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# EVIDENCE OF FORMER TREE GROWTH AT CLONSAST

A
THESIS.
IN TWO PARTS

## PART I. TEXT

1957

Accepted for Ph.D.

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The following thesis "Evidence of Former Tree Growth at Clonsast" is submitted by Neil Robert William Murray, Agr.(Forest.)B. for the degree of Doctor in Philosophy.

The analytical work was carried out by me under the direction of my supervisor G.F.Mitchell, M.A., M.Sc., F.T.C.D.
The conclusions reached are my own and all references to the work or opinions of others are clearly stated at the appropriate points in the text. A full list of these is included.
The text and diagrams have been prepared throughout by me.
The thesis has not been submitted as an exercise for a degree at any other University.

Neil Murray

Dublin University

28th.February,1957.

# INDEX.

Only certain illustrations have been indexed. Their page numbers are in brackets under the subject to which they refer.

Part 2 of this thesis contains the following---

1. Map of Clonsast Bog.
2. Detailed Boring 3. 1956 --- Arboreal Pollen Diagrams.
3. " " " Non-Arboreal Pollen Diagrams.
4. Detailed Boring 2. 1956 --- Arboreal Pollen Diagrams.
5 " " " Non-Arboreal Pollen Diagrams.
6. Detailed Boring 1. 1955 --- Arboreal Pollen Diagrams.
7. " " " Non-Arboreal Pollen Diagrams.
8. Detailed Profile 1.1955 --- Arboreal Pollen Diagrams.
9. " " " Non-Arboreal Pollen Diagrams.
10. " " " Seed Diagrams.
11. " " " Table of "Washing-Sample" Finds.
12 Key to Stratigraphic Symbols.

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# Evidence of Former Tree Growth at Clonsast.

## Summary of Thesis.

Six thousand years ago practically all the ground now covered by peat in the area investigated at Clonsast, County Offaly, was woodland.
The main object of the research was to trace the disappearance of woodland due to peat formation; and to investigate the subsequent sporadic colonisation of the bog surface by new trees.

By means of pollen analysis and the identification of macroscopic remains from the peat the changes in vegetational cover which took place down to the present day were traced.
Pollen diagrams from four sites in the bog and an analysis of seeds and other macroscopic material from one of these sites are presented.
The oldest peat examined was formed just at the late-Boreal to Atlantic transition.

In addition, the woody remains found had to be identified and a section of the thesis is devoted to this problem.
Photomicrographs illustrating points by which timbers were identified are included, as is also a brief section on charcoal identification.

Further sections comment on the possibility of applying dendrochronological methods to bog timbers, and on the difficulties involved in the afforestation of peatlands.

The thesis is presented in two parts - Part 1, Text, and Part 2, Diagrams.

## "Evidence of Former Tree Growth at Clonsast"

An error in transcription occurs in the last four lines of page 4. The passage should read ---

"That nearest the zero line represents the pollen value expressed as a percentage of the total of all arboreal and non-arboreal pollen present (but excluding wet-habitat species). The outer curve of each pair represents the pollen value expressed as a percentage of total arboreal pollen only, in the case of trees, and as a percentage of total non-arboreal pollen only, in the case of non-arboreal plants"

# FOREWORD.

Investigations, of which the results are here presented, were carried out with a view to tracing the sequence of events leading to the overwhelming by peat of the forests or woods which once grew on the mineral soil in the Clonsast area and also any subsequent colonisations of the peat by trees.

A visual estimation of tree growth in the area prior to peat formation has been made possible following the cutting away of the deposit by Bord na Mona, the national organisation engaged in developing peat for fuel uses.

From a palaeobotanical viewpoint this clearance is unfortunate as it means the destruction on a large scale of evidence of past happenings as they are recorded in the peat strata.

Clonsast Bog lies 6.5 Km. North of the town of Portarlington in Co. Offaly. (see inset on map)
In extent the bog is 3 Km.x 6.5 Km. and its topography may be seen represented on the accompanying map which has been copied by permission of Mr.Mitchell.

Fine profiles of both peat and the underlying moraine material are visible throughout the bog making features of lateral extent easily traceable.

The four points from which material for analysis was collected all lie along Trench 2. On the map they are circled in red and numbered 1 to 4 as follows

Detailed Profile 1. 1955........(1)
Detailed Boring 1. 1955.........(2)
Detailed Boring 2. 1956.........(3)
Detailed Boring 3. 1956.........(4)

Sites from which pollen-analytical results have been published --- (Mitchell 1951 and 1956) are also surrounded by a red circle. Other sites investigated by Mr.Mitchell but which are unpublished are marked with an X and have the year recorded alongside.

The average annual rainfall on the bog for the years 1937 - 1955 was 27.64 inches or approximately 70 cm.

During the course of numerous visits to the bog, material for pollen analysis was collected, in one case directly from a profile but elsewhere by the standard method using a Hiller borer.

The plant nomenclature followed is that of Clapham, Tutin and Warburg (Flora of the British Isles, 1st.Edition.)

The first part of the text deals with the stratigraphy and the pollen and seed analyses. This is followed by notes on Taxus, Pinus, and peatland afforestation. Finally there is a section on the identification of woody remains found in peat.
Descriptions of techniques employed and results of some tree ring-growth measurements etc., have been relegated to appendices.

The work, including initial training in pollen and seed identification and techniques, and the preparation of diagrams and text occupied a period of two and a half years from Autumn 1954 to February 1957.

The researches were carried out with the assistance and under the direction of Mr.Mitchell to whom I am indeed most thankful.

My thanks are also due to Miss H.M.Parkes for patiently assisting me to become acquainted with the principles of pollen analysis.

Thanks also go to Mr.W.Watts for assistance in several seed identifications.

