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A "LOCAL" LATE-GLACIAL POLLEN DIAGRAM FROM LIMBURG, NETHERLANDS

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SUMMARY

A conventional late-glacial and early postglacial percentage pollen diagram that only registers changes in the lake ecosystem in the late-glacial and not necessarily vegetational events outside the lake basin is, by recalculation of the data and by ^{14}C dating, correlated with the Allerød and late-Dryas time.

1. INTRODUCTION

In 1947 IVERSEN proposed to calculate the pollen frequencies for late-glacial relative pollen diagrams on the basis of a pollen sum including trees, anemophilous herbs, and Ericales. In limnic sediments pollen of aquatics were excluded because they may have been part of the parent material and may, by local overrepresentation, distort the trends in the remaining part of the pollen curves. The underlying assumption of this way of presenting the data is that the changes in the proportion of the remaining arboreal pollen (AP) and non-arboreal pollen (NAP) are supposed to reflect in some way changes in the proportion of the areas of forested and non-forested vegetation or changes in the density of forests (FIRBAS 1934).

Pollen diagrams calculated in this way, often called "Iversen" diagrams, in the past twenty years have been a powerful tool for detecting stadia and interstadia in sediments deposited during the Quaternary. FLORSCHÜTZ (1958), however, pointed out that these "Iversen" diagrams may be applied for limnic sediments only. When the parent material is telmatic, e.g., when it consists of remains of Cyperaceae or Hypnaceae, the proportion of the AP/NAP, when pollen of Cyperaceae are left in the pollen sum, may not reflect the extent of the forested areas but merely the presence of a sedge vegetation in the depositional basin. But also in limnic sediments the "Iversen" diagram may give a false picture of the regional events if the depositional basin is small and if the lake water is base-rich, the latter a much more common feature in the late-glacial than today. The marsh vegetation at the edge of the lake may contribute sufficiently to the pollen deposition in the centre of the lake to influence the trends of the curve of the total NAP. The Putbroek pollen diagram presented here may serve as an example.

2. LOCATION

The Putbroek site is located in the southeastern part of the Netherlands (*fig. 1*). The area is characterized by sand ridges and low-lying areas (broeken) underlain by terrace-sands of the Meuse river and Weichselian cover-sands.

The site is a pond in an upland area between the "broeken". The origin of the depression is not clear. No connection with the present drainage pattern is apparent. It may be a collapsed pingo. The Putbroek site is only c. 6 km from a late-glacial deposit (Gülikshof) in a valley described by VAN DER HAMMEN (1951).

3. SAMPLING AND PROCESSING

The Putbroek core was obtained with a Dachnowski peat corer with a diameter of 6 cm and an effective length of 40 cm. The lithostratigraphy is as follows:

0–75 cm: upper part disturbed, lower part detritus gyttja.
75–87 cm: black and light brown detritus gyttja with some small wood fragments. Rootlets and fibers, mainly from Hypnaceae, among which abundant *Calliergon stramineum*.
87–153 cm: Lake marl, yellowish; from 93–140 cm with oogones of *Chara*, mostly in upper part. From 140–153 cm colour of marl darker.
153–193 cm: Black-brown Hypnaceae peat, mainly *Calliergon stramineum*; in upper part material slightly calcareous.
193–246 cm: Lake marl, orange-grey from 193–207 cm; below 207 cm colour brown-grey. Calcareous material abundant. Remains of Hypnaceae present in upper part, diminishing in quantity downwards.

Treatment of the core samples included boiling with 10% KOH, sieving and acetolysis at 95 °C for 3–5 minutes. The material was mounted in silicone oil 2000 × csk. No staining was applied, only entire slides were counted.

4. POLLEN DIAGRAMS

The pollen analytical results are displayed in two diagrams. In the Putbroek A diagram (*fig.* 2, appendix 1) the pollen percentages were calculated on the basis of a pollen sum including pollen of trees, shrubs, upland herbs, Poaceae, and Cyperaceae, thus essentially the "Iversen" pollen sum. In a composite diagram the curves for *Corylus*, *Salix*, *Betula*, *Pinus*, and a curve for total herb pollen are shown.

The Putbroek B diagram (*fig. 3*, appendix 2) shows some selected curves calculated on the basis of the same pollen sum applied for diagram Putbroek A, but without Poaceae and Cyperaceae.[1])

5. RESULTS AND DISCUSSION

The pollen diagram has been divided into four main assemblage zones, PUB-II, PUB-III, PUB-IV, and PUB-V that resemble in a rough way the pollen zones II,

[1]) Appendix 1 and 2 in back cover.

