. Consequently, the few counted pollen grains do not allow conclusions. However, in certain forest types *Ilex* would have been fairly common. Thus in the lower part of the Nieuw-Dordrecht diagram *Ilex* pollen occurs regularly, indicating that this tree was not uncommon in the forest on the most south-eastern offshoot of the Hondsrug. That *Ilex* pollen is lacking in the upper part of this profile is probably due to the expansion of the peat, thus increasing the distance between the spot where the profile was sampled and the forest in which holly grew.

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