## POLLEN AND STRATIGRAPHY - INTRODUCTION.

### Collection of pollen samples.

Except in Detailed Profile 1. 1955 where samples were taken directly from the peat profile, all samples were obtained by Hiller-borer. The sampling interval was 5 cm. though in some cases however there is a gap of 10 cm. due to the last sample being taken from the borer chamber at 45 cm. and the first sample of the next chamberful being taken at the 5 cm. mark.

Samples were placed in open-ended glass tubes the corks of which were sealed with paraffin wax to prevent desiccation.

### Treatment of samples.

Samples were treated according to the method set forth by Faegri and Iversen.(Faegri and Iversen 1950) Briefly, the peat was first heated gently in 10% KOH. The larger material was filtered-off and examined for macroscopic remains. The filtrate was washed, centrifuged and examined, and if on counting at least five microscope-slide traverses it was found that pollen grains were too few and far between, the material was subjected to acetolysis.(The method is described in Appendix 1.)

### Pollen Zonation.

The zonation followed is that set down by Mitchell (Mitchell,1956)

The deepest of the borings pollen-analysed for the work here presented reaches the Zone VI to Zone VII transition.(Boreal/Atlantic transition.)

Zone VI is terminated where Pinus pollen values fall, Alnus values increase and Corylus is at its late-Boreal minimum.

Zone VII ends and VIII begins with the general fall in Ulmus, followed a little later by a rise in Quercus to its highest values succeeded by a decline.

Zone VIII is divided into two sub-zones --- VIIIa where Quercus is rising to attain its highest value, and VIIIb where it is falling from this maximum.

As Sub-Zone VIIIb draws to its close Ulmus rises to a maximum while Alnus sinks to low values.

Sub-Zone VIIIb ends and Zone IX begins where Ulmus falls to low values which persist till the pollen of planted elm causes an expansion of the curve in Zone X. Corylus is at a minimum and Quercus, Alnus, and Betula show higher values.

Zone X begins where the pollen of Fagus and Picea appear, and where the curves for Pinus and Ulmus expand --- all resulting from the planting of these species.

Mitchell places the following approximate dates on these transitions

Zone VI-VII c. B.C.4000
" VII-VIII c. B.C.2500

Zone VIII-IX A.D.500
" IX-X A.D.1700

## Indications of Agriculture.

Agricultural interference with the woodlands is inferred from the curves where Ulmus falls to a minimum, Corylus, Alnus, and Betula rise and Fraxinus, where present, falls in value.

These movements in the Arboreal pollen (A.P.) curves are accompanied by the appearance of, or increase in value of, Plantago lanceolata, Artemisia, and Cerialia. Rumex, though having certain species as weeds of cultivation, is not here used as an indicator as seed finds show it to have been growing on the bog.

## Pollen Diagrams.

Generally speaking, samples were analysed every 10 cm. though at points of interest such as zonal transitions etc., the intensity was increased to 5 cm. intervals. Rarely do the distances between samples increase to 15 cm., and only once to 20 cm. (D.B.2.56) where a sample was found to be anther-contaminated.

The curves were plotted on tracing paper mounted over millimeter paper and reproduced by a commercial drawing-office process.

The Arboreal pollen results and the Non-Arboreal pollen results are each graphed on seperate diagram-sheets but each pair of these will, for the sake of convenience, be referred to in the text as one diagram, the context making it obvious whether the Arboreal or the Non-Arboreal section is referred to. Thus the diagrams from four points in the bog number eight sheets. There is also a single sheet diagram and a Table showing results obtained from "Washing Samples" (see below)

Due to their size, these together with a map of the area will be presented under a separate cover.

## Explanation of the diagram-sheets.

The first column shows the zonation. It should here be pointed out that the zonal transitions are based entirely on the pollen curves and were placed without any reference to the stratigraphy. The latter was produced from the field notes.

The second column shows the stratigraphy. Conventional symbols were used for the peat types and these are explained in a key together with the diagrams.

The third column shows depths with a horizontal stroke at every 20 cm. After this the pollen curves start. With the exception of definitely wet-habitat species (see below) each species or family is shown with two curves. That nearest the zero-line represents the pollen value expressed as a percentage of total Arboreal pollen only, in the case of trees, and as a percentage of total Non-Arboreal pollen only, in the case of Non-Arboreal plants. Here again, wet-habitat species are excluded. These curves occasionally coincide but obviously cannot intersect.

The term "wet-habitat species" refers to those plants normally living in pools on the bog surface --- Rosaceae, Potamogeton, Menyanthes Rosaceae is put in this category as the pollen found was probably Potentilla palustris.

In each sample analysed 300 tree pollen including Corylus were counted. In four samples this total was exceeded. They are specified below in the appropriate analysis results.

Where any particular pollen fails to appear in a sample, its curve is joined to the base-line 2.5 mm. (on paper) from the level of its last appearance. Theoretically it should be brought to zero at the level of the sample in which it does not appear, but it was thought better to draw no inference from any unanalysed sample in which that species might or might not be represented. This may be inconsistent in view of the fact that values in well-represented curves are joined often over gaps of 15 cm. implying that the pollen value in the intervening unanalysed samples lies along the curve. However, in the case of "trickle" values it seems safer not to do this but to infer nothing from the unanalysed samples. It may then be borne in mind that gaps if shown in the diagram are at their maximum extent, and are probably less than shown in the curve.

It was necessary to over-represent some values, for instance, where only one or a few grains of a particular pollen occur the percentage value may be only, say, 0.1%. The lowest value which could be represented is 0.5%.
All values up to 0.7% are drawn as 0.5% and decimal parts of higher values are expressed to the nearest 0.5%.

In the diagrams the pollen curves are followed by a curve labelled NAP/AP x 10 which shows the relationship existing between Arboreal and Non-Arboreal pollen. It is thus the sum of Non-Arboreal pollen divided by 300 the result of which calculation it was thought better to magnify by 10 as it could not otherwise have been shown satisfactorily as a curve, many of the values being too low.
The arithmetical relationship between A.P. and N.A.P. may readily be obtained by referring to the third last column labelled "Sum of NAP" and comparing this with the constant value of 300 A.P. counted in each sample.

The next group of curves from left to right, is cross-hatched. It shows Sphagnum and Polypodium spores and also the pollen of the above-mentioned wet-habitat species. They are all expressed as a percentage of the sum of all pollen counted in the sample to which they belong without themselves being counted in this sum. Hence on one occasion Sphagnum shows a value of 108%

In the N.A.P. sheets of the diagrams the first table follows the cross-hatched curves. The first vertical row of the table shows "Unidentified NAP" followed by similar vertical rows showing percentages of wet-habitat species which were so infrequently present as not to warrant drawing a special curve for them. They are all expressed as a percentage of the sum of all pollen without themselves being added in and are thus calculated in the same manner as the cross-hatched curves.
The remainder of the table values are percentages calculated in the same way as the values for the inner curves i.e. the number of grains of pollen of the particular species expressed as a percentage of the sum of all pollen (N.A.P. + A.P.) of which total it is itself a part.

The next column is that already referred to above and shows the "Sum of NAP" exclusive of the wet-habitat species.
The second last column gives the sample number - only the numbers of samples actually analysed being included. The horizontal strokes alongside each of these numbers shows their actual position in the diagram and the final column of figures shows the depth of each sample, or every second sample if the analysis interval is only 5 cm. The scale at both right and left sides of the diagrams facilitates reading by laying a straight-edge in line with corresponding depths.

A horizontal scale appended at the lower right-hand edge of each diagram shows percent values.
A further scale for quick assessment of curve values is placed at the base of each curve. The distance between each vertical stroke measured-off from the zero line of the curve to which it refers, represents 5%.

## Description of the peat and its contents.

The description of the peat made in the field during the collection of samples is given followed by an enumeration of any finds made in the laboratory and not already noted in the field description thus forming the headings "Field" and "Laboratory".

Two slightly different methods of recording the depths of the field description are followed. Both are obvious and require no explaining. Double query marks (??) indicate an indefinite identification.

Photo 1.

Photo 1. General view looking Northward in Trench 2. D.B.2.56 and D.B.3.56 are situated on this peat cutting-bank.

Photo 2.

Photo 2. Closer view of the peat bank pictured in Photo 1 above.

Photo 3.

Photo 3. Same peat bank looking Southwards from rising ground close to the ridge where the Base-line crosses Trench 2. The mineral soil is just below the water surface. Small roots of pine can be seen protruding from the bank. The apparently lighter colour in this horizon is due to greater light reflection from the wetter, more humified peat.

## DETAILED BORING 3. 1956.

Detailed Boring 3. 1956 (hereafter D.B.3.56.) was made in deep peat lying in a trough between two rises in the topography of the underlying Boulder-Clay.
The point was situated in Trench 2 and is located on the accompanying map at the red-encircled point 4. The boring was made 2 metres from the cutting-face of the deposit.(The peat at the exact location has since been cut away)
The top of the bog had been levelled prior to utilization and it was not possible to say how much peat had been removed at any particular point and to what extent the surface had been disturbed.
All levels of the bog have of course been drastically altered by shrinkage following drainage.

Of the diagrams presented, this one represents the deepest and also the oldest peat.

Description.

0-9 cm.

| | |
|---|---|
| Field. | Brown humified peat perhaps disturbed. |
| Laboratory | Shoots and leaves of *Sphagnum* including those of *S. imbricatum*. Cereal pollen mainly of the *Triticum* type but ??*Avena* and ??*Hordeum* also represented. One grain of ??*Carpinus* and one grain of *Drosera* cf. *longifolia*. |

9-50 cm.

| | |
|---|---|
| Field. | Fresh *Sphagnum* peat. Fine rootlets of ??*Oxycoccus*. Fibre of *Eriophorum*. |
| Laboratory. | *S. imbricatum* and others present. Ericaceous wood. Traces of burnt material in pollen slides at 20 cm. and 40 cm. |

50-60 cm.

| | |
|---|---|
| Field. | Fresh *Sphagnum* peat with much fibre. |
| Laboratory. | *S. imbricatum* and others. |

60-95 cm.

| | |
|---|---|
| Field. | Fresh *Sphagnum* peat, H about 4. |
| Laboratory. | *Sphagnum* including *S. imbricatum*. ??Charred material in pollen slide at 80 cm. Pollen of cf. *Urtica dioica*. Ericaceous root. |

95-100 cm.

| | |
|---|---|
| Field. | More humified *Sphagnum* peat with rootlets of *Ericaceae*. |
| Laboratory. | *Sphagnum* including *S. imbricatum*. ??Vessels of a hardwood. |

100-110 cm.
Field. As before.
Laboratory. *Sphagnum* including *S. imbricatum*. 2 seeds of *Calluna*.

110-135 cm.
Field. Wet *Sphagnum* peat with Ericaceous rootlets. Rootlets of ??*Myrica*
Laboratory. *Sphagnum* including *S. imbricatum*.

135-150 cm.
Field. Fresh *Sphagnum* peat containing rootlets of ??*Oxycoccus*. H about 3.
Laboratory. *Sphagnum*, including *S. imbricatum*. 2 Ericaceous seeds. ??Scalariform perforation plate of *Alnus* or *Betula*.

150-157 cm.
Field. Layer rich in *Oxycoccus* rootlets. Moss leaves and seed of *Rumex acetosella*.
Laboratory. *Sphagnum* remains. *Betula* seeds. 2 seeds of *Taxus*.

157-190 cm.
Field. Layer rich in wood remains, twigs, fine Ericaceous roots and roots of *Pinus* and hardwood trees.
Laboratory. Moss leaves and stems, 4 *Betula* seeds, wood of *Betula*. ??Perforation plate of *Alnus* wood. Possible piece of charred material at 170 cm. Fragments of bark and veined leaves. Piece of *Phragmites*. Pollen of cf. *Urtica dioica*.

190-200 cm.
Field. Layer with *Phragmites*.
Laboratory. Seeds of ??*Menyanthes* and ??*Cyperaceae*. Piece of ??charred ??*Pinus* wood in pollen slide.

200-210 cm.
Field. Humified *Sphagnum* peat.
Laboratory. Pollen very battered and corroded. Some charred material in pollen slide.

210-230 cm.
Field. Brown humified peat with *Phragmites* and seeds of *Menyanthes*.
Laboratory. Pollen slide at 220 cm. contained charred material with a possible wood vessel visible. There was more charred material at 230 cm. Moss remains. *Basidiomycete* hyphae Seed of *Juncus* sp. and oospore of *Chara*. Non-coniferous stoma.

230-250 cm.

Field. As before but more humified.

Laboratory. Contained much battered and corroded pollen. Pollen slides at 240 cm. and 250 cm. contained burnt material Very rotten unidentified wood fragments.

250-260 cm.

Field. Highly humified black peat with *Phragmites* and fibre.

Laboratory. Occasional *Sphagnum* leaves. Unidentified wood fragments and some ??burnt material.

260-270 cm.

Field. As before, with hardwood root remains. Less fibre.

Laboratory. Pollen sample at 270 cm. contained a large number of grains battered beyond recognition. The Dipsacaceous grain recorded in the diagram table is almost certainly *Succisa pratense*. Occasional *Sphagnum* leaves. Oospores of *Chara*.

270-280 cm.

Field. As before, with *Phragmites* and many *Menyanthes* seeds.

Laboratory. Occasional *Sphagnum* leaves. Fragment of unidentified wood.

280-295 cm.

Field. Less-dark humified peat with *Phragmites* and *Menyanthes*.

Laboratory. Occasional *Sphagnum* leaves. Much battered pollen. Pollen slide at 290 cm. contained some apparently burnt material.

295-300 cm.

Field. Highly humified peat; some wood.

Laboratory. Piece of *Alnus* wood. Occasional *Sphagnum* leaves including those of *S. imbricatum*. Burnt material in pollen slide at 300 cm.

300-305 cm.

Field. Occupied by a piece of hardwood which interfered with sample 563 at 305 cm.

305-350 cm.

Field. Highly humified black peat H about 8. Piece of hardwood interfered with sample 571 at 345 cm.

Laboratory. Wood of *Alnus* and ??*Betula*. Seeds of *Betula*. Twigs of ??*Ericaceae*. Moss leaves. Occasional *Sphagnum* leaves. Seed of *Cyperaceae* at 330 cm. Vessels of ??*Corylus* occurred in a pollen slide. The pollen was fairly battered and corroded, that of *Alnus*, *Betula*, and *Corylus* seemingly in worst condition.

350-370 cm.

Field. Highly humified friable peat with much wood.

Laboratory. Piece of Alnus wood. In the bottom sample (576 at 350cm) the pollen was badly crumpled. 5 cm. lower was grey clay containing a slight amount of sandy material. The peat was very highly humified and very little material was retained by the sieve during filtering in pollen preparation.

The pollen diagrams of D.B.3.56.

In four samples the target of 300 Arboreal pollen was exceeded. These were 531 (320), 533 (309), 534 (309), and 536 (328). The actual totals counted are shown in brackets.

The Zone divison VI toVII is placed just above the base of the diagram at 366 cm.
In the basal sample just above the grey sandy clay Pinus has a high value though it has presumably already dropped from its Boreal maximum. Alnus is present at only 1% and Corylus has not quite reached its late-Boreal minimum. Quercus and Ulmus are at low values.

Sample 574 at 360 cm. shows a considerable change. Pinus has rapidly fallen and a correspondingly rapid movement in the opposite direction has taken place in the curve for Alnus. Quercus and Ulmus have increased and Corylus has reached its minimum. It rises again above this level. It is between these two samples that the VI to VII zonal border has been placed. To the corresponding level in his Clonsast B. diagram Mitchell (Mitchell 1956 pp.203-204) has assigned the date of approximately B.C.3900.
The N.A.P. curves at this level and for several samples above it are not to be trusted as examination of the "Sum of NAP" column will show that the percentages are derived from, statistically speaking, undesirably low N.A.P. totals. This is reflected in the NAP/AP x 10 curve.

Polypodium is well represented but Sphagnum spores and remains were not present, being first found at 350 cm.

Zone VII ends and Sub-Zone VIIIa begins at 350 cm. where Ulmus has decreased in value and Plantago lanceolata appears for the first time indicating some form of agricultural interference. At this point also, Alnus is at its highest value for this diagram and Betula proceeds to rise.
Fraxinus puts in a fleeting appearance at the termination of Zone VII and does not appear again until the middle of Sub-Zone VIIIa.
According to Mitchells dating (Mitchell 1956 p.204) the beginning of Sub-Zone VIIIa is somewhat older than B.C. 2195 or in round figures, B.C. 2500.

Also at the 340 cm. level one pollen grain each of Potamogeton sp. and Menyanthes trifoliata occurred. Salix began an increase which brought it to its maximum for this series. P. lanceolata soon disappears and does not reappear till 30 cm. higher up where it puts in a brief appearance before again vanishing.
At 320 cm. Ulmus increases to a maximum for the Sub-Zone and there are corresponding increases in the curves for Alnus and Betula, while Quercus and Pinus reach minima.
At the 300 cm. level are the first statistically reliable numbers of N.A.P. and the NAP/AP curve maintains significant values throughout the remainder of the diagram.
The evidence of the curves shows that farmer people were again active at this period.

Quercus rises and then falls to much lower values at 270 cm. before rising again to a peak. This is the highest value Quercus reaches in this diagram before the end of Sub-Zone VIIIb. The VIIIa to VIIIb sub-zonal division is placed at this Quercus maximum.
Just before the end of Sub-Zone VIIIa Plantago lanceolata reappears and is present throughout the remainder of the diagram indicating continued activity of greater or lesser intensity by man right up to modern times.
Approaching the end of the Sub-Zone Rumex also puts in its appearance, however, its value as an indicator of agriculture is rendered ineffective by the fact that it grew on the bog, as evidenced by the finding of its seeds both in this boring and in the "Washing Samples" referred to elsewhere (D.P.1.55)

Taxus comes into the diagram and occurs spasmodically till towards the end of the Sub-Zone where it expands its values (also see "Taxus")
The pollen of Cerealia first appear at this level at which disturbances caused by agricultural operations may be seen.
About this time conditions on the bog surface apparently became wetter starting about the middle of the Sub-Zone as shown by the presence of the pool species Potamogeton and by the rise in the curve for Sphagnum spores. This curve is a complete over-representation, and just how misleading Sphagnum spore representation can be is readily seen on inspection of the stratigraphy and the laboratory analysis results where in this case only "occasional Sphagnum leaves" were found.
An agricultural horizon can again be traced at 240 cm.

At 190 cm. despite the presence of Potamogeton there would appear to have been a drying out of the bog surface as Sphagnum decreases and stays constant for a while, while the pollen frequency of Gramineae rises indicating that Gramineae spread over the bog.

Farmers appear to have again become active in the period corresponding to a depth of 210 cm. to 200 cm.

Examination of the NAP/AP.curve will show false peaks at 200 cm. and 180 cm. due to largs numbers of Cyperaceae and Gramineae.
Here again a further set of frequencies show the results of man's operations.
At 155 cm. Rumex disappears from the diagram possibly due to a return to wetter conditions. The curve for Sphagnum behaves more realistically and the stratigraphic column shows the presence of a layer of Oxycoccus palustris. A Taxus seed found here is commented upon under the heading"Taxus".
The Ericaceous pollen curve reaches a peak at 130 cm. This rise is probably initiated by pollen of Oxycoccus palustris and assisted by Erica tetralix, though there was no positive identification of the latter (E.tetralix leaves occurred at a corresponding level in D.P. 1. 55.) but merely a record of unidentified Ericaceous seeds. The Ericaceous wood from this level is probably due to Calluna.

The Sphagnum species contained in the profile from 150 cm. to the surface include the readily identifiable S.imbricatum.
A further agricultural horizon is apparent at 140 cm. and it is at this level that Artemisia first comes into the picture

Ulmus increases and just before the termination of Sub-Zone VIIIb it reaches a final peak. It then falls, and subsequently maintains a languid existence throughout Zone IX, not increasing again till historic time.(Zone X)
The zonal border is fixed in relation to this permanent fall-off in Ulmus, which is accompanied by a marked drop in Alnus values from which the latter later recovers as the wet period proceeds, and also in relation to the Corylus minimum and the Quercus maximum which in this diagram slightly precede the Ulmus decrease.

The Taxus peak at 100 cm. coincides more or less with the drier period when pine colonised the bog. The break in the curve for Taxus is not due to extinction of the tree as the curve is unbroken in the "Trackway" diagram(see D.B.2.56. below) but it probably represents a period of suppression or destruction when pollen production was at a minimum.
Mitchell (Mitchell 1956 p.202) places this Zone VIII to IX division at approximately A.D. 500.

The remainder of the diagram is more or less uninteresting but for one important point, that is; Pinus though low in value is present right to the top of the diagram. This is commented upon under the heading "Pinus".

Due to the possibility of disturbance of the surface sample and also due to the lack of conclusive evidence in the form of the presence of Fagus, Picea, and definite expansions in the Pinus and Ulmus curves, Zone X is not indicated on the diagram. If the boundary is in actual fact not reached, it is certainly not far above the last sample. In any case Zone X is well represented in diagram D.B.1.55 and the *Pinus* curves can be overlapped to show the continuous presence of pine pollen to the present day surface.

0

## DETAILED BORING 2. 1956.

### Near Trackway or Platform in Trench 2.

The site of Detailed Boring 2 1956 (D.B.2.56) is marked on the map by a red encircled "3"
The boring was made near the cutting face of the peat bank overlying the structure.

0-50 cm.

| | |
|---|---|
| Field. | 7 cm. Dry fresh peat perhaps disturbed. |
| Laboratory. | Contained *Sphagnum* leaves. |
| Field. | 43 cm. Dark brown peat with much fibre of *Eriophorum*. Some *Calluna*. Generally well humified but with fresh *Sphagnum* peat threaded through it. |
| Laboratory. | Seed of *Cyperaceae* at 10 cm. *Sphagnum* includes *S.imbricatum*. Seed and flowers of *Calluna*. Moss leaves. Ericaceous twig or root. Burnt material at 20 cm. and further burnt material at 40 cm. including burnt stomata and an Ericaceous pollen grain which was grey in colour and may have been scorched. Samples at 20 cm., 30 cm., and 40 cm., each contained one grain of ??*Urtica dioica*. |

50-100 cm.

| | |
|---|---|
| Field. | 15 cm. As before. |
| Laboratory. | Shoot and leaf of *Calluna*. |
| Field. | 10 cm. Fresh peat H2 - H3 with fine brown moss and *Calluna*. |
| Laboratory. | Seeds and flowers of *Calluna*. *Sphagnum* leaves. |
| Field. | 7 cm. Wet dark-brown peat, ??muddy, with *Eriophorum* fibre and *Calluna*. |
| Laboratory. | *Sphagnum* leaves. Seed and shoot of *Calluna*. Wood of Ericaceous species. |

| | |
|---|---|
| Field. | 15 cm. Red-brown fine-grain peat, ??muddy, with *Oxycoccus* and *Calluna*. |
| Laboratory. | *Sphagnum* leaves. Pieces of Ericaceous root and/or twig. |
| Field. | 3 cm. Wet fresh peat with *Sphagnum*. |
| 100-150 cm. | |
| Field. | 30 cm. Yellow-brown very wet fresh peat H2. Some fibre of Eriophorum. Stems of *Oxycoccus*. |
| Laboratory. | *Sphagnum* leaves. Ericaceous flower, probably *Calluna*. |
| Field. | 20 cm. Wet muddy peat with some *Eriophorum* and some *Scirpus*. Wood debris including that of *Betula* scattered throughout. |
| Laboratory. | *Betula* catkin scale and 8 seeds. Leaf of *Oxycoccus*. |
| 150-200 cm. | |
| Field. | 20 cm. As before. At 5 cm. a layer rich in stems and leaves of *Oxycoccus*. |
| Laboratory. | *Betula* catkin scales and 17 seeds most of which occurred at 170 cm. In the pollen slide at 170 cm. was a group of *Betula* pollen stuck together. Perianth segment of *Rumex*. Moss leaves and stems. |
| Field. | 10 cm. Muddy peat with yellow radicels and traces of *Phragmites*. |
| Laboratory. | One seed each of *Carex* and *Cladium*. |
| Field. | 20 cm. Yellow-brown muddy peat full of yellow radicels and fibre of *Phragmites*. Traces of wood. Seeds of *Menyanthes* and *Cladium*. |
| Laboratory. | 2 seeds of *Juncus* and 1 of *Cladium*. Wood vessel in pollen slide probably *Alnus* or *Betula*. |
| 200-250 cm. | |
| Field. | 40 cm. As before. |
| Laboratory. | Sample 75 at 225 cm. had to be discarded as it was apparently contaminated by an anther of *Alnus* as the clumps of that pollen in the slide would seem to indicate. A tree stump protruding from the peat at a slightly lower level than the structure though not examined was probably *Alnus*. Sample 73 also had large numbers of this pollen, probably from the same source. Samples 71, 73, 75, and 77, all contained wood vessels probably of ??*Corylus*, ??*Alnus*, and/or ??*Betula*. Sample 75 contained 2 *Betula* seeds |
| Field. | 3 cm. Large piece of wood.<br>7 cm. Sandy clay rich in vegetable debris above. |

In addition to the above description of peat from the boring the profile in which the structure is visible has been separately described below.

### Description of the profile at the Trackway or Platform.

| | |
|---|---|
| 0-40 cm. | Fresh *Sphagnum* peat. |
| 40-70 cm. | Humified peat with wood. Layer very rich in *Oxycoccus* rootlets and leaves. |
| 70-80 cm. | Transition to *Phragmites*-*Cladium* peat |
| 80 cm.+ | *Phragmites*-*Cladium* peat. |
| 100 cm. | Horizontal timbers which apparently formed a trackway or platform. |

From the peat immediately below the fresh peat, i.e. 40-50 cm. many roots and stumps including those of *Pinus* protruded from the bank.

### The Pollen Diagrams.

In the stratigraphical column the trackway or platform is represented by two closely spaced horizontal lines at 192 cm. in Sub-Zone VIIIb. Hereafter it will be referred to as the "track". 160 cm. of peat had formed at the site of D.B.3.56 (post shrinkage measurements) when the "track" was laid down. This point is indicated by a "T" to the left of the stratigraphic column in the D.B.3.56 diagram sheets.

The high values in the *Alnus* curve just below the "track" level are almost certainly due to local trees, and a stump protruding from peat slightly lower than the "track" appeared in the field to be *Alnus* though unfortunately none of it was preserved for laboratory inspection. The main *Betula* maximum, which with its over-representation "drowns-out" some of the other curves,mainly reflects the pollen of birch scattered over the whole bog area. But its very high values at this point was without doubt due to trees of this genus growing in the immediate vicinity as shown by the seeds and catkin scales found. This feature shows up the advantage of having more than one diagram from any given locality, largely obviating the risk of accepting a false maximum as factual.
This *Betula* maximum taken in conjunction with the increase in *Ericaceae* marks the change-over to acid conditions.

The high values for *Taxus* at 205 cm. coincide with the 85 cm. peak in the D.P.1.55 diagram. A comparison of nearly all curves both A.P. and N.A.P. in D.P.1.55 and D.B.2 56 at this level serves to confirm this .

The above-mentioned *Betula* maximum starts its rise at the "track" level: its peak coinciding with a slight bump in the *Pinus* curve which is a trace on this diagram of the A.D. 365 pine colonisation. In D.P.1.55 Betula pollen reaches a peak somewhat in advance of the pine maximum. This is the main upper pine-layer and it seems likely that Betula preceded pine in its local expansion. Betula roots and stumps are found in association with the Pinus layer.

A rapid expansion to high values occurs in the Gramineae and appears to herald in the drier conditions evidenced in the other diagrams at this period.
Concurrently with the upward surge in the Ericaceous curve the Gramineae curve falls suggesting that probably Molinia invaded the drier bog surface only to yield to an invasion of Calluna.
Cyperaceae have dropped to low values and Sphagnum spores remain at a constant low level. The pine colonisation now takes place.

The recurrence of rapid peat growth is seen where Betula values quickly drop; Gramineae have fallen and the fresh Sphagnum peat which figures in the stratigraphy causes the percentage of its spores to reach a value of 108% at the VIIIb to IX zonal transition. It might be no harm to re-state here that the zonation was carried out without any reference to the stratigraphy.
The VIIIb to IX dividing line was placed in the optimum position with regard to the permanent Ulmus drop, the Alnus minimum and the slightly later Quercus spike. There is still a small kick left in the Ulmus curve but this would appear to be due to a premature depression of its values caused by the contemporaneous presence of such large (though falling) numbers of Betula and Corylus pollen.

The Ericaceae build up solidly in value and remain, roughly speaking, constant for the remainder of the diagram. They reach their overall peak at 50 cm. in conjunction with minima for Sphagnum, Cyperaceae, and Gramineae illustrating that the surface became, for a period, drier.
The Ericaceae maximum at 50 cm. is succeeded by a rise in the Pinus curve to a peak at 40 cm. It would be very interesting if it could be shown conclusively that this drying-out led to a new colonisation or rather expansion of pine onto the bog margins to explain the presence of increased Pinus pollen values. There are slight corresponding increases in the pine curves in D.B.1.55 and D.B.3.56.
It is difficult to visualise pine as having had any chance at this period of expanding anywhere but onto the bog and it is therefore very tempting to see in this apparent drying of the surface a reflection of Granlunds R.Y.1. recurrence surface which he dated for Sweden at A.D. 1200.
It might be of interest to quote here the "Annals of the Four Masters" for the year 1252.

> Great heat and drought prevailed this summer, so that the people passed with dry feet over the principal rivers of Ireland. The people commenced reaping the

> corn twenty days before Lammas (1st.of August), and the trees became ignited by the heat of the sun.

Could this have been about the peak of a climatic dry-period in which pine spread onto the bog margins ?
The laboratory analyses show burnt material at this level.

At the top of the diagram <u>Alnus</u> falls-off in value and Betula actually does not appear in the uppermost sample. This is probably due to the fact that Betula values at this level are, at best, low and have not had a fair chance of representation in the pollen count due to the enormous <u>Corylus</u> value of 86% caused by local scrub.

The top of the bog here almost certainly still reaches Zone X despite machine preparation of the surface for development operations.
There is a sudden expansion of the <u>Pinus</u> curve probably due to planted trees and <u>Fagus</u> appears at 5 cm. and 10 cm. However, both stratigraphy and zonation are omitted as the top 7 cm. are perhaps disturbed.

## <u>The Trackway or Platform</u>.

An attempt was made to pick up traces of the structure in the adjacent "cutaway" (bogland from which the peat has been removed) but no evidence of a definite trackway came to light. On the other hand, the width (about 1.5 to 2 metres) and the lenght of the structure (2 m. were visible at the time of first examination.Since then the "Bagger" cutting machine has removed a further 4 m. of peat and the structure continues into the peat bank.) seem to point strongly to its having been some form of **trackway**.
As the pine roots protruding from the peat profile are contemporaneous with the <u>Pinus</u> stump dated by Carbon-14 (Mitchell 1956 p.202) to c. A.D. 365 the structure must be considerably older than this date as it lies approximately 35 cm. below the root spread of this pine layer.
It is associated with an agricultural horizon in which there is a drop in the <u>Fraxinus</u> curve for which latter its constructors merit at least some of the blame as they used this wood in their operations.
Two pieces of worked <u>Fraxinus</u> showed respectively 76 and 90 plus, annual rings. (The diameters were 6.5 cm. and 8.0 cm.) These by their narrowness bear witness to a struggling existence under shade suppression or unfavourable soil habitat. Such ash could have been found close at hand and may even have come from the location of D.P.1.55.
A large balk of <u>Quercus</u> wood burnt more or less flat on one side lay adjacent to,and at the same level as the structure, but could not be definitely said to be contemporaneous.

The outer timbers had been removed from the profile before the following photographs were taken. About 18 cm. of the knife are visible.

General views of Profile at "Trackway"

Photo 4.

Photo 5.

Photo 6.

## DETAILED BORING 1. 1955.

Detailed Boring 1. 1955 (D.B.1.55) was made close to the site of D.P.1.55 to record the upper peat layers which had been removed from the latter. It is marked on the accompanying map by a red-encircled "2".

Description.

0-50 cm.

Field. 20 cm. Brown fine grained peat with yellow fibres.

Laboratory. Pollen sample 50 at 5 cm. contained many fragments of the"wings" of coniferous pollen.These were not counted. Sample 53 at 20 cm. contained a small amount of stone grit. The club-shaped ascus(containing 8 ascospores) of an *Ascomycete* was seen in a pollen slide of sample 51. *Sphagnum*, including *S.imbricatum* was found at 20cm.

Field. 20 cm. Fresh brown *Sphagnum* peat H2.

Laboratory. *Sphagnum* including *S.imbricatum*. 3 *Calluna* seeds.

Field. 10 cm. Borer chamber full of muddy water.

50-100 cm.

Field. 50 cm. Wet coarse brown *Sphagnum* peat, H2.

Laboratory. *Sphagnum* including *S.imbricatum*. Seeds, flowers and shoot of *Calluna*. Seed of ??*Rhynchospora* and another Cyperaceous type.

100-150 cm.

Field. 3 cm. As before.

12 cm. Finer brown peat with many twigs of *Calluna*.H4.

Laboratory. Shoots and 3 seeds of *Calluna*.

Field. 35 cm. Wet peat, H2, with fibre of *Eriophorum* and stems of ??*Oxycoccus*.

Laboratory. *Calluna* shoots.

150-200 cm.

Field. 8 cm. As before.

40 cm. Brown humified peat H7 with many red rootlets of ??*Oxycoccus*. Scattered twigs of *Calluna*. Some fibre of *Eriophorum*. Rootlet of *Pinus* at 175 cm.

Laboratory. *Sphagnum* remains. Seed of *Betula*.

Field. 2 cm. Similar but with fibre of *Phragmites* and a leaf of *Betula*.

This transition at 198 cm. parallels the corresponding transition at 50 cm. in D.P.1.55.

The peat description was continued to the base of the deposit but no further samples were taken as there was now considerable overlap between the material from this boring and the adjacent profile. The peat was further described ---

200-250 cm.

Field. 50 cm. Phragmites peat. Piece of soft-wood at 3 cm. More wood at 35 cm. and 42 cm. Seeds of Menyanthes scattered through it.

225-275 cm.

Field. 25 cm. Seen before.
13 cm. Fine-grained brown peat with much wood debris and less fibre. Seed of Menyanthes. Cenococcum.
12 cm. Sandy clay, drill on stone.

## The Pollen Diagrams.

Here the peat is still thinner than in the two borings already described.
The D.B.1.55 diagrams may be conveniently "joined" with those of D.P.1.55 at the Sub-Zone VIIIb to Zone IX transition. In both, the Ericaceae, Myrica, and P.lanceolata curves compare well, and the break in the Gramineae and the minima in the Cyperaceae curves are a little in advance of the transition. The curves for Ulmus and Alnus in both diagrams behave typically for the VIIIb to IX zonal border. The comparison is further strengthened by the behaviour of the Betula, Corylus, and Fraxinus curves.

The upper part of the D.B.1.55 diagrams show the following features. The value of 1% shown by Taxus just before the Sub-Zone ends is the only trace here of the higher values exhibited by this species in D.P.1.55, D.B.2.56, and D.B.3.56 at this level.
At 95 cm. the Arboreal curves illustrate the characteristics of agricultural interference. The pollen of Cerealia and of the weeds of cultivation to be found at this level concur with this inference. This is one of three levels in this diagram where N.A.P. values are in excess of those for A.P. and this fact is shown clearly by the NAP/AP. curve.

A peak at 40 cm. to which Ulmus slowly mounts coincides with a minimum in the P.lanceolata curve and even though Cerealia are here at a small maximum the trends are difficult to explain other than as indicating that for a while at least, and possibly only locally, there was a slackening in the intensity of the agricultural onslaught

Zone IX is terminated where Alnus, Quercus, and Betula fall-off in value and where Pinus and Ulmus values start creeping up with the appearance of Fagus and Picea. The fall-off of Alnus, Quercus, and Betula doubtless reflects the woodland clearance for material for making the charcoal necessary for iron-smelting in the 17th. Century leaving worthless Corylus scrub to supply the bog with its pollen.

The disappearance of Fraxinus from this diagram coincides with the highest value for Cereal pollen and a mounting P.lanceolata curve. Just before the top of the bog Ericaceous values expand and while the Corylus percent of Arboreal pollen rises, its value expressed as a percentage of total pollen falls-off in value. Both of these curves expand in the top sample where the NAP/AP. curve declines.

Photo 7.

Photograph 7 shows the view Northwards from the "Works Road". This is Trench 2. Several hundred metres Northwards the peat becomes deep enough to develope. See photos 1 and 2. The transmission pole just visible on the skyline is beside D.P.1.55 and D.B.1.55.

Photo 8.

Photograph 8 is taken from the same position as 7 above but facing Southwards. Timber remains decrease towards the South end of this sector of the bog. Part of "Works Road" in foreground.

## DETAILED PROFILE 1. 1955.

This incomplete profile is situated in the face of a truncated peat bank on the East side of Drainage Trench 2 immediately beside D.B.1.55. It overlies a local high-point in the moraine deposit into which the drain is deeply cut. It is referred to in the text as D.P.1.55.
Material was collected for both pollen analysis and for the analysis of macroscopic fossil remains, notably seeds.
The field and laboratory notes on the material pollen-analysed will be given first followed by the description of the peat which was prepared for "Washing-analysis" (see below). There is thus a double description of the peat from this site but whereas the field description of the material for pollen-analysis is divided on stratigraphic considerations, that for the "Washing" samples is divided into arbitrary units of 5 cm. throughout the profile.
It was therefore thought better for the sake of clarity to keep both sets of descriptive results separate.

Observations on the pollen diagrams and the macroscopic material found in the "Washing" samples will be presented concurrently.

Photo 9.

Photograph 9, showing the profile, was taken about 18 months after the samples were collected and the bank had in the meantime disimproved due to erosion and growth of vegetation. The pine stump referred to in the text is that to the right hand side.
About 18 cm. of the knife are visible.

| | |
|---|---|
| Description. | |
| Field. | The point was beside two upper *Pinus* stumps whose root spreads lay between 20 cm. and 40 cm. |
| 0-15 cm. | |
| Field. | Fresh light-brown moss peat perhaps disturbed. |
| Laboratory. | *Sphagnum* leaves, shoot of *Polytrichum*, shoot and seed of *Calluna*, seed of *Carex*. |
| 15-50 cm. | |
| Field. | Highly humified *Sphagnum* peat very rich in fibre of *Eriphorum angustifolium*. Twigs of *Calluna*. At base of this layer is a horizon very rich in stems of *Oxycoccus palustris*. |
| Laboratory. | Flower and seed of *Calluna*. |
| 50-72 cm. | |
| Field. | Abrupt transition to yellow-brown laminated peat with *Phragmites*, *Eriophorum*, *Menyanthes* seeds, and also small twigs. Moving downwards *Eriophorum* diminished while *Phragmites* and *Equisetum* increased. |
| Laboratory. