UNTERSUCHUNGEN AN NIEDERLÄNDISCHEN MOOREN

K. WESTERWOLDE *).

Researches of Bogs in Westerwolde, province of Groningen

by

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The bogs of S. E. Groningen are part of the great peat-marshes extending from S. E. Drente as far as N.W. Germany inclusive. So far as the territory of Westerwolde is concerned, people have begun digging off very early. According to the map by K r a y e n h o f f in 1816 nearly the whole peat-marsh westward from the line Blijham—Termaarsch had already been reclaimed, only a few parts still being covered with the original peat-layer (cf. map, fig. 1). The digging off east of the above line commences at the beginning of the 19th century on the borderland of Groningen and Drente.

Borings were performed in three places and the samples pollen-analytically and stratigraphically examined.

I. „Veenhuizer stukken".

The first profile is from the „Veenhuizer stukken" north of Termaarsch. Peat has been dug off for the greater part here, in some places down to the sand. The bog still existing is about 1,50 m thick, this bigness probably having been greater: the stratigraphic investigations established that probably a portion has already been dug off.

The percentage of Pinus (cf. diagram I) is very great at the commencement of the pollen-diagram (98%), Betula hardly occurs (2%). The extension of Corylus is already very great (71%) and increases at once to a maximum (140%). Beyond the top of the diagram the Corylus-percentage decreases rapidly; nevertheless it keeps occurring largely (40%) in the whole profile up to 25 cm below the surface and then it descends to 20%.

As soon as the Corylus-curve begins to decline after its maximum,

*) See Recueil des Travaux botaniques néerlandais Vol. XXIX (1932), p. 1 and Vol. XXXII (1935) p. 430, also in Mededeelingen van het Botanisch Museum en Herbarium v. d. Rijksuniversiteit te Utrecht no. 1, 23 and 24.

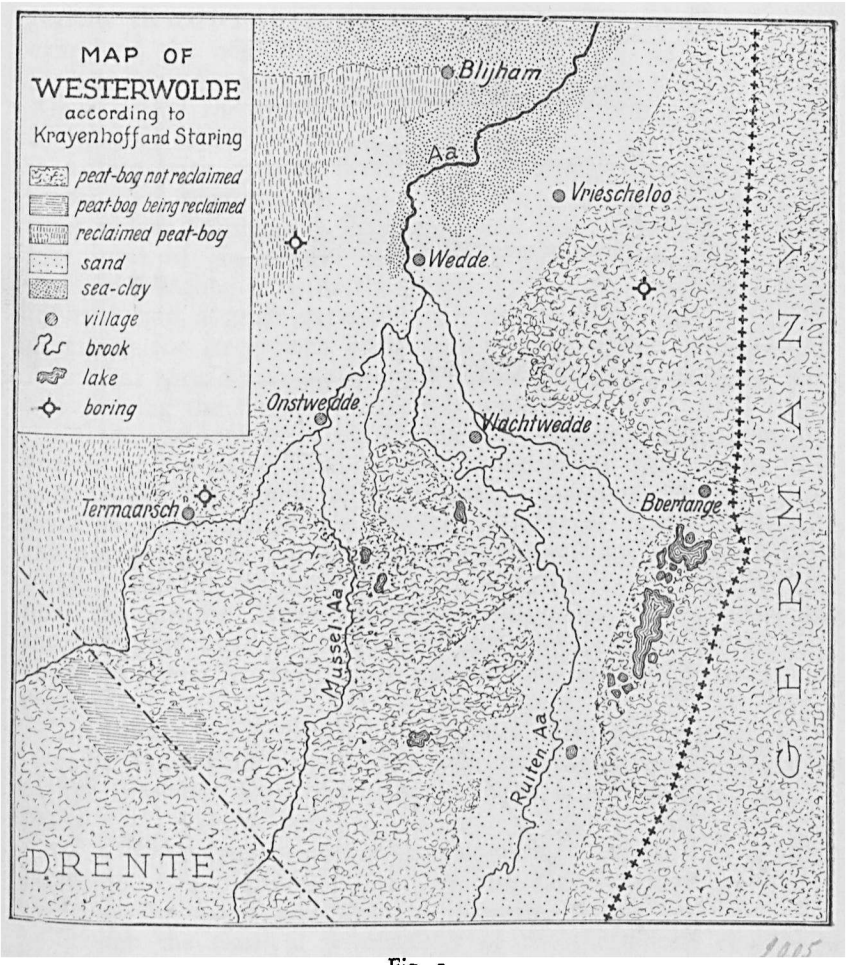


Fig. 1.

the percentage of Pinus also falls off very quickly and it continues to move with slight deviations round an average of 5% up to the surface.

Meanwhile Alnus has augmented and as in most of the N.W. European profiles, Alnus also here has the greatest percentage of the pollen in het younger layers of the bog. Although in post-glacial times Alnus has been a tree greatly coming to the front in these parts, it is not in general characteristic of a definite period.