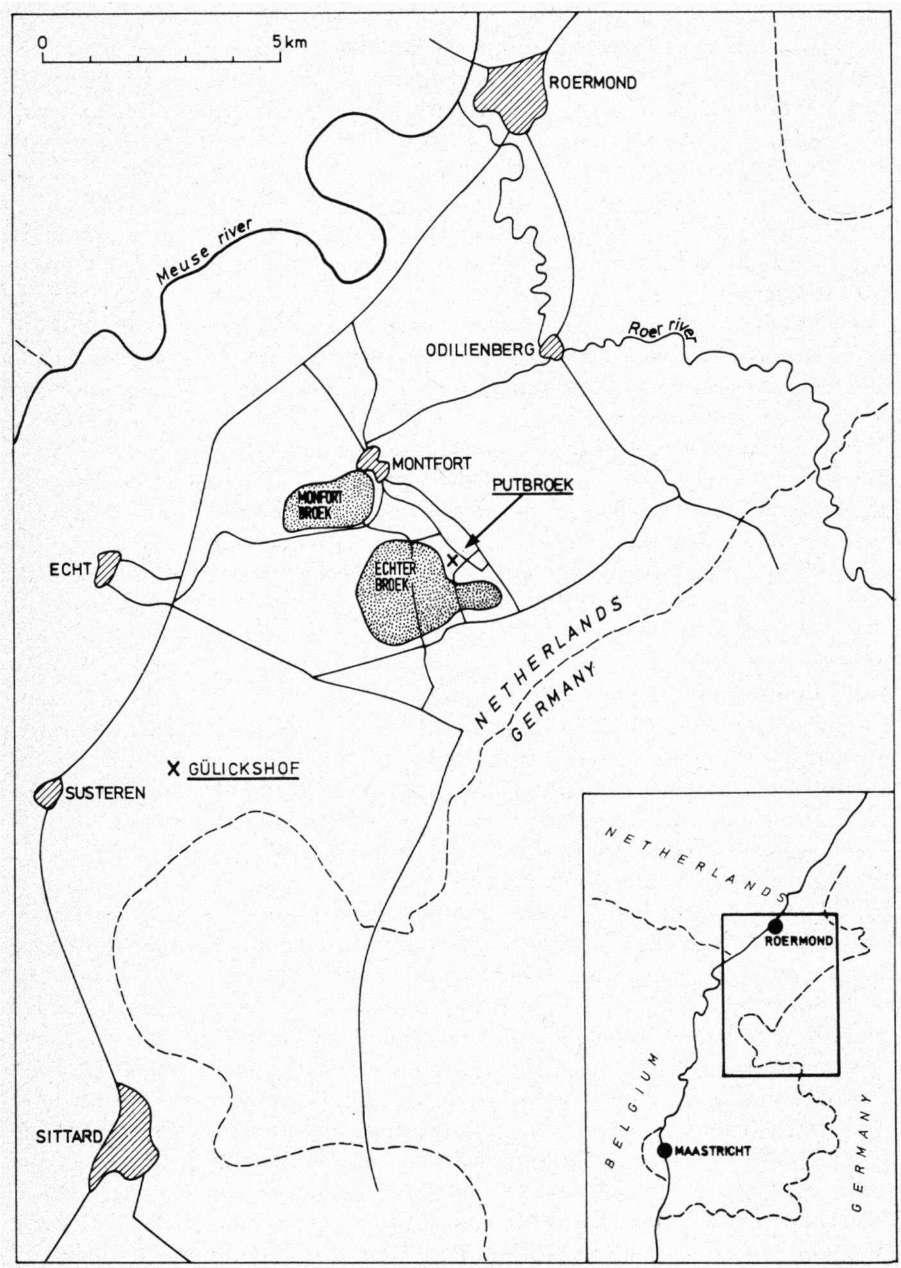

Fig. 1. Location of the Putbroek site.

III, IV, and V of FIRBAS (1949) thus the Allerød, late Dryas, Preboreal and Boreal time. In zone PUB-II and zone PUB-III only pollen of *Betula*, *Salix*, and *Pinus* are present among the tree pollen and the values for herb pollen are high. In zone PUB-IV the values for *Corylus* start rising, the percentage of *Pinus* pollen reaches a maximum and there is a strong decline of the values for herb pollen. There is no indication of the Piottino stadial. In zone PUB-V *Corylus* becomes the dominant pollen type; the curve for *Ulmus* becomes continuous. In the upper part of this zone pollen of *Tilia* and *Alnus* appear. Such an order of appearance of pollen of thermophilous trees is common in West European pollen diagrams.

