A PALYNOLOGICAL STUDY OF THE LATE-GLACIAL AND THE POSTGLACIAL IN THE PARIS BASIN

Etude palynologique du Tardiglaciaire et du Postglaciaire dans le Bassin Parisien

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CONTENTS

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1. INTRODUCTION

In this paper the results will be discussed of the palynological examination of Late-glacial and Postglacial sediments in the Paris Basin. This study forms, as it were, the continuation of the palynological examination of peat deposits in Brittany (van Zeist, 1964). In the pollen diagrams from Brittany the activity of prehistoric and early-historical man shows up clearly. This fact induced us to examine to what extent in the Paris Basin the presence of early man could be demonstrated palynologically. The question was raised whether it would be possible to correlate indications of the interference of man with the vegetation, as these show up in the pollen record, with particular archaeological cultures. The latter does not imply that the period from before the introduction of farming would be of less interest. On the contrary, the study includes the whole of the Late-glacial and Postglacial, that is to say the last 15,000 years.

The palynological study of the Paris Basin started in 1961, when a first series of sediment cores was taken. The analysis of the samples was carried out by the second author (M.R.v.d.S.-W.) who undertook this study as a Ph.D.-thesis project. Due to various circumstances the examination of the sediment cores lasted longer than had been anticipated. The subsequent drawing up of the report slowed down more and more in the course of time until it came to a final standstill. At that time the greater part of the results had been treated.

In spite of the fact that due to the many delays the study had lost some of its current interest, the results were considered to be nevertheless still important enough to be published, particularly because only little information on the Late-glacial and Postglacial vegetational history in the Paris Basin had appeared in press in the mean time. Consequently, the first author was left no other choice than to complete the manuscript and to prepare it for publication. The completing of the manuscript led to a virtual re-writing of the greater part of it. The first author takes the sole responsibility for the form in which the results are presented and for the final correlation and interpretation of the pollen diagrams.

In order to avoid further delay it was necessary to reduce the planned scope of the publication. Thus, chapters on the geography of the area, on soils and climate, and on the extant and potential natural vegetation had to be omitted. The publication, in the mean time, of the volumes on the prehistory of France (La Préhistoire Française), in particular of part II "Les civilisations néolithiques et protohistoriques de la France" (ed. J. Guilaine), released us from the necessity to compile reviews of the prehistoric habitation in the area under consideration.

The location of the sites mentioned in this paper is indicated in fig. 1.

This investigation and its publication would not have been possible without the co-operation of various people.

Dr. S. Bottema, Dr. W. A. Casparie, Mr. A. Meijer, Professor H. T. Waterbolk, Mrs. W. Waterbolk-van Rooyen and Dr. W. H. Zimmermann assisted in the field work. Laboratory assistance was rendered by Mrs. I. W. J. Wolters-van Otterloo. The radiocarbon determinations were carried out in the Department of Isotope Physics of the Laboratorium voor Algemene Natuurkunde (University of Groningen) under the direction of Professor W. G. Mook.

Rough drafts of the pollen diagrams were prepared by Mr. H. Woldring and Mrs. G. Entjes-Nieborg. The neat drawings were executed by Mr. H. R. Roelink, Mr. W. J. Dijkema and Mr. J. Smit. The English text was improved by Mrs. S. M. van Gelder-Ottway. Mrs. L. van der Have translated the summary into French. Dr. M. Reille (Marseille) suggested linguistic improvements.

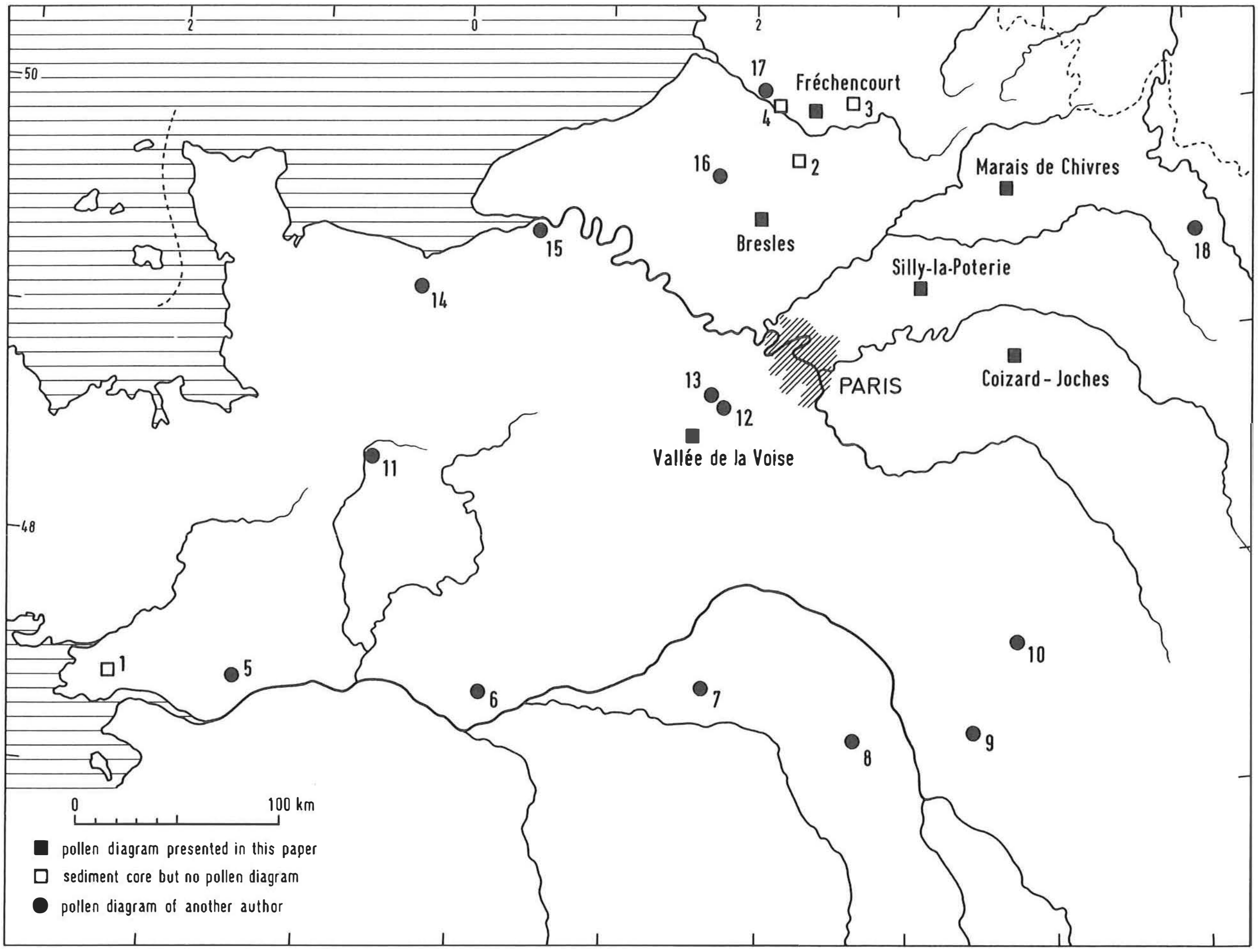
Mrs. G. Entjes-Nieborg assisted in the preparation of the manuscript.

2. THE POLLEN-DIAGRAM SITES (fig. 1)

2.1. Coizard-Joches

2.1.1. *Location*

The Coizard-Joches cores are from the Marais de St. Gond, c. 25 km S of Epernay, Département Marne. This marsh is drained by the Petit Morin, a small river which debouches into the Marne river c. 60 km ENE of Paris. The borings were carried out c. 1000 m S of the villages of Coizard and Joches,



south of the Petit Morin (48°47'N, 3°52'E). The Coizard-Joches I core was taken on 23 May 1961 at c. 200 m E of road D 45. On 23 September 1962 a boring was carried out at c. 150 m E of D 45 (Coizard-Joches II). The local vegetation consisted of predominantly *Phragmites australis*. To the south of the coring localities peat had been cut.

2.1.2. *Lithology*

Coizard-Joches I

0.10-1.80 m	monocot peat, the upper part with modern roots
1.80-2.63 m	clay gyttja with shell remains
2.63-3.87 m	moss peat with bands of clay or clay-gyttja
3.87-5.02 m	clay-gyttja with shell remains
5.02-5.45 m	weathered limestone
5.45 m	bed-rock (limestone)

Fig. 1. Map of Northern France showing the location of sites referred to in this paper.
Carte du Nord de la France avec localisation des sites mentionnées dans cette publication.

1. Grande Brière (2.7.);
2. Ailly-sur-Noye (2.7.);
3. Aveluy-sur-Ancre (2.7.);
4. Belloy-sur-Somme (2.7.);
5. Marais de l'Erdre, Petit-Mars (Planchais, 1971);
6. Gizeux (Planchais, 1967);
7. Mur-de-Sologne (Planchais, 1970);
8. Rians (Planchais, 1971);
9. Prémery (Planchais, 1966);
10. Arcy-sur-Cure (Leroi-Gourhan, 1965);
11. Melleray (Corillion & Planchais, 1963);
12. Tourbière de Poigny (Jalut, 1966);
13. Tourbière de l'Archet (Jalut, 1967);
14. Bellengreville (Elhai, 1959);
15. Marais Vernier (Elhai, 1959);
16. Forêt de Bray (Frileux & Huault, 1971);
17. Marais de Long (Nilsson, 1960);
18. Tourbière de la Bar (Mullenders, 1960).

Coizard-Joches II

0.10-2.63 m	monocot peat, the upper part with modern roots
2.63-3.96 m	moss peat with clay bands
3.96-4.98 m	clay-gyttja with shell remains
4.98 m	weathered limestone

2.1.3. *Radiocarbon dates*

Coizard-Joches I

1.10-1.19 m 8490 ± 70 B.P. GrN-4714

Coizard-Joches II

2.51-2.59 m	10520 ± 95 B.P.	GrN-4715
3.51-3.59 m	10860 ± 90 B.P.	GrN-4716
3.88-3.93 m	11780 ± 60 B.P.	GrN-4717

The last sample (CJ II, 3.88-3.93 m), from just above a change in the sediment, was obtained from a duplicate core section. The sediment of the bottom part of the CJ II profile and the sediment below 1.80 m in the CJ I profile were not suitable for radiocarbon dating.

2.2. Chivres

2.2.1. *Location*

The Marais St. Boëtien is situated c. 15 km NE of Laon, Département Aisne. This marsh is drained to the northwest by the Souche which has been canalized. As a result of peat cutting many ponds have formed here. A boring was carried out on 22 September 1962 at a locality c. 3 km W of Chivres and c. 2 km S of Pierrepont (49°37'N, 3°49'E). The local vegetation included *Betula*, *Populus*, *Salix*, *Quercus*, *Eupatorium cannabinum*, *Filipendula ulmaria*, *Cirsium oleraceum*, *Angelica sylvestris*, *Lycopus europaeus*, *Mentha aquatica*, *Potentilla erecta*, *Calamagrostis lanceolata*, *Deschampsia caespitosa*, *Phragmites australis* and Cyperaceae.

2.2.2. *Lithology*

0.35-0.60 m	slightly decayed monocot peat with many roots
0.60-4.21 m	moderately to severely decayed monocot peat
4.21-4.37 m	moss layer
4.37-4.80 m	amorphous, severely decayed peat
4.80-5.15 m	calcareous clay gyttja
5.15 m	sand

2.2.3. *Radiocarbon dates*

1.70-1.85 m	2700 ± 55 B.P.	GrN-4859
2.05-2.25 m	3160 ± 65 B.P.	GrN-4860
3.11-3.19 m	6110 ± 65 B.P.	GrN-4689
3.51-3.59 m	8910 ± 80 B.P.	GrN-4690
3.74-3.84 m	9200 ± 80 B.P.	GrN-4691
4.51-4.59 m	11430 ± 60 B.P.	GrN-6528

2.3. Tourbière de Bresles

2.3.1. *Location*

The Tourbière de Bresles is situated c. 14 km ESE of Beauvais, Département Oise. In former days peat had been cut here which gives the terrain an irregular appearance. On 2 October 1962 a boring was carried out at a locality c. 1.5 km S of Bresles, 320 m E of road D 125 (between Hermes and Bresles), north of a brooklet (49°24'N, 2°15'E).

2.3.2. *Lithology*

0.65-0.74 m	clayey peat
0.74-1.46 m	peaty calcareous gyttja with shell remains
1.46-1.79 m	monocot peat
1.79-2.00 m	alternating calcareous gyttja and peat
2.00-3.14 m	severely decayed monocot peat
3.14-3.38 m	coarse detritus gyttja
3.38 m	sand

2.3.3. *Radiocarbon dates*

No radiocarbon dates were obtained for the Bresles profile.

2.4. Silly-la-Poterie

2.4.1. *Location*

The core of Silly-la-Poterie is from the marshes in the valley of the Ourcq river, c. 8 km SSE of Villers-

Cottêrets, Département Aisne. On 23 March 1961 a boring was carried out at a locality c. 400 m S of Silly-la-Poterie, between road D 17 (from la Ferté-Milon to Troesnes) and the Ourcq river (49°11'N, 3°8'E).

2.4.2. *Lithology*

0.30-5.98 m monocot peat
5.98-6.40 m clay
6.40 m sand

2.4.3. *Radiocarbon dates*

1.95-2.05 m 2270 ± 45 B.P. GrN-5386
2.45-2.60 m 3445 ± 45 B.P. GrN-5387
4.45-4.65 m 5865 ± 45 B.P. GrN-5388
4.95-5.10 m 6865 ± 50 B.P. GrN-5389

2.5. Vallée de la Voise

2.5.1. *Location*

The valley of the upper reaches of the Voise river, c. 18 km to the E and ENE of Chartres, Département Eure et Loir, is filled with peat. On 1 October 1962 a core was taken at the left side of the Voise, a few hundreds of metres below the confluence of the Voise and Aunay rivers. The coring locality is situated c. 2 km N of Oinville, at a distance of c. 150 m from the river, c. 50 m W of road I.C. 122 (48°25'N, 1°45'E).

2.5.2. *Lithology*

0.10-0.27 m clay with small flint-stones
0.27-0.54 m monocot peat
0.54-0.71 m calcareous gyttja-like sediment with monocot remains
0.71-0.96 m fibrous monocot peat
0.96-1.07 m gyttja-like band
1.07-1.41 m moderately decayed monocot peat
1.41-1.55 m calcareous gyttja-like sediment
1.55-2.40 m monocot peat, the lower part with wood remains
2.40-3.00 m clayey monocot peat with wood and shell remains
3.00-4.54 m clayey decayed monocot peat with shell remains
4.54 m subsoil

2.5.3. *Radiocarbon dates*

0.90-1.00 m 1545 ± 35 B.P. GrN-6239
1.70-1.80 m 2405 ± 35 B.P. GrN-6247
2.30-2.45 m 3865 ± 40 B.P. GrN-6248
2.97-3.05 m 6880 ± 45 B.P. GrN-6249
4.30-4.45 m 9110 ± 80 B.P. GrN-6240

2.6. Fréchencourt

2.6.1. *Location*

The Fréchencourt core is from the valley of the Hallue, a tributary of the Somme river. The boring was carried out on 26 April 1964, at c. 1 km S of Fréchencourt, Département Somme (49°57'N, 2°26'E).

2.6.2. *Lithology*

0.45-0.85 m clayey sediment with monocot remains, gradually changing into less clayey monocot peat
0.85-2.45 m decayed monocot peat, below 2.20 m changing into underlying sediment
2.45-2.80 m gyttja with monocot remains
2.80-3.15 m peaty, calcareous gyttja with monocot remains
3.15-3.85 m calcareous clay with concretions, below 3.65 m yellow coloured
3.85-4.25 m reddish yellow-brown clay
4.25 m subsoil

2.6.3. *Radiocarbon dates*

0.97-1.05 m 3415 ± 35 B.P. GrN-5385
1.51-1.63 m 4130 ± 45 B.P. GrN-5959

2.7. Other borings

In addition to those mentioned above, sediment cores have been taken at Grande Brière (Loire-Atlantique), near Aveluy-sur-Ancre (Somme), near Ailly-sur-Noye (Somme) and near Belloy-sur-Somme (Somme). For various reasons these cores have not further been examined.

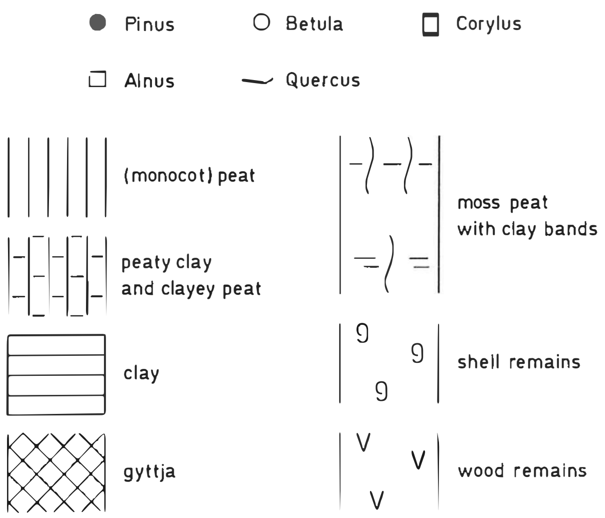


Fig. 2. Key to the symbols employed in the pollen diagrams. Légende des signes employés dans les diagrammes polliniques.

3. THE POLLEN DIAGRAMS

3.1. Construction of the diagrams

In connection with the construction of the pollen diagrams of figs. 3-5, 8-11 the following remarks should be made here. The pollen sum includes the pollen of trees and shrubs and that of herbs of the upland vegetation. The main diagram shows the ratio between the percentages for arboreal pollen (AP) and herbaceous pollen (NAP) included in the basic sum. In the main diagram the curves for *Pinus*, *Betula* (not always), *Corylus*, *Quercus* and *Alnus* are also drawn. On the left of the main diagram the curves for shrubs and other trees are represented, on the right those for herbaceous pollen types. On the right of the column with the pollen sums the curves for the pollen types not included in the sum are drawn. All pollen frequencies in the diagrams mentioned above are expressed as percentages of the basic pollen sum.

As for the herbaceous pollen, one may wonder why not more types are included in the pollen sum. It is self-evident that the pollen of marsh and water plants which are of local origin should be excluded from the basic sum. Thus, taxa such as *Lythrum*, *Menyanthes*, *Typha*, *Sparganium*, *Potamogeton*, *Nymphaea* and Cyperaceae have to be left out of the pollen sum. In the case of Gramineae one is faced with the problem that grasses may have formed part of the regional upland vegetation as well as of the local marsh vegetation. In view of the frequently very high grass pollen values which are undoubtedly due to local conditions the exclusion of this pollen type from the basic sum is justified. On the other hand, various other herbaceous pollen types, such as *Polygonum aviculare*, Tubuliflorae and Liguliflorae Compositae, Caryophyllaceae, *Mercurialis*, *Melampyrum* and others, which should predominantly have originated from the upland vegetation, are as well left out of the pollen sum. This was done because in principle only wind-pollinated herbs and Ericales were to be included in the basic sum. On second thoughts the authors believe that, indeed, more types should have been included in the pollen sum, but as the neat pollen diagrams had already been drawn things were left as they are.

In addition to the diagrams mentioned above, so-called Quercetum-mixtum diagrams are constructed for Fréchencourt, for the greater part of Vallée de la Voise and Silly-la-Poterie and for the upper part of Chivres (zones 8-11). In the latter diagrams (figs. 12-15), the basic pollen sum includes the same types as in the other diagrams except for *Alnus* and *Salix* which have been excluded because of the fact that they are trees from marshy areas. Furthermore, the numbers of pollen grains of *Corylus*, *Pinus* and *Betula* have been divided by 4. This was done because of the considerable over-representation of these taxa in the pollen precipitation as compared to the other constituents of the upland forest. Only the pollen types included in the basic sum are presented in the Quercetum-mixtum diagrams. The Quercetum-mixtum diagrams should provide the best possible impression of the vegetation on the higher soils. One may expect that particularly the influence of prehistoric man on the vegetation finds a proper expression in these diagrams. For prehistoric farmers exploited especially the higher soils.

3.2. The zonation of the pollen diagrams

3.2.1. *Introduction*

It would have been most obvious to use one of the existing pollen-floristic zonation schemes for subdividing the pollen diagrams presented in this study, covering approximately the last 15,000 years. Most generally applied to French pollen diagrams are the well-known tripartition of the Late-glacial (Older Dryas, Allerød, Younger Dryas) and the so-called Blytt/Sernander periodization of the Postglacial (Preboreal, Boreal, Atlantic, Subboreal, Subatlantic). However, the application of this zonation to our pollen diagrams met with various difficulties, particularly for the Postglacial period. Other zonation schemes, such as that established by Godwin (1956) for Great Britain and that of Firbas (1949), were equally less suitable. For that reason own pollen assemblage zones, which generally do not coincide with existing pollen-floristic zones, have been established for the pollen diagrams from the Paris Basin. These zones are based upon changes in the curves of one or more pollen types and/or changes in the ratio of AP/NAP. Although the pollen diagrams under discussion sometimes show fairly considerable differences with respect to one another, the same zonation is applied to all of them. This implies that the pollen assemblage zones established are not equally well represented in the various diagrams. In some diagrams a particular pollen assemblage zone is subdivided into two or more subzones. In conclusion, corresponding zone numbers in the diagrams discussed in this paper refer to the same pollen assemblage zone, but a possible subdivision of pollen zones is always of strictly local character. The radiocarbon dates enable a comparison of this regional zonation with the more general zonation schemes.

Below (3.2.2.) characteristics will be given in brief of the pollen assemblage zones in the diagrams from the Paris Basin. Discussions of the particular features of these pollen zones in the separate diagrams (including some problematical pollen assemblages) and of the possible subdivision of the zones will be presented in chapters 5-8.

3.2.2. *Pollen assemblage zones*

3.2.2.1. Zone 1

This pollen-floristic zone is represented only in the Chivres diagram (see 5.2.). It is characterized by very high herbaceous pollen values. (In evaluating the AP/NAP ratio it should be taken into consideration that Gramineae and Cyperaceae are not included in the basic pollen sum.) *Betula* is the dominant tree pollen type, but *Pinus* pollen values are comparatively high. The transition from zones 1 to 2 is placed at the level where Σ AP values increase but where, on the other hand, *Pinus* pollen percentages drop to almost zero.

3.2.2.2. Zone 2

Zone 2 is characterized by high *Betula* pollen percentages. *Juniperus* and *Artemisia* values are generally fairly high. *Pinus* pollen values are very low, but the pine curve rises at the top of the zone. *Juniperus* values decrease in the upper part of zone 2. A decrease in *Artemisia* marks the zone 2/3 contact.

3.2.2.3. Zone 3

This pollen assemblage zone shows comparatively low *Artemisia* and *Juniperus* percentages. *Pinus* attains high values and is the dominant tree pollen type in many spectra of zone 3. The zone 3/4 border is placed at the distinct rise of the *Artemisia* curve.

3.2.2.4. Zone 4

Relatively high *Artemisia* and *Juniperus* percentages characterize pollen assemblage zone 4. Various other herbaceous pollen types show comparatively high values. *Pinus* remains the dominant tree pollen type. *Juniperus* values decrease in the upper part of the zone. A marked decline in *Artemisia* and other herbs constitutes the zone 4/5 boundary.

A date of 8910 ± 90 B.C. was obtained for a level just above the zone 3/4 contact at Coizard-Joches II, while the zone 4/5 border in the same diagram is radiocarbon dated to 8570 ± 95 B.C.

3.2.2.5. Zone 5

Herbaceous pollen types fall to low values in the lower part of zone 5. The *Juniperus* curve becomes discontinuous. *Pinus* pollen values are very high, with *Betula* in second place. Of the other tree pollen types, only *Salix* shows a continuous curve. Thermophilous species are scarcely represented. The zone 5/6 border is placed at the first increase in *Corylus*. On account of the radiocarbon date of 7250 ± 80 B.C. for a level slightly above the zone 5/6 contact at Chivres, this zone border may be dated to about 7500 B.C.

3.2.2.6. Zone 6

Pollen assemblage zone 6 is characterized by a notable rise in the *Corylus* curve and a drastic decrease of the *Pinus* percentages. *Quercus* values increase; *Ulmus* shows a continuous curve which rises in the upper part of the zone. Σ NAP values are even lower than in the preceding zone. The marked increase in *Ulmus* percentages constitutes the zone 6/7 border which is dated to about 6800 B.C. This dating is based upon the radiocarbon date of 7160 ± 80 B.C. in the la Voise core for a level somewhat below the zone contact and the date of 6540 ± 70 B.C. at Coizard-Joches I for the base of zone 7.

3.2.2.7. Zone 7

Ulmus values are comparatively high. *Quercus* and *Corylus* are generally the predominant pollen types in zone 7, but *Pinus* values are sometimes equally fairly high. *Betula* percentages are low. *Tilia* and *Fraxinus* show continuous curves in the upper part of the zone. The zone 7/8 contact is placed at the level of the rise in the curves for *Tilia* and *Fraxinus*. For this zone border two radiocarbon dates are available: 4930 ± 45 B.C. at la Voise and 4915 ± 50 B.C. at Silly-la-Poterie.

3.2.2.8. Zone 8

Ulmus, *Tilia* and *Fraxinus* show in general comparatively high values, although in particular *Ulmus* percentages may fluctuate markedly. *Quercus* and *Corylus* percentages are equally high, whereas *Pinus* and *Betula* values are low. *Alnus* may reach high percentages in zone 8; the expansion of this tree in the Paris Basin was not a synchronous phenomenon but must largely have been determined by local conditions. *Fagus* occurs discontinuously. Pollen of *Plantago lanceolata* and Cerealia was counted in low numbers and discontinuously. The beginning of the continuous *Fagus* curve marks the zone 8/9 transition. The zone border is dated to c. 2000 B.C.: at Fréchencourt the level at c. 35 cm below the zone contact is radiocarbon dated to 2180 ± 45 B.C., and at la Voise a date of 1915 ± 40 B.C. was obtained for the base of zone 9.

3.2.2.9. Zone 9

A low but continuous *Fagus* curve characterizes this pollen zone. The percentages for the other tree pollen types are at about the same level as in the previous zone, except locally for *Alnus* (Vallée de la Voise!). *Plantago lanceolata* does not yet show a continuous curve. The upper zone border is placed at the first increase in *Fagus* pollen percentages. The zone 9/10 contact is dated to c. 1300 B.C.: Silly-la-Poterie, 1495 ± 45 B.C. for the upper part of zone 9; Fréchencourt, 1465 ± 35 B.C. for the level just below the zone contact; Chivres, 1210 ± 65 B.C. for the base of zone 10.

3.2.2.10. Zone 10

Fagus reaches relatively high percentages (not in Vallée de la Voise). *Ulmus*, *Tilia* and *Corylus* decline. Σ NAP percentages rise markedly in the upper part of the zone. *Plantago lanceolata* shows a continuous curve. The beginning of the continuous *Secale* curve constitutes the zone 10/11 border which is dated to c. 200 B.C. This dating is based upon the interpolation of the la Voise ^{14}C dates of 455 ± 35 B.C. and A.D. 405 ± 35 for the levels of 170-180 and 90-100 cm, respectively, and upon the date of 320 ± 45 B.C. for a level about 15 cm below the zone contact at Silly-la-Poterie.

3.2.2.11. Zone 11

Pollen assemblage zone 11 is characterized by comparatively high herbaceous pollen values, in particular *Secale*, *Plantago lanceolata* and *Rumex*. *Fagus* shows generally high but fluctuating percentages. *Carpinus* is present, be it in low percentages. *Ulmus* and *Tilia* decline further, the latter virtually disappearing. In none of the diagrams which form part of this study are the last 400-500 years represented.

3.3. Periodization of the vegetational history

To facilitate the discussion of the results of the palynological examination presented in this paper, the time range covered by the pollen record will be subdivided into four periods.

Pollen assemblage zones 2-4 belong to the *Late-glacial*. The lower limit of this period, the Pleniglacial/Late-glacial border, is somewhat vague and has consequently not been dated satisfactorily, but a date of 12,000 B.C. (14,000 B.P.) is generally accepted as a fair approximation. For the upper limit, the Late-glacial/Postglacial transition, a date of c. 8300 B.C. has been established. As will be discussed below (5.2.) pollen assemblage zone 1 could perhaps reach back into the Pleniglacial, but it is also possible that it is of early Late-glacial age.

The *Lower Postglacial*, which includes pollen assemblage zones 5, 6 and 7, is dated from c. 8300 to c. 4900 B.C. During this period predominantly pine forest was gradually replaced by deciduous forest vegetations.

Pollen assemblage zones 8 and 9 constitute the *Middle Postglacial* (c. 4900-c. 1300 B.C.), the period of the fully developed mixed-oak forest and the beginning of the interference of prehistoric farmers with the vegetation.

The *Upper Postglacial* (c. 1300 B.C.-present) is represented by pollen assemblage zones 10 and 11. The upper Postglacial covers the period in which *Fagus* and later also *Carpinus* expanded; besides, an increasing influence of man on the vegetation is reflected in the pollen record.

4. LOCAL VEGETATION AND SEDIMENTATION

4.1. Coizard-Joches I (fig. 4)

In samples 1-14 relatively much pollen of aquatic plants was found, as may be expected in a gyttja deposit. *Potamogeton*, *Myriophyllum verticillatum/spicatum* and *Nymphaea* show maxima in this section. *Pediastrum* is continuously present in low percentages. Besides, there is pollen of marsh plants, such as *Potentilla/Comarum*, *Galium*-type, *Filipendula*, *Typha latifolia*, Gramineae, Cyperaceae and *Sparganium*. A marsh vegetation surrounded the lake in which the clay-gyttja was deposited.

In spectra 15-33 (3.90-2.65 m), which section consists of moss peat with clay bands, aquatic pollen types remain present, although generally in lower values than in spectra 1-14. Marsh-plant and possible marsh-plant taxa, such as *Caltha*, *Ranunculus/Batrachium*, *Filipendula*, *Potentilla/Comarum*, *Valeriana*, *Menyanthes*, Cruciferae, Umbelliferae, *Galium*, *Sparganium*, *Hippuris* and *Equisetum*, attain higher pollen values above spectrum 14. Moreover, Gramineae and Cyperaceae show occasionally high peaks in the section between spectra 14 and 30. Part of the gramineous and perhaps also of the cyperaceous pollen in the section covering spectra 1-33 (Late-glacial!) must have been or regional origin. The relatively large numbers of pollen of Tubuliflorae and Liguliflorae Compositae in samples 17-32 originate most likely from the upland vegetation and not from the peat-forming vegetation. Mosses must have played an important part in the local marsh vegetation. In periods of high water, when clay was deposited, water plants must have been present at the coring locality.

Between 1.80 and 2.65 m, corresponding with spectra 34-42, the CJ I core consists of gyttja. *Nuphar* pollen was counted in this section, while *Potamogeton* is also represented. At the time open water was found again at the coring locality. High percentages for Gramineae and *Dryopteris* are recorded for spectra 34-42 (2.65-1.80 m), indicating that fen peat was formed in the vicinity of the coring locality. The marsh-plant pollen types mentioned for spectra 15-33 are also present in spectra 34-42.

Between spectra 43 and 50, when monocot peat was formed on the spot, *Cladium* was one of the peat-forming species. *Dryopteris* had disappeared from the coring locality, but Gramineae and other Cyperaceae still formed part of the local marsh vegetation.

In the section covering spectra 51-57, *Alnus* and *Dryopteris* show high percentages, suggesting the presence of an alder brook at or near the coring locality. It should be mentioned here that the pollen record points to a hiatus in the sedimentation between spectra 50 and 51. The section of spectra 51-57 could not satisfactorily be assigned to one of the pollen assemblage zones distinguished in this study.

4.2. Coizard-Joches II (fig. 5)

The succession of the vegetation at the locality of the CJ II core is to a large degree comparable to that established for the CJ I coring site. In the clay gyttja of the lower part of the core (spectra 1-9), pollen of the aquatic taxa *Myriophyllum verticillatum/spicatum*, *Nymphaea* and *Potamogeton* was found. The latter species reaches high values in a few spectra, while *Pediastrum* is also present.

The aquatic species mentioned above are also represented in the succeeding core section (spectra

10-24) consisting of alternating clay and moss peat, although they become rare in the upper part of the section. Gramineae are abundant in spectra 10-16, while very high cyperaceous percentages were obtained up to spectrum 27. Comparison of the gramineous curve with that of *Artemisia* suggests that the high grass pollen percentages must chiefly have been due to the local vegetation. Other marsh and shallow-water plant taxa, such as *Sparganium*-type, *Filipendula*, *Potentilla/Comarum*-type, *Galium*-type, Umbelliferae and *Equisetum*, show relatively high values in the section of spectra 10-24. *Typha latifolia* was found from spectrum 15 onwards. Other local pollen types mainly restricted to the lower part of the diagram are *Menyanthes*, *Valeriana*, *Mentha*-type, *Caltha*, *Ranunculus/Batrachium* and *Ophioglossum*. Locally a moss-rich vegetation must have been present in which in addition to sedges and grasses, a great number of other marsh plant species played a part. Aquatic species expanded to some extent during periods of a high water level (deposition of clay).

In the monocot-peat section (spectra 25-38), *Dryopteris* has a maximum in spectra 28 and 29, whereafter *Cladium* shows comparatively high values in spectra 31 and 32. One must assume that grasses, sedges, *Cladium* and *Dryopteris* played in turn a predominant part in the local marsh vegetation. In addition, other taxa, such as *Filipendula*, Cruciferae, *Sparganium* and *Galium*, were present.

The sections with the high *Cladium* pollen frequencies are largely synchronous in both Coizard-Joches profiles. Apparently during zone 6 time, this species played an important part in the marsh vegetation over a larger area. In this connection it should be noted that at CJ I the *Cladium* expansion took place just after or at the transition from open water to marsh, whereas at CJ II no marked change in the local conditions is suggested at the level of the rise of the *Cladium* curve.

4.3. Chivres (fig. 3)

In the lowermost section consisting of calcareous clay gyttja (spectra 1-4) *Potamogeton* shows somewhat higher values, but *Nymphaea* and *Myriophyllum* are hardly represented. On the other hand, *Pediastrum* is frequent in this section. The rather high percentages for Gramineae and Cyperaceae must very probably be ascribed to the regional upland vegetation. Zone 1 (spectra 1-4) reflects a virtually treeless vegetation (5.2.).

The start of the monocot peat formation at the level of spectrum 5 coincides with a *Salix* maximum of 46.4%. At the same depth cyperaceous values increase markedly up to spectrum 20, except for spectra 15 and 16. Besides, other plants contributed to the peat formation. In spectrum 6, *Galium* and *Potentilla/Comarum* show maxima. The *Equisetum* curve is continuous between spectra 6 and 12. In spectra 10 and 11 extremely high values of *Typha latifolia* occur. Higher *Dryopteris* values were obtained from sample 12 onwards. *Menyanthes* pollen was counted in various samples of the section between spectra 5 and 20, while seeds of this species were recovered from the level of sample 12. In spectrum 14 Gramineae show a peak, followed by a decline parallel to that of Cyperaceae; both taxa recover in spectra 18, 19 and 20. Tubuliflorae Compositae and *Sparganium*-type show higher values in spectra 15 to 18 and in spectra 17 and 18, respectively.

Most of the time covered by spectra 5-20 Cyperaceae, probably sedges, must have played a predominant part in the local marsh vegetation, but various other taxa must likewise have been important constituents during a longer or shorter period. The composition of the marsh vegetation underwent noticeable changes in the course of time. The moss peat layer, which from 4.37 to 4.21 m (spectra 9 and 10) is intercalated in the monocot peat, does not find expression in the pollen record by particular changes in the curves of local types.

In the section of spectra 26-38 high *Dryopteris* values coincide with high *Alnus* percentages. Gramineae and Cyperaceae, on the other hand, show relatively low values in this section, except for spectra 31 and 32. Hardly any alder wood was found in the core section concerned, so that it is not likely that an alder marsh forest occurred at the locality of the boring. The *Alnus* pollen would mainly have originated from an alder-carr belt around the marsh.

From spectrum 40 onwards Cyperaceae show very high values, suggesting that sedges must again have played a very important part in the local marsh vegetation.

4.4. Bresles (fig. 8)

In the two bottom spectra, obtained from gyttja samples, *Pediastrum*, *Nymphaea*, *Myriophyllum verticillatum/spicatum* and *Potamogeton* are represented. Part of the Gramineae and Cyperaceae pollen may have originated from the open vegetation of the higher soils, but there can be little doubt that marsh vegetation with abundant grasses and sedges was found at a short distance from the coring locality.

In spectrum 3, at the transition to monocot peat (3.14-1.46 m, spectra 3-15), a maximum of *Typha latifolia* pollen is found, while the *Cladium* curve starts. In spectrum 4 *Dryopteris* appears, but this fern does not attain high values in the Bresles core. Gramineae and Cyperaceae show maxima in spectra 6-7 and 9-10, respectively. *Filipendula*, *Galium*, Umbelliferae and *Sparganium* are relatively well represented only in the lower part of the monocot-peat section. Cyperaceae and Gramineae must alternately have been predominant in the peat-forming vegetation. Other marsh-plant species were of some importance only in the early phases of monocot peat formation (spectra 3-8).

In spectra 16 to 23 only *Sparganium*, Gramineae, Cyperaceae, *Dryopteris* and *Cladium* have continuous curves, but none of these taxa seems to have been of great importance. As the core section concerned consists of gyttja one would have expected a better representation of water plants.

4.5. Silly-la-Poterie (fig. 10)

The sediment consists largely of monocot peat. Up to spectrum 70 *Dryopteris* must generally have played an important part in the marsh vegetation, this in addition to grasses and sedges. From spectrum 14 on, *Alnus* shows fairly high values, but as hardly any wood was found in the core it is not likely that alder formed part of the local marsh vegetation.

As for the other possible peat-forming species the following can be remarked. In spectra 1-11, in addition to *Galium*, which pollen type was found throughout the whole diagram, Tubuliflorae, *Filipendula*, Umbelliferae and *Equisetum* are fairly well represented. *Cladium* was regularly counted between spectra 13 and 47, *Polypodium* between spectra 13 and 64 and *Typha latifolia* between spectra 13 and 44. Cruciferae show a nearly continuous curve from spectrum 10 on.

In the section above spectrum 66 (possible) marsh-plant taxa, such as *Caltha*-type, *Ranunculus/Batrachium*, *Filipendula*, *Galium*, *Mentha*-type, *Hypericum*, *Lythrum*, *Lysimachia*, *Valeriana*, Cruciferae, Umbelliferae, *Sparganium*-type and *Equisetum*, show relatively high values. In spectrum 68 an isolated *Ophioglossum* maximum of 15% is present. It is clear that in spite of the predominant role of Gramineae, and in particular of Cyperaceae, the marsh vegetation represented in the upper part of the core must have shown a large variety of species. The high *Salix* values in the upper spectra point to the presence of willow at a short distance from the coring locality.

4.6. Vallée de la Voise (fig. 9)

The bottom part of the la Voise diagram (spectra 1-7) suggests the presence of a willow carr on or at a short distance from the coring site. Gramineae, Cyperaceae, *Dryopteris*, *Equisetum*, *Sparganium*, Tubuliflorae, *Filipendula* and Umbelliferae must have been common in the local marsh vegetation. In the period covered by spectra 8-36, *Cladium*, other Cyperaceae and *Dryopteris* must in turn have contributed greatly to the peat formation. *Potamogeton* and *Pediastrum* in spectra 12 and 13 indicate the presence of open water. Between spectra 15 and 27 *Rumex* and *Galium* show higher values; besides, five tetrads of *Epipactis* were counted. *Typha latifolia* is represented in spectra 15-20, in which section *Sparganium*-type reaches somewhat higher percentages.

An alder carr developed in the section of spectra 38-47. Herbaceous pollen values are generally low in this section. Only *Dryopteris* shows a conspicuous maximum in spectrum 45.

In the upper part of the diagram (spectra 48-62), Gramineae and Cyperaceae show noticeably high values. In addition, various other pollen types which probably originate from the bog vegetation, such as *Equisetum*, *Sparganium*, *Typha latifolia*, Umbelliferae, *Mentha*, *Lythrum*, *Lysimachia*, *Menyanthes*, *Galium* and *Filipendula*, were found. The local marsh vegetation must have been rich in species.

Above a depth of 1.07 m (spectrum 55) gyttja-like bands are intercalated in the monocot peat. It is in this core section that various water plants are represented: *Nymphaea* (spectra 57-62), *Myriophyllum* (spectra 55-57), *Potamogeton* (spectra 55-58). *Pediastrum* has a continuous curve between spectra 55 and 62.

4.7. Fréchencourt (fig. 11)

During most of the time covered by the Fréchencourt pollen record, Gramineae, Cyperaceae and *Dryopteris* must in turn have constituted the most important taxa of the local marsh vegetation. In spectra 5-11 other pollen types, such as *Sparganium*-type, *Typha latifolia*, Umbelliferae *Ranunculus/Batrachium* and Tubuliflorae and Liguliflorae Compositae, show somewhat higher values.

In the marsh vegetation of the upper part of the core (spectra 45-48), in addition to Gramineae and Cyperaceae, various other taxa, such as *Equisetum*, Cruciferae, *Galium*-type, *Potentilla/Comarum*, *Ranunculus/Batrachium* and *Caltha*-type, played a more or less important part. Some of the higher herb pollen values in spectra 45-48 have to be ascribed to the increase in human activity, e.g. *Polygonum aviculare*, *Polygonum persicaria*, *Mercurialis* and *Centaurea*.

5. THE LATE-GLACIAL

5.1. Introduction

The Late-glacial is represented in the diagrams of Chivres (fig. 3) and Coizard-Joches (figs. 4 and 5) and in the lower two spectra at Bresles (fig. 8). It is self-evident that in the first place it should be attempted to fit the Late-glacial sections of the diagrams mentioned above in the zonation of the Late-glacial of West, Northwest and Central Europe: Earliest Dryas, Bolling, Earlier Dryas, Allerod and Late Dryas periods; zones Ia, Ib, Ic, II and III according to Iversen (1954). (The Lower Dryas (cf. 5.3.) includes the Earliest Dryas, Bolling and Earlier Dryas periods.) However, the application of this zonation to Late-glacial pollen diagram sections from the plains of Northern France meets with difficulties in various instances. The pollen diagrams concerned deviate from the pattern characteristic of Late-glacial pollen sequences in Western Europe. Planchais (1970), who discusses this problem, adduces regional factors, such as different periglacial zones and local climatic and edaphic conditions, to account for the differences in the pollen record of Late-glacial sections in Northern France.