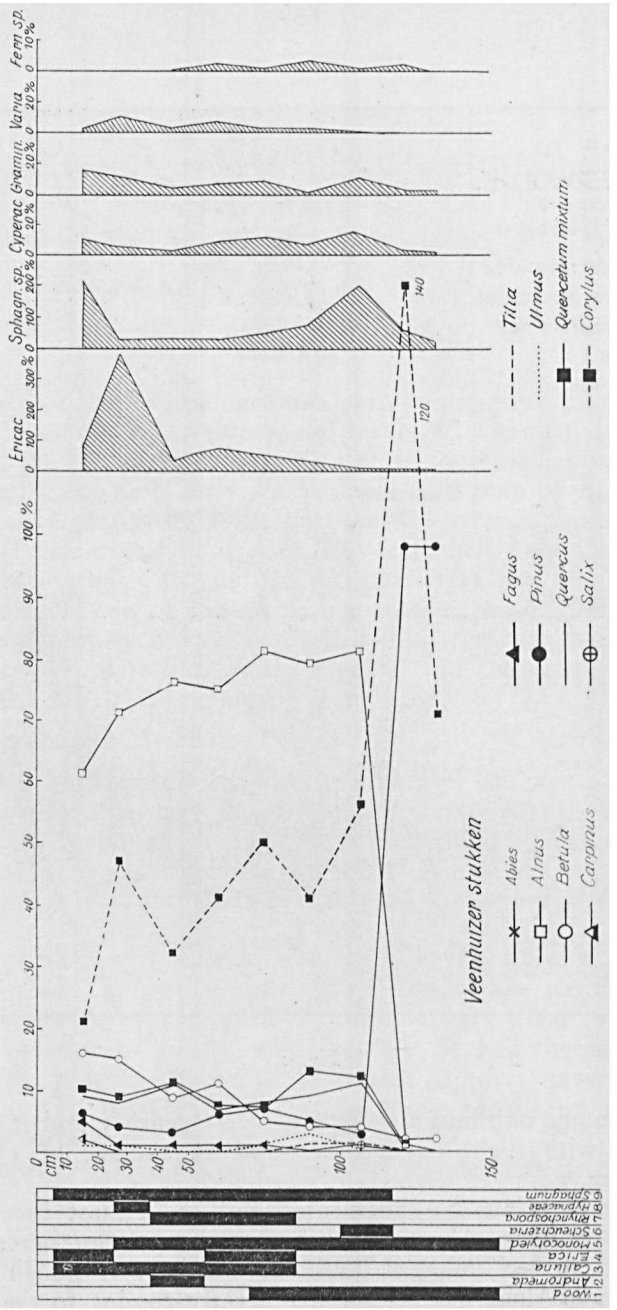


Diagram I: „Veenhuizer stukken". 1906

1 = Wood; 2 = Andromeda; 3 = Calluna; 4 = Erica; 5 = Monocotyledones; 6 = Scheuchzeria; 7 = Rhynchospora; 8 = Hypnaceae; 9 = Sphagnum.

Its extension in Central Europe is not nearly so great as in these regions (Rudolph 1930) and therefore the authors who have examined the bogs of N.W. Germany (Koch, Overbeck & Schmitz, Schubert and others) do not take a separate Alnus period for granted. For the growth of Alnus is determined by edaphic factors. Tüxen (1931) pointed to the fact that Alnus is a tree with typical demands of standing-place. Especially it grows on a very wet soil. The alder-marsh is poor in plant nutritious matter, it furnishes, however, good pasture-ground and therefore most of the Alneta which have existed have changed into grass-land. Along most of the brooks of Westerwolde Alnus is sure to have had a great extension, the nature of the soil which was necessary for its growth being present. Soon after its appearance Alnus has spread maximally (81%). The percentage decreases when approaching the surface where it is yet 61.

Of the components of the Quercetum mixtum Quercus and Tilia appear at the same time, in the second place also Ulmus. Tilia and Ulmus are found only in small quantities, Quercus is the principal component of the Quercetum mixtum. A short time after the appearance of the Quercetum mixtum Fagus appears in very small quantities only, which quantities, however, increase quite near the surface. There also appears Carpinus. In the same time the Ericaceae have a maximal development (380%); Betula originally occurring in small quantities only at last also somewhat increases.

The whole profile practically includes only two periods:

1. a Pinus-Corylus-period, which terminates at the beginning of the diagram; Pinus and Corylus have a maximum, Alnus appears.

2. a Quercetum mixtum-Corylus-period: Alnus has a great extension, Fagus appears, later on also Carpinus; at the end of the diagram Alnus and Corylus decrease, Betula increases.