Although no ^{14}C dates are available at the zone boundary of zone PUB-III/IV, it seems likely that this boundary marks the transition of late-glacial to post-glacial time about 10.000 years ago when a more open landscape gave way to more densely forested country.

In the following discussion we will focus our attention mainly on the interpretation of zone PUB-II and PUB-III. The outstanding feature in diagram Putbroek A is the tremendous rise of herb pollen in zone PUB-III. This could be interpreted as a reflection of an expansion of treeless areas. Consequently zone PUB-II would be synchronous with the Allerød oscillation, zone PUB-III with the late-Dryas stadial.

However the rise of the pollen values of herbs is almost exclusively the result of a strong increase of the pollen values of the Cyperaceae. The values of other herb pollen types included in the pollen sum remain constant through zone PUB-II and zone PUB-III in diagram A. There is, however, a change in the frequencies of the types excluded from the pollen sum. This is most striking for spores of *Isoetes*, which at the transition of zone PUB-II/III completely disappear. But also the values for pollen types of other aquatic plants, such as *Potamogeton*, *Nuphar*, *Lemna*, and *Nymphaea* decrease. This change in the biostratigraphy is related to a change in the lithostratigraphy. In zone PUB-II the sediment is a calcareous gyttja deposited in a lake; in zone PUB-III Hypnaceae peat prevails. The lithostratigraphic as well as the biostratigraphic change in zone PUB-III can be interpreted as a lowering of the lake level. In zone PUB-II the lake must have been rather deep, with a floating and submerged vegetation of *Isoetes*, *Potamogeton*, *Nuphar*, *Nymphaea*, and *Myriophyllum*. Along the shores plants such as Cyperaceae, *Thalictrum*, *Filipendula*, *Menyanthes*, and *Equisetum* may have occurred. In zone PUB-III the lake must have been much shallower, creating suitable habitats for species of the Hypnaceae. The presence of *Calliergon stramineum* may indicate that at least parts of the lake were not submerged at all, for today this species occurs in such habitats. Also the presence of pollen of *Myriophyllum alterniflorum* may indicate that the lake was quite shallow (WESTHOFF & DEN HELD 1969: Potamion graminei).

CASPARIE & VAN ZEIST (1960) regard a decrease of the values of spores of *Isoetes* as an indication of a deterioration of the climate. However, *Isoetes* grows preferably in mineral soil and its absence from the pollen record in zone PUB-III may be a result of the organic substrate that came into existence. Such a decline of the values for *Isoetes* in moss-peat is also found in the Westrhauderfehn-II diagram (BEHRE 1966).

The decline of the values of *Nuphar* and *Nymphaea* may also indicate a decline in thermophilous conditions (IVERSEN 1954), but here it can also be related to falling lake levels.

Along the more exposed shores expansion of fen species, in the first place those of the Cyperaceae, took place. Also the pollen types of other shore plants listed for zone PUB-II are present in zone PUB-III. However, the lake did not dry up completely, since most of the indicators of open water (e.g. *Pediastrum*, *Lemna*, *Myriophyllum*) remain present.

It is more difficult to assess the trophic status of the lake. Part of the pollen assemblage in zone PUB-II consists of pollen of plants that today occur in rather eutrophic habitats (*Myriophyllum verticillatum/spicatum*, *Nymphaea* p.p., *Nuphar* and some species of *Potamogeton*: Potametea). But the occurrence of *Isoetes*, *Menyanthes*, and *Calliergon* may point to more mesotrophic conditions, quite striking because these taxa must have been present on a calcareous substrate. Such a mixture of species of different minerotrophy is often found in the late-glacial (e.g. LANG 1967). This contrast is also present in zone PUB-III. The environment, however, may have been more mesotrophic then that during zone PUB-II: pollen of *Nuphar* is absent and there are scattered occurrences of pollen of *Myriophyllum alterniflorum*, *Comarum*, and *Valeriana dioica*.

At the top of zone PUB-III and in zone PUB-IV there is again a maximum of *Isoetes* at the levels where the sediment type reverts from Hypnaceae peat to lake marl. In the lake marl frequently oogones of *Chara* were found, a genus that today may occur in lakes with great depth. The local pollen assemblage much resembles that of zone PUB-II. This may indicate a rising water level, perhaps in response of a shift towards a warmer climate at the advent of the postglacial.

In zone PUB-V at last the first stages of the present pattern of lake filling, become apparent. The local pollen assemblage is dominated by *Nymphaea*, *Typha angustifolia*, and *Sparganium*, the latter two taxa characteristic at present of the Phragmitetea. The sediment becomes increasingly organic, which explains, as in zone PUB-III, the absence of spores of *Isoetes*.