As will be discussed below the present authors wonder to what extent differences between Late-glacial pollen diagrams from Northern France could be due to the incompleteness of the pollen record. It looks as if various Late-glacial deposits show considerable gaps in the sedimentation, in consequence of which pollen records obtained for these sections are not continuous but of rather fragmentary character.

5.2. Pollen assemblage zone 1

This pollen assemblage zone is represented only in the Chivres diagram (spectra 1-4). It is characterized by high herbaceous percentages; particularly the high *Helianthemum* pollen values are striking. As the sediment in the section concerned consists of gyttja one may assume that the majority of the gramineous and cyperaceous pollen, neither of which is included in the basic pollen sum, are of regional origin. Pollen spectra 1-4 at Chivres suggest an almost treeless vegetation with some juniper, willow and birch. As no measurements of *Betula* pollen in the Chivres sediment have been carried out, it cannot be established whether predominantly dwarf birch is concerned here. One must assume that *Pinus* did not grow in the area, but that the presence of its pollen in zone 1 is due to long-distance transport. In this connection it should be pointed out that in spectra 5 and 6 at Chivres, which reflect a less open vegetation and consequently milder climatic conditions, pine pollen values are almost zero. A relatively large proportion of *Pinus* in sections representing open vegetations is a common feature in European pollen diagrams and must be ascribed to the extraordinarily good dispersal of pine pollen.

Zone I of the diagram of Mur-de-Sologne (Planchais, 1970) shows a pollen assemblage comparable to that of the lower spectra of the Chivres diagram. At Mur-de-Sologne, too, both *Helianthemum* and *Artemisia* values are notably high, while *Pinus* pollen percentages are higher than in the succeeding section, the pollen record of which suggests a more forested landscape.

Planchais (1970) dates zone I at Mur-de-Sologne to the Lower Dryas period and consequently pollen assemblage zone 1 at Chivres should belong to the same period. No radiocarbon dates are available to confirm the view that the pollen diagram sections concerned are of early Late-glacial age and one wonders whether they are perhaps of the final phase of the Pleniglacial. Be this as it may, if the lowermost pollen zones at Chivres and Mur-de-Sologne are of Late-glacial age, they most likely do not cover the whole of the Lower Dryas period (Iversen's zone I) as suggested by Planchais, but at most only the lower part of it, viz. the Earliest Dryas period (Iversen's subzone Ia).

5.3. Pollen assemblage zone 2

Coizard-Joches I, spectra 1-9; Coizard-Joches II, spectra 1-6; Chivres, spectra 5-6.

From this zone, which is characterized by predominant *Betula* and generally high *Artemisia* pollen percentages, one feature of Late-glacial diagram sections from Northern France becomes already apparent, viz. their differences in the pollen record. Thus, at Coizard-Joches I, *Juniperus* percentages are high throughout the whole of zone 2, whereas at Coizard-Joches II, at a distance of no more than 50 m, only in the upper part of the zone does juniper reach high pollen values. As juniper must have been a shrub from the uplands, the differences in the *Juniperus* percentages in both Coizard-Joches diagrams cannot be ascribed to local factors. The Chivres diagram, in which the zone 1/2 transition is represented, may perhaps provide the clue for the differences in the *Juniperus* curves at Coizard-Joches. In Chivres spectra 5 and 6, which very probably belong to the lower part of zone 2, *Juniperus* values are still fairly low. This leads to the suggestion that the lower part of the zone is not represented at Coizard-Joches I, and that consequently zone 2 at Coizard-Joches I corresponds with spectra 5 and 6 at Coizard-Joches II. On the other hand, at Chivres the upper part of zone 2 is missing. As will be discussed below (5.5.), a hiatus in the Chivres pollen record between spectra 6 and 7 is very likely.

For various levels of the lower part of the Coizard-Joches I diagram, measurements of *Betula* pollen have been carried out. The *Betula* pollen in Coizard-Joches II samples were too swollen to give reliable data. The frequency distribution of the measurements does not suggest two size groups of birch pollen. Consequently, it cannot be determined as to how far the *Betula* pollen in zone 2 could have been of dwarf birches or of tree birches.

The vegetation of zone 2 time consisted very probably of an open birch forest in which at a later stage juniper expanded. There must have been a rich ground cover in which *Artemisia* and perhaps also *Betula nana* played an important part. *Pinus* did definitely not form part of the vegetation during the greater part of zone 2 time. It was not until the final stages of this period that pine arrived in the Coizard-Joches area and started to replace birch.

Zone I in the pollen diagram of the Tourbière de l'Archet (Jalut, 1967) compares rather well with the lower part of the Coizard-Joches diagrams, although *Juniperus* pollen was not counted in the former sediment section. On the other hand, high juniper pollen values are shown in zone II at Mur-de-Sologne (Planchais, 1970). The very low *Pinus* percentages at Mur-de-Sologne would equally plead for the correlation of zone II at Mur-de-Sologne with zone 2 at Coizard-Joches. It should, however, be admitted that *Betula* pollen values at Mur-de-Sologne are not particularly high. (In comparing the diagrams of Mur-de-Sologne and Coizard-Joches with each other it should be borne in mind that in the former diagram Gramineae and Cyperaceae are included in the pollen sum.)

As for the dating of regional pollen assemblage zone 2 and its position in the classical Late-glacial zonation scheme, the following should be remarked. The ^{14}C date of 9480 ± 60 B.C. for the level between spectra 6 and 7 at Chivres gives a *terminus ante quem* for pollen zone 2. However, as at this very level a hiatus in the sedimentation is assumed, this radiocarbon measurement does not date the upper limit of zone 2. The ^{14}C date of 9830 ± 60 B.C. for a level in the middle of zone 3 at Coizard-Joches II suggests that our pollen zone 2 must be placed in the Lower Dryas period (Iversen's zone I) and that very probably it coincides largely with subzone Ia (Earliest Dryas), subzones Ib and Ic not being represented in this pollen assemblage zone (see also discussion of zone 3 in section 5.4.). Jalut (1967) dates the lowermost section of the l'Archet diagram to the Lower Dryas period (Dryas ancien). Planchais (1970) attributes the section with the high *Juniperus* values in the diagram of Mur-de-Sologne to the Allerod period (Iversen's zone II). It is clear that either the synchronization of zone II at Mur-de-Sologne with pollen zone 2 at Coizard-Joches and Chivres is incorrect or that the dating of Planchais is wrong. As will be discussed below (5.4.), there is reason to doubt an Allerod age of zone II at Mur-de-Sologne.

5.4. Pollen assemblage zone 3

This zone is represented in the Coizard-Joches diagrams (Coizard-Joches I, spectra 10-17; Coizard-Joches II, spectra 7-14). As will be discussed below (5.5.), due to a hiatus in the sedimentation pollen zone 3 is very likely missing in the Chivres diagram. Although both Coizard-Joches diagrams show the main characteristics of this pollen assemblage zone, viz. generally high *Pinus* and relatively low *Artemisia* and *Juniperus* percentages, they are not quite identical in this respect. The Coizard-Joches I diagram shows a distinct subdivision of zone 3, viz. subzone 3a (spectra 9-12) with predominant *Betula* pollen values and subzone 3b (spectra 13-17) with predominant *Pinus* percentages. At Coizard-Joches II, on the other hand, pine pollen values are very high from the beginning of the zone on, but in contrast to the Coizard-Joches I diagram, *Betula* and *Pinus* percentages show marked fluctuations. It is tempting to assume that subzone 3a is not represented at Coizard-Joches II; the abrupt fall in the *Juniperus* curve may be considered as another indication of a hiatus in the pollen record.

During zone 3 time, forest vegetation must have covered the Coizard-Joches area. At first birch may have been the most important tree, whereas at a later stage pine took over this role. Juniper was probably a fairly common constituent in the birch-dominated forests of subzone 3a, but played a very minor part in the forest vegetation of subzone 3b time. The still fairly high herbaceous pollen values point to a rich ground cover in consequence of the favourable light conditions in the birch and pine forests.

Pollen assemblage zone 3 compares well with zone II in the diagram from the Tourbière de l'Archet (Jalut, 1967). The lower part of zone II at l'Archet shows very high *Betula* percentages, whereas *Pinus* is the dominant tree pollen type in the upper part of the zone. It is very likely that the pollen zones concerned cover the same time period. On account of the pollen-floristic features Jalut regards his zone II as equivalent to the Allerod period (c. 9800-8800 B.C.). The radiocarbon date of 8910 ± 90 B.C. at Coizard Joches II for a level at c. 10 cm above the zone 3/4 transition indicates that the end of pollen assemblage zone 3 corresponds with the upper limit of the Allerod period. On the other hand, the date of 9830 ± 60 B.C. for a sample from the middle of zone 3 suggests that this zone covers a longer time period than the Allerod zone. The sample submitted for radiocarbon dating is not from the sediment core for which the pollen diagram was prepared, but from a duplicate core section taken at about one metre distance. There is, however, little reason to doubt that the radiocarbon measurement does not date the approximate level of spectrum 10 as indicated in the pollen diagram. The dated sample covers the lowermost 5 cm of the moss peat. At Coizard-Joches II as well as in the duplicate core section a distinct change in the sediment (from clay gyttja to moss peat) was found. A date of c. 9830 B.C. corresponds with the beginning of the Allerod period and consequently pollen zone 3 would also cover the upper part of the Lower Dryas period. It is not possible to establish how much of Iversen's zone I is included in our pollen zone 3, but very probably at least subzones Ib and Ic, i.e. Bolling and Earlier Dryas. For the sake of convenience we assume that our pollen assemblage zone 3 coincides with zones Ib, Ic and II of the classical Late-glacial zonation, and the same would apply to zone II of the l'Archet diagram (Jalut, 1967).

As for zone II in the diagram of Mur-de-Sologne, which is attributed to the Allerod period by Planchais (1970, 1971), it has already been remarked (5.3.) that this diagram section probably corresponds with our pollen assemblage zone 2 and consequently with Iversen's subzone Ia. The conspicuously low *Pinus* pollen percentages in zone II of the Sologne diagram plead against an Allerod date. Planchais (1970) treats at some length the possible causes of the absence of pine in the Sologne area during the Allerod period and she arrives at the conclusion that this behaviour of pine must probably be ascribed to the periglacial environmental conditions of the area ("désert de gélivation"). It is not clear in which way periglacial conditions, which prevailed several thousand years before the Allerod period, could have prevented the migration and expansion of *Pinus* in the Sologne area, particularly because in other areas, where periglacial conditions must have been much more severe, pine did become an important tree during the Allerod period. Even if local conditions at Sologne were unfavourable for pine during zone II one would nevertheless have expected higher *Pinus* pollen percentages due to long-distance transport from areas with pine and birch-pine forests. Once again, it is more likely that Planchais' zone II, and most probably her zone III too, must be attributed to Iversen's subzone Ia. This would imply that a considerable part of the Late-glacial is missing in the Sologne pollen diagram and that the early Postglacial (zone IV) lies discordantly on the lower Late-glacial. It is true that the sediment of the section concerned (slightly humified, clayey peat) does not point to a hiatus of any importance, but the Coizard-Joches and Chivres diagrams provide also indications of considerable interruptions in the pollen record which do not find expression in sudden changes in the sediment. Irregular sedimentation and/or an alternation of deposition and erosion seem to have been common in Late-glacial lakes and marshes in Northern France.

The Allerod period (zone II) is mentioned for a few more pollen diagrams from the plain of Northern France. A Late-glacial age for the lower part of the Bellengreville diagram (Elhai, 1959) is not very convincing. One wonders why the section covered by Elhai's zones II and III could not belong to the early Postglacial. The Allerod age of the lower section of the diagram of Asnelles-Belle-Plage 1 (Elhai & Larsonneur, 1969) is based upon a radiocarbon date, but according to the pollen assemblage it could equally well be attributed to the Late Dryas period. In the lower section of the diagram from the Tourbière de la Bar, Mullenders (1960) distinguishes an Allerod and a Younger (Late) Dryas section. The distinction between both zones is based mainly upon the noticeably higher gramineous pollen values in the section attributed to the Late Dryas period. As the sediment consists of peat one wonders as to how far the increase in Gramineae pollen was caused by an expansion of grasses in the local marsh vegetation. The *Artemisia* curve does not show an increase as may be expected at the transition from the Allerod to the Late Dryas sections. The high *Juniperus* pollen percentages in the lower part of the la Bar diagram are in conformity with similarly high values in pollen assemblage zone 4 at Coizard-Joches I which is attributed to the Late Dryas period (see 5.5.). In conclusion, although an Allerod age of the lowermost part of the la Bar diagram cannot be excluded, it is equally well possible that this section belongs to the Late Dryas (Iversen's zone III).

The radiocarbon date of 9480 ± 60 B.C. for the level between spectra 6 and 7 in the Chivres diagram would indicate that the section concerned must be attributed to the Allerod period. However, on closer inspection it becomes apparent that exactly between spectra 6 and 7 the pollen record shows a gap. Spectra 5 and 6 belong to pollen assemblage zone 2 (5.3.), whereas spectra 7-10 are assigned to zone 4 (5.5.). For that reason one must seriously consider the possibility that the radiocarbon dated sample consisted of sediment of two different periods and that the date obtained is a kind of mean age of Earliest Dryas and Late Dryas sediment.

5.5. Pollen assemblage zone 4

Coizard-Joches I, spectra 18-33; Coizard-Joches II, spectra 15-25; Chivres, spectra 7-10; Bresles, spectra 1-2.

Compared to pollen zone 3, this zone shows again higher values for *Juniperus*, *Artemisia* and various other herbs. Pine pollen values are lower than in the preceding zone, but nevertheless *Pinus* remains the predominant tree pollen type. During zone 4 time, rather open birch and pine forests or mixed birch-pine forest must have prevailed in the areas from which the diagrams mentioned above originate. *Juniperus* must have played an important part at least locally. The luxuriant ground cover had the character of a steppe vegetation (*Artemisia*, *Rumex*, *Thalictrum*, *Helianthemum*). The near-absence of Ericaceae and *Empetrum* pollen suggests that so-called tundra elements were insignificant.

At Coizard-Joches II, the beginning of the zone may be dated to about 9000 B.C. (8910 ± 90 B.C. for a level at c. 10 cm above the zone 3/4 transition), while a date of 8570 ± 95 B.C. was obtained for the zone 4/5 transition. These dates suggest that our regional pollen zone 4 roughly corresponds with the Late Dryas period (Iversen's zone III).

Zone III at l'Archet (Jalut, 1967) compares well with our pollen assemblage zone 4, except that in the l'Archet diagram *Betula* values are higher than those of *Pinus*. According to the interpretation of the Late-glacial section of the Mur-de-Sologne diagram advocated above (5.4.), the Late Dryas should not be represented there. On the other hand, the lower section of the Prémery 2 diagram (Planchais, 1971), with fairly high herbaceous percentages and a predominance of *Pinus* over *Betula*, corresponds perfectly with other Late Dryas pollen assemblages from Northern France. The Late Dryas section at la Bar (Mullenders, 1960), irrespective of the question whether or not this covers the whole of the lower part of the diagram (see 5.4.), shows a pollen assemblage which agrees reasonably well with that in the corresponding section of the other pollen diagrams. It seems justified to conclude that during the Late Dryas period open forests with predominantly pine, birch and juniper prevailed in the plain of Northern France.

In contrast to the diagrams from more northerly regions, such as the Netherlands, Northwest Germany and Denmark, which show rather high Ericales percentages in the Late Dryas period, in the diagrams from Northern France *Empetrum* and Ericaceae are scarcely represented in this zone. The increase in Ericales is ascribed to a more oceanic climate during the Late Dryas period. One wonders whether in Northern France it remained fairly dry in the final phase of the Late-glacial.

5.6. Thermophilous tree pollen in Late-glacial sediments

In Late-glacial sediments from Northern France pollen of thermophilous trees, such as *Alnus*, *Quercus*, *Corylus* and *Ulmus*, is found quite regularly, raising the question whether these species may have occurred in the area in low frequencies. The Late-glacial at Chivres and Coizard-Joches yielded

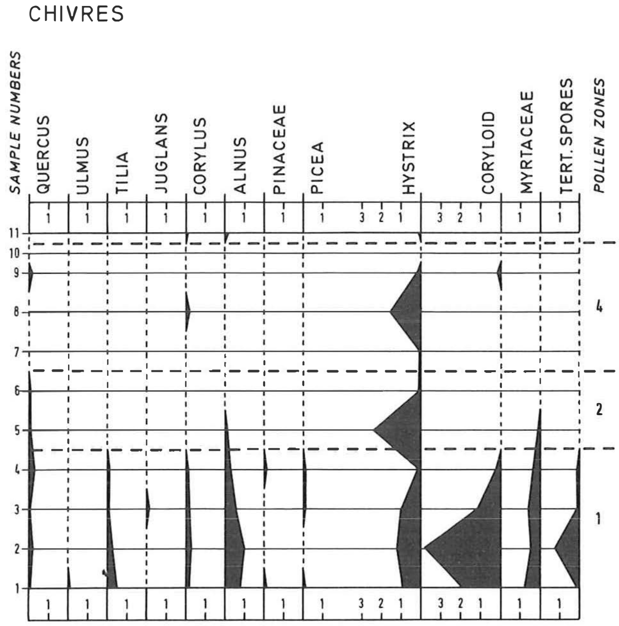


Fig. 6. Pollen of thermophilous trees and Tertiary pollen and spores in the Late-glacial section of the Chivres sediment core.
Pollens d'arbres thermophiles et pollens et spores Tertiaires dans le secteur Tardiglaciaire de la carotte de Chivres.

likewise thermophilous tree pollen. Curves for these pollen types are not drawn in the diagrams of figs. 3, 4 and 5, but they are shown separately, together with curves for some types of unquestionably secondary origin (figs. 6 and 7). It should be noted that these types are not included in the basic pollen sum.

It is striking that in the Chivres diagram thermophilous pollen is most frequent in zone 1, which zone reflects the most open and "coldest" vegetation of the whole diagram. Some pre-Quaternary pollen and spore types are likewise relatively common in this section. The thermophilous pollen in zone 1 is mainly to be ascribed to redeposition, but it cannot be excluded that some of these grains had been blown in from far away (long-distance transport). In case of clayey sediments one must always reckon with re-embedded pollen.

The Late-glacial section of the Coizard-Joches I diagram shows considerable numbers of thermophilous pollen grains. The conspicuous maxima in spectra 13/14 and 27 suggest that here contami-

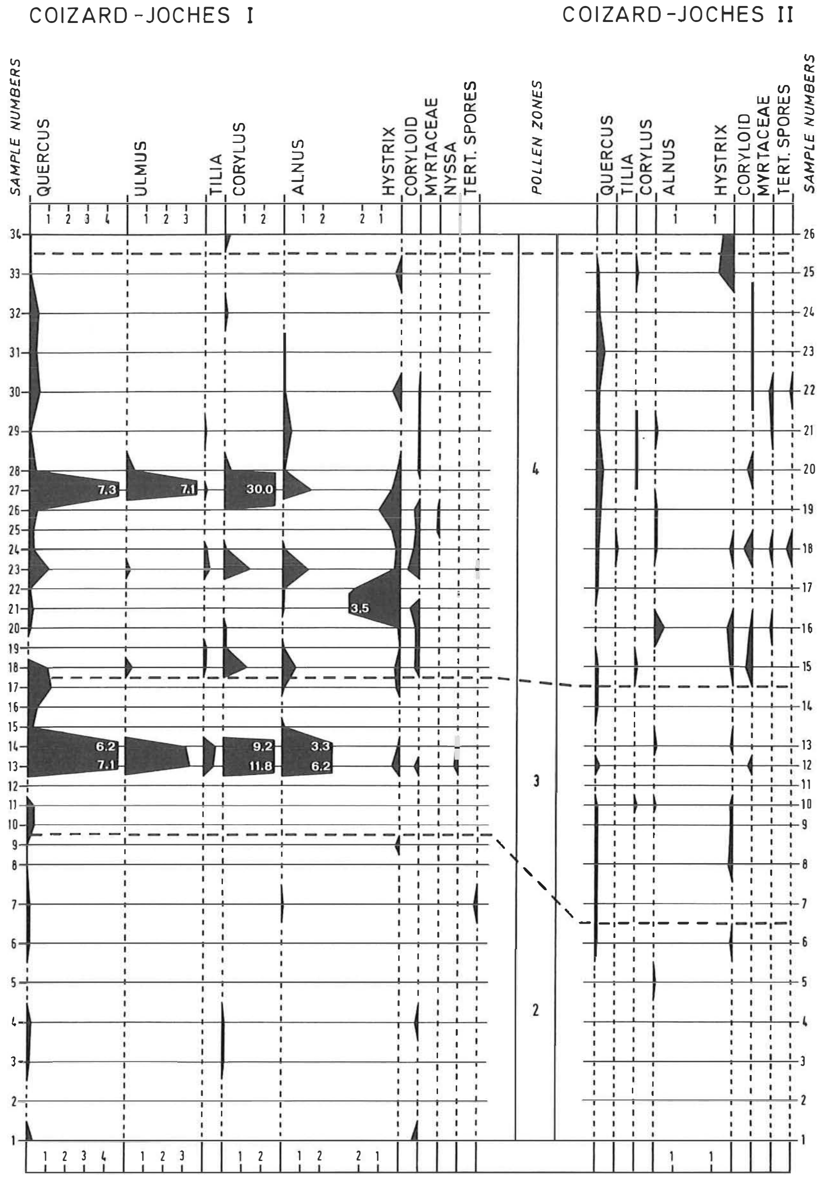


Fig. 7. Pollen of thermophilous trees and Tertiary pollen and spores in the Late-glacial section of the Coizard-Joches sediment cores.
Pollens d'arbres thermophiles et pollens et spores Tertiaires dans le secteur Tardiglaciaire des carottes de Coizard-Joches.

nation with younger sediment must have occurred. During the coring operation, sediment from upperlying layers may have been pushed down and subsequently have been incorporated in the sediment taken by the borer. The fact that the Coizard-Joches II diagram shows no comparable thermophilous pollen maxima is in favour of the suggestion mentioned above. Re-embedded pollen in the clayey bands intercalated in the moss peat must have been reponsible for the Tertiary pollen types and at least for some of the thermophilous pollen. The regular occurrence of *Quercus* pollen could perhaps indicate that during the later stages of the Late-glacial, oak may have grown in the Coizard-Joches area or at least at not too great a distance. However, in the corresponding section of the l'Archet diagram (Jalut, 1967), *Quercus* has no continuous curve. On the other hand, in the Late-glacial section of the latter diagram, *Corylus* does show an almost continuous curve. The question whether or not oak or any other thermophilous trees had reached Northern France in the course of the Late-glacial must remain undecided for the time being.