Though the classical terminology of the postglacial climate by Blytt & Sernander has been waved aside by Von Post (1930), Grosz (1930), K. Bertsch (1935) and others, we may use their nomenclature without the climatological connotation. Von Post pointed to the fact that the terminology established by Blytt & Sernander, originally only meant for Scandinavia, however conveyed to other regions of Europe, is now even obsolete for Sweden too. In the first place because neither in Sweden nor elsewhere the sole definite border-line between its periods, the subboreal-subatlantic limit, was a turning point for forest-evolution in the same degree as it was for bog-stratigraphy,

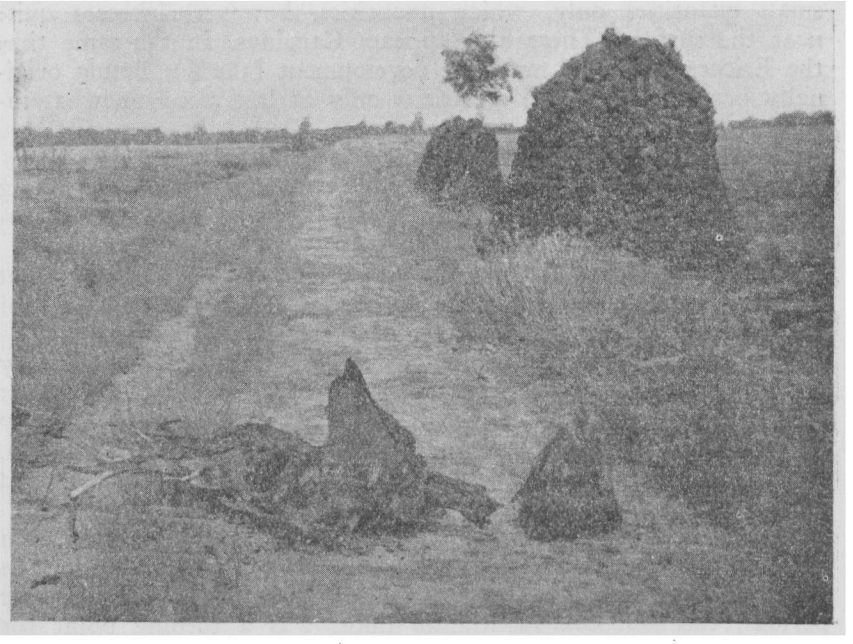
while the terms boreal, atlantic etc. were also inadequate for the other stages of development. Secondly, because more recent investigations, especially in Sweden, have shown that the changes of climate had been considerably more complicated than the old scheme suggested.

As a general division of the postarctic epoch Von Post proposed in accordance with the main features of European forest-development a system of three periods:

1. The stage of the approach of the warm period, characterized by the appearance and the first increase of relatively heat-loving trees of different kinds.
2. The stage of the culmination of these forest-elements.
3. The stage of the decrease of the characteristic trees of the warm period and the appearance or the return of the predominant forest-constituents of the present day.

Summarizing the research of the last and best developed profile we will trace how far the division of Von Post is useful here.

If we use the terminology of Blytt & Sernander only as a division of time, therefore without the climatological connota-



Tree-stumps, found in the peat. *(photo A. Pulle)*

tion, we may suppose after comparison with the results of the investigation of neighbouring German bogs that the Pinus-Corylus-period is boreal, the Quercetum mixtum-Corylus period, falling past the crossing of the Pinus- and Alnus-curves, atlantic.

As we were saying the peat has been dug off down to the sand in some places. Fairly many tree-stumps have come out during the process, obviously originating from Pinus and having two forms. One kind (on the right side of the photo) has a normal vertical root-system, among whose parts there are great clods of sand. The tap-root of the other kind (on the left side of the photo), however, has been reduced and the lateral roots have developed horizontally; often the roots have curbed upwards partly. This latter kind of tree-stump contains peat among the roots.

Evidently the stump coming from the sand is the older one, it stood in the diluvial underground. When the soil became wetter and peat began being formed, the tap-root remained rudimentary and the lateral roots have strongly developed, that the roots should find sufficient oxygen for their existance.

The conic form of the stumps of Pinus in the bog is striking. Their origin will have been as follows: The foot of the tree getting surrounded by peat, also the horizontal roots in the long run became short of oxygen and finally the tree died. The atmosphere and the water now acted most upon the border-line of air and peat (at A in fig. 2) and this process gradually decreases down to the lower end of the tree (B in fig. 2). When the decay has pro-

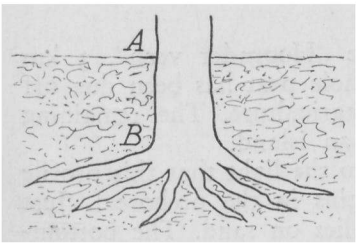


Fig. 2

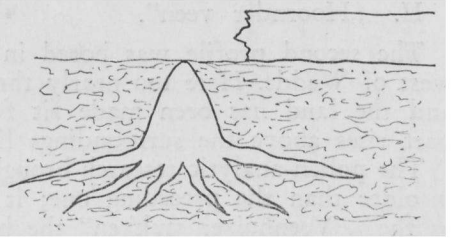


Fig. 3

ceeded far enough the tree snaps off on the border-line of peat and air, and the conically formed lower end sticks with the roots in the soil, thus being no longer open to the influence of the weather (cf. fig. 3). The tree which keeps lying on the peat decays totally and this explains why mostly only tree-stumps and seldom whole trees are found in the peat. This, however, principally

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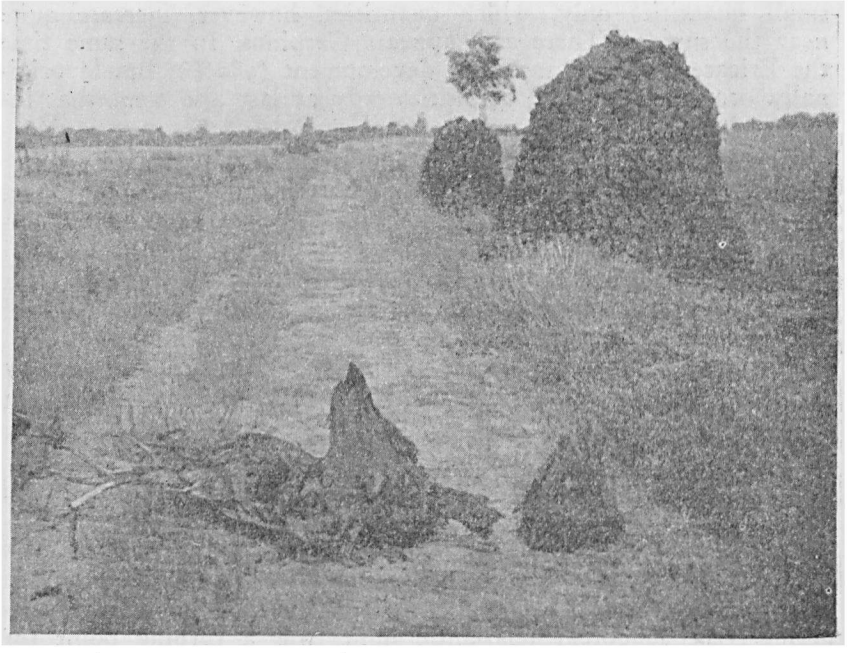

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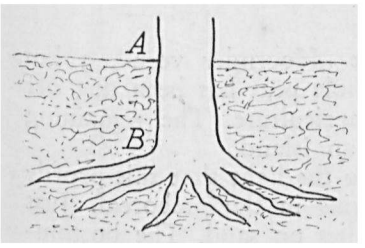

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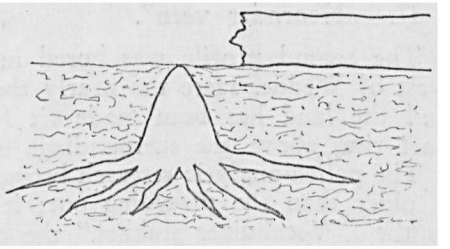

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holds good for Pinus; of Quercus often stems are found and no roots.

It is evident from the preceding, that the „Veenhuizer stukken" found their origin in the fact, that the soil of a forest changed into a marsh. In Germany this is called „Versumpfungsmoor".

As to the further stratigraphic research, this has produced little that is of value. Of the principal elements of the peat in the older layers only wood and Monocotyledones prove to be recognizable; a nearer classification, however, was impossible in general. Exceptions to this are offered by Scheuchzeria and Rhynchospora: the former was easily to be recognized by its fibrous structure, of the latter fruits were found. The whole, however, gives an impression of wood-peat; gradually the trees must abandon the contest against the growth of the bog.

More upwards, in the atlanticum, first Sphagnum appears and next Ericaceae (twigs, leaves and flowers of Calluna and Erica, a seed of Andromeda): so the peat-formation has become from meso- oligotrophic. These layers belong to the old peat, which appears from the high degree of weathering; young Sphagnum-peat fails all over. Perhaps the upper part of the peat already belongs to the border-layer, i.e. the peat underlying the Grenz-Horizont (the percentage of Ericaceae is great here); it is not clear, however. We must take it for granted that the young Sphagnum-peat, if it has ever been present, has been dug off all over.

II. „Hoornder veen".

The second profile was bored in the „Hoornder veen", 3 km west of Wedde. Here too nearly the whole peat has been dug off and the land has been made fit for agriculture. The remaining part rises above the surroundings like an island.

The pollen-analytic research brought to the light that this profile is older than the preceding one; it begins in the preboreal. Just as the „ Veenhuizer stukken" the bog lies on sand. The bottom-sample is very poor in pollen of trees, on the other hand many Cyperaceae-pollen were found: in onze preparation 2 Betula-, 2 Pinus-, and 4 Corylus-, but 65 Cyperaceae-pollen (cf. diagram II). From this we might conclude that at this time there were no forests (cf. Firbas 1935).

The late-glacial, i.e. the time which passed between the recession of the ice from the inmost Baltic final-moraine and the second Finnish Salpausselkä, was divided by Firbas into three periods:

1. an arctic period, which is characterized by forestlessness.

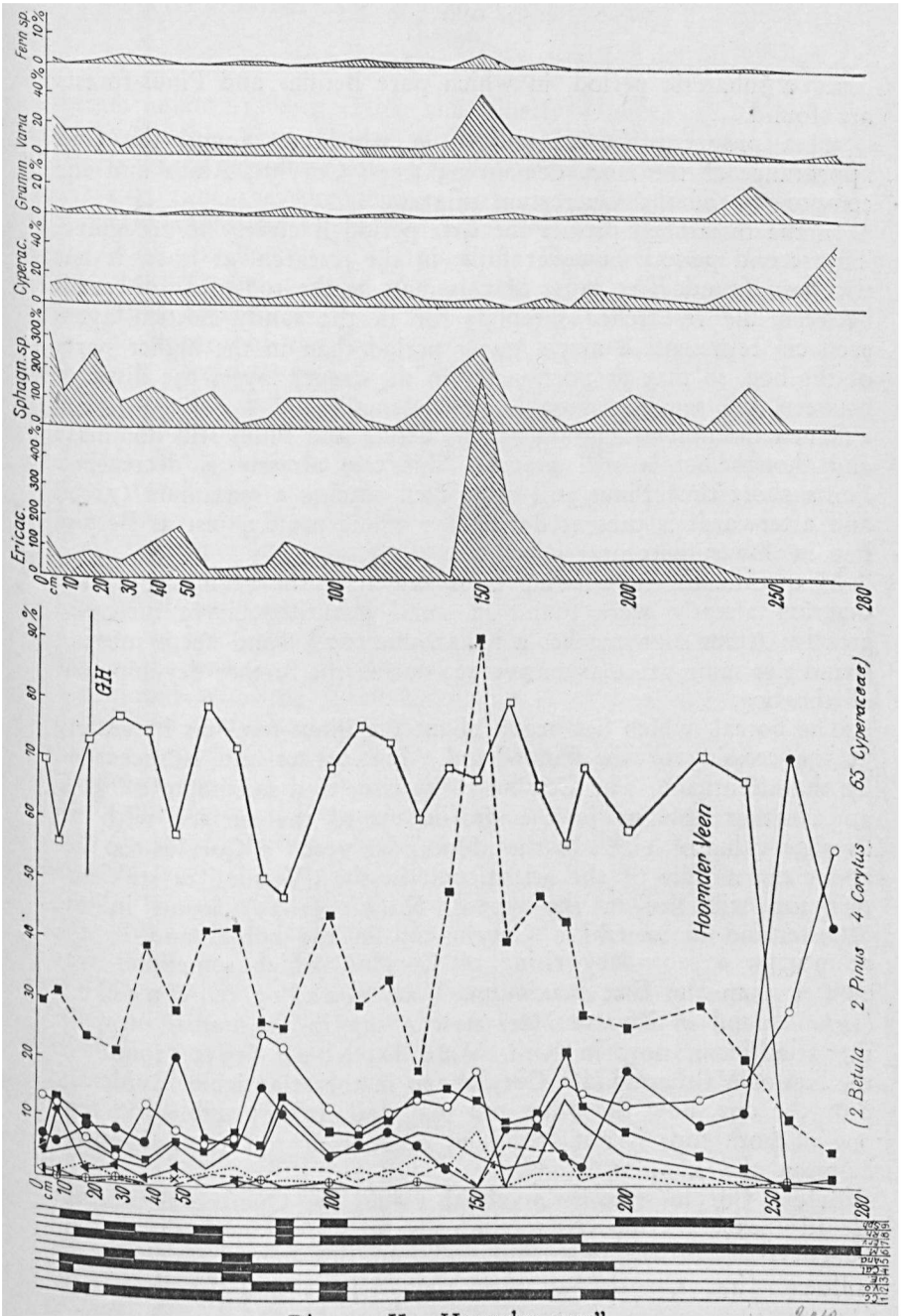

Diagram II: „Hoornder veen".

1 = Charcoal; 2 = Vaccinium Oxycoccus; 3 = Erica; 4 = Calluna; 5 = Andromeda; 6 = Monocotyledones; 7 = Eriophorum vaginatum; 8 = Rhynchospora; 9 = Sphagnum.

2. a subarctic period, in which pure Betula- and Pinus-forests are found.

3. a proper preboreal period, in which we found the first appearance of the more demanding trees: Corylus, Alnus and the components of the Quercetum mixtum.

In the researched profile the first period is clearly to recognize. The second period, however fails; in the research, at least, it has not been found. The cause of this may be the too great distances between the researched samples; for in the sandy bottem-layers each cm represents a much longer period than in the higher parts of the bog, so that proportionally in the deeper layers the distance between the samples must be much smaller.

When the pollen-diagram begins, Betula and Pinus still dominate and though Betula still prevails, this tree already is decreasing. For a short time Pinus still rises, then reaches a maximum (71%) and afterwards is present during the whole profile, just as Betula, but in lower percentages.

Meanwhile the heat-loving trees, which at the beginning of the diagram already were found in small quantities, have increased greatly: Alnus soon reaches a high value (67%) and keeps moving round this same value as an average during the further development of the bog.

The boreal, which has begun about the Pinus-top, has its ending at the crossing of the Pinus- and Alnus-curves and is succeeded by the atlanticum. The Corylus-curve rises to a maximum of 91% and further remains in the profile up to the surface with an average value of 31%. In the „Hoornder veen" a Corylus-top lies about the middle of the atlanticum; in the „Veenhuizer stukken" this top still lies in the boreal. Koch (1929) found in the Münsterland in general a Corylus-top in the boreal and in the atlanticum a secondary rising of Corylus, which sometimes was greater than the first maximum. Van Raalte & Wassink (1932) found in Zwarte Meer now a top in the boreal, now in the atlanticum, now in both. Van Dobben (1932) found in the bog of Valthermond a Corylus-top in the atlanticum. Evidently now the one, now the other top may fail. It is possible too that one of both tops is not found on account of too great distances between the samples.

Before Corylus has its maximal value, the Quercetum mixtum already reaches a top. As to the order of appearance of the component parts of the Quercetum mixtum this must be thought as follows: first Quercus appears, then Ulmus and finally Tilia. Quercus first reaches a top (and together with Quercus the Quer-

cetum mixtum), then Tilia and finally Ulmus.

Two other tops concur with the Corylus-top: the group of Varia has a maximum of 42%, the Ericaceae even exceed 650%. At that time the surroundings may have been thinly wooded.

Even before the Grenz-Horizont now and again Fagus appears in small percentages; only passed the Grenz-Horizont Fagus rises above 10%, be it only for a short time. Then also the first Carpinus appears.

The history of the forests may be resumed here as follows:

1. a forestless period.
2. a short Betula-Pinus-period succeeded by
3. a Quercetum mixtum-Corylus-period in which Alnus immediately has a high value, Quercus, Tilia, Ulmus, and Corylus in turns reach maxima, Betula sometimes occurs in still important percentages and Fagus begins to appear.

A Fagus-period such as the German bogs mostly show and such as Ten Houten (1935) found in the „Korenburger veen" also, does not occur here.

Just as with the other two profiles, the stratigraphic research has been done less thoroughly, because when we aim at getting acquainted with the forest-history, it is of less importance than the pollen-analytic research.

In the preboreal and in the boreal only remnants of Monocotyledones are found. Shortly after the crossing of the Pinus- and Alnus-curve, in the atlanticum therefore, Sphagnum begins to help in the formation of the peat. Later on it is especially Eriophorum vaginatum and Calluna (twigs, leaves and flowers) and some less important Ericaceae (Vaccinium Oxycoccus, Erica and Andromeda) that compose the bulk of the samples. The main constituent is old Sphagnum-peat.

Remarkable is the occurrence of charcoal, which may be found from the atlanticum up to the Grenz-Horizont. The Grenz-Horizont is easily observed, and lies at 17 cm below the surface. The upper 7 cm of the peat have greatly decayed and are full of roots of the recent vegetation.

III. „Veeler veen".

The last profile was bored in the „Veeler veen", 6 km east of Wedde. At the time when Krayenhoff drew his map these regions were totally consisting of bog yet. Little by little large fragments have been reclaimed, indeed, but still there is original bog, which is being worked until the present day.

The formation of the peat has begun in moss-hags, great basins

in the ground from 10 to 20 m diameter. When these moss-hags had been filled, the bog kept growing in an upward direction, at the same time overgrowing the space between the moss-hags, so that at last the whole soil was covered with a layer of peat. By sounding it was possible to find the middle of a moss-hag, so that a profile of 4,38 m could be bored.

The bog lies on sand. A typical forestless period with high values for the Cyperaceae was not found, alas. The diagram

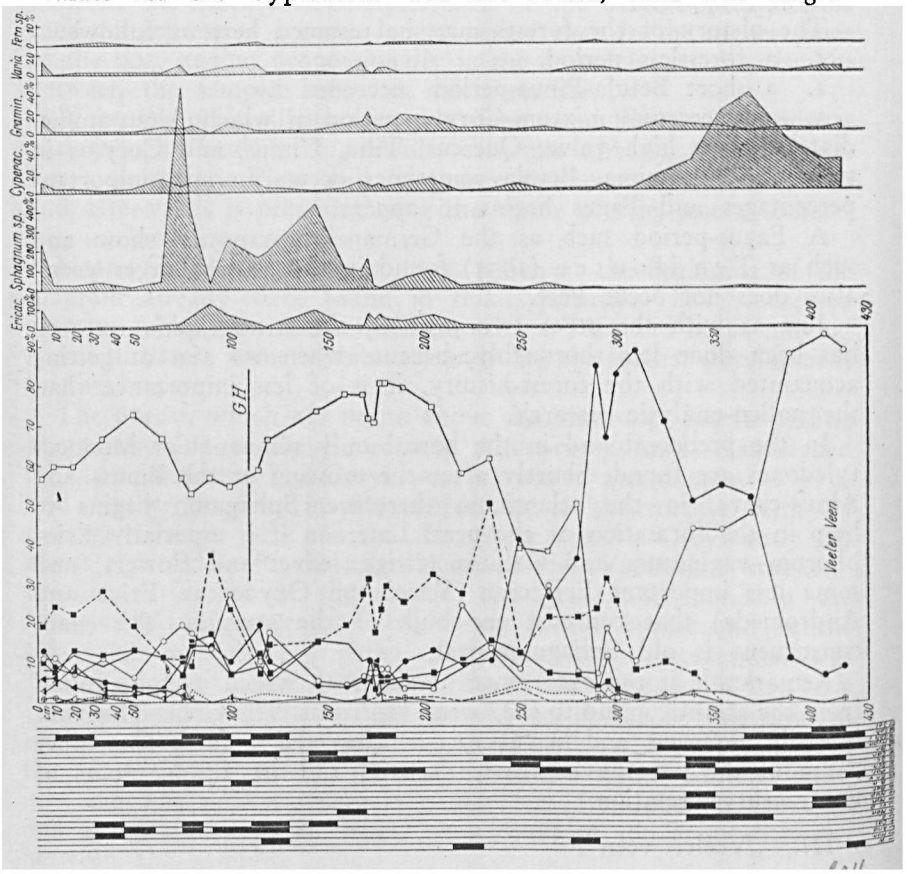

Diagram III: „Veeler veen".

1 = Wood; 2 = Monocotyledones; 3 = Andromeda; 4 = Calluna; 5 = Erica; 6 = Menyanthes; 7 = Viola palustris; 8 = Myriophyllum; 9 = Nuphar; 10 = Batrachium; 11 = Betula nana; 12 = Eriophorum vaginatum; 13 = Potamogeton; 14 = Scheuchzeria; 15 = Scirpus; 16 = Carex; 17 = Bryales; 18 = Hypnaceae; 19 = Sphagnum imbricatum; 20 = Sphagnum spec.; 21 = Selaginella.

(cf. diagram III) begins at the time of the subarctic Betula- and Pinus-forests, the second period of Firbas. As remnants of the former tundra-vegetation in these layers were found Selaginella selaginoides (microspores) and Betula nana (leaf-fragments). In the „Soesterveen" Selaginella was found in the first, forestless period of Firbas; in the same period and at the rise of the subarctic forests also Betula nana. In the „Veeler veen" both are found somewhat later. Probably they found in the bog a refuge, which met their demands in the best way. The research of Vriezenveen („Bruine Haar") by Florschütz & Wassink (1935), where Selaginella is found as late as the Pinus-Corylus-period, proves that also later on Selaginella may be found.

Betula, which at first with an average value of 90% far exceeds Pinus, decreases after some time and is then almost completely crowded out by Pinus. Near this change of domination a maximum of the Cyperaceae is found. This does not attain the 100% but points to a smaller density of forests during a short time or to a stronger growth of Carices.

Now there appear in succession Quercus, Corylus and Alnus, so here the third period of Firbas is reached. The preboreal ends more or less when the Pinus-curve reaches a top. In the boreal a rise of Corylus appears. Pinus soon declines, Alnus increases, and as in the former profiles the atlanticum begins with the crossing of the Pinus- and the Alnus-curve at about 40%.

Of the components of the Quercetum mixtum only Quercus is a rather important element. Tilia and Ulmus have a small share in the composition of the forests; the greatest percentage of Tilia is 3, of Ulmus 4. The Quercetum mixtum reaches a top, with Corylus. Except as for Fagus, the diagram has a normal course.

Fagus, however, is to be found here in the atlanticum already at a depth of 1,75 m below the surface soon finding a maximum of extension there; next it is soon reduced again to nought and not until 0,75 m below the surface it appears again. In general Fagus begins in the Netherlands shortly before or after the Grenz-Horizont, at least with somewhat important percentages (Florschütz & others 1932, Florschütz & Wassink 1935, Ten Houten 1935). An exception to this is the bog of „Boerendijk" (Vriezenveen), which was explored by Florschütz & Wassink. The authors suppose Fagus to have settled during the atlanticum here and there on the sand, so that only at the outskirts it sent pollen into the bog.

Vermeer—Louman (1934) also mentions some finds of Fagus from old layers. In a boring near Sloten (province of

N. Holland) she found the empirical limit of Fagus-pollen (i.e. the beginning of the cohesive curve) in the boreal. In the atlanticum Fagus attains 4% of the total at a depth of 4 m; then the percentage gets low again. The rational limit of the pollen (i.e. the beginning of the continued rise of the curve) lies at 2,35 m, the bottom of the young Sphagnum-peat.

Polak (1929) too found already regularly Fagus in the old Sphagnum-peat of the „Riekerpolder".

Ernst (1934) who also noticed the great fluctuation in the empirical and the rational limit of Fagus-pollen, distinguishes three types of curves of Fagus-pollen with regard to the Grenz-Horizont:

1. the Fagus-curve begins below the Grenz-Horizont, while the absolute, empirical and rational limit coincide. The curve rises without a minimum to a top.

2. the Fagus-curve begins as sub 1, while also the absolute, empirical and rational limit coincide. The curve makes a top immediately, but soon falls again, after which only above the Grenz-Horizont a maximum is formed.

3. the absolute, empirical and rational pollen-limits are separated by great distances. Only above the Grenz-Horizont the formation of a top begins.

Ernst points to the fact that Fagus must have spread irregularly and that at first only here and there it has obtained a foothold. Edaphic factors will have played a part here. The distribution by animals and men, which according to Ernst possibly has contributed to the spreading of Fagus, probably is of little importance. What factors, however, cause the minimum with the second type, to which the present case of the „Veeleer veen" belongs, Ernst does not point out. As Fagus according to F. Bertsch (1935) occurs only in a specific climate (Fagus wants an oceanic and shuns the continental climate), we might expect here a change of climate. The three types of Ernst, however, are not found regionally divided but in almost all districts explored, from the Ems as far as in the north-east of Denmark close together. So a factor of climate is impossible.

Though we cannot indicate a further distinct cause for the minimum in the Fagus-curve of the second type, it is evident that the importance of the Grenz-Horizont, at least with regard to the appearance of Fagus is only slight.

Summarizing we may distinguish in the „Veeler veen":

1. a Betula-Pinus-period.

2. a Pinus-Betula-period, during which Quercetum mixtum,

Corylus and Alnus begin to appear.

3. a Quercetum mixtum-Corylus-period, in which Alnus has a great extension and Fagus a small top.

4. a Quercetum mixtum-Corylus-Fagus-period, during which the quantity of Fagus increases for the second time, but in small density.

Distinguishing the climate-periods according to Von Post in this diagram meets with difficulties. The first period, the approach of the warm period with the appearance and the first extension of the heat-loving trees goes in the diagram nearly as far as the Pinus-Betula-period inclusive. This period is succeeded by the Quercetum mixtum-Corylus-period in which both Quercus and Corylus show a top, a culmination therefore of heat-loving trees, which is typical of the second period of Von Post. Limiting the third period, however, is more difficult. For a typical decrease of the characteristic trees of the second period (components of the Quercetum mixtum and Corylus) does not actually occur. Perhaps it is right to draw this line between the Quercetum mixtum-Corylus-period and the Quercetum mixtum-Corylus-Fagus-period as according to F. Bertsch Fagus might point to the fact that the climate became rather atlantic.

The stratigraphic research brought to the light that the peat in the moss-hag is caused by the change of a pool into land. From the sand as far as 3,20 m Hypnaceae are found which point to this fact. Further seeds of Potamogeton, Nuphar luteum, Myriophyllum alterniflorum, Batrachium, Scirpus and Menyanthes. Also Carex and Scheuchzeria were found in rather large quantities. Remarkable, however, is the presence of Sphagnum in the first eutrophic vegetation.

From 3,20 m up to 1,55 m as principal finds may be mentioned: Scheuchzeria, Carex, Scirpus and other Monocotyledones which could not be determined. Above this layer begins the old peat which, however, is not composed all over of Sphagnum, but for the greater part of Bryales indeterminatae. Rather soon there appear Ericaceae, first Erica, next Calluna.

Between 1,40 m and 1,30 m there was a layer of water in the bog, hence the interruption of Erica and Bryales.

A distinct border-layer cannot be distinguished; this proceeds unobservably from the old peat which ends at 1,10 m, where the young peat begins. The latter consists of not-determined Sphagna and especially of Sphagnum imbricatum. There are to be found Ericaceae (Erica, Calluna and Andromeda) and especially Eriophorum vaginatum.

To conclude a short comparison may follow of the profiles researched here with the bogs that are nearest: the bog of Valthermond (Van Dobben 1932) and the bogs of Emsland (Koch 1934 a, b, c). On most points these researches exhibit a great resemblance with the outcomes at Westerwolde.

The bog near Valthermond has developed in about an equal thickness as the „Veeler veen". Of both the forest-history may be retraced as far as in the preboreal. The further development of the forests is nearly the same with both of them, with these exceptions, however, that Van Dobben found the absolute limit of the Fagus-pollen only after the Grenz-Horizont, and that he observed a decline of the Corylus-percentage after the subboreal-subatlantic contact. The stratigraphic research brought to the light that as far as the limit of the boreal and the atlanticum the peat was formed by Hypnaceae. This way of originating points to the change of a pool into land, so the same as happened with the formation of the „Veeler veen". Here this was more evident, however, through the finds of Potamogeton, Nuphar, Myriophyllum and Batrachium.

Koch, on the other hand, nowhere found as origin of the peat-formation the change of a pool into land but always the change of a forest into marsh, probably by the rising of the ground-water; in the same way, therefore, as has been described as to the „Veenhuizer stukken" and the „Veeleer veen" outside the moss-hags. The bottom-layers of Koch's bogs always are wood-peat.

Koch's most fully developed profiles begin in the preboreal, in the subarctic period, in which no Selaginella was found indeed, but where Betula nana was shown by pollen-statistical numerations. The exactness of this method to demonstrate Betula nana is called in question, however; at any rate leaf-fragments are of more importance and these where not found by Koch.

Koch's oldest profile which is from the „Walchumer Moor" (8—10 km S.S.E. of Boertange) shows in the preboreal and the boreal repeatedly change of domination between Betula and Pinus. Possibly these changes would have been found in the „Veeler veen" and the „Hoornder veen" too, if the distances between the researched samples had been taken shorter. With Koch these are 5 cm, with the present researches 15 cm.

As for the further process of the forest-history this agrees especially with that of the „Veeler veen", which is so to say part of the bogs of Emsland.

Fagus in most of the profiles appears before the Grenz-Horizont

and then takes an extension (e.g. in the „Walchumer Moor") of 6 to 7% in the atlanticum and subboreal (in the „Veeler veen" 10%). After the Grenz-Horizont Fagus reaches values of 25%, percentages not found at Valthermond nor at Westerwolde. Anyhow, in S.E. Groningen Fagus is already a very old tree.

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