All in all the trends of most of the herbaceous pollen types can be interpreted entirely in terms of changes in the lake ecosystem that do not necessarily depend on regional changes but can be triggered by a purely local event. However, in lake sediments the trends in the curves of tree and shrub pollen have a more regional aspect and, as we have seen, can be used for the delimitation of zone PUB-III/IV and that of zone PUB-IV/V. However, the trends in the curves of tree and shrub pollen are less helpful for the delimitation of zone PUB-II/III. Pollen of *Empetrum*, so abundant in the late-Dryas in the North, is rare. This is a common phenomenon in the southern Netherlands. Also the maximum of the *Pinus* curve, often observed in the later part of the Allerød in the Netherlands and northwestern Germany (VAN DER HAMMEN 1951; BEHRE 1966; VAN DER HAMMEN & WYMSTRA 1971), is absent. It also fails to show up at the Gülickshof site (VAN DER HAMMEN 1951). Pollen of *Juniperus* is also rare, and its curve can not be used for establishing a zone boundary.

As a result we are faced with a zone division entirely based on the curves of lowland species, and we may well ask whether the transition of zone PUB-II/III is the transition from the Allerød time to the late-Dryas time.

As the rise of the values of pollen of herbs in zone PUB-III is almost entirely due to possible local occurrence of the Cyperaceae, the frequencies of a number of selected pollen types were recalculated on the basis of a pollen sum excluding Cyperaceae and Poaceae. TEUNISSEN & VAN OORSCHOT (1967), too, excluded pollen of the Cyperaceae from the pollen sum.

For the Putbroek-B diagram pollen of the Poaceae were also excluded because in this small basin several species of the grass family might have been growing in marshy habitats.

The Putbroek-B diagram shows that upland herb pollen types, such as Chenopodiaceae, *Empetrum*, *Plantago*, and *Artemisia* show maximum values in zone PUB-III, contributing to the notion that this zone represents a time with a decreasing density of forested areas, thus possibly the late-Dryas stadial.

The rise of these types in zone PUB-III does not show up in the Putbroek-A diagram because their frequencies are depressed by the rise of the pollen values of the Cyperaceae.

To check the assumption that the zone boundary PUB-II/III is the Allerød/late-Dryas transition, two ^{14}C dates were obtained. The first date comes from moss remains at the top of zone PUB-II: 11,195 $\pm$ 120 B.P. (GrN-5842). This date suggests a late Allerød age. According to VAN DER HAMMEN et al. (1967) the Allerød period lasted from 11,000–11,800 B.P. This agrees with new ^{14}C dates from Twenthe, where Allerød materials have been dated at 11,240–11,630 B.P. (VAN DER HAMMEN & WYMSTRA 1971), whereas dates from the Allerød/late-Dryas transition from Twenthe and Belgium range from 10,900–11,300 B.P. (DE VRIES et al. 1958; DE PLOEY 1963; GILOT et al. 1969). However, the sediment from which the date was obtained is calcareous. It has been demonstrated that ^{14}C dates obtained from organic materials in hard-water lakes are too old because in these lakes part of the carbon incorporated in the organic material comes from inactive carboniferous materials ($CaCO_3$) derived from older periods (DEEVEY et al. 1954; OGDEN 1967; DONNER et al. 1971). The source of the carbon at Putbroek in zone PUB-II may be largely aerial CO_2, but the possibility exists that part of it is "dead" carbon from an unknown source. As a result the date of the upper part of zone PUB-II might be too old and the sediments thus might have been deposited in a later time, i.e., the late-Dryas stadial. Therefore a second date was obtained from noncalcareous material at the base of zone PUB-III: 10,890 $\pm$ 65 B.P. (GrN-6308), suggesting early late-Dryas time. The transition of zone PUB-II/III thus truly represents the transition between the Allerød time and the late-Dryas time.

In conclusion: an atypical pollen diagram from the late-glacial that shows only trends in the pollen curves pointing to changes in the lake ecosystem in the depositional basin can in this case be correlated with known regional phases of the late-glacial. Perhaps the changes in the moisture regime observed at the Putbroek site have a wider application. According to BUURMAN (1970) the "warmer" interstadials are frequently represented by marl on the border of basins, where Hypnaceae peat was deposited in the "drier" Dryas stadials. If this is more generally true then all late-glacial pollen diagrams showing only changes of the values of lowland pollen types can be correlated with known time-stratigraphic units of the late-glacial. We may, however, expect quite a variety of lowland habitats at that time, depending on the nature of the surrounding upland, water depth, size of the basin, and many other environmental parameters. Without insight in these factors any generalization of the phenomena described here may lead to erroneous results.

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PUTBROEK A

Appendix 1. *Acta Botanica Neerlandica*, **Vol. 22** (3) 1973
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A „local" Late-Glacial pollen diagram from Limburg, Netherlands

Fig. 2. Pollen diagram A of Putbroek. Poaceae and Cyperaceae included in the pollen sum.

Appendix 2. *Acta Botanica Neerlandica*, **Vol. 22** (3) 1973
Art. C. R. Janssen and W. IJzermans-Lutgerhorst

A „local" Late-Glacial pollen diagram from Limburg, Netherlands

PUTBROEK B.

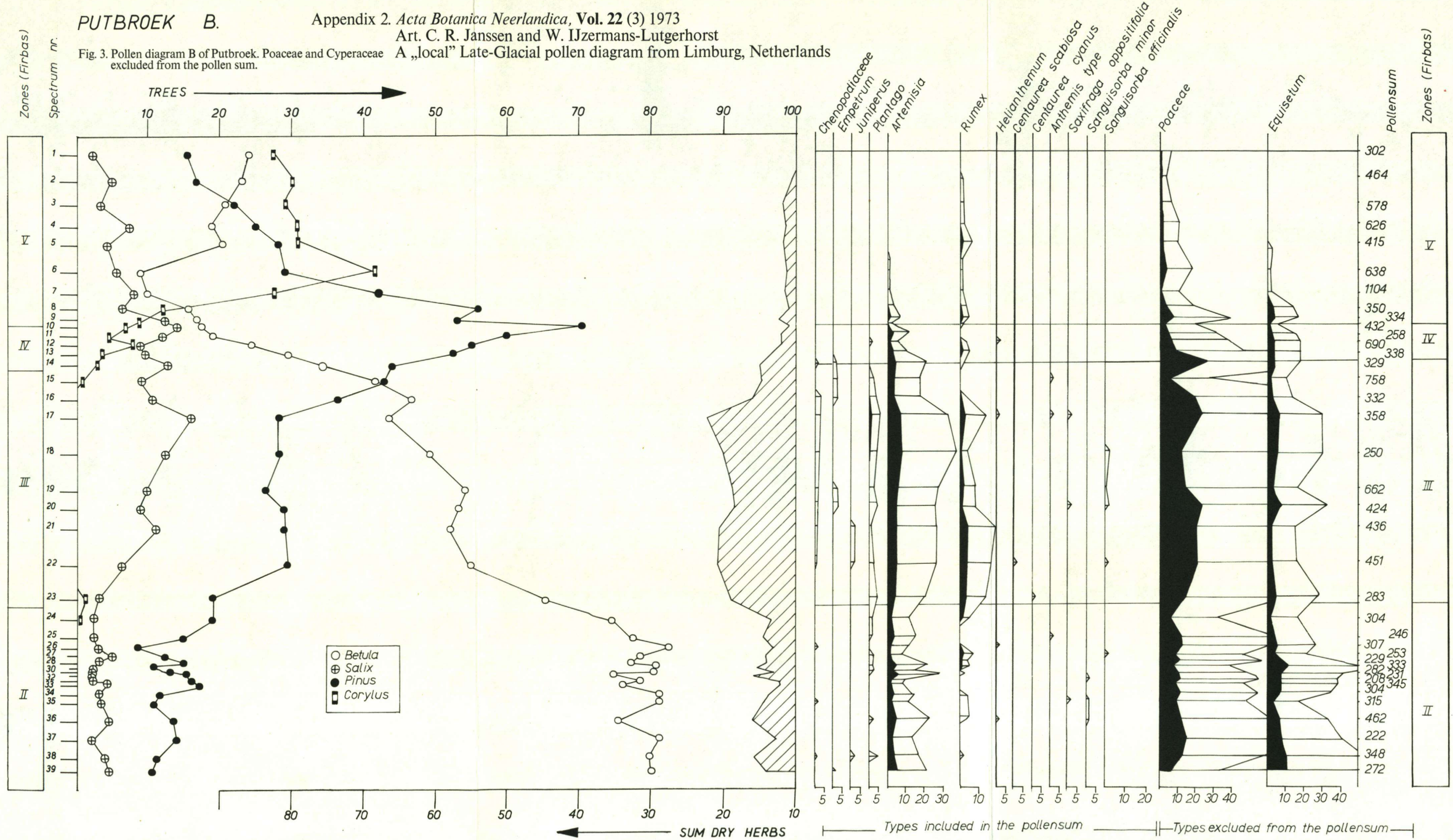

Fig. 3. Pollen diagram B of Putbroek. Poaceae and Cyperaceae excluded from the pollen sum.