5.7. Notes on some Late-glacial pollen types

Pollen of *Hippophaë* was rarely counted (Chivres, spectra 4 and 5; Coizard-Joches I, spectra 1, 2 and 4; Coizard-Joches II, spectra 5, 12, 20 and 21). At Mur-de-Sologne, too, a few *Hippophaë* pollen grains were found, but no mention is made of the occurrence of this pollen type in other Late-glacial deposits from Northern France. Although *Hippophaë* has a poor pollen dispersal, it is likely that this shrub did not play a significant part in the Late-glacial vegetation of the area. This is the more remarkable as the rather calcareous soils should have been favourable for *Hippophaë*.

Five pollen grains of *Populus* were found (Coizard-Joches I, spectrum 11; Coizard-Joches II, spectra 13 and 19; Chivres, spectrum 12). One may safely assume that poplar played a more important part in the Late-glacial vegetation than is suggested by its scarce pollen representation. The notorious under-representation of *Populus* in the pollen precipitation and the problems in recognizing poplar pollen are well known.

Two types of *Ephedra* pollen are distinguished, viz. *E. distachya*-type and *E. fragilis*-type (cf. Beug, 1961). The numbers of grains counted for each of both types are shown in table 1.

TABLE 1

Numbers of *Ephedra* pollen grains.

Profile	*E. distachya*-type	*E. fragilis*-type
Coizard-Joches I	33 grains (28 in zone 4)	13 grains (10 in zone 4)
Coizard-Joches II	29 grains (23 in zone 4)	4 grains (in zone 4)
Chivres	12 grains (7 in zone 1)	3 grains (in zone 1)

The *E. distachya*-type pollen is reported also for other Late-glacial sites in Northern France: Mur-de-Sologne (Planchais, 1970), Bellengreville (Elhai, 1959), Arcy-sur-Cure (Leroi-Gourhan, 1965) and Prémery (Planchais, 1966). Of *E. fragilis*-type pollen, 18 grains were counted at Arcy-sur-Cure (in addition to 25 *E. distachya*-type grains) and one at Prémery.

Polemonium is represented in both Coizard-Joches profiles (8 grains in zone 4, 1 grain in zone 1 and 1 grain in zone 3). No other records of *Polemonium* pollen for the Late-glacial of Northern France have so far been published.

Helianthemum pollen is rather frequently found in the Late-glacial of Northern France. Particularly high values for this pollen type occur in the lowermost sections of the diagrams of Chivres and Mur-de-Sologne (Planchais, 1970) which both reflect treeless vegetations. The calcareous soil must undoubtedly have favoured *Helianthemum*.

Sanguisorba minor pollen is most frequent in the lower section of the Coizard-Joches diagrams. The *Sanguisorba minor* pollen curve becomes discontinuous at the level at which *Pinus* becomes dominant. At Chivres *Sanguisorba minor* is scarcely represented. The *Sanguisorba minor* pollen curve differs from that of most other heliophilous herbs, such as *Artemisia*, *Helianthemum*, *Rumex* and *Thalictrum*, in that it does not show again higher values in zone 4 (Late Dryas). A comparable course of the *S. minor* curve is shown in the diagram of l'Archet (Jalut, 1967). *Sanguisorba minor* must at least locally have played a rather important part in the vegetation of the early Late-glacial, but it did not recover in the Late Dryas period.

Only in part of the analyses has it been attempted to distinguish between Caryophyllaceae pollen types. It should be mentioned that pollen grains resembling those of *Gypsophila fastigiata* L. were found (Chivres and Coizard-Joches II). This pollen type includes other *Gypsophila* species as well.

Six pollen grains of *Onobrychis* (cf. Faegri, 1956) were found in Coizard-Joches I (spectra 1, 2, 4 and 18). The *Onobrychis*-type pollen which is included in the curve for Leguminosae resembles that of *O. montana* DC. and *O. viciifolia* Scop. In sample 16 of Coizard-Joches II a considerable number of *Onobrychis*-type pollen was counted (7.4%). These grains differ from the other *Onobrychis* pollen grains by their shorter colpi.

The spores of *Allosurus crispus* (L.) Bernh. (*Cryptogamma crispa* (L.) Hook & Bauer) and *Botrychium lunaria* (L.) Sw. are difficult to distinguish from each other. Descriptions of the spores of *Allosurus* and *Botrychium* are given by Seddon (1962, p. 474) and Erdtman, Berglund & Praglowski (1961, p. 63). The present authors found that in *Botrychium* spores, the verrucae are more irregularly shaped than in *Allosurus*. Only a few spores were found which may belong to *Allosurus* (Coizard-Joches I, spectra 12, 18, 19 and 27). *Allosurus* shows relatively high values in the lower part of the Bellengreville diagram (Elhai, 1959), and a single spore of this type is reported for Mur-de-Sologne (Planchais, 1970).

Sample 5 at Chivres and sample 22 at Coizard-Joches I yielded each one spore of *Selaginella*. In the Late-glacial section of l'Archet (Jalut, 1967), *Selaginella selaginoides* is represented in a greater number of samples. In other pollen diagrams from Northern France, *Selaginella* is conspicuously absent suggesting that in this area this species may only locally have been a constituent of the Late-glacial vegetation.

6. THE LOWER POSTGLACIAL

The Lower Postglacial, which includes our pollen zones 5, 6 and 7, is represented in the diagrams of Chivres (fig. 3), Coizard-Joches (figs. 4 and 5), Bresles (fig. 8), Vallée de la Voise (fig. 9) and Silly-la-Poterie (fig. 10).

6.1. Pollen assemblage zone 5

Coizard-Joches I, spectra 34-42; Coizard-Joches II, spectra 26-31; Chivres, spectra 11-14; Bresles, spectra 3-7.

6.1.1. *The pollen record*

The transition from the Late-glacial to the Postglacial is characterized by a marked decline in herbaceous pollen values. As for the pollen from predominantly upland species (the types included in the basic pollen sum), regional pollen zone 5 displays no obvious differences in the four diagrams mentioned above. *Pinus* is the dominant pollen type, while *Betula* is rather well represented. *Juniperus* shows a continuous curve in the lower part of this pollen assemblage zone, whereas continuous curves for thermophilous *Corylus*, *Ulmus* and *Quercus* start in the uppermost section of the zone. Although *Artemisia* pollen values are conspicuously lower than in zone 4, this type is still comparatively well represented in zone 5. On account of the inferred date of c. 7500 B.C. for the upper zone border (3.2.2.5.) zone 5 coincides with the lower half of the Preboreal (Godwin's zone IV) which is dated to 8300-6800 B.C.

6.1.2. *The vegetation*

During zone 5 time, the Paris Basin must have been covered by predominantly pine forest. It is likely that birch formed part of the pine forest, but a mosaic of pine- and birch-forest vegetations is also possible. In the latter case birch forests may have occurred on the poorer soils. The pollen record suggests that at first juniper could maintain itself to some extent in the pine-birch forest vegetations, but that in the course of zone 5 this heliophilous shrub virtually disappeared. It is not clear whether *Salix* formed part of the upland vegetation or whether willow was confined to moist places, such as stream valleys. Birch may also have found suitable habitats in wet places.

A rather luxuriant ground flora may have been present in the *Pinus-Betula* forests of zone 5. This is at least suggested by the *Artemisia* pollen values. In this respect it should be remembered that light conditions must have been rather favourable under the canopy of birch and pine. The continuous curve for *Artemisia* and the representation of various other "Late-glacial" herbs in zone 5, such as *Thalictrum*, *Sanguisorba minor* and *Plantago*, seem to indicate that the climate was still rather dry.

It is likely that at the end of zone 5, *Ulmus*, *Corylus* and *Quercus* were present in the area under consideration. In both Coizard-Joches diagrams *Quercus* occurs nearly continuously in the whole of zone 5, be it in very low percentages. In the Chivres diagram, on the other hand, *Quercus* is only represented in the upper spectrum of zone 5. This leaves us with the question whether during the whole of the period covered by zone 5 oak may have been present in the Coizard-Joches area, this in contrast to the more northward lying Chivres area. A similar behaviour of oak is considered for the later stages of the Late-glacial (5.6.). On the other hand, the discontinuous occurrence of *Ulmus* and *Corylus* in the lower part of zone 5 at Coizard-Joches I must in all likelihood be ascribed to secondary deposition. In the corresponding section of the Coizard-Joches II diagram these thermophilous types are not present. Moreover, for the Late-glacial sections of the Coizard-Joches and Chivres deposits the presence of re-embedded thermophilous pollen could be demonstrated convincingly.

As for the question whether other diagrams provide indications for the presence of thermophilous trees in the Paris Basin during the lower Preboreal, the following may be remarked. In the lowermost section of the diagram prepared for the Tourbière de Poigny (4.50-4.30 m), which is ascribed by Jalut (1966) to the Preboreal, *Corylus*, *Quercus* and *Ulmus* are represented, but for lack of radiocarbon dates it cannot be ascertained whether this section corresponds with out zone 5. Moreover, the presence of re-embedded pollen cannot be excluded for the lowermost 20 cm of the Poigny section (black clay deposits!). Planchais' zone IV at Prémery (Planchais, 1966) does not correspond with our zone 5, but with zone 6, whereas zone III at Prémery seems to correspond with the upper spectra of our zone 5. The difficulties in the interpretation of the lower 150 cm of the diagram of Mur-de-Sologne (Planchais, 1970) have already been discussed at some length (5.4.). It is questionable whether zone IV at Sologne correlates with our zone 5; it is more likely to be equivalent to zone 6. The same seems to be true for zone IV in the diagram of Rians (Planchais, 1971). Judging from the course of the pollen curves, zones IV and V at l'Archet (Jalut, 1967) must correspond with our zone 5. *Corylus* shows a nearly continuous curve in zones IV and V at l'Archet, suggesting that hazel was present in the area during the lower Preboreal. On the other hand, stray pollen grains of *Fagus* and *Carpinus* in the section concerned clearly point to the presence of redeposited pollen. It must be admitted that the above discussion of thermophilous pollen in sections corresponding with our zone 5 is far from exhaustive, but it seems justified to state that so far no firm evidence for the presence of *Quercus*, *Corylus*, *Alnus* or other thermophilous trees in the lower Preboreal (and the Late-glacial) of the Paris Basin has been provided. Particularly the possible effect of redeposition of pollen should not be underestimated.

6.2. Pollen assemblage zone 6

Coizard-Joches I, spectra 43-47; Coizard-Joches II, spectra 32-34; Chivres, spectra 15-17; Bresles, spectra 8 and 9; Vallée de la Voise, spectra 1-7.

6.2.1. *The pollen record*

Pollen zone 6, which is characterized by a conspicuous increase in *Corlyus* and a corresponding decline in *Pinus*, shows a fairly uniform picture in the diagrams of Coizard-Joches, Chivres and Bresles. At about the level of the upper zone border, which is placed at the rise in the *Ulmus* curve (3.2.2.6.), the rising *Corylus* curve intersects the falling *Pinus* curve in the diagrams mentioned above. *Quercus* shows a gradual increase, while *Ulmus* constitutes a continuous curve. *Betula* pollen values are markedly lower than in zone 5.

Zone 6 at la Voise differs from the corresponding section in the other diagrams in that the *Pinus*/*Corylus* intersection lies well below the level of the marked increase in *Ulmus*. One wonders as to how far local conditions at la Voise (more than 30% *Salix*!) may have been responsible for this deviating behaviour of the pollen curves. On the other hand, the more southerly position of la Voise may explain the differences (see 6.2.2.). The lower part of zone 6 is very probably not represented at la Voise.

The zone 6/7 border has an inferred date of c. 6800 BC. (3.2.2.6.). This implies that pollen assemblage zone 6 corresponds with the upper half of the Preboreal (c. 7500-6800 B.C.).

6.2.2. *The vegetation*

During zone 6 time, *Corylus* must have expanded considerably. It is likely that in the pine forests, light-demanding hazel found suitable habitats. During this period oak became a progressively more important constituent of the vegetation, while *Ulmus* increased likewise to some extent. It is clear that in the second half of the Preboreal, oak-elm forest expanded gradually at the expense of the pine forest. Very probably deciduous forest was present particularly on the most fertile soils.

It has already been discussed (6.1.2.) that the correlation of the Lower Postglacial in the pollen diagrams presented in this study with that in other diagrams from Northern France meets with some difficulties. A section showing markedly rising *Corylus* values and continuous curves for *Ulmus* and *Quercus* can be observed in other diagrams, although the authors concerned may not always attribute this section to a period corresponding with the upper half of the Preboreal. Zones IV and V at Prémery (Planchais, 1966) and zone IV at Rians (Planchais, 1971) show a picture largely comparable to that of our zone 5. Phase VI at Poigny (Jalut, 1966) shows a conspicuous rise in *Corylus*, suggesting that this diagram section corresponds with our zone 6. There remain, however, a few uncertainties. At Poigny the increase in oak during phase VI is much more pronounced than in our zone 6, and in our diagrams no section comparable to phase V at Poigny is present. Most likely phase V at Poigny corresponds with the beginning of our zone 6. At Gizeux (Planchais, 1967; 1971) the section covered by the upper part of zone IV and the lower part of zone V seems to correspond with our zone 6. A marked increase in *Corylus* accompanied by a decline in *Pinus* can be observed in the lower half of zone VI at l'Archet (Jalut, 1967), but in this section *Ulmus* and *Quercus* are hardly represented. Zones IV and V at Mur-de-Sologne (Planchais, 1970) may correspond with our zone 6.

In zone IV at Mur-de-Sologne and phase VI at Poigny *Alnus* is fairly well represented, whereas in our pollen diagrams this pollen type is conspicuously absent in zone 6. This incongruity does not necessarily indicate that our correlations are wrong. As will come up for discussion (7.4.4.) the behaviour of *Alnus* in Northern France must have varied greatly depending on local conditions. In some areas alder expanded already in early Postglacial times, whereas the arrival and subsequent increase of this tree in other areas took place at a much later date.

The upper part of zone III and the whole of zone V at Bellengreville (Elhai, 1959) seem to correspond with our zone 6, and the same may be true for zone V^{E} in the pollen diagram prepared by Nilsson (1960) for a section in the Marais de Long, in the Somme valley between Amiens and Abbeville.

In conclusion one may remark that a phase with notably increasing hazel and decreasing pine pollen values can be observed in the Lower Postglacial of nearly all pollen diagrams from Northern France. Differences in the pollen record may mainly be due to local factors. Radiocarbon dates obtained for the pollen diagrams of Chivres, Coizard-Joches I and la Voise suggest that this stage in the vegetational history must be dated to the upper half of the Preboreal (c. 7500-6800 B.C.) and not to the Boreal (c. 6800-5500 B.C.).

6.3. Pollen assemblage zone 7

Coizard-Joches I, spectra 48-50; Coizard-Joches II, spectra 35-37; Chivres, spectra 18-21; Bresles, spectra 10-18; Vallée de la Voise, spectra 8-24; Silly-la-Poterie, spectra 1-11.

6.3.1. *The pollen record*

Pollen assemblage zone 7 is characterized by comparatively high values for *Ulmus*, *Quercus* and *Corylus*, whereas *Pinus* pollen percentages are generally much lower than in the preceding zone (3.2.2.7.). The pollen record of zone 7 displays some differences in the diagrams mentioned above and, moreover, this zone is not equally well represented in these diagrams. Pollen zone 7 seems to be best developed at la Voise and Silly-la-Poterie, although the lower part of the zone is very probably missing in the latter diagram. At Silly-la-Poterie, *Corylus* pollen values remain dominant in zone 7, whereas at la Voise, *Quercus* increases more considerably and becomes the dominant pollen type in the upper part of the zone. In both diagrams *Tilia* and *Fraxinus* show continuous curves in the upper part of the zone. It is likely that at Chivres the upper part of zone 7 and the lower part of zone 8 are missing. This is suggested by the sudden appearance of *Tilia* and *Fraxinus* in spectrum 22; the section with low, but continuous pollen values for these trees is not represented at Chivres. At Coizard-Joches I, *Pinus* values remain relatively high in zone 7; at Coizard-Joches II, the picture is less clear because of the anomalously low *Pinus* percentage in spectrum 36.

One may conclude that apart from local and/or regional differences, our pollen zone 7 provides a rather consistent picture. The zone 7/8 border is dated to c. 4900 B.C. (3.2.2.7.). The lower border of zone 7 has an inferred date of c. 6800 B.C. (3.2.2.6.). Consequently, zone 7 covers the whole of the Boreal (Godwin's zones V and VI) and the lower part of the Atlantic (Godwin's zone VIIa), which latter period is dated from c. 5500 to c. 3000 B.C.

6.3.2. *The vegetation*

During zone 7 time, pine-dominated forest was at least partly replaced by deciduous forest, in which oak and elm must have played a predominant part. The high *Corylus* pollen percentages suggest that hazel must also have been a common constituent of the deciduous forest. In the final stages of zone 7, *Tilia* and *Fraxinus* established themselves in the deciduous forest, but for the time being these species were of less importance. Pine forest or perhaps mixed pine-oak forest was probably found on poorer soils. *Betula* may hardly have occurred any more on the higher soils, but just as *Salix* this tree was probably confined to low-lying, marshy places. It is striking that at la Voise, with the highest oak pollen percentages, *Hedera* is well represented in zone 7. In the other pollen diagrams under discussion *Hedera* pollen is present in zone 7, but not as frequently as in the la Voise diagram.

A pollen assemblage similar to that of our zone 7 can be observed in various other pollen diagrams from Northern France: Marais de Long, zone VI^{E} a-b and lower part of zone VI^{E} c (Nilsson, 1960); Poigny, phase VIIa, zones a and b, 3.50-1.25 m (Jalut, 1966); Prémery, zone VI (Planchais, 1966; 1971); Rians, zones V and VI (Planchais, 1971); Bellengreville, zone VI (Elhai, 1959). In spite of the unusual course of the *Pinus* curve, the upper part of zone V and the whole of zone VI at Gizeux (Planchais, 1967; 1971) very probably correspond with our zone 7. High *Pinus* pollen values are also recorded in the presumably synchronous section of the Bellengreville diagram (Elhai, 1959). The situation at l'Archet (Jalut, 1967) is less clear, which is probably due to a hiatus at a depth of 1.65 m, at the transition from peat to clay. Zone VI at Mur-de-Sologne (Planchais, 1970; 1971) may with some reserve be correlated with our zone 7.

The pollen record demonstrates convincingly that in the period of c. 6800-4900 B.C. the forest vegetations of Northern France must have shown marked local and/or regional differences. The composition of the deciduous forest was certainly not uniform. Thus, at la Voise oak must have been by far the dominant tree, whereas the Long diagram indicates that there elm was as important as oak. Spectra 1-7 at Silly-la-Poterie suggest that during the period concerned elm and oak were probably of equal importance in the deciduous forests of the area. In some areas, such as those of la Voise, Chivres and Poigny, pine forests must have been of only minor importance, whereas the diagrams of Bellengreville, Prémery, Gizeux and Rians suggest that during the greater part of this period pine forests must have played a predominant part. Local and regional differences in soil conditions must most probably be held responsible for the differences in the vegetation.

A few pollen grains of *Plantago lanceolata* and one specimen of *Plantago major* were counted in zone 7 at la Voise. Whether these stray grains of *Plantago* could point to the presence of prehistoric (Neolithic) farmers will be discussed below (7.2.2.3.).

7. THE MIDDLE POSTGLACIAL

7.1. Introduction

The Middle Postglacial, which includes our regional pollen zones 8 and 9, covers the period from c. 4900 to c. 1300 B.C. This period is represented in the diagrams of Chivres (fig. 3), Bresles (fig. 8), Vallée de la Voise (fig. 9), Silly-la-Poterie (fig. 10) and Fréchencourt (fig. 11).

During the greater part of the Middle Postglacial, prehistoric farmers were present in the Paris Basin and in the whole of Northern France. Consequently, in the interpretation of the palynological data the possible effect of farming practices on the vegetation must be taken into account. Moreover, the well-known palynological indications of the activity of prehistoric farmers may be expected in the Middle Postglacial section of the pollen diagrams. The so-called Quercetum-mixtum diagrams are constructed (3.1.) to provide a better impression of the vegetation on the higher soils and of the effect of human activity on the vegetation: Chivres (fig.

12), Vallée de la Voise (fig. 13), Silly-la-Poterie (fig. 14), Fréchencourt (fig. 15).

In the period of c. 4900-1300 B.C., Neolithic, Early and Middle Bronze Age cultures were successively present in Northern France. For surveys of the archaeology of the area under consideration the reader is referred to volume II of La Préhistoire Française (ed. J. Guilaine, 1976). In this volume, the Neolithic of the Paris Basin and Northern France is treated by G. Bailloud, while G. Gaucher presents a survey of the Bronze Age of the area.

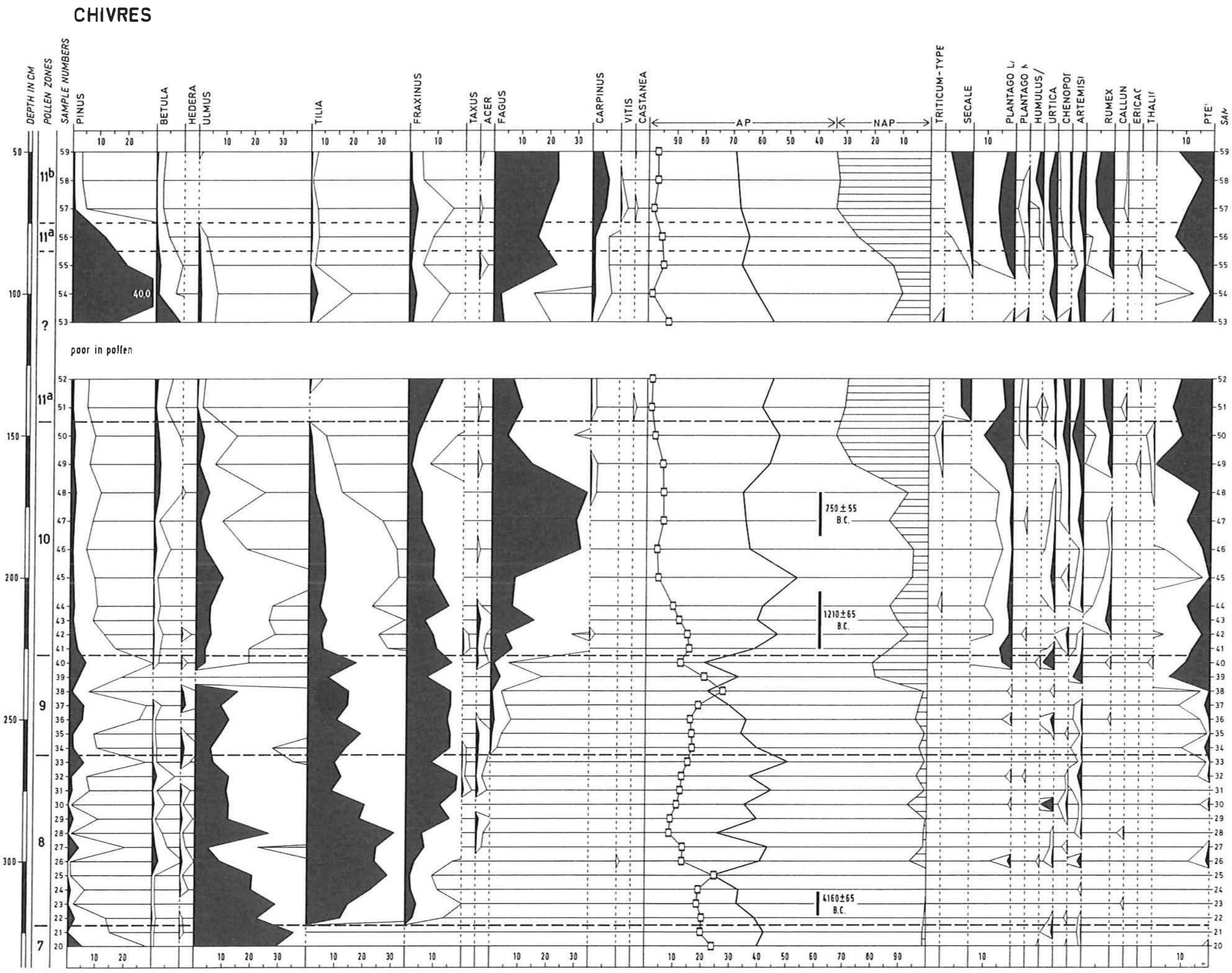
7.2. Pollen assemblage zone 8

Chivres, spectra 22-33; Bresles, spectra 19-23; Vallée de la Voise, spectra 25-36; Silly-la-Poterie, spectra 12-52; Fréchencourt, spectra 1-36.

7.2.1. *The pollen record*

Pollen assemblage zone 8 is characterized by comparatively high values for *Fraxinus*, *Tilia* and *Ulmus*, although elm pollen percentages show marked fluctuations. *Fagus* occurs only discontinuously; the upper zone border is placed at the beginning of the continuous *Fagus* curve. *Corylus*

Fig. 12. Chivres. "Quercetum-mixtum" diagram. All pollen types presented in this diagram are included in the pollen sum. The numbers of pollen grains of *Corylus*, *Pinus* and *Betula* were divided by 4 before calculation of the percentages.
Chivres. Diagramme de type "Quercetum mixtum". Tous les types de pollen présentés dans ce diagramme sont compris dans la somme de base. Les nombres de pollen de *Corylus*, *Pinus* et *Betula* ont été divisés par 4 avant le calcul des pourcentages.



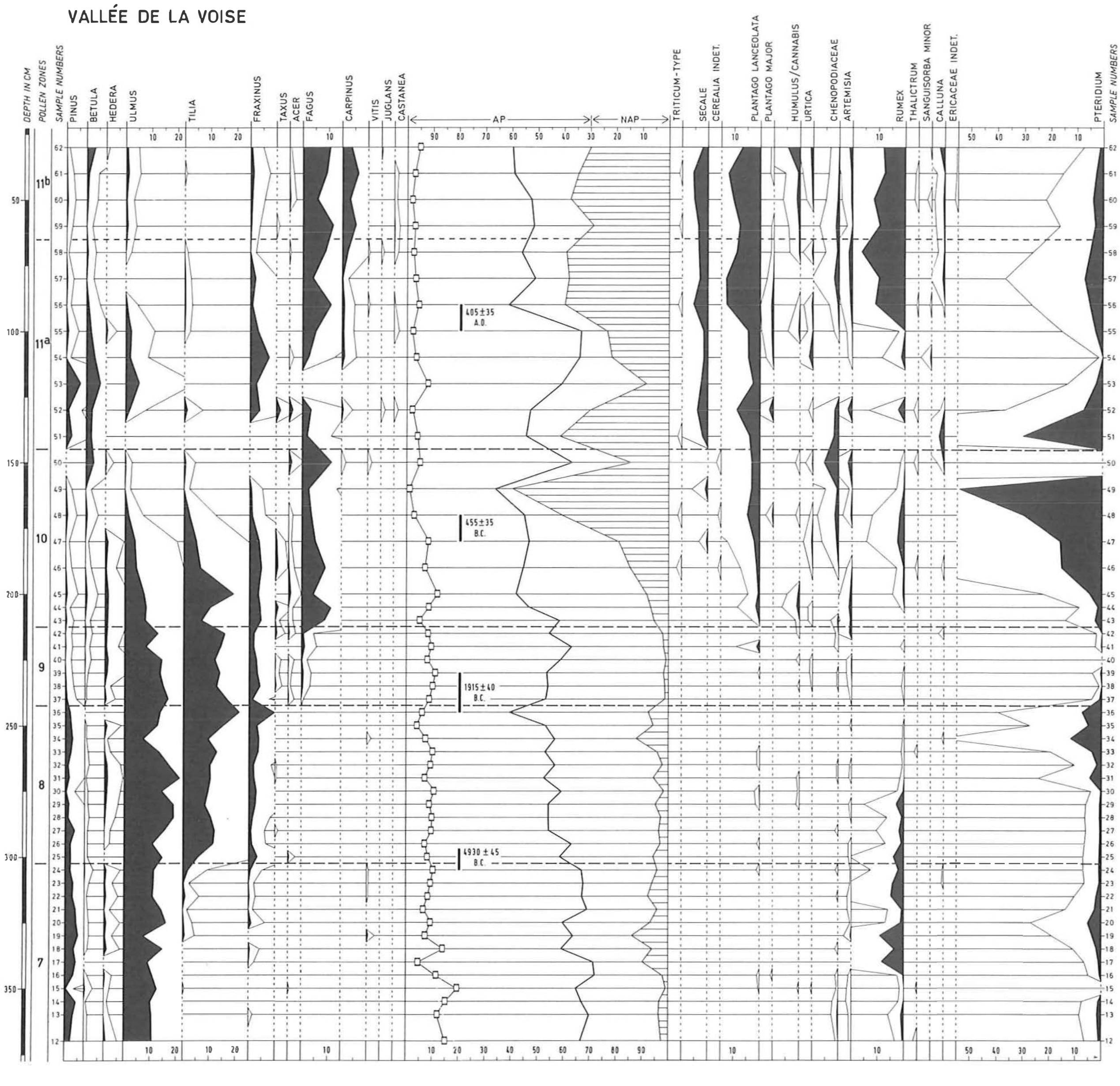


Fig. 13. Vallée de la Voise. "Quercetum-mixtum" diagram. See caption fig. 12.
Vallée de la Voise. Diagramme de type "Quercetum mixtum". Voir la légende de fig. 12.

and *Quercus* show high percentages. At Silly-la-Poterie and in particular at Fréchencourt pollen of *Acer* and *Taxus* was found quite frequently in the section attributed to zone 8. In zone 8, pollen of *Plantago lanceolata* is counted in low numbers. Zone 8 is dated from c. 4900 to c. 2000 B.C. (3.2.2.7. and 3.2.2.8.) and covers the greater part of the Atlantic (Godwin's zone VIIa) and the lower half of the Subboreal (Godwin's zone VIIb).

Pollen assemblage zone 8 is not equally well developed in the diagram sections mentioned above, and, moreover, the pollen record displays local differences. At Chivres, the lower part of the zone is probably missing. It has already been discussed (6.3.1.) that the course of the curves for *Fraxinus* and *Tilia* suggests that the upper part of zone 7 is not represented at Chivres. The radiocarbon date of 4160 ± 65 B.C. for a level just above the zone 7/8 border indicates that the beginning of zone 8 may equally not be represented in the pollen record. In the Bresles diagram only the lower part of zone 8 seems to be present. In the diagrams of Silly-la-Poterie and Fréchencourt a subdivision of zone 8 is made (see below). The subzones concerned are only of local significance.

The course of the *Alnus* curve shows conspicuous differences. Thus, at Silly *Alnus* increases rapidly at the beginning of zone 8, whereas the diagrams of Chivres and Fréchencourt show a conspicuous rise in the alder curve somewhere in the middle of the zone. At la Voise, *Alnus* pollen values do not increase markedly until at the level of the zone 8/9 transition. Consequently, at Silly the *Alnus* expansion occurred nearly 3000 years earlier than at la Voise. The behaviour of *Alnus* in Northern France will come up for discussion in section 7.4.4.

7.2.1.1. Silly-la-Poterie

The subdivision is primarily based upon the course of the *Ulmus* curve. *Subzone 8a* (spectra 12-22) shows comparatively high values for *Ulmus* and *Tilia*. *Alnus* rises conspicuously in the lower part of this subzone. In *subzone 8b* (spectra 23-38) *Ulmus* values are considerably lower than in subzone 8a, while *Tilia* percentages are likewise somewhat lower. *Subzone 8c* (spectra 39-52) shows again higher values for *Ulmus* and *Tilia*. *Fraxinus* percentages are distinctly higher than in the other subzones.

7.2.1.2. Fréchencourt

Here again the subdivision of pollen assemblage zone 8 is mainly determined by the fluctuations in the *Ulmus* curve. *Subzone 8a* (spectra 1-5) shows high values for *Ulmus* and particularly for *Tilia*. *Fraxinus* percentages, on the other hand, are still comparatively low. In *subzone 8b* (spectra 6-18) *Ulmus* values decrease to a minimum in the upper part of the subzone. The *Tilia* curve shows a similar behaviour, but the values remain higher than those of *Ulmus*. *Fraxinus* percentages fluctuate, but are distinctly higher than in the previous subzone. *Subzone 8c* (spectra 19-30) shows again higher *Ulmus* percentages. *Alnus* increases notably in the lower part of this subzone. In *subzone 8d* (spectra 31-36) *Ulmus* and *Tilia* are lower than in subzone 8c. *Fraxinus*, on the other hand, is much better represented than in the other sections of zone 8.

7.2.2. *The vegetation*

Pollen zone 8 (c. 4900-2000 B.C.) constitutes the period of the fully developed deciduous forest in which, however, *Fagus* did not yet occur or was at most scarcely represented. The main constituents of the deciduous forest were *Quercus*, *Ulmus*, *Fraxinus*, *Tilia* and *Corylus*, while at least regionally *Taxus* and *Acer* must have played a rather prominent role (Silly-la-Poterie, Fréchencourt). It is self-evident that the composition of the upland forest, that is the proportion of the various tree species, varied depending on the soil conditions.

Particularly the curves for *Ulmus* and *Tilia* show fluctuations in zone 8. Besides, pollen of *Plantago lanceolata* and *Triticum* is found in this section, which could point to the activity of prehistoric (Neolithic) farmers. One wonders as to how far changes in the pollen percentages for elm, linden and other trees could have been due to the interference of early man with the vegetation. To that end some special attention will be paid to palynological and archaeological indications of the presence of prehistoric farmers in the area under consideration.

In Postglacial pollen diagrams from temperate Europe, *Plantago lanceolata* and *Plantago major* are generally considered as indicators of the activity of prehistoric farmers. These species, which had disappeared from temperate Europe as a result of the closing of the forest in the early Postglacial, and which were re-introduced to Europe by prehistoric man, found suitable habitats in the forest clearings made by the Neolithic farmers. However, some of the *Plantago* pollen grains counted in the Postglacial sections of the pollen diagrams under discussion cannot possibly be ascribed to the activity of early farmers. The grains of *P. lanceolata* and *P. major* counted in samples 11, 13 and 14 at Chivres (zone 5) could indicate that after the Late-glacial these species had been able to maintain themselves in the pine forests of the early Postglacial. In any case there can have been no question of farming activities during zone 5 time (c. 8300-7500 B.C.). The same applies to both *P. major* pollen grains

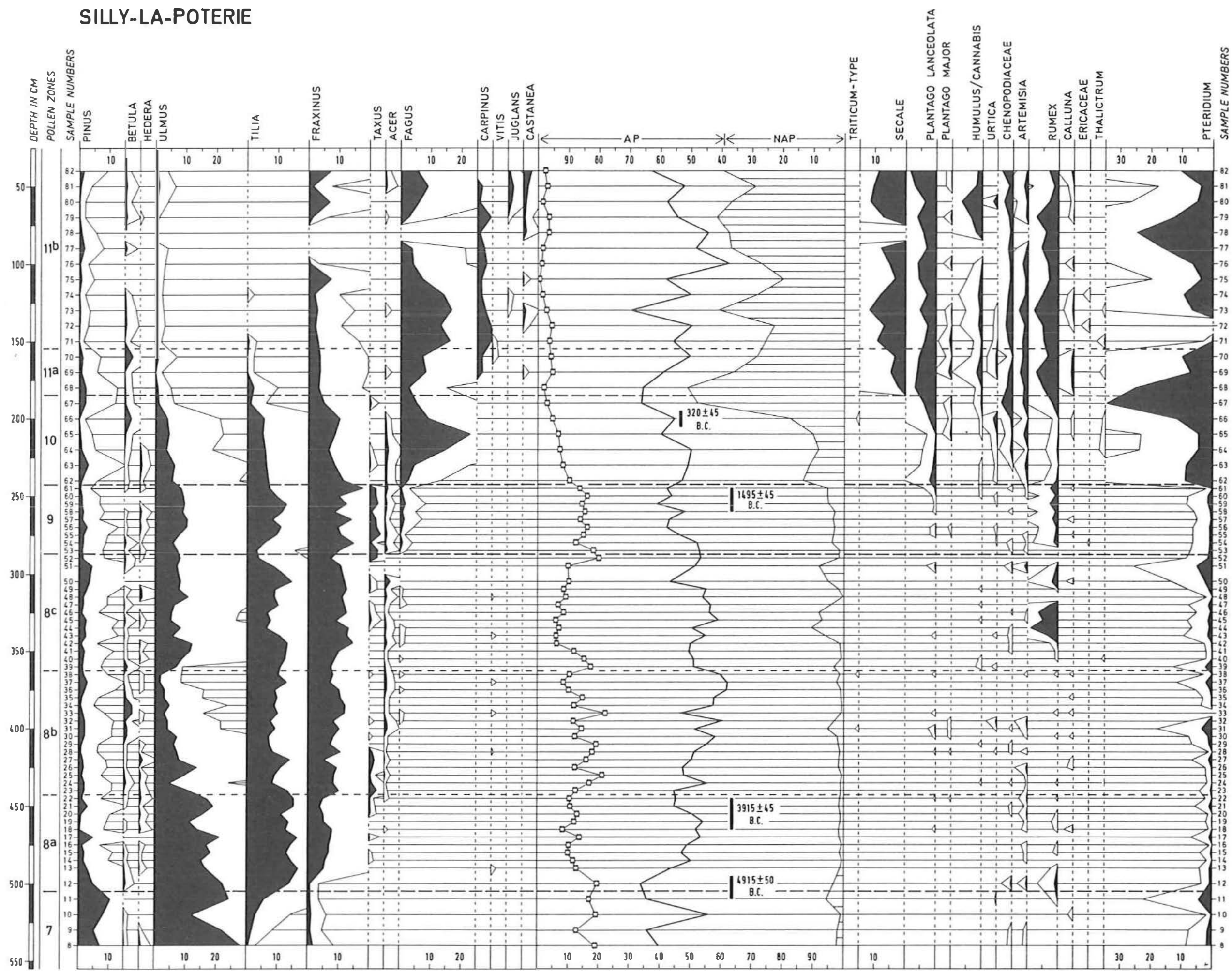


Fig. 14. Silly-la-Poterie. "Quercetum-mixtum" diagram. See caption fig. 12.
Silly-la-Poterie. Diagramme de type "Quercetum mixtum". Voir la légende de fig. 12.

counted in zone 5 at Coizard-Joches I.

A few pollen grains of *Plantago* occur in zone 7 of the la Voise diagram, at levels from before 4900 B.C. These grains can equally not be ascribed to the activity of prehistoric farmers. At least there is absolutely no archaeological evidence of prehistoric farmers before 5000 B.C. in the Paris Basin or in the whole of Northern France. At la Voise it is doubtful whether plantain formed part of the vegetation. A contamination during the coring operation or the sample preparation seems more likely. Be this as it may, the above should be a warning not to over-emphasize the significance of a single *Plantago* pollen grain with regard to prehistoric farming.

7.2.2.1. *Silly-la-Poterie*

The fluctuations in the *Ulmus* curve on which the subdivision of zone 8 is based (7.2.1.1.) show up clearly in the Quercetum-mixtum diagram (fig. 14). On the other hand, the changes in the *Tilia* percentages, viz. the lower values in subzone 8b, are less pronounced than in the other Silly-la-Poterie diagram. From the Quercetum mixtum diagram it appears once again that during zone 8 time, in addition to *Quercus*, *Tilia* and *Ulmus* must have played an important part in the upland forest, although the proportion of the latter tree underwent marked changes. *Taxus* and *Acer*, which are both under-represented in the pollen record, must likewise have been rather common constituents of the deciduous forest. If *Fagus* was already present in the area during the second half of zone 8 time, its share in the vegetation must have been negligible. On the other hand, *Hedera* was certainly a common species. *Fraxinus* may have been present particularly in the wettest parts of the upland forest and in river and stream valleys. At Silly-la-Poterie, the increase in *Fraxinus* at the beginning of the zone is accompanied by the rapid expansion of *Alnus* which is likewise a tree of wet and marshy habitats. A synchronous expansion of ash and alder is not recorded in the other pollen diagrams from the Paris Basin, so that this must have been a local coincidence. The increase in *Fraxinus* seems to have been more or less synchronous over a large region, whereas in the Paris Basin and in the whole of Northern France the conspicuous expansion of *Alnus* was definitely not synchronous (see 7.4.4.).

As for palynological indications of the activity of prehistoric man at Silly-la-Poterie, the following should be mentioned. A few pollen grains of *Plantago lanceolata* and one of *P. major* were recorded in subzone 8a (spectra 18 and 22). If these pollen grains were due to human activity, the regional group of the *Bandkeramik* culture (*culture à céramique rubanée*) should come into consideration. It is true that these possible indications of the presence of prehistoric farmers are from before and around 4000 B.C., which is too early in view of the generally accepted dating of the Danubian in the Paris Basin, viz. the first centuries of the 4th millennium B.C. However, the radiocarbon date of 4540 ± 160 B.C. for the *Bandkeramik* site of Longrais in Calvados (Edeine, 1972) could indicate that this culture had expanded over Northern France well before 4000 B.C. Consequently, one may not exclude the possibility that the plantain pollen grains in subzone 8a at Silly reflect the activity of farmers of the *Bandkeramik* culture.

The stray grains of both *Plantago* species and the two *Triticum* pollen grains (spectra 31 and 38) in subzones 8b and 8c may be ascribed to the farmers of the Middle and Late Neolithic cultures established for the Paris Basin. It is striking that indisputable palynological indications of the presence of Neolithic farmers in the area of Silly-la-Poterie are rather meagre. This may seem in contradiction with the archaeological evidence; particularly for the Middle and Late Neolithic a great number of sites is reported for the Paris Basin (Bailloud, 1976). It is conceivable that the immediate vicinity of Silly-la-Poterie was not attractive to prehistoric farmers. On the other hand, it is equally possible, and even more likely, that the kind of land occupation exercised by these farmers did not result in large clearings. If the Neolithic farmers in the area around Silly-la-Poterie practised the type of *landnam* described by Troels-Smith (1953, 1955), only very small numbers of *Plantago* pollen may be expected. In this case a small forest area was cleared in order to obtain arable land. For the domestic animals little or no pasture land was available. The livestock would have been allowed to graze on the open places around the settlement and probably also in the forest. The foliage of various deciduous trees must have constituted an important animal fodder.

As has already been mentioned more than once, the *Ulmus* curve shows some conspicuous fluctuations in zone 8. Troels-Smith (1953, 1955) has advocated the view that 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 farming culture appear, has to be ascribed to the interference of Neolithic man. This leads us to the question whether perhaps the gradual decrease of elm in subzone 8b could be due to the activities of prehistoric man, or more correctly, whether there is a correlation between the course of the *Ulmus* curve and the occurrence of culture indicators, such as *Plantago*. In the lower part of subzone 8b, in spectra 28-32, palynological indications of the presence of prehistoric farmers are comparatively strong. In this section not only *Plantago lanceolata* and *P. major* are present fairly regularly, but pollen of *Urtica*, Chenopodiaceae and *Artemisia* was also found in somewhat greater frequencies than in the upper part of the subzone. It should be admitted that low *Artemisia* percentages are in themselves not indicative of human activity, but the combination of herbaceous pollen types in spectra 28-32 may be considered as good evidence of prehistoric farmers. Consequently, for the lower part of subzone 8b a correlation between elm decline and human activity could be assumed. However, the upper part of subzone 8b does not show a recovery of the elm pollen percentages, although the pollen record suggests much less human activity than in the lower part of the subzone. On the other hand, *Ulmus* does recover quite rapidly at the beginning of subzone 8c, but no obvious differences can be observed in the frequencies of culture indicators in the upper part of subzone 8b and in the lower part of subzone 8c. This invalidates in no small measure the hypothesis of human interference as the explanation for the decrease of *Ulmus*. Although it cannot be ruled out that in one way or another the elm decline in subzone 8b was brought about by prehistoric man, for the time being another cause for the decline and subsequent recovery of *Ulmus* at Silly-la-Poterie seems more likely.

7.2.2.2. Chivres

The lower part of pollen zone 8 is not represented at Chivres. The sudden appearance of *Tilia* and *Fraxinus* in spectrum 22 points to a hiatus in the sediment and in the pollen record between spectra 21 and 22. Although the *Ulmus* curve shows some fluctuations no subdivision of zone 8 has been made. In the lower three spectra of the zone, *Ulmus* values are higher than in the rest of the zone, this with the exception of the elm peak in spectrum 27. At Silly-la-Poterie, in the lower part of zone 8 (subzone 8a) elm pollen values are likewise higher than in the succeeding subzones. In comparing pollen zones 8 at Chivres and Silly-la-Poterie one should take into consideration that the latter site provides a much more detailed record. At Silly-la-Poterie the sedimentation rate was much higher than at Chivres and in addition to the hiatus at the zone 7/8 transition, more gaps may occur in the Chivres sediment section covering zone 8.

The forest vegetations in the Chivres area would not have differed essentially from those in the vicinity of Silly-la-Poterie. Again, *Quercus*, *Ulmus*, *Tilia* and *Fraxinus* must have played an important part in the upland forest. *Acer* and *Hedera* must likewise have been common constituents of the forest vegetation, but it seems that *Taxus* was less frequent than at Silly-la-Poterie. *Fagus* is conspicuously absent in zone 8 at Chivres, which supports the conclusion arrived at for Silly-la-Poterie that beech was at most a rare constituent of the forest of zone 8 time.

The relatively high value for *Plantago lanceolata* in spectrum 26 makes one wonder whether this could indicate that the type of land occupation described by Iversen (1941) had been practised in the Chivres area. With this *landnam* type a rather large area was cleared. On a small part of the clearing crops were cultivated, whereas the rest would have been used as grazing land for the domestic animals. The small plantain peak coincides with a conspicuous minimum in the *Ulmus* curve suggesting that the elm decline had been brought about by the activity of the prehistoric farmers. The level of spectrum 26 cannot be dated at all accurately. For that reason it is not possible to determine the cultural affinity of the farmers concerned (late *Bandkeramik*, Cerny culture, Chasséen?). It should be emphasized that the evidende for the Iversen type land occupation at the level of spectrum 26 is not particularly strong, implying that it must be considered with some reserve. Palynological indications of farming activity in the upper part of the zone remain confined to a few stray grains of *Plantago*. This picture compares well with that of zone 8 at Silly-la-Poterie and needs no further discussion.

7.2.2.3. Vallée de la Voise

At la Voise, pollen assemblage zone 8 which covers about 3000 years is only 55 cm thick. This implies that either the accumulation rate was very low or that one or more gaps in the sediment occur, although there is no palynological evidence for interruptions in the pollen record.

The upland forest vegetation must largely have been comparable to that in the vicinity of Silly and Chivres during zone 8 time. There are, however, a few differences. Thus at la Voise, *Fraxinus* seems to have played a less prominent role and, moreover, *Taxus* and *Acer* are hardly represented. During zone 8 time, *Alnus* did not expand in the la Voise area.

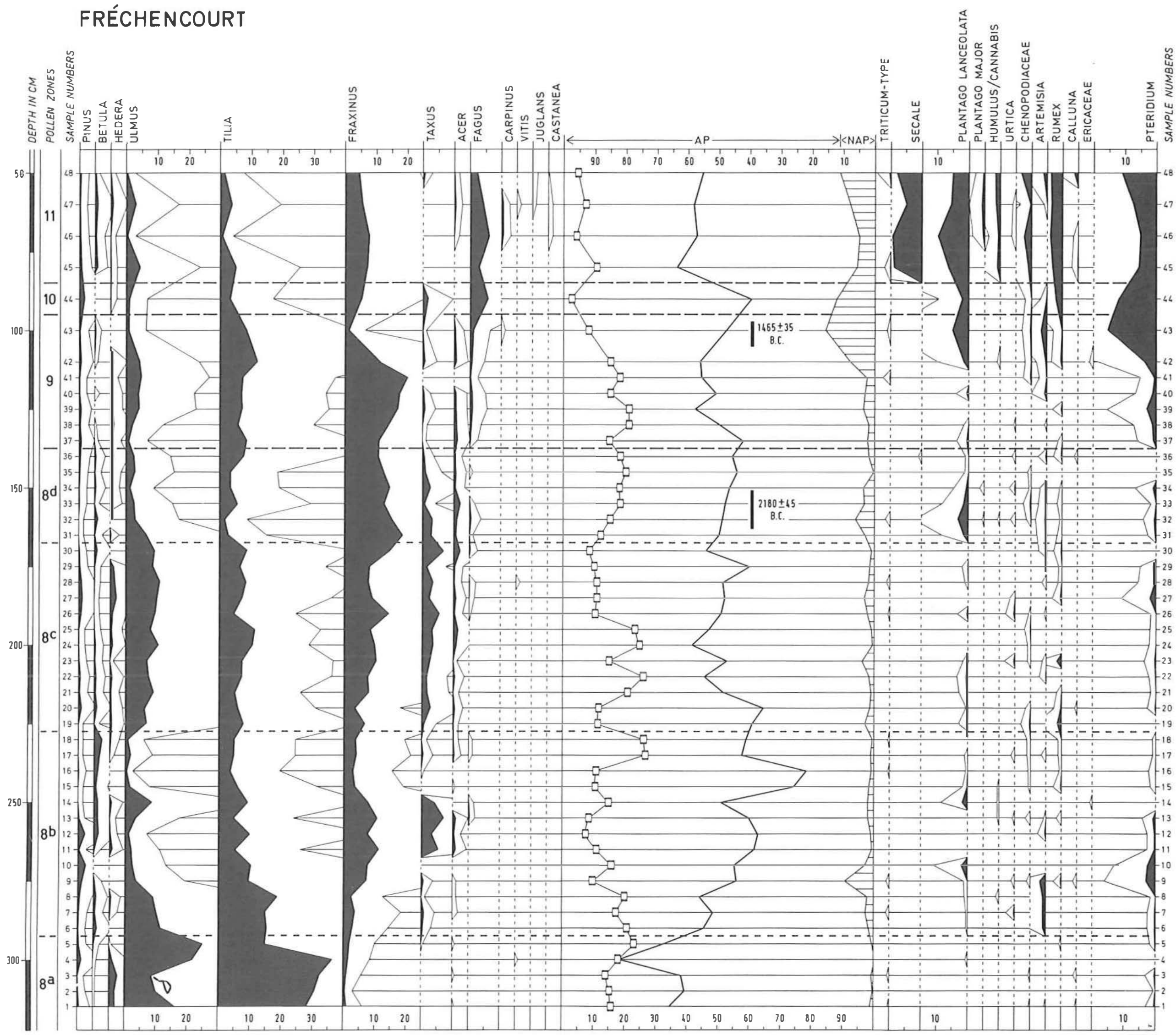
The *Plantago* pollen grain in spectrum 24 (the upper spectrum of zone 7) is difficult to explain in terms of human interference with the vegetation. At least the radiocarbon date of 4930 B.C. for the level of spectrum 24 excludes the possible presence of prehistoric farmers who did not arrive in the Paris Basin until the second half of the fifth millennium B.C. at the earliest (see 7.2.2.1.). The same may be true for the single plantain pollen grain found in sample 26. It should be remembered that already in samples 15 and 16 of the la Voise diagram a few plantain pollen grains were counted (see 6.3.2.), suggesting that in Postglacial pollen diagrams from the Paris Basin one or a few stray grains of *Plantago* are not necessarily due to the activity of prehistoric farmers. It must be left undecided whether *Plantago* occurred here already before the arrival of Neolithic farmers or whether the pollen grains concerned must be ascribed to contamination or long-distance transport.

The absence of *Plantago* in the upper part of zone 8 and in the lower part of zone 9 corresponds with the fact that remains of the late-Neolithic Seine-Oise-Marne culture are not reported for the la Voise area (Bailloud, 1976). It is striking that other possible culture indicators are likewise not or scarcely represented in the section concerned.

7.2.2.4. *Fréchencourt*

Assuming a correct interpretation, pollen assemblage zone 8 at Fréchencourt covers about 1.80 m of sediment. As at Silly-la-Poterie, the pollen record suggests distinct fluctuations in the composition of the upland forest during the time period

Fig. 15. Fréchencourt. "Quercetum-mixtum" diagram. See caption fig. 12.
Fréchencourt. Diagramme de type "Quercetum mixtum". Voir la légende de fig. 12.



concerned. The main constituents of the upland forest in the Fréchencourt area were the same as those in the other areas discussed above. *Taxus* seems to have played a very prominent role in the Fréchencourt area, and during the upper part of the zone *Fagus* may actually have been present here.

The extraordinarily high *Tilia* pollen percentages in subzone 8a may indicate that at the time linden occurred at a short distance from the coring locality. Later, when peat formation in the valley expanded laterally, the *Tilia* pollen source came to lie at a greater distance. Locally high *Tilia* pollen values are more often observed in peat deposits at the edge of the higher soils.

Most striking in the Fréchencourt diagram are the distinct indications of the activity of Neolithic farmers. The maxima for *Plantago lanceolata* in spectra 10 and 14 very clearly point to rather large-scale forest-clearing operations; in other words, to the kind of land occupation described by Iversen (1941). The comparatively high plantain pollen percentages in spectra 19-23 may likewise point to farmers who practised the Iversen-type *landnam*. The reaction of *Ulmus* and possibly of other trees to the farming activities reflected in subzones 8b and 8c is not consistent. The elm decline in the lower spectra of subzone 8b correlates fairly well with the presence of *Plantago* in spectra 6-10. After a partial recovery in spectra 13 and 14, elm values decrease again which seems to be connected with plantain in spectra 14-17. However, no reaction of *Ulmus* to the continuous *Plantago lanceolata* curve in spectra 19-23 can be observed. Although *Corylus* shows fluctuations in subzones 8b and 8c, a possible connection with the *Plantago* curve is difficult to discover.

From the above it is clear that the pollen record of subzones 8b and 8c indicates that during the time period concerned prehistoric man must have been rather active in the Fréchencourt area. No exact dating can be given for the period covered by subzones 8b and 8c, but c. 4000-2500 B.C. may be a fair estimate. This implies that the farmers whose activities are reflected in the above-mentioned section of the pollen diagram must be placed in the Early Neolithic (*Bandkeramik* culture) and Middle Neolithic (Cerny culture, Chasséen). Archaeological information on Early and Middle Neolithic habitation of the Somme valley is very scarce. Only a few Early and Middle Neolithic finds are reported for the Somme valley; this is more likely due to inadequate archaeological research than to a near-absence of prehistoric habitation. The Fréchencourt diagram demonstrates that in Early and Middle Neolithic times an Iversen-type land occupation was practised.

Subzone 8d, which can roughly be dated to 2500-2000 B.C., shows comparatively high values for *Plantago lanceolata*, whereas *Ulmus*, *Tilia* and *Taxus* decline at the beginning of the subzone. It is tempting to connect these indications of rather intensive interference of prehistoric man with the vegetation with the Seine-Oise-Marne culture. This Late Neolithic culture, which is dated to c. 2500-1600/1700 B.C., largely coincides with subzone 8d. The S-O-M culture must have been common in the Somme valley according to Bailloud (1976), although no actual sites are mentioned for this area.

7.2.2.5. Bresles

The pollen record of zone 8 at Bresles does not give rise to any particular comments.

7.3. Pollen assemblage zone 9

Chivres, spectra 34-40; Vallée de la Voise, spectra 37-42; Silly-la-Poterie, spectra 53-61; Fréchencourt, spectra 37-43.

7.3.1. The pollen record

Pollen assemblage zone 9 is characterized by a low but continuous *Fagus* curve. The four diagrams mentioned above do not show conspicuous differences as far as regional taxa are concerned. At la Voise, *Alnus* rises sharply at the beginning of the zone. In the other diagrams alder pollen values are already high at the zone 8/9 transition. Pollen zone 9, which is dated from c. 2000 to c. 1300 B.C. (3.2.2.8., 3.2.2.9.), includes the final phases of the Late Neolithic Seine-Oise-Marne culture, the Early and the Middle Bronze Age.

7.3.2. The vegetation

During zone 9 time, the composition of the upland forest may not have differed much from that in (the later phases of) the previous period, except that now

Fagus is present, although only in low numbers. At Fréchencourt the proportion of *Taxus* in the forest vegetation was smaller than during zone 8 time, whereas at la Voise and Silly-la-Poterie the reverse is suggested by the pollen record. In the area of Silly-la-Poterie, *Taxus* reached its greatest expansion during zone 9, while at la Voise it was not until the beginning of zone 9 that this tree occurred regularly in the area. *Hedera* could maintain itself during zone 9. Everywhere *Alnus* must have occupied stream valleys and other marshy places.

As for indications of human activity in pollen zone 9, the following should be remarked. At Silly-la-Poterie, *Plantago lanceolata* is somewhat better represented than in zone 8. This may at least in part be ascribed to Early Bronze Age farmers. Although the Early Bronze Age in the Paris Basin and in the whole of Northern France is poorly known, a few sites are reported for the region to the east of Silly-la-Poterie. The distinct rise in the *Plantago lanceolata* and *Pteridium* curves at the zone 9/10 transition may mark the arrival of the Late Bronze immigrants (Gaucher, 1976). At Chivres, indications of farming activities during zone 9 time are not particularly strong, except for the conspicuous increase in *Plantago lanceolata* and *Pteridium* at the end of the zone, which, again, may probably be related to Late Bronze Age habitation of the area.

In zone 9 of the la Voise diagram, culture indicators occur in only low numbers, suggesting that during the final phases of the Neolithic and the Early and Middle Bronze Age, the area was only scarcely inhabited. At Fréchencourt, the lower spectra of zone 9 may reflect the presence of people of the Seine-Oise-Marne culture (cf. 7.2.2.4.). It is also possible that farmers of the Bell Beaker culture, which is found in the north of France, for example in the Somme valley, must be held responsible for the *Plantago* in the lower part of the zone. It is striking that the conspicuous increase in *Plantago*, which is again accompanied by a marked rise in the *Pteridium* curve, takes place well before the zone 9/10 border. This would imply that in the Fréchencourt area the intensive interference of man with the vegetation started at an earlier date than in the areas of Chivres and Silly-la-Poterie. In this case the beginning of the greatly increased agricultural activities would not correspond with the arrival of Late Bronze Age immigrants. One could hypothesize that at Fréchencourt the first increase in *Fagus* took place at a later date than in the other areas, implying that here the zone 9/10 border would lie chronostratigraphically above that in the other diagrams. However, this cannot be true because for the upper part of zone 9 a radiocarbon date of 1465 ± 35 B.C. was obtained. This date suggests that at Fréchencourt the increased farming activities started already in the Middle Bronze Age, if not earlier.

7.4. Comparison with other pollen diagrams

7.4.1. *The Middle Postglacial in other diagrams*

In various other pollen diagrams from Northern France a section which compares fairly well with our zones 8 and 9 can be observed:

Marais de l'Erdre, Petit-Mars (Planchais, 1971), 8.10-3.60 m; the abrupt increase in *Tilia* suggests a hiatus at the level of 8.10 m.

Rians (Planchais, 1971), 1.30-0.60 m (Planchais' zone VIIa); because of a hiatus in the sedimentation our zone 9 and probably a part of zone 8 are not represented at Rians.

Mur-de-Sologne (Planchais, 1970; 1971), 2.80 m (Planchais' zone VI/VIIa border)-1.80 m; Planchais' zone VIIa/VIIb border corresponds with our zone 8/9 transition.

Marais de Long (Nilsson, 1960), 3.80-0.85 m (slight increase in *Fagus*).

Tourbière de l'Archet (Jalut, 1967), 1.60-1.25 m; the sudden, sharp increase in *Fagus* at the level of 1.25 m suggests a hiatus in the sedimentation.

Marais Vernier (Elhai, 1959), 5.80-2.90 m.

Bellengreville (Elhai, 1959), 3.80-0.60 m; the section corresponding with our pollen zone 9 is very probably not present at Bellengreville.

In other pollen diagrams the section covering the period of approximately 4900 to 1300 B.C. shows less similarity with our pollen assemblage zones 8 and 9. Sometimes it is difficult to establish with any degree of certainty which section represents the period of c. 4900-1300 B.C.

7.4.2. *The vegetation*

The picture provided by the pollen diagrams which form part of this study on the development of the upland vegetation in Middle Postglacial times (c. 4900-1300 B.C.) is confirmed by the other diagrams from Northern France. As may be expected local or regional differences in the vegetation become more evident if the pollen record from a greater number of sites is included in the discussion. Thus, it seems that in the vicinity of l'Archet and Marais Vernier *Fraxinus* was hardly present. At Long, *Fraxinus* must have appeared rather late, assuming that the section of 3.80-0.85 m does indeed correspond with our zones 8 and 9. On the other hand, the Fréchencourt diagram, at a distance of 35 km from that of Long, indicates that here from a much earlier date on ash must have been a common tree. Differences in the upland vegetation in the vicinity of Fréchencourt and Long are also suggested by the *Pinus* pollen percentages. At Fréchencourt pine pollen values are very low, indicating that this tree did not occur in the area. On the other hand, *Pinus* values of 20% and more in the section of 3.80-2.40 m at Long suggest that pine was found at not too great a distance from the coring site during the period concerned. At Bellengreville, too, *Pinus* could very probably maintain itself to some extent after c. 5000 B.C., but finally this tree must have disappeared from the upland forest.

7.4.3. *Indications of human activity*

The pollen diagrams of Chivres, la Voise, Silly and Fréchencourt show differences in the frequencies of *Plantago lanceolata* and other culture indicators in the section covering the period of c. 4900-1300 B.C. The Fréchencourt diagram reflects the most distinct indications of the activity of Neolithic farmers.

The diagrams enumerated in 7.4.1. show similar differences as far as culture indicators are concerned. Stray grains of *Plantago lanceolata* are observed in the diagrams of Rians, Mur-de-Sologne, l'Archet and Long. The diagrams of Bellengreville and Petit-Mars show a few low *Plantago* maxima, suggesting an Iversen-type land occupation. The plantain peak at the level of 3.20 m at Marais Vernier may be due to Bronze Age farmers. The rather weak indications of the activity of Neolithic man in the Long diagram are in contrast to the comparatively frequent occurrence of *Plantago lanceolata* at Fréchencourt. This seems to point to differences in agricultural practices in areas not very far apart.

7.4.4. *The rise in the Alnus curve*

In most areas of Western and Central Europe the marked rise in the *Alnus* curve, which is usually accompanied by a pronounced decline in *Pinus* percentages, seems to be a synchronous phenomenon which is one of the criteria for defining the Boreal/Atlantic transition, the zone VI/VIIa border (c. 5500 B.C.). However, radiocarbon measurements demonstrate that in Atlantic Western Europe, the expansion of alder may have taken place at a much later date and that, moreover, this was not a synchronous phenomenon. Very striking are the differences in the age determinations for the increase in *Alnus* pollen percentages in Great Britain and Ireland (cf. Smith & Pilcher, 1973). In pollen diagrams from the British Isles the radiocarbon dates for the increase in *Alnus* range from c. 5600 B.C. to c. 3600 B.C.

These differences in the date of the alder expansion are not confined to the British Isles. In the pollen diagram prepared for the Tourbière de Saint-Michel-de-Brasparts in Brittany, it is not until the level radiocarbon dated to 3450 B.C. that *Alnus* reaches values of more than 10% (van Zeist, 1964). The diagram of Marais Vernier shows low *Alnus* values in the greater part of the section assigned to the Atlantic (zone VIIa), which according to Elhai (1959) would be due to the brackish environment of the area during the period concerned.

For four diagrams which are the subject of this study an estimated date of the *Alnus* rise is presented:

Silly-la-Poterie	c. 4700 B.C.
Chivres	c. 4000 B.C.
Fréchencourt	c. 3500 B.C.
Vallée de la Voise	c. 1900 B.C.

From these inferred dates it is evident that also in the Paris Basin the expansion of alder was by no means a synchronous phenomenon. One is inclined to ascribe the conspicuous time differences in the *Alnus* increase to local factors, although at present it is not possible to specify which factors could have been concerned.

8. THE UPPER POSTGLACIAL

8.1. Introduction

The Upper Postglacial includes our regional pollen zones 10 and 11 and covers the period after c. 1300 B.C. This period is represented in the diagrams of Chivres (figs. 3 and 12), Coizard-Joches I (fig. 4), Vallée de la Voise (figs. 9 and 13), Silly-la-Poterie (figs. 10 and 14) and Fréchencourt (figs. 11 and 15). At least the last few centuries but perhaps more are not covered by any of the diagrams mentioned above.

The Upper Postglacial is the period of increasing interference of prehistoric and early-historical farmers with the vegetation. It must be borne in mind that the natural development of the vegetation as a result of changes in climate and soil conditions may have been counteracted to a great extent by the influence of man. It may often be impossible to determine whether changes in the vegetation were brought about by natural environmental factors or whether they were the result of the activity of man.

The Late Bronze Age, which is dated from c. 1200 to c. 700 B.C., coincides with the lower half of pollen assemblage zone 10. For a survey of the Late Bronze Age in the Paris Basin and in the north of France the reader is referred to Gaucher (1976). The Iron Age (Hallstatt and La Tène) in the same area is treated by Duval & Buchsenschutz (1976).

8.2. Pollen assemblage zone 10

Chivres, spectra 41-50; Vallée de la Voise, spectra 43-50; Silly-la-Poterie, spectra 62-67; Fréchencourt, spectrum 44.

8.2.1. *The pollen record*

Pollen assemblage zone 10 is characterized by comparatively high values for *Fagus*, whereas *Ulmus*, *Tilia* and *Corylus* show a decline. Herbaceous pollen values are generally higher than in pollen zone 9 and increase conspicuously in the upper part of the zone. The zone 10/11 border which is placed at the beginning of the continuous *Secale* curve has an inferred date of 200 B.C. (3.2.2.10.). This zone corresponds with the final phases of the Subboreal (Godwin's zone VIIa) and the early Subatlantic (Godwin's zone VIII).

Zone 10 is not equally well developed in the pollen diagrams mentioned above. At Fréchencourt, this pollen zone would comprise only one spectrum. It has already been discussed (7.3.2.) that in the latter diagram the course of the *Fagus* curve as well as the radiocarbon date for the level of spectrum 43 indicate that the zone 9/10 transition must be placed between spectra 43 and 44, although the rise in the curves for *Plantago* and *Pteridium* may suggest a zone border between spectra 42 and 43.

At Silly-la-Poterie and Chivres, a distinct *Fagus* maximum is present in the middle section of zone 10, but similarly high beech pollen values cannot be observed in the la Voise diagram. These are no indications that a hiatus in the pollen record could be responsible for the absence of a *Fagus* maximum at la Voise.

Culture indicators, such as *Plantago lanceolata*, *Urtica*, Chenopodiaceae, *Rumex*, *Artemisia* and *Pteridium*, are quite frequent suggesting the continuous presence of prehistoric farmers in the areas concerned. Pollen zone 10 (c. 1300-200 B.C.) includes the Late Bronze Age and the greater part of the pre-Roman Iron Age (Hallstatt, La Tène I and II).

8.2.2. *The vegetation*

8.2.2.1. Chivres

Zone 10 at Chivres shows a conspicuous expansion of *Fagus*. In the middle section of the zone (spectra 46-48) beech reaches high values, suggesting that in the period concerned this tree must have become a very prominent constituent of the upland forest. The pollen record indicates that oak and beech must have been the predominant species of the forests on the higher soils. *Fagus* seems to have expanded at the expense of all other deciduous trees: *Ulmus*, *Tilia*, *Fraxinus* and *Quercus*. The marked decline of *Corylus* must be due to the fact that this shrub does not grow well in the shade of beech. In many pollen diagrams from northwestern Europe the increase in *Fagus* percentages is accompanied by a distinct fall of the *Corylus* curve. As for the natural upland vegetation pattern in the period represented by spectra 46-48, it is possible that beech and oak formed mixed forests, but it seems more likely that depending on the soil conditions oak-dominated and beech-dominated forests were present.

The forest succession described above could take place in spite of the activity of prehistoric farmers in the area. In zone 10, culture indicators show notably higher values than in the previous zone. It has already been remarked that the increase in the interference of man with the vegetation around the zone 9/10 transition, as is suggested by the pollen evidence, may have been due to the arrival of the Late Bronze Age immigrants. Although in the period covered by spectra 41-48 Late Bronze Age and early Iron Age (Hallstatt) farmers must have been quite active, beech could expand apparently without being seriously hampered by the activities of man. One could imagine that the heavy, moist soils which are preferred by beech, were not used for agricultural practices, but that the fields had been laid out on the somewhat lighter and drier soils.

The conspicuous decline in the *Fagus* curve in spectra 49 and 50 coincides with a marked increase in the percentages for *Plantago lanceolata*, Chenopodiaceae, *Artemisia*, *Rumex* and *Pteridium*. The pollen evidence suggests that now also the beech forest was cleared for farming purposes. The beginning of the exploitation of the beech-forest area may be dated to 400-500 B.C. and could consequently be related to the early La Tène culture. However, this is only speculation and does not explain anything unless a considerable increase in population can be demonstrated archaeologically for the period concerned.

8.2.2.2. Silly-la-Poterie

At Silly-la-Poterie, the vegetational development during zone 10 time must have been largely identical to that in the Chivres area discussed above (8.2.2.1.). Here, too, beech expanded at the expense of other deciduous trees. At Silly *Taxus*, which must have been a rather common constituent of the forest of zone 9 time, was seriously affected by the expansion of beech. Although *Taxus* is not a particularly light-demanding tree, it cannot maintain itself in shadowy beech (and hornbeam) forests. It looks as if in the Silly area the proportion of beech-dominated forests was somewhat smaller than at Chivres.

The decrease of *Fagus* after its maximum in spectrum 65 is, just as at Chivres, accompanied by an increase in culture indicators. *Pteridium* rises conspicuously which may indicate that a considerable area of land had been abandoned or that at least it was not used intensively.

8.2.2.3. Vallée de la Voise

The vegetation of the la Voise area during zone 10 time was unlike that at Chivres and Silly in that here *Fagus* did not become such an important tree. As is particularly clear from the "Quercetum-mixtum" diagram (fig. 13), beech shows an increase at the beginning of the zone, but no subsequent expansion is suggested by the pollen record. In this respect it is interesting that here *Taxus*, which was probably never a very common tree in the area, could maintain itself during zone 10, this in contrast to the behaviour of this tree at Silly-la-Poterie (8.2.2.2.). The continued decrease in *Ulmus*, *Tilia* and *Fraxinus* in the course of zone 10 cannot have been the direct result of an expansion of *Fagus* as was suggested for Chivres (8.2.2.1.). The influence of man must probably be held responsible for the virtual disappearance of these trees at the end of zone 10.

As at Chivres and Silly, also at la Voise higher percentages for culture indicators can be observed in the upper part of the zone suggesting an increase in human activity or at least an expansion of the deforested terrain.

8.2.2.4. Fréchencourt

Zone 10 is hardly represented at Fréchencourt. The fact that various herbaceous pollen curves show a sudden increase in the lowermost spectrum of zone 11 suggests a hiatus between spectra 44 and 45. The greater part of zone 10 and probably also a part of zone 11 are missing in the Fréchencourt pollen record.

8.3. Pollen assemblage zone 11

Chivres, spectra 51-59; Vallée de la Voise, spectra 51-62; Silly-la-Poterie, spectra 68-82; Fréchencourt, spectra 45-48; Coizard-Joches I, spectra 58-59.

8.3.1. *The pollen record*

Pollen assemblage zone 11 shows high Σ NAP values to which various herbaceous pollen types contribute. *Secale* pollen occurs in rather high frequencies. *Fagus* reaches comparatively high values. *Carpinus* shows a small but distinct increase in the course of the zone. This rise in *Carpinus* pollen values which must be dated after A.D. 400 (cf. Vallée de la Voise; fig. 9) marks the border between subzones 11a and 11b.

Pollen zone 11 is perhaps best represented at la Voise. Following low values in the lower part of the zone *Fagus* shows a distinct rise between spectra 54 and 56, although this tree does not reach similarly high percentages as at Chivres and Silly-la-Poterie. *Ulmus* and *Tilia* decrease further to become rather inconspicuous in the upper part of the zone. The decline in *Fraxinus* is somewhat less dramatic. The cultivated trees *Juglans* and *Castanea* are represented in this zone. The subzone 11a/11b border does not mark any noticeable change in the herb-pollen percentages.

At Silly-la-Poterie, subzone 11a includes only three spectra (68-70). After the comparatively low values in spectra 67-70, *Fagus* regains comparatively high percentages in the lower part of subzone 11b. It will be clear that neither the increase in *Fagus* nor the rise in *Carpinus* was synchronous at la Voise and Silly. *Juglans* and *Castanea* show comparatively high values in the upper spectra of the diagram.

It has already been mentioned that at Fréchencourt the lower part of pollen zone 11 may be missing (8.2.2.4.). The low *Carpinus* percentages suggest that the whole of subzone 11b is not represented at Fréchencourt. Consequently, only a part of subzone 11a would be shown in this diagram. Mention may be made of the noticeably high *Mercurialis* percentages at Fréchencourt.

The upper part of the Chivres diagram poses a few problems. Spectra 53-55 show anomalously high *Pinus* values. Moreover, the curves for herbaceous pollen types, such as *Secale*, *Plantago lanceolata*, Chenopodiaceae and *Rumex*, show a conspicuous decline in these spectra, which phenomenon is not matched by a similar behaviour in the other pollen diagrams discussed in this paper. It is clear that there is something wrong with spectra 53-55. Most likely the sediment of the section concerned, and consequently its pollen contents, is of mixed origin. Be this as it may, these spectra will be left out of consideration here. Thus, subzone 11a includes spectra 51, 52 and 56, while spectra 57-59 are attributed to subzone 11b.

Pollen zone 11 reflects the vegetational history after c. 200 B.C. It includes the final phases of the pre-Roman Iron Age (La Tène III), the Roman period and the Middle Ages. There are no indications that any pollen diagram presented in this paper would extend into post-medieval times.

8.3.2. *Coizard-Joches I*

The upper two spectra (58 and 59) are attributed to zone 11. *Secale*, *Carpinus* and *Juglans* show rather high pollen values in these spectra. Spectra 51-57 are not attributed to any of our pollen assemblage zones. The pollen contents of samples 51-53 suggest a mixed origin. Spectra 54-57 could possibly belong to zone 10.

8.3.3. *The vegetation*

Pollen zone 11 represents a period of seemingly uninterrupted large-scale interference of man with the vegetation. During this period the proportion of open terrain, in use as fields and as grazing land, must have been quite considerable. On the other hand, the pollen record suggests that forests must still have covered large areas.

8.3.3.1. The upland forest vegetation

It will often be difficult to determine as to how far changes in the composition of the forest were due to natural factors, such as climate and edaphic conditions, or to the activity of man. In the diagrams of Chivres and Silly, *Fagus* shows a striking recovery after the decline in the upper part of pollen zone 10. To explain this decrease in *Fagus* pollen percentages it is assumed (8.2.2.1.) that from that time on also beech-dominated forest was being cleared for agricultural purposes. The rise in the beech curve in zone 11 does not necessarily imply that beech-forest areas were given up as farming land. It is more likely that as a result of an increase in humidity and perhaps also of the acidification of the soil, conditions for beech had become more favourable, in consequence of which the proportion of *Fagus* in the remaining forests increased. In addition to beech, *Carpinus* was able to expand to some extent. The expansion of beech would certainly not have been favoured by man. On the contrary, beech was of much less economic value than oak which tree yields excellent building timber and produces valuable food (acorns) for pigs. Moreover, the bark of oak was indispensable for tanning. One wonders whether the decrease in beech percentages in the upper part of zone 11b at Silly (see particularly the Quercetum-mixtum diagram, fig. 14) may be the reflection of the beginning of the intentional replacement by man of *Fagus* by *Quercus*, which would ultimately lead to the exclusive dominance of oak in most of the extant forests of the lowlands of western Europe.

8.3.3.2. The decline of alder

Alnus pollen values are low in the upper sections of the diagrams of Chivres, Silly, la Voise and Fréchencourt and one should consider the question whether the decline in alder was due to the cutting of brook forests in the stream valleys and other wet places by man or to some more natural phenomenon. In the diagrams mentioned above the decline of *Alnus* is accompanied by a conspicuous increase in Gramineae and Cyperaceae. Other marsh plant types, such as *Sparganium*, *Typha latifolia*, *Menyanthes*, *Filipendula ulmaria* and *Caltha*, show likewise comparatively high values in the upper sections of the diagrams. It is clear that the alder forest was replaced by open marsh-plant vegetations. This change in the local marsh vegetation was not a more or less synchronous phenomenon. At la Voise, a conspicuous decrease of *Alnus* pollen percentages can be observed in the upper half of zone 10; the decline in alder must have started here around 500 B.C. At Silly, it was not until the subzone 11a/11b transition, that is not until after A.D. 400, that the alder forests gave way to open marsh vegetations. The decrease in *Alnus* at Fréchencourt must have proceeded gradually in the course of zone 9, in the period of ca. 2000-1300 B.C. Chivres shows likewise a more gradual decline in *Alnus*; alder pollen values decrease, with some interruptions, in the section between spectra 38 and 50, that is in the period from about 1500 to 200 B.C. The differences in the behaviour of *Alnus* in the diagrams mentioned above suggest that the decrease of alder brook forest must have been due to natural factors, probably to a rise in the water-level.

8.3.3.3. Farming activities

During the whole of zone 11 time, *Secale cerale* must have been an important crop plant. However, from the pollen record it may not be concluded that other crop plant species would hardly have played a part in the economy of the inhabitants of the Paris Basin in the period concerned. No carbonized seeds and fruits have yet been reported for settlement sites in the Paris Basin to be dated to the period covered by zone 11, but palaeobotanical information from other areas in western Europe indicates that *Hordeum* (barley), *Triticum* (wheat), *Avena* (oats), *Panicum* (millet), *Papaver somniferum* (opium poppy), *Linum usitatissimum* (linseed), *Lens* (lentil), *Pisum* (pea), *Vicia faba* (celtic bean) and a few other species come into consideration for being cultivated during that time. The *Papaver* pollen in spectra 80-82 at Silly-la-Poterie could have originated from opium poppy. The relatively high percentages for the *Humulus/Cannabis* pollen type indicate that hop or hemp, or perhaps both, were grown. The stray pollen grains of the *Humulus/Cannabis*-type in other sections of the diagrams must very probably be ascribed to hop growing naturally in the alder forests.

The comparatively high values for various herbaceous pollen types suggest that in addition to the arable land which was in use for growing crops, there must have been much open terrain which was left to the domestic animals for grazing. In this connection not only herbaceous types included in the pollen sum should be considered but also other types, such as Tubuliflorae and Liguliflorae Compositae, Cruciferae, *Polygonum aviculare* and Leguminosae. The noticeably high *Mercurialis* pollen frequencies in the Fréchencourt diagram could point to the expansion of *Mercurialis perennis* in forest clearings.

Juglans and *Castanea* were very probably introduced by the Romans (the first pollen grains of these trees occur in zone 10), but the pollen record suggests that it was not until well into medieval time that walnut and sweet chestnut were cultivated on a somewhat larger scale. No period of decreased agricultural activity just after the retreat of the Romans is suggested by the pollen diagrams presented in this paper, but this may be due to the rather great sample distance of 5-10 cm. On the other hand, it seems that in early medieval times the area became more densely populated or at least more intensively exploited than during the preceding periods, including the time of Roman occupation. This is suggested by the increase in the percentages of culture indicators in the upper part of subzone 11a (la Voise) and at the base of subzone 11b (Silly, Chivres).

In the upper spectra of the diagrams no pollen of *Zea mays*, *Fagopyrum* or of any other species which have been introduced rather recently are recorded, suggesting that the last 4 to 5 centuries are not represented. It has already been mentioned (8.3.1.) that the diagram of la Voise very probably extends farthest towards modern times.

8.4. Comparison with other pollen diagrams

8.4.1. *The Upper Postglacial in other pollen diagrams*

The upper section of various other pollen diagrams from Northern France matches rather well with our pollen zones 10 and 11.

Marais de l'Erdre, *Petit-Mars* (Planchais, 1971), 3.60-0.10 m. The very high Cerealia percentages above 2.50 m must largely have been due to *Secale* pollen. The level of 2.50 m should correspond with our zone 10/11 border (c. 200 B.C.). *Juglans*, *Castanea* and *Carpinus* are only scarcely represented in this diagram. The marked increase in Cerelia pollen percentages coincides with a decrease in *Fagus* values, suggesting that beech-dominated forests were cleared for the sake of crop-plant growing. The high *Rumex* and *Plantago* pollen values point to large-scale grazing. *Alnus* shows a conspicuous recovery in the upper part of the diagram succeeded by another decline.

Melleray-la-Vallée (Corillion & Planchais, 1963; Planchais, 1971). Already in the lower spectra of Melleray-la-Vallée *Fagus* shows fairly high pollen values, suggesting that the whole of this diagram is of Upper Postglacial age. The beginning of the continuous Cerealia curve at 2.40 m marks our zone 10/11 transition; Cerealia-type pollen reaches high percentages in the upper part of the diagram. Other culture indicators, such as *Rumex* and *Plantago*, show likewise high percentages in the section above 2.40 m. *Carpinus* is poorly represented in the pollen record of Melleray-la-Vallée, suggesting that hornbeam was only of minor importance. *Alnus* attains maximum values in the section corresponding to our pollen zone 11. The decline in alder must have occurred here in (late) medieval times.

Mur-de-Sologne (Planchais, 1970; 1971), 1.80-0.20 m. The section with the continuous curves for *Carpinus* and Cerealia (between 0.60 and 0.20 m) may correspond with our pollen zone 11. Culture pollen percentages are not particularly high, suggesting that the region was less intensively used by man than the areas in the vicinity of the Marias de l'Erdre and Melleray-la-Vallée.

Tourbière de l'Archet (Jalut, 1967), 1.25-0.10 m. The section between 0.90 and 0.10 m, with fairly high values for Cerealia, *Rumex*, *Plantago*, *Urtica* (!) and other culture indicators, should correspond with our zone 11. *Juglans* is rather well represented in this section. Mention should be made of the comparatively high percentages for *Centaurea cyanus*, a weed in autumn-sown grain crops, particularly rye. If the level of 0.90 m at l'Archet really corresponds with our zone 10/11 transition, cornflower would have been re-introduced in the l'Archet area (after it had disappeared at the end of the Late-glacial) already around 200 B.C. and not only in medieval times. The increase in culture pollen percentages is accompanied by a marked decline in the *Fagus* curve. *Alnus* pollen percentages fluctuate strongly, but remain high, on average.

Marais Vernier (Elhai, 1959), 2.90-0.90 m. *Fagus* reaches high values (up to over 50%, calculated from a tree pollen sum without *Corylus*) in the upper part of the Vernier diagram, but *Carpinus* and Cerealia remain rather low. It is not certain whether our pollen zone 11 is represented at Vernier, but a few *Juglans* pollen grains counted at the levels of 1.60 and 1.50 m suggest that the upper part of the diagram may be attributed to zone 11. This suggestion is supported by the somewhat higher Cerealia pollen values in the section concerned.

Forêt de Bray, *Saumont* (Frileux & Huault 1971: after Planchais 1976), 1.30.0.10 m (Frileux & Huault's zone VIII). The lower part of zone VIII, the section of 1.30-0.70 m, corresponds with our pollen zone 10. In the upper part of the diagram (above 0.70 m), Cerealia-type pollen shows a continuous curve, while *Juglans* and *Castanea* are represented.

8.4.2. *Discussion*

The diagram sections mentioned above (8.4.1.) show a picture which, in broad outline, is comparable to that of the Upper Postglacial in the pollen diagrams which are the subject of the study presented in this paper. A conspicuous feature constitutes the (strongly) increased influence of man on the vegetation as this is registered in the subfossil pollen precipitation. The pollen diagrams point to considerable regional differences in the magnitude of the impact of man on his environment. Regional differences in the natural upland forest vegetation are likewise suggested by the pollen record. Particularly *Fagus* pollen percentages display marked differences. Thus, at Vernier (Elhai, 1959) *Fagus* attains values of more than 50%, whereas at l'Archet (Jalut, 1967) and Petit Mars (Planchais, 1971) beech pollen percentages do not exceed 15% (calculated from a tree pollen sum). Similar differences are recorded for *Carpinus* although this pollen type always has significantly lower values than *Fagus*.

Above (8.3.3.2.) it has been pointed out that the decline of alder in the upper part of the diagrams of Chivres, Silly-la-Poterie, la Voise and Fréchencourt was no synchronous phenomenon. In these diagrams the beginning of the decrease in *Alnus* percentages ranges from c. 2000 B.C. to A.D. 400. The local differences in the behaviour of *Alnus* are confirmed by the other pollen diagrams from Northern France. At Mur-de-Sologne the gradual decline in the *Alnus* curve must have started well before 2000 B.C., whereas at Vernier it was not until (late) medieval times that a conspicuous decrease in alder took place. At Marais de l'Erdre a marked, although temporary recovery of the alder curve can even be observed in the upper part of the diagram. The course of the curves for water and marsh plants points again to a natural and not to an anthropogenous (cutting of alder brook forest) cause of the decline of *Alnus*. A rise in the water-level must have drowned (part of) the alder brook.

9. SUMMARY

In this paper the palynological examination of peat and lake-bottom sediments in the Paris Basin is discussed. The following sediment cores were analysed for this study: Coizard-Joches, Chivres, Bresles, Silly-la-Poterie, Vallée de la Voise and Fréchencourt (for location of the sites see fig. 1). The pollen diagrams prepared for these sediment cores are shown in figs. 3-5 and 8-11. The main objectives of this study are the reconstruction of the Late-glacial and Postglacial vegetational history of the Paris Basin and the elucidation of the interference of man in prehistoric and early-historical times with the vegetation. The so-called Quercetum-mixtum diagrams (figs. 12-15) should provide the best possible impression of the vegetation on the higher soils and of the influence of man on the vegetation.

For the diagrams under discussion pollen assemblage zones have been established. This zonation does not correspond with one of the existing pollen-floristic zonations. In some diagrams a particular pollen assemblage zone is subdivided into two or more subzones.

The development of the local vegetation (aquatic, swamp and peat-bog vegetations) is discussed in chapter 4.

The Late-glacial (c. 12,000-c. 8300 B.C.). This period includes pollen assemblage zones 2-4 and perhaps also zone 1. Pollen zone 1, which is only represented in the Chivres diagram (5.2), is characterized by high herbaceous percentages suggesting a treeless vegetation. This pollen zone must be dated either to the earliest Late-glacial (Iversen's subzone Ia) or to the final phase of the Pleniglacial.

Pollen zone 2 (5.3.) is characterized by predominant *Betula* percentages and rather high *Artemisia* and *Juniperus* values. The vegetation during zone 2 must have consisted of open birch forest, in which juniper subsequently expanded. *Artemisia* played an important part in the ground cover. In the final phase of zone 2 pine arrived in the Coizard-Joches area. This zone must be placed in the Lower Dryas period (Iversen's zone I); very probably it covers the greater part of subzone Ia. The ^{14}C date of 9480 ± 60 B.C. for a sample between spectra 6 and 7 at Chivres does not date the

upper limit of zone 2 because of a hiatus in the sedimentation at this level.

In pollen assemblage zone 3 (5.4.) *Pinus* attains high percentages, whereas *Artemisia* and *Juniperus* have comparatively low values. The *Betula* pollen curve shows a considerable decline in the course of zone 3. In the forests which covered the Coizard-Joches area during zone 3, at first birch may have been the most important tree, whereas at a later stage pine took over this role. Juniper was probably a rather common constituent of the birch-dominated forest. The radiocarbon dates obtained for the Coizard-Joches II core suggest that pollen zone 3 covers the upper part of Iversen's zone I, probably subzones Ib and Ic, and the whole of zone II (Allerod period).

Relatively high *Artemisia* and *Juniperus* values characterize pollen zone 4 (5.5.). *Pinus* shows lower values than in zone 3, but it remains the predominant tree pollen type. During zone 4 rather open birch and pine forests or mixed birch-pine forest must have prevailed. Juniper played an important part in these forests. The well-developed ground cover had a steppic character. Pollen zone 4 corresponds roughly with the Late Dryas period (Iversen's zone III). Pollen of *Empetrum* and Ericaceae is almost absent in the upper Late-glacial of Northern France.

The presence of pollen of thermophilous trees in Late-glacial sections is briefly discussed (5.6.). It must remain undecided whether or not oak and hazel had reached Northern France in the course of the Late-glacial.

Of the pollen types more or less characteristic of the Late-glacial (5.7.) are mentioned here: *Hippophaë*, *Ephedra distachya*-type, *Ephedra fragilis*-type, *Polemonium*, *Helianthemum* and *Sanguisorba minor*. The presence of *Botrychium* and *Allosurus* has been established. Only two spores of *Selaginella selaginoides* were counted.

The Late-glacial in the diagrams presented in this study is compared with the Late-glacial sections in pollen diagrams from Northern France previously published (Mur-de-Sologne, l'Archet, Bellengreville, Prémery, Tourbière de la Bar). The correlation of the diagrams meets with various difficulties. This must partly be ascribed to regional differences in the vegetation. One must also consider the possibility of gaps in the sedimentation. Moreover, the scarcity of radiocarbon dates constitutes a serious handicap in correlating pollen diagram sections.

The Lower Postglacial (c. 8300-c. 4900 B.C.) includes pollen assemblage zones 5, 6 and 7. In zone 5 (6.1.) herbaceous pollen types fall to low values. *Pinus* is the dominant pollen type, while *Betula* is rather well represented. During zone 5, the Paris Basin must have been covered by predominantly pine forest. At the end of the zone various thermophilous trees reached the area. The first increase in *Corylus* constitutes the zone 5/6 border (c. 7500 B.C.).

Pollen zone 6 (6.2.) is characterized by a conspicuous increase in *Corylus* and a decrease of *Pinus* percentages. *Ulmus* and *Quercus* have continuous curves. The zone 6/7 transition (c. 6800 B.C.) is placed at the marked increase in *Ulmus*. It is likely that hazel could have spread in the pine forests. In the course of zone 6, oak-elm forest expanded to some extent, probably at the expense of the pine-hazel forest.

In pollen zone 7 (6.3.), *Quercus* and *Corylus* are usually predominant. *Ulmus* values are comparatively high, but *Pinus* percentages are generally much lower than in zone 6. The rise in the curves for *Tilia* and *Fraxinus* marks the zone 7/8 contact, which level is dated to c. 4900 B.C. During zone 7, pine-dominated forest was, at least partly, replaced by deciduous forest.

Other pollen diagrams from Northern France suggest a Lower Postglacial vegetational history which, in broad outline, is comparable to that arrived at in this study. However, the correlation of the various pollen diagrams meets with difficulties and opinions concerning the dating of the diagram sections concerned may differ rather widely. One must assume that the forest cover of Northern France displayed considerable regional differences.

The Middle Postglacial (c. 4900-c. 1300 B.C.) includes pollen assemblage zones 8 and 9. Comparatively high values for *Fraxinus*, *Tilia* and *Ulmus* characterize zone 8 (7.2.); *Quercus* and *Corylus* percentages are high. Pollen of *Plantago lanceolata* occurs in low numbers in zone 8. The zone 8/9 transition (c. 2000 B.C.) is placed at the beginning of the continuous *Fagus* curve. Pollen zone 8 constitutes the period of the fully developed deciduous forest, the composition of which varied depending on the soil conditions.

Pollen grains of *Triticum* and *Plantago lanceolata* in zone 8 point to the activity of prehistoric (Neolithic) farmers. The palynological indications of the interference of man with the vegetation and the possible correlation of the pollen record with particular Neolithic cultures are discussed (7.2.2.1., 7.2.2.2., 7.2.2.4.). Two types of land occupation (those described by Troels-Smith and Iversen, respectively) could be demonstrated for the Neolithic of the Paris Basin. The pollen diagrams of Chivres, la Voise, Silly and Fréchencourt show distinct differences in the frequencies of culture indicators, suggesting differences in the Neolithic occupation history of the areas concerned.

Pollen assemblage zone 9 (7.3.) is characterized by a low but continuous *Fagus* pollen curve. The first increase in beech percentages marks the zone 9/10 contact (c. 1300 B.C.). The composition of the upland forest did not differ much from that in zone 8, except that now *Fagus* formed part of it. Palynological indications of the activity of Late-Neolithic and Early and Middle Bronze Age farmers differ locally.

In the Paris Basin, and in Western France, the expansion of alder must have occurred at widely diverging periods (7.4.4.).

The Upper Postglacial (after c. 1300 B.C.), including pollen zones 10 and 11, is the period of the increasing interference of man with the vegetation. The last 500 years or so are not represented in the pollen diagrams that are the subject of this study.

Fagus reaches comparatively high values in pollen assemblage zone 10 (8.2.), whereas *Ulmus*, *Tilia* and *Corylus* decline. The beginning of the continuous *Secale* curve (c. 200 B.C.) constitutes the zone 10/11 border. During this period beech expanded at the expense of other deciduous trees. Oak and beech must generally have been the predominant species of the upland forest, although locally *Fagus* may have been less prominent (cf. la Voise, 8.2.2.3.). Culture indicators are quite frequent, suggesting the continuous presence of man (Late Bronze Age, Hallstatt, La Tène I and II). The upper part of the zone suggests a marked increase in the deforested area, beech-dominated forest also being affected.

Pollen zone 11 (8.3.) is characterized by high herbaceous percentages. *Fagus* reaches again fairly high values, suggesting that in spite of the interference of man beech expanded markedly. *Carpinus* also formed part of the forest of this period. In zone 11 time, rye (*Secale*) must have been an important crop plant. The cultivation of hemp (*Cannabis*) or hop (*Humulus*) could be demonstrated. *Juglans* and *Castanea* were introduced, probably by the Romans.

The upper sections of various other pollen diagrams from Northern France provide a picture which, in broad outline, is comparable to that of zones 10 and 11 (8.4.). Most diagrams show a marked increase in culture pollen percentages. Regional differences in the upland forest cover are suggested by the pollen record.

10. RESUME

Dans cette publication l'examen palynologique des sédiments tourbeux et lacustres provenant du Bassin Parisien est discuté. Des carottes provenant des localités suivantes furent analysées pour cette étude: Coizard-Joches, Chivres, Bresles, Silly-la-Poterie, Vallée de la Voise et Fréchencourt (pour la localisation voir fig. 1). Les diagrammes polliniques correspondants sont montrés dans les figures 3-5 et 8-11. Les buts principaux de cette étude sont la reconstitution de l'histoire de la végétation du Tardiglaciaire et du Postglaciaire du Bassin Parisien et la mise en lumière de l'action de l'homme préhistorique et protohistorique sur la végétation. Les diagrammes du *Quercetum-mixtum* (figs. 12-15) pourraient bien être les meilleurs indicateurs du couvert végétal des hautes terres ainsi que de l'influence de l'homme sur la végétation.

Pour les diagrammes en question des zones polliniques locales ont été établies. Cette zonation ne correspond pas avec une des zonations polliniques existantes. Dans quelques-uns des diagrammes une certaine zone pollinique est subdivisée en deux ou plusieurs subzones. Le développement de la végétation locale (plantes aquatiques, végétations de marais et de tourbière) est discuté au chapitre 4.

Le Tardiglaciaire (12,000-8300 B.C. environ). Cette période comprend les zones polliniques 2-4 et peut-

être aussi la zone 1. La zone 1, qui est représentée uniquement dans le diagramme de Chivres (5.2.), est caractérisée par de forts pourcentages d'herbacées, ce qui suggère une végétation presque dépourvue d'arbres. Cette zone doit être rapportée ou au Dryas ancien inférieur (la subzone Ia d'Iversen) ou à la phase finale du Pléniglaciaire.

La zone pollinique 2 (5.3.) est caractérisée par des pourcentages dominants de *Betula* et des valeurs assez élevées d'*Artemisia* et de *Juniperus*. La végétation pendant la zone 2 a dû consister en une forêt de bouleau claire, dans laquelle le genévrier s'est étendu. *Artemisia* jouait un rôle important dans la strate herbacée. Dans la phase finale de la zone 2 le pin apparaît aux environs de Coizard-Joches. Cette zone-ci doit être située dans le Dryas ancien (la zone I d'Iversen); elle couvre très probablement la majeure partie de la subzone Ia. La datation au C14 de 9480 ± 60 B.C. pour une échantillon entre les spectres 6 et 7 à Chivres ne date pas la limite supérieure de la zone 2 à cause d'une lacune dans la sédimentation de ce niveau.

Dans la zone pollinique 3 (5.4.) *Pinus* atteint de forts pourcentages, tandis qu'*Artemisia* et *Juniperus* ont des valeurs assez faibles. La courbe de *Betula* chute considérablement au cours de la zone 3.

Dans la région de Coizard-Joches, au début de la zone 3, le bouleau était l'arbre dominant; à la fin de cette zone c'est le pin qui jouait ce rôle. Le genévrier était probablement une essence assez commune de la forêt dominée par le bouleau. Les dates au radiocarbone obtenues pour la carotte de Coizard-Joches II suggèrent que la zone 3 couvre la partie supérieure de la zone I d'Iversen, probablement les subzones Ib et Ic, et toute la zone II (Allerod).

La zone pollinique 4 (5.5.) est caractérisée par des valeurs relativement élevées d'*Artemisia* et de *Juniperus*. Les fréquences de *Pinus* baissent dans cette zone, mais le pin reste le type de pollen d'arbres dominant. Pendant la zone 4 des forêts assez ouvertes de bouleau et de pin ou mixtes bouleau-pin ont dû prédominer. Le genévrier jouait un rôle important dans ces forêts. La strate herbacée, bien développée, avait un caractère steppique. La zone 4 correspond approximativement au Dryas récent (la zone III d'Iversen). Le pollen d'*Empetrum* et des Ericacées était à peu près absent durant le Tardiglaciaire récent du Nord de la France.

La présence de pollen d'arbres thermophiles dans les sédiments du Tardiglaciaire est discutée brièvement (5.6.). La question de savoir si le chêne et le noisetier ont atteint ou non le Nord de la France au cours du Tardiglaciaire reste posée.

Sont mentionnés ici des types de pollen plus ou moins caractéristiques du Tardiglaciaire (5.7.): *Hippophaë*, *Ephedra* type *distachya*, *Ephedra* type *fragilis*, *Polemonium*, *Helianthemum* et *Sanguisorba minor*. La présence de *Botrychium* et d'*Allosurus* a pu être établie. Deux spores de *Selaginella selaginoides* ont été rencontrées.

Le Tardiglaciaire des diagrammes présentés dans cette étude est comparé avec celui des diagrammes polliniques du Nord de la France déjà publiés (Mur-de-Sologne, l'Archet, Bellengreville, Prémery, Tourbière de la Bar). L'établissement de corrélations entre les diagrammes rencontre plusieurs difficultés qui doivent être imputées, en partie, à des différences régionales de la végétation. Il faut aussi considérer la possibilité de lacunes dans la sédimentation. La rareté de dates au radiocarbone constitue en outre un handicap sérieux pour l'établissement des corrélations entre les diagrammes polliniques.

Le Postglaciaire inférieur (8300-4900 B.C. environ) comprend les zones polliniques 5, 6 et 7. Dans la zone 5 (6.1.) les fréquences des herbacées chutent et atteignent de faibles valeurs. *Pinus* est dominant, tandis que *Betula* est assez bien représenté. Pendant cette zone, le Bassin Parisien a dû être couvert par une forêt à pin dominant. A la fin de la zone 5 plusieurs espèces d'arbres thermophiles apparaissent. La première extension de *Corylus* constitue la limite des zones 5/6 (7500 B.C. environ).

La zone pollinique 6 (6.2.) est caracterisée par une montée considérable de la courbe de *Corylus* et une chute des pourcentages de *Pinus*. *Ulmus* et *Quercus* ont des courbes continues. La transition des zones 6/7 (6800 B.C. environ) se situe au début de la forte croissance de la courbe d'*Ulmus*. Il est probable que le noisetier a pu s'étendre dans les forêts de pin. Au cours de la zone 6 la forêt de chêne et orme s'est étendue modérement, probablement au détriment de la forêt pin-noisetier.

La zone pollinique 7 (6.3.) montre en général une dominance de *Quercus* et *Corylus*. Les valeurs d'*Ulmus* sont relativement élevées, mais les pourcentages de *Pinus* sont généralement beaucoup plus bas que dans la zone 6. La montée des courbes de *Tilia* et *Fraxinus* caractérise le contact des zones 7/8, dont le niveau est daté de 4900 B.C. environ. Pendant la zone 7 la pinède était, en partie du moins, remplacée par la forêt caducifoliée.

D'autres diagrammes polliniques du Nord de la France suggèrent une histoire de la végétation du Postglaciaire inférieur, qui dans ses grands traits concorde avec celle qui est établie dans cette étude. La corrélation, cependant, des différents diagrammes polliniques rencontre des difficultés et les opinions concernant la datation des secteurs de diagrammes en question peuvent différer assez fort. Il faut admettre que le couvert forestier du Nord de la France présentait des différences régionales considérables.

Le Postglaciaire moyen (4900-1300 B.C. environ) comprend les zones polliniques 8 et 9. Des valeurs relativement hautes pour *Fraxinus*, *Tilia* et *Ulmus* caractérisent la zone 8 (7.2.); les pourcentages de *Quercus* et *Corylus* sont élevés. Le pollen de *Plantago lanceolata* est présent en petit nombre dans la zone 8. La transition des zones 8/9 (2000 B.C. environ) se situe au début de la courbe continue de *Fagus*. La zone 8 constitue la période de la forêt caducifoliée optimale, tandis que les proportions des espèces ont dû être dépendantes des conditions édaphiques.

Les pollens de *Triticum* et *Plantago lanceolata* dans la zone 8 indiquent l'activité des paysans préhistoriques (Néolithique). Les indications palynologiques de l'action de l'homme sur la végétation et les corrélations possibles entre les données palynologiques avec les différentes cultures néolithiques sont discutées (7.2.2.1., 7.2.2.2., 7.2.2.4.). Deux types d'occupation de pays ont pu être démontrés (ceux qui ont été décrits par Troels-Smith et Iversen, respectivement) pour le Néolithique du Bassin Parisien. Les diagrammes polliniques de Chivres, la Voise, Silly et Fréchencourt montrent des différences marquées dans les fréquences des indicateurs de culture, ce qui suggère des différences dans l'histoire de l'occupation néolithique dans les régions en question.

La zone pollinique 9 (7.3.) est caractérisée par une courbe basse mais continue de *Fagus*. La première montée des fréquences de hêtre dénote le contact des zones 9/10 (1300 B.C.). La composition de la forêt ne différait pas beaucoup de celle de la zone 8, sauf pour la présence de *Fagus*. Les indications palynologiques de l'activité des paysans du Néolithique final et de l'Age du Bronze ancien et moyen diffèrent suivant les localités.

Dans le Bassin Parisien, et dans l'Ouest de la France, l'expansion de l'aulne a dû se manifester à des périodes fort différentes (7.4.4.).

Le Postglaciaire supérieur (après 1300 B.C. environ), qui recouvre les zones polliniques 10 et 11, est la période de l'intervention accrue de l'homme dans la végétation. Les 5 dernièrs siècles environ ne sont pas représentés dans les diagrammes polliniques qui font l'objet de cette étude.

Fagus atteint des valeurs relativement élevées dans la zone 10 (8.2.), tandis qu'*Ulmus*, *Tilia* et *Corylus* déclinent. Le début de la courbe continue de *Secale* (200 B.C. environ) constitue la limite des zones 10/11. Pendant cette période le hêtre s'étendait au détriment d'autres arbres à feuillage caduc. Chêne et hêtre ont dû être les espèces prédominantes de la forêt, quoique *Fagus* fût peut-être moins important localement (cf. la Voise 8.2.2.3.). Les indicateurs de culture sont vraiment fréquents, ce qui suggère la présence continue de l'homme (Age du Bronze final, Hallstatt, La Tène I et II). La partie supérieure de la zone laisse supposer une forte extension des défrichements affectant même la forêt de *Fagus*.

La zone pollinique 11 (8.3.) est caractérisée par des hauts pourcentages d'herbacées. *Fagus* atteint de nouveau des valeurs assez élevées, ce qui indique que malgré l'intervention de l'homme le hêtre s'étendait de façon notable. *Carpinus* faisait aussi partie de la forêt de cette période. Pendant la zone 11 le seigle (*Secale*) a dû être une plante cultivée importante. La culture du chanvre (*Cannabis*) ou du houblon (*Humulus*) a pu être démontrée. *Juglans* et *Castanea* furent introduits, probablement par les Romains.

Les secteurs supérieurs d'autres diagrammes polliniques du Nord de la France fournissent une image qui ressemble approximativement à celle des zones 10 et 11 (8.4.). La plupart des diagrammes montrent une augmentation notable des pourcentages des pollens de plantes rudérales ou cultivées. Les séquences polliniques laissent supposer des différences régionales dans la couverture forestière.

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