RETROGRESSIVE FOREST DEVELOPMENT, AS REFLECTED IN A MOR POLLEN DIAGRAM FROM MANTINGERBOS, DRENTHE, THE NETHERLANDS

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CONTENTS

PREFACE

In 1970, Johs. Iversen and H. T. Waterbolk visited the small forest Mantingerbos in central Drenthe, the Netherlands (fig. 1), which is known as an almost pure *Ilex* grove. Iversen discovered that the soil was a mor "thicker than a pencil is long" and, therefore, could be excellent for pollen analysis. In 1971, I visited the forest and collected material for pollen analysis.

Unfortunately, Iversen never saw the total pollen diagram, and after his death in 1971 I decided to publish it.

The pollen analytical work has been carefully done by Mr. C. Vang Nielsen. Dr. Waterbolk and Dr. van Zeist assisted in the interpretation, and Dr. Waterbolk has been very hospitable during my visits to the Netherlands. Kirsten Andersen made the drawings. My sincere thanks are due to them.

AIM OF THE INVESTIGATION

It is now more than 25 years since Iversen found that the Draved area in S. Jutland contains some of the most original mixed deciduous woods of Denmark. Draved is situated in a isolated area and was originally surrounded by moorlands. Except for some minor areas, human activity in the forest has been rather low until the last centuries.

The soils in the forest are almost unchanged by human activity. In some parts very thick mor layers (> 30 cm) were discovered. Iversen (1964) has demonstrated that mor layers are suitable for pollen analysis. C^{14} determinations suggest that the fossil mor in Draved is very old, more than 6000 radiocarbon years (Iversen 1969). During the past 20 years many mor profiles have been analysed, elucidating the vegetational history of Draved forest (Iversen 1958, 1964, 1967, 1969, 1973). The diagrams give a very local picture, but the same type of vegetational development may be expected in other places where thick mor layers are present. In Draved Iversen worked on problems concerning the soil development and especially on the interplay of soil, vegetation and human activity.

Iversen demonstrated that in the bleached sand below the mor *Tilia* and *Corylus* were the most common tree pollen types, indicating that the bleached sand was a former mull. At the transition from sand to mor *Quercus* and *Betula* usually increased at the expense of *Alnus*, *Tilia* and *Corylus* (plus *Ulmus* when the transition was old enough). The present lower mor, which contains a considerable amount of sand, should be explained as a former amphimull (see below).

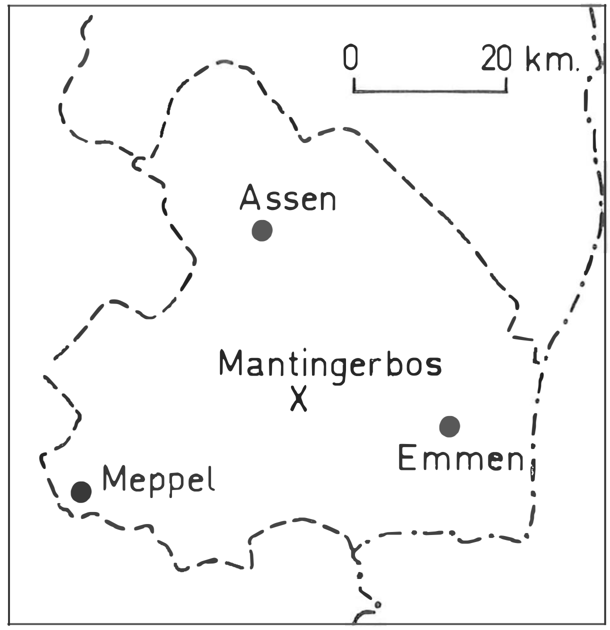
Iversen described five important events in the mor diagrams. The first was the neolithic landnam, probably 4,500 B.P. It was followed by weak traces of local clearings and cattle browsing. The next event was the re-immigration of *Ilex*. In Draved, *Ilex* was found in Atlantic time, and after an absence, for still unknown reasons, during a period of 1000 to 1500 years, it returned in late Subboreal time. Iversen estimated that the climate perhaps was unsuitable for *Ilex* in the intervening period. However, it is also clear that in the late Iron Age *Ilex* was favoured by cattle browsing. The third event was the Iron Age clearing (1800-1900 B.P.), which favoured the expansion of the recently immigrated *Fagus*. The greatest clearing (the fourth event) was the Viking Age one (1100 B.P.). Parts of the forest were clear-cut and they became covered by grasses or *Calluna*. It took a long time before the forest was able to take possession again of the cleared areas (the fifth change in the diagrams).

During the work at Draved, Iversen got an intimate knowledge of the forest dynamics, of which he published only a minor part before his untimely death.

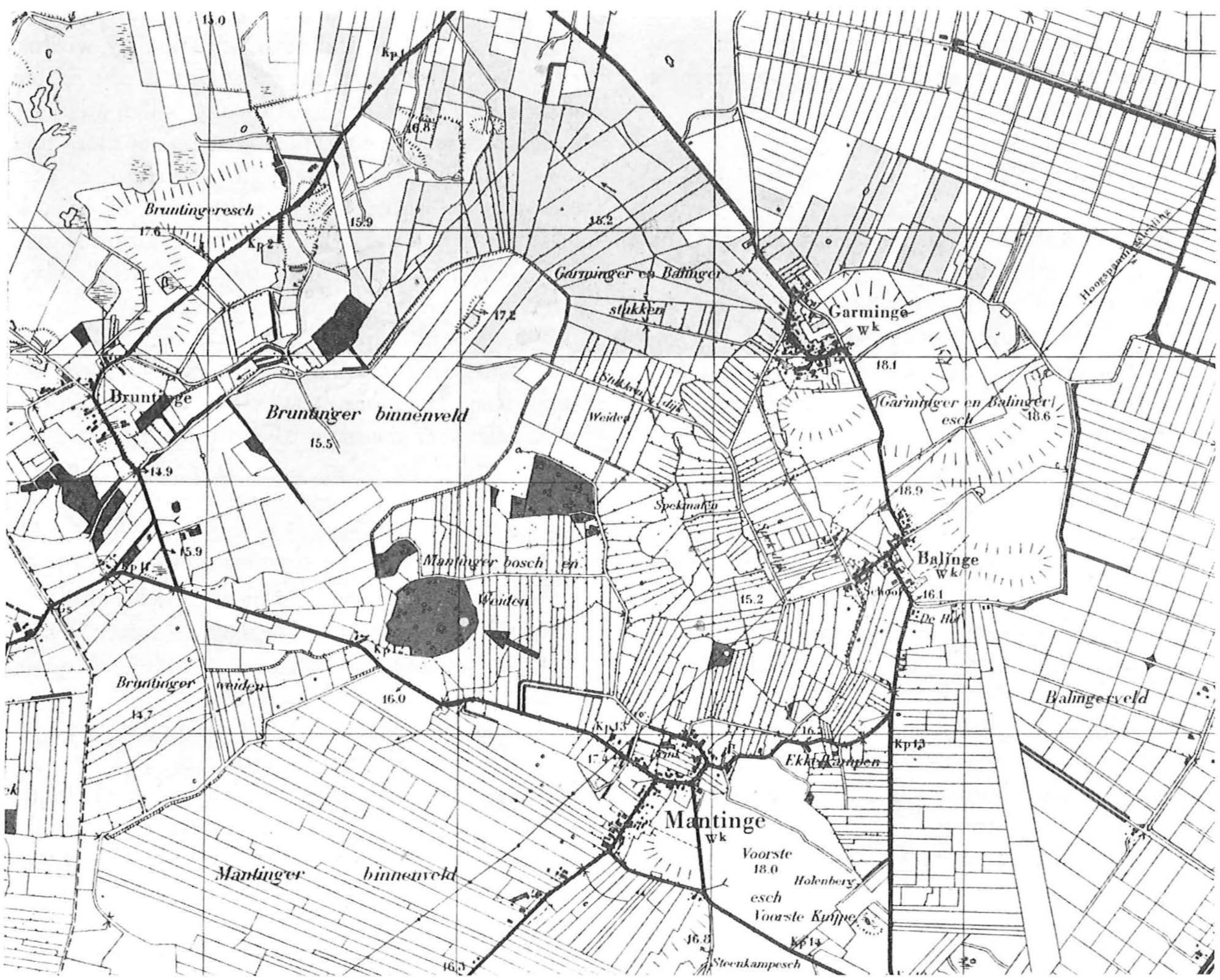
The study of the Mantingerbos soil was started because Iversen hoped that by tracing *Ilex* back to the Atlantic or at least to early Subboreal time, it could help to elucidate the phenomenon of the early Subboreal absence of the tree in Draved.

The Mantingerbos (bos = forest) is only 400 m in diameter and lies on the fringe of the old village fields. Today, the forest consists of a ringshaped

Fig. 1. The location of Mantingerbos in Drenthe, the Netherlands. The scale of the map is 1 : 30.000. The arable fields are situated to the south of Mantinge, and between Garminge and Balinge. Mantingerbos (Mantinger Bosch) is standing on the fringe of the pasture area (with ditches). See also fig. 6. The position of the section, from which the samples of the pollen diagram were taken, is indicated by a white dot.



0
20 km.
Assen
Mantingerbos
X
Emmen
Meppel



Bruntingeresch
Garminge
Bruntinger binnenveld
Mantinger bosch en Weiden
Balinge
Balingerveld
Mantinge
Mantinger binnenveld
Voorste
esch

Ilex forest with 3 or 4 great old *Fagus* trees and some old *Quercus* trees. It is from this part of the forest that the pollen diagram is made. The central part of the forest consists of middle-aged *Quercus* trees with some *Sorbus* and a few young *Ilex* trees. This part is surrounded and intersected by dikes and ditches. When this area went into forest is unknown.

Ilex is one of the most shade-tolerant trees in northwestern Europe, but it is very susceptible to cold winters (Iversen 1944). In closed forest it grows as a shrub with many suckers and moderate flowering. It could be a terrible weed in the 19th century forest (Vaupell 1863). *Ilex* has a poor pollen dispersal and its pollen is not commonly found in lake and bog sediments, but in mor deposits it may be found in small amounts. *Ilex* is susceptible to fire, but suckers will rise quickly in great amounts if the soil was not heated too much. Also forest clearing, especially when it is followed by cattle grazing, seems in some cases to favour *Ilex*, and then it may become a tree of medium height.

SOIL FORMATION

Mantingerbos stands on holocene brooksand (Geol. map of the Netherlands no. 17, III, 1: 50,000) at an elevation of approximately 15 m above sea level, and its topography is very smooth. In the forest a profile was opened up alongside a low bank from where the following description was made on moist material (see also fig. 4).

0 -	4.5	cm	mycomor, brown
4.5-	9.5	cm	fossil mycomor, chocolate brown
9.4-	14.5	cm	fossil mor, brown with sparse sand, transition from fossil copromor to mycomor
14.5-	22.5	cm	fossil copromor with some sand, dark brown
22.5-	29.5	cm	greasy humus sand or fossil copromor with sand, blackish brown
29.5-	35.5	cm	humus sand, grey-blackish brown
35.5-	39.5	cm	sand, grey with little humus (upper bleached sand)
39.5-	55	cm	bleached sand, light grey with humus schlieren
55 -	70	cm	dark brown humus pan
70 -	>85	cm	red- and yellow-brown humus hard pan, not penetrated.

The words copromor and mycomor, which are adopted from Iversen's unpublished notes, refer to mor dominated by arthropod droppings and fungal hyphae respectively.

To explain the soil profile it is first necessary to describe the development of a forest podsol.

P. E. Müller (1879) writes that the biologically active layers, the mull and the "upper ground" (the submull), are usually 0.5-1.0 m, and sometimes even 1.5 m thick. When a mull changes into a mor these layers become a podsol (Müller 1884, Havinga 1963, 1968).

In the mull stage the litter on the soil surface is mixed with material from lower layers, fragmentated and digested mainly by earthworms. Also nematods, protozoa, bacteria and fungi play an important role in the decomposition of the organic matter both before and after digestion by worms. Even the pollen exine, the outer part of the pollen wall, which forms the basis for the pollen analysis, is decomposed. In time the soil becomes more and more acid because of the high production of carbon dioxide, during the decomposition of organic matter. Carbon dioxide in aqueous solution is acid and together with the organic acids, it dissolves first lime, and later other minerals.

When the mull becomes too acid the earthworms disappear, first the larger species and later the small ones. The more superficially working arthropods take over the main role in the rotation of the upper soil. The other mull fauna and flora is partly replaced by enchytraids and new fungi species, while the remaining bacteria are not able to break down the pollen exines. This is the transitional stage from mull to mor, called amphimull (Lafond 1952). The change may go faster if man helps by cutting, burning and cropping the wood without manuring or fertilizing.

During the degradation, the submull at a deeper level is isolated and mineralized, and through leaching it will change into bleached sand. In the amphimull stage the organic debris is not totally mineralized and some insoluble humus will remain in the soil. Also the pollen exines begin to remain untouched by microbiotic activities, but they may still take part in the soil mixing process in the

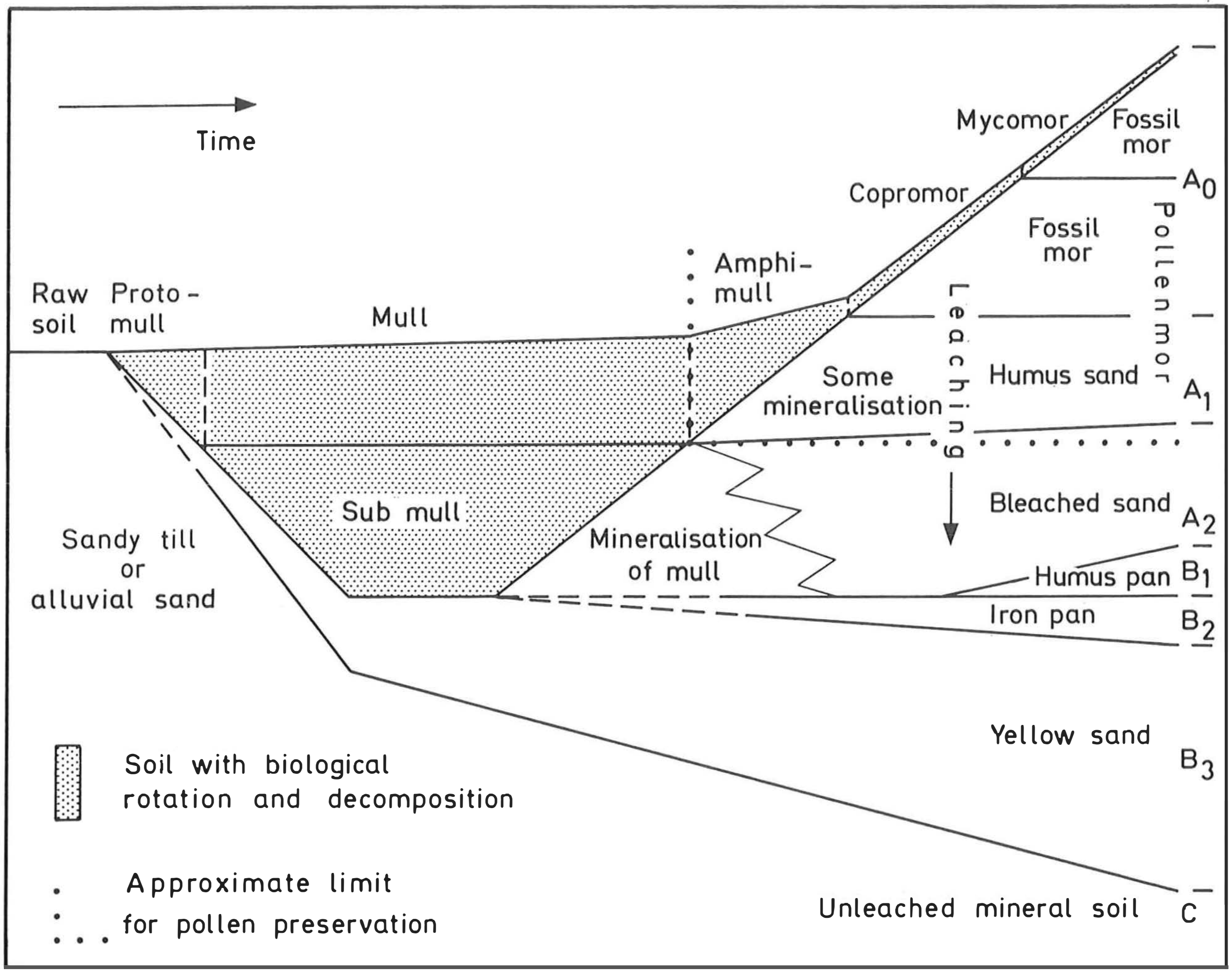


Fig. 2. A theoretical, generalized sketch of the natural forest-soil development in Northwest Europe, from well-drained raw alluvial sand or sandy till to a mature podsol (partly based on Müller (1879, 1884)). On poor sands the development may go directly from protomull (the word is derived from Iversen's unpublished notes) to poor acid mull or amphimull. On moist soils the conditions will be somewhat different, but the sequence will be almost the same: hydromull, hydroamphimull and hydromor. The characters to the right are some of the internationally used symbols for the horizons in a mature podsol.

upper soil layer. This means that pollen grains or charcoal (see below), deposited on the soil surface at a given moment in the amphimull stage, will be distributed over the whole of the active amphimull layer, though probably in the uppermost level in particular. As a consequence, in a forest soil profile, pollen grains or charcoal from a single event will not be found in a distinct horizon, but in a more or less thick zone.

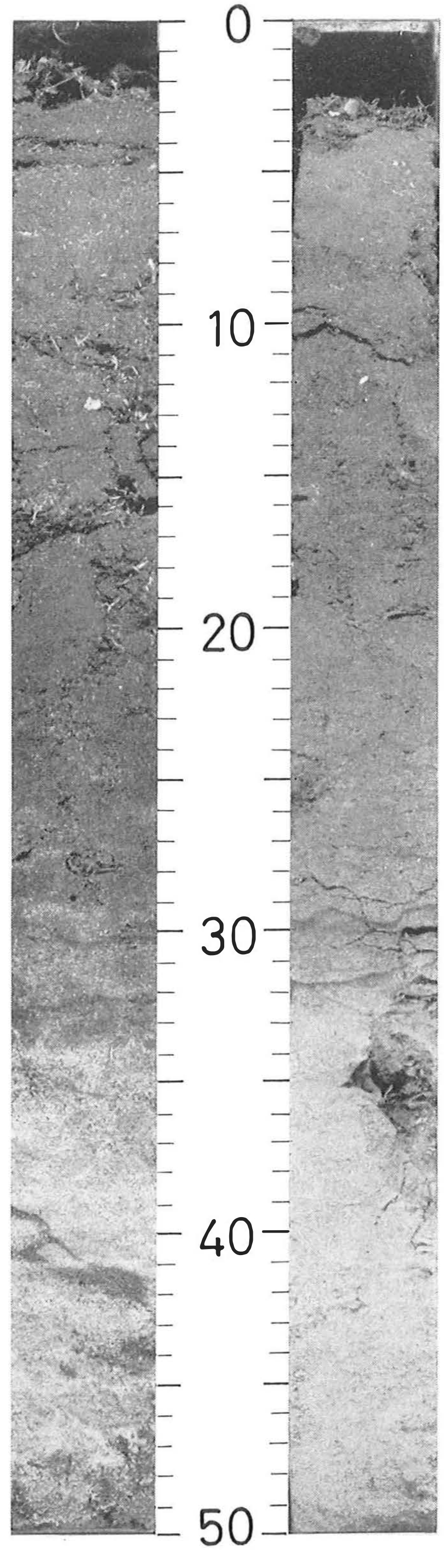
Through further leaching the numbers of living organisms decrease, the active layer becomes thinner, the mor begins to form and the amphimull changes into the humus sand. The pollen content of the humus sand as well as that of the bleached sand need not be explained as infiltration from above (Havinga 1963). As the lower part of the biologically active soil is gradually isolated, the pollen composition will almost reflect the actual flora composition. Thus, fossil amphimull is also suitable for pollen analysis (Havinga 1963), but the diagrams are not as unambiguous as the mor diagrams.

In the mor stage, decomposition goes on more slowly and organic sediment begins to develop on the soil surface, with a thin active layer, where arthropods digest the litter and thus form the copromor. Also enchytraids, fungi and some bacteria are responsible for the decomposition. In the mor, the organisms are not able to decompose the organic material in its mineral parts and, apart from the pollen exines and some bark remains, the organic matter is transformed into more or less soluble humus compounds. In the course of time the mor changes from a loose, crumble-structured mor into a dense, greasy mass, the fossil pollen mor (Iversen 1967, 1969, 1973), which is extremely rich in pollen grains. The pollen mor may have a rather high sand content, and thus it may be difficult to determine the limit between the fossil mor and the humus sand, which in the upper part is so rich in pollen that it must be regarded as a pollen mor too. When the soil development has been continuous the sand content in the mor will decrease gradually. On the other hand if the change from amphimull to mor was abrupt, the mor may be almost free of sand.

The copromor may be succeeded by a mycomor if certain plants immigrate, like *Fagus* or *Calluna*. Is seems that *Ilex* too may be responsible for this effect. The living mycomor has only a very thin active layer, although the brown fungal hyphae may be found up to a somewhat deeper level, where all plant debris is very tightly woven together by the hyphae. Whereas the mull, the amphimull and the copromor have a crumbly structure, the mycomor has a tough, but more porous structure. As far as I know, strongly fossil mycomor has not yet been described anywhere.

In the profile from Mantingerbos all the podsol layers above the humus hard pan are present, but the problem is where the limits between the different layers are situated.

The limit between the bleached sand and the upper bleached sand probably represents the former boundary between the submull and the mull. The upper bleached sand is expected to represent the transition from mull to amphimull. The transition from humus sand (former amphimull) to fossil mor is gradual and must be determined in the pollen diagram. On the basis of the loss on ignition (fig. 4), the original raw mineral soil surface can be roughly determined: the amphimull surface must have been situated at ca. 20 cm.



The distinction between copromor and mycomor was done by counting the hyphae in relation to

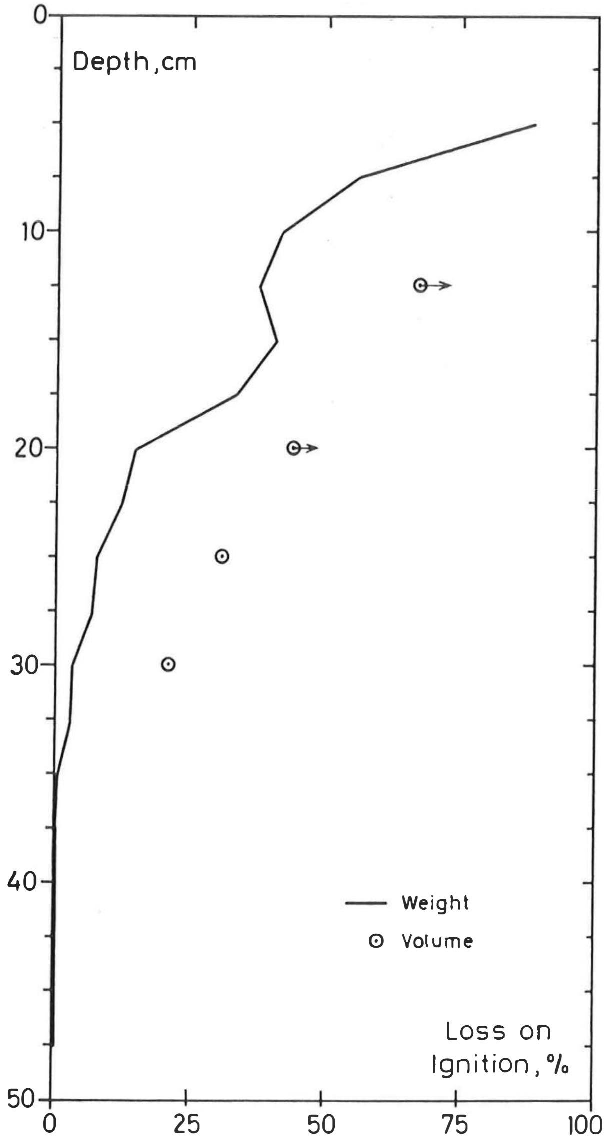


Fig. 4. Loss on ignition at 1000°C in % of dry weight, of soil samples from the right profile in fig. 3. The four dots give the approximate volume percentages of organic matter before ignition. These analyses seem to indicate that the raw soil surface was situated 20 cm below the present-day surface. The length of the arrows shows the approximate amount of acid-soluble salts.

◀

Fig. 3. Two profiles from the section. The distance between them was 1 m. The right one is dry, whereas the left one has been treated with glycerin before drying. The left one was used for pollen analysis. The upper 2-3 cm have disappeared.

the number of pollen grains (Iversen 1964). In the same way the amount of charcoal in the soil samples was determined. In the slides counts were made of the number of points of the index lines of an eye-piece micrometer that touched the hyphae and the charcoal particles, and these counts were then set in relation to the total number of counted pollen grains.

The fossil copromor and the greasy humic sand (fossil amphimull) that becomes light when dried constitute the pollen mor, which covers a great span of time. The sand which in the original living copromor was more sparse, has been concentrated by the decomposition of the organic debris in the mor. The sand in the fossil mor originates mainly from the underlying sand that was brought up by arthropods in the former living mor. Another part of the sand was brought in by man, cattle and other animals, because in the upper mor, sand grains of another composition than the bleached sand are found.

Chemical analyses of the two B horizon layers show that both are humus pans. The most characteristic chemical features are given below, in percentages of dry weight, after solution in 20% HCl. The analyses were made at the geochemical laboratory of the Geological Survey of Denmark.

	humus pan	humus hard pan
Fe_2O_3	0.11	0.67
Al_2O_3	0.55	1.60
MgO	0.02	0.05
MnO	0.002	0.003
loss on ignition (1000°C)	7.90	7.06
Fe division		
Fe^{++}	0.08	0.41
Fe^{+++}	0.00	0.07

The hard pan is richer in cation than the other humus pan layer. Almost all the iron is present as ferrous iron, which indicates that it was bound to humus. Thus, in spite of the reddish colour, the humus hard pan can not be an iron pan.

The loss on ignition curve (Fig. 4) was prepared from samples taken at 1 m from the pollen profile, which accounts for a vertical difference of 1-2 cm. Added to the loss on ignition curve are four samples for which the organic matter is calculated in relation to volume. The purpose was to make an estimate of the position of the orginal raw sand surface. Although the values are approximate values and the upper sample contained quite a lot of ash from the organic material (the approximate volume of ash is indicated by the arrow) it can be seen that the amount of sand above a depth of 20 cm almost equals the loss on ignition below. This demonstrates that the former mull and amphimull surface was situated ca. 20 cm below that of today (*i.e.* ca. 22 cm in the pollen diagram).

ABSOLUTE DATING

Five radiocarbon datings have been provided by Mr. Henrik Tauber, the Copenhagen Carbon-14 Dating Laboratory,

K-1944	mor	depth 20-25 cm	1810 ± 100 B.P.
K-1937	mor	depth 25-35 cm	2140 ± 100 B.P.
K-2161	humus pan	depth 55-70 cm	1870 ± 100 B.P.
K-2162	humus pan	depth 70-85 cm	2320 ± 100 B.P.
K-2255	charcoal	depth 15-35 cm	2370 ± 100 B.P.

The charcoal dating was made on 2.3 g oak charcoal separated from 4 samples:

15-20 cm: 0.4 g charcoal
20-25 cm: 0.7 g charcoal
25-30 cm: 0.8 g charcoal
30-35 cm: 0.4 g charcoal

The dating of the humus pan was only done to make sure that humus pan and mor are pedogenetically related but the dating can not tell much about the beginning of the humus pan formation. It is probable that the initial pan was formed at the same time as the amphimull developed.

Prior to dating the mor and the charcoal, soluble humus was extracted by a 10% potassium hydroxide solution. Thus, the mor was dated by its content of pollen, charcoal and root fragments. The root fragments make the datings too young and the charcoal may make them too old, because it must be assumed that old charcoal was mixed up together with the sand. Therefore, the sparse macroscopic charcoal was collected and dated separately. This dating was a little older than the mor datings. The charcoal dating could be taken as an indication that the mor and the charcoal have almost the same age. However, it is more likely that the charcoal content of the dated mor was so high that it dominated the dating. This problem arose because the first occurrence of *Secale cereale* and *Centaurea cyanus* in the pollen diagram should probably be assigned to early Medieval time, as elsewhere in the north of the Netherlands (van Zeist 1968 and personal communication), and not to Roman Iron Age as indicated by the radiocarbon datings and as in the south of the Netherlands (Janssen 1972, van Zeist 1968).

The dated charcoal probably contained charcoal from more than one fire. One fire of early Medieval age is indicated in the pollen diagram. An older fire with an estimated age of 2800 B.P. seems to be contemporaneous with the soil change from mull to amphimull. The estimate must be taken as rather uncertain.

POLLEN DIAGRAM

Like in the pollen diagrams from the Draved soil profiles (Iversen 1969), a correction of the pollen counts has been carried out before calculating the pollen percentages. Andersen's (1970) correction factors for trees were used and so *Quercus* too was reduced by 4 and not by 2, as Iversen did in Draved. The tentative correction factors for *Corylus*, *Calluna* and a few herbs are after Iversen. The correction factor for *Corylus* growing in a closed forest may, according to Andersen, be wrong. Per sample between 1000 and 1500 grains have been counted, except for the bleached sand were only 250 to 600 grains could be found within a reasonable time.

The zonation is a local one and some comments are given below concerning the subdivision of the Mantingerbos diagram.

1. First signs of agricultural activities, contemporaneous with the change of soil from mull into amphimull, probably 2800 B.P.
2. Expansion of *Fagus* and *Ilex*, both preceded by an increase of the activities of man.
3. Second expansion of *Ilex* preceded by forest clearance, grazing and browsing. Abrupt decrea-

se of *Alnus, Betula* and *Corylus* after the introduction of local agriculture with *Secale*. The forest changes into a more open mor forest with *Melampyrum*. Early Medieval age.

4. Beginning of the clear-cutting, which goes on until just before horizon 5 where almost all trees had disappeared. Introduction of *Fagopyrum* probably ca. 500-600 B.P. Between horizon 4 and 5 the local agriculture reaches its maximum value.
5. Regeneration of the forest to an almost pure *Ilex* forest.

The mull phase

Samples 37-40, from the upper part of the bleached sand, rich in well-preserved pollen, reflect a mull forest with *Tilia, Quercus* and *Corylus. Viscum* was attached to *Tilia.* This must be the late mull stage or the initial amphimull stage, still rich enough for *Tilia* and *Corylus*, but already acid enough for pollen preservation. This forest type was probably almost the same as that represented in the rest of the bleached sand, where selective corrosion may have changed the pollen composition. Whereas the forest on the amphimull was in balance with the soil, the mull forest represented in the analyses from the bleached sand had no natural climax composition. As in the former amphimull, *Tilia* was the dominant tree pollen type. This tree must also have been dominant in the almost virgin poor mull forest. The high *Ilex* pollen values are puzzling, because the forest must have been too dark for profuse flowering. Thus the only acceptable theory seems to be selective corrosion of the former mull pollen content.

It is presumed that the soil surface corresponded with a depth of ca. 22 cm in the diagram when the forest had the composition reflected at horizon 1. This would indicate an active layer of about 15 cm when the soil changed from mull to amphimull.

First human interference

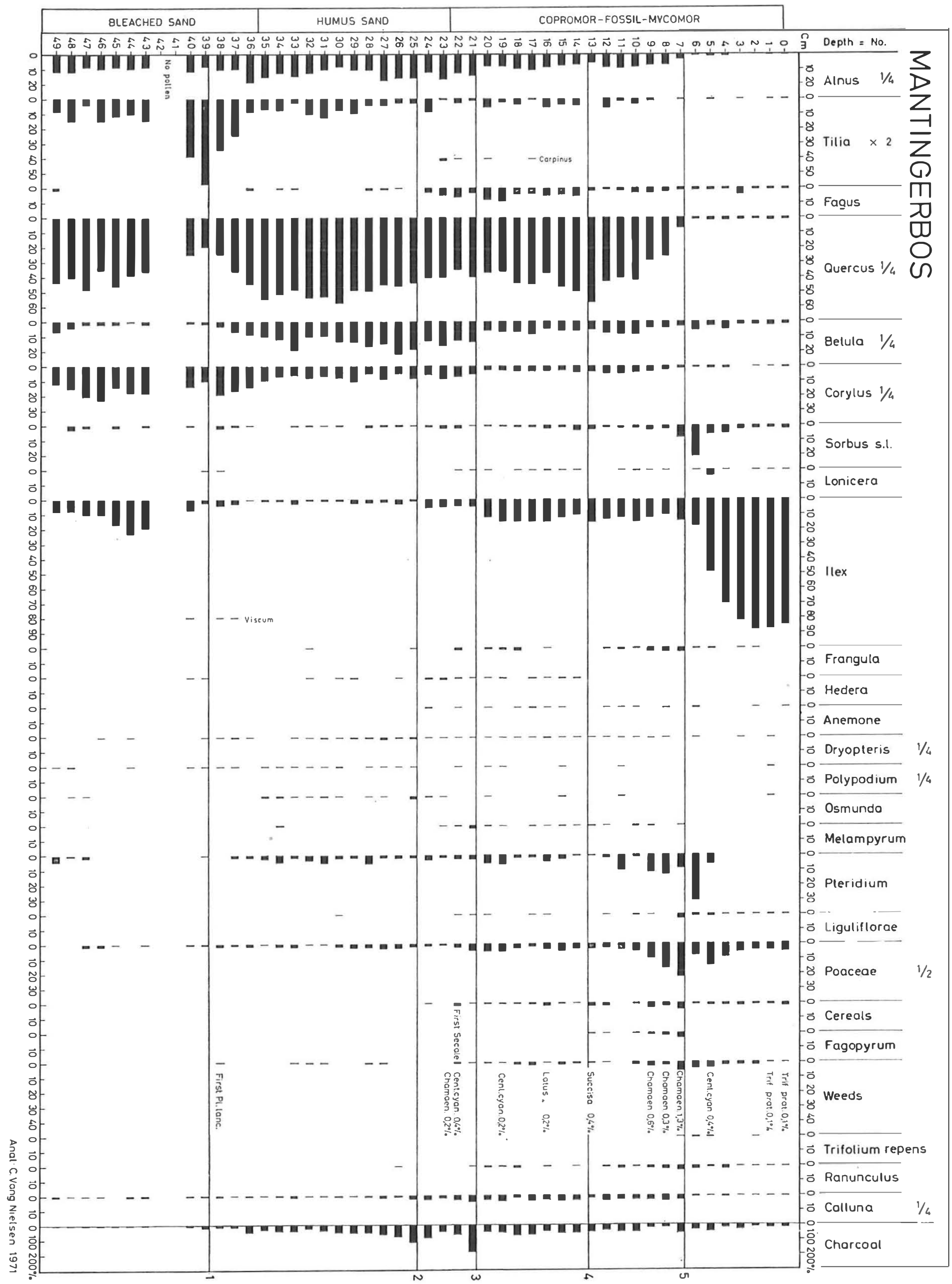
At the transition from mull to amphimull, horizon 1, the first indications of agricultural activities appear with the pollen grain of *Plantago lanceolata* and the charcoal dust. Thinning took also place in the forest at that time, as is suggested by the rise in *Betula*, *Corylus*, *Sorbus*, *Pteridium* and Poaceae. As the soil surface was supposedly situated at 22 cm, the pollen grains of weeds in samples 31-33 may have the same age. The first *Plantago* may be dated to ca. 2800 B.P.

The amphimull forest

After the first human interference and the soil change to an amphimull, the forest seems to have been left for about 1500 years without any considerable human interference. The forest was absolutely in balance, except for some possible felling of *Quercus* in the upper part (no. 25-30). The soil changed slowly into a mor-like amphimull. In areas where fresh drainage water was still available *Alnus* was growing together with some *Tilia* and *Corylus. Fagus* was probably found in the *Quercus* areas. The very small numbers of *Calluna* pollen must have been due to long distance transport. The *Sorbus* s.l. pollen type was probably from *Malus silvestris* growing in the *Quercus* forest. The forest was rather dark, and *Lonicera* and *Hedera* did not flower or flowered very little. It is also characteristic that the herb vegetation almost entirely consisted of shade tolerant ferns (*Pteridium*, *Osmunda*, *Dryopteris* and *Polypodium*).

Second human interference

Between horizons 2 and 3 the forest as well as the soil changed, due to the renewed strong human interference. Through the felling of *Quercus* and *Betula*, *Fagus* was favoured, while the better light conditions in the forest caused an increased flowering of several plants, such as *Ilex*, *Sorbus* s.l. (probably dominated by *Sorbus* s.str.), *Hedera* and *Anemone.* The influx of *Calluna* pollen rose, at least in relationship to the local pollen. *Carpinus* arrived at the spot for the first time. Thereupon, agriculture with *Secale* began in the vicinity, which is reflected in the pollen diagram by a rise in Cereals, Liguliflorae, and Poaceae. The forest changed into a more open mor forest as is indicated by the occurrence of *Melampyrum*, the rise in *Frangula* and *Lonicera* and the influx of *Calluna* pollen. The clearing was followed by burning of the forest. This burning is indicated by *Chamae-*


MANTINGERBOS
BLEACHED SAND
HUMUS SAND
COPROMOR-FOSSIL-MYCOMOR
Depth = No.
Cm
Alnus 1/4
Tilia × 2
Carpinus
Fagus
Quercus 1/4
Betula 1/4
Corylus 1/4
Sorbus s.l.
Lonicera
Ilex
Viscum
Frangula
Hedera
Anemone
Dryopteris 1/4
Polypodium 1/4
Osmunda
Melampyrum
Pteridium
Liguliflorae
Poaceae 1/2
Cereals
Fagopyrum
Weeds
Trifolium repens
Ranunculus
Calluna 1/4
Charcoal
No pollen
First Pl. lanc.
First Secale
Centcyan 0,4%
Chamaen 0,2%
Cent.cyan 0,2%
Lotus 0,2%
Succisa 0,4%
Chamaen 0,6%
Chamaen 0,3%
Chamaen 1,3%
Cent.cyan 0,4%
Trif. prot. 0,1%
Trif. prot. 0,1%
Anal. C.Vang Nielsen 1971

nerion (*Epilibium angustifolium*) which is common after woodland clearings and especially if fire is used. Probably the fire was rather superficial because both *Pteridium* and *Ilex* withstood the soil heating and no real charcoal layer was found in the profile.

At horizon 3 *Alnus*, *Betula* and *Corylus* decreased to half of their original value and *Osmunda* disappeared almost completely, probably because they were growing mainly in the area that was cleared. At the same time cattle grazing and browsing began as indicated by the occurrence of *Ranunculus*. The only *Ranunculus* species which thrive on mor are *R. acer* and *R. repens,* and that only when cattle grazing occurs (Iversen 1969). *Ilex* and *Pteridium* increased at the same time. The cattle avoids them and thus were they favoured by the grazing.

The forest regenerated after the fire at horizon 3, and the section between horizons 3 and 4 reflects a very stable *Quercus-Ilex* mor forest with some *Fagus* and *Betula.*

Third human interference

At horizon 4 a phase of large-scale agriculture commenced. The first sign of the late Medieval agricultural phase is the rise in Cereals accompanied by the introduction of *Fagopyrum. Fagopyrum* was in the Netherlands usually cultivated on the burned surface of raised bogs, but in this case the influx from the raised bogs was very low (indicated by the low *Calluna* curve) and for that reason *Fagopyrum* must have been grown in the forest area itself, probably in the central part of the forest where the old fields with dikes and ditches are found.

During the period between horizons 4 and 5 the whole forest, with exception of *Ilex*, was systematically cut. Many low, oblong depressions in the forest floor are explained as "saw-depressions" *i.e.* depressions made to be able to cut through the thick tree trunks (Waterbolk, personal information). *Fagus* decreased at the beginning of the period, and *Hedera* was totally absent. May be *Hedera* was used for cattle feeding, but other explanations are also possible. As the forest was cut, *Pteridium* and Poaceae spread enormously and *Chamaenerion* pollen grains are found in various samples, this time not because of fire but as a result of the sudden liberation of nutrients. The influx of pollen grains from cereals and weeds from the neighbouring fields rose.

Fig. 5. Pollen diagram of Mantingerbos. Calculations based upon the total of all pollen and spores, after correction (see text). The number of grains counted per sample is 250 to 600 in the bleached sand, and between 1000 and 1500 above this layer. The charcoal curve is based on microscopic dust in the slides. Five C^{14} datings are given in the text. Horizons 1-5 are local horizons.

It is a question why *Ilex* was not cut together with the other trees. We do not known whether it was a tree at all, but probably it was. Today, the forest is composed of small *Ilex* trees.

Suddenly the agriculture in the neigbourhood stopped and the forest was left for regeneration (horizon 5). Some forest grazing and browsing may still have continued, but the fields were covered with weeds and in the forest first *Sorbus* s.l. and *Pteridium* spread. Soon afterwards *Ilex* took over the full dominance and shaded away the other plants, especially *Pteridium*, and the present-day *Ilex* forest (see above) came into existence. Unfortunately quite a lot of *Ilex* trees were lodged during the autumn storms of 1973. The Poaceae pollen in the youngest part of the diagram is the influx from surrounding pastures.

CONCLUSION

Like Draved, Mantingerbos is situated in a formerly rather isolated area (compare the maps in Waterbolk 1967). Human activity was low until about 1000 years ago, when the first agriculture developed in the forest area, probably contemporaneous with the origin of the hamlet of Mantinge. Fortunately the mor soil, which was a result of human activity, was never cut away as in almost all other areas in Northwestern Europe.

The mor forms the basis for the pollen analysis in Mantingerbos. Until ca. 2800 B.P. the forest soil was a mull developed on brook sand, but as the mull was poor it only needed a small "push" to change into a more acid form. This "push" came from man who began to cut some trees, and the mull changed into amphimull, the transitional stage between mull and mor. This amphimull became slowly more and more mor-like and as man intensified tree cutting in early Medieval time the amphimull changed into a mor. The mor forest was rather stable until the whole forest was cleared probably only a few hundred years ago. When this clearing took place, *Ilex* was already a common tree or shrub in the forest, and because it was apparently not felled, it spread very quickly from suckers. Very soon a pure *Ilex* forest developed. At the same time the soil changed from a copromor into a mycomor and for that reason it is obvious, that *Ilex* must have been responsible for the soil change.

The pollen diagram from Mantingerbos demonstrates a strictly local vegetational development, and it is difficult to compare with other diagrams from Drenthe (van Zeist 1955, 1959), which are regional diagrams from more or less extensive *Sphagnum* bogs. Fossil mor has earlier not been found in the Netherlands, and so far no Postglacial diagrams prepared for small lakes in Drenthe have been published. Furthermore, the last one to two thousand years are not commonly represented in the pollen diagrams, because the upper part of the bogs has been destroyed by peat cutting and cultivation in recent centuries.

Iversen's purpose in Mantingerbos was, if possible, to obtain information on the behaviour of *Ilex* during Subboreal time. As the diagram includes only the last few hundred years of the Subboreal, no answer on that question can be given. However, it seems as if in Mantingerbos as well as in Draved, *Ilex* was to some extent favoured by human activities, and especially cattle grazing.

Through the work done in Draved and Mantingerbos, together with inspiration from P. E. Müller and others, it has been possible to put forward a theory for the soil development in areas with alluvial sand, sandy till or similar sediments. The theory explains, to some extent, the development of the soil from raw soil via protomull, amphimull, copromor to mycomor.

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APPENDIX

THE HUMAN OCCUPATION OF THE MANTINGERBOS AREA

H. T. Waterbolk

The Mantingerbos (fig. 1) is situated on a slight elevation of a low-lying area at an altitude of about 15 meters. The surrounding ridges go up to 18 meters. They bear the hamlets of Bruntinge, Garminge, Balinge and Mantinge with their fields ("esch"), meadows ("maten", "weiden") and former common grass- and heathlands ("veld"), which recently have been reclaimed and cultivated. The area drains to the west into the "Oude Diep".

To the east and south of the area we find the "Witteveen", a northern extension of the former large raised bog which bordered the Drenthe plateau to the south. It has now completely been reclaimed. Originally the northern part of this extension let its surface waters off in western direction through a number of rivulets passing through the low-lying area. Later, a canal, the Boksloot, was dug in southern direction, which took over the drainage of the raised bog, and made its exploitation and cultivation possible.

To the west and north of the four hamlets the former heathlands occur of the larger villages of Drijber, Wijster, Holthe, Westerbork (with the hamlet of Eursinge) and Orvelte. Originally the greater part of the low-lying area, including the four hamlets belonged to the territory ("marke") of the village of Westerbork. This area was called "'t Broeck", a name probably referring to its original forested character. It seems to have gradually obtained an independent status as a "marke". The southwestern part of the low-lying area belonged to the "marke" of Wijster; it is still called Wijsterbroek.

The hamlets have probably grown from isolated outlying farms (Waterbolk 1973). The exact date of their foundation is not known, but it is not probable that they should go back beyond the Medieval period. The villages Wijster, Westerbork and Orvelte would be much older; they might go back to the beginning of our era and without interruption be connected with the prehistoric occupation of the area.

The Mantingerbos is situated at roughly equal distances (1000-1500 meters) from the four hamlets, but closest to Mantinge. At present it is the property of the "Vereniging tot Behoud van Natuurmonumenten in Nederland" (Society for the Protection of Nature Reserves in the Netherlands). The map of 1851/52 (fig. 6) shows the "Mantinger Bosch en Weiden" still to be common property of the farmers.

Before the foundation of the hamlets, the Mantingerbos would be quite isolated, being situated at equal distance of c. 5 kilometers from the villages of Drijber, Wijster, Holthe, Westerbork and Orvelte.

Certainly the Mantingerbos has in historic times been more isolated than any other natural forest remnant in Drenthe. Only the Kinholt, situated in the valley of the Oude Diep, c. 14 kilometers downstream of Mantinge, once occupied a comparable position near the hamlets of Fluitenberg and Hondhang between the villages of Echten, Pesse and Ten Arlo and the raised bog.

From the later parts of the prehistoric period finds are definitely scarce in the four hamlet area. Neolithic finds are restricted to a few axes and flints. The air photographs do now show any traces of Celtic Fields (Late Bronze Age/Early Iron Age) in the vicinity, the nearest on record being situated 3 kilometers SE of Drijber (Brongers, in prep.).

Van Giffen (1934) excavated a small Late Bronze Age urn field N of Garminge. E of this village Beijerinck (1932) mentions a barrow, possibly dating from the Bronze Age. The Assen museum obtained Early Iron Age sherds (of RW-I type) from a settlement pit in the fields ("es") of Garminge (Van der Waals, 1967).

These three observations suggest a permanent human activity in the Garminge area during the Bronze and Early Iron Ages, at a distance of c. 2 kilometers from the Mantingerbos.

In 1969 the Assen museum obtained a rotary quern stone from basalt lava, which was found SE of Mantinge near the beginning of the road crossing the Witteveen bog. This imported quern type is common in the Late pre-Roman Iron Age and the Early Roman period (Harsema, priv. comm.). The find suggests a settlement, although the possibility that it was a bog offering cannot

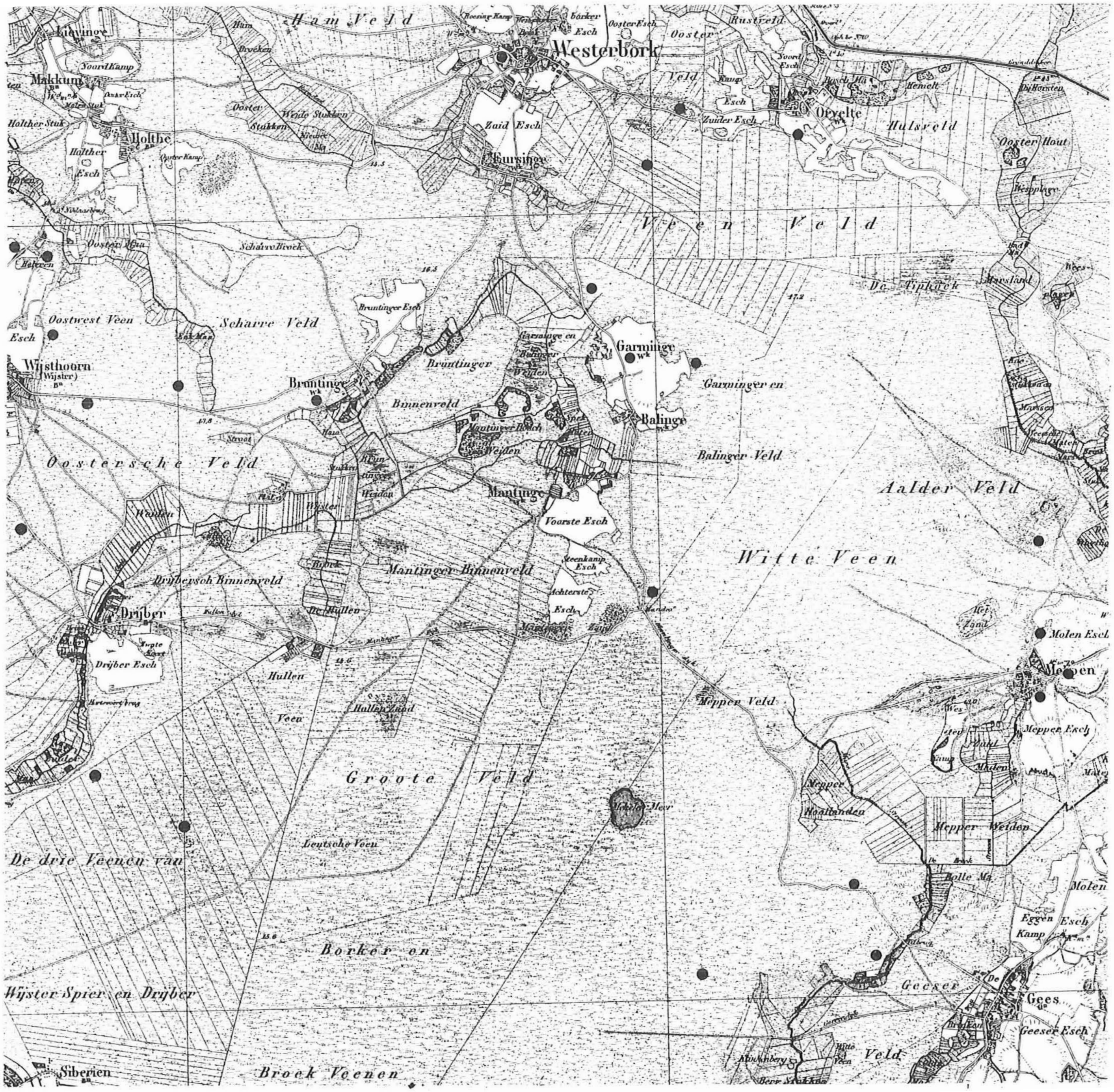

Fig. 6. Part of sheet 17 of the Topographic Map of the Netherlands, showing Mantinge and its surroundings (situation 1851/52; original scale 1 : 50.000, reproduced at scale 1 : 70.000. Dots indicate later prehistoric and early historic archeological sites (documentation Provinciaal Museum van Drenthe, Assen).

be ruled out. In any case, it proves a human activity in the area at a somewhat later date than the Garminge finds. It also argues for the ancientness of the bog passage.

Finally mention should be made of some potsherds of "Germanic" character, found by Beijerinck (1932) on a recently reclaimed field c. 0.3 kilometer west of Bruntinge. They may have had any date from the Bronze Age to the Migration period, with the Early Iron Age perhaps being the best guess. The distance to the Mantingerbos would be c. 2 kilometers.

There are no finds from the area that could be used to give a more exact date of the foundation of the four hamlets. There is, however, a historical argument that four farm-steads were in existence around A.D. 1000. According to D. P. Blok (priv. comm.) the number of units of a certain grain tax ("schultmodde") that the "marke" had to pay to the bishop of Utrecht, would correspond to the number of farms in the Late Carolingian period. For the "marke" of 't Broek this number was four.

The archeology and settlement history of the area suggest that the first human interference reflected in the pollen diagram took place some time during the Bronze Age/Early Iron Age occupation of the Garminge (and possibly the Bruntinge) area. The second human interference might be placed in the Early Medieval period, when the hamlets were founded, after a long period of human absence from the area. The third and major human interference may perhaps be related to the growth of the population in the hamlets, which also resulted in their independence as a "marke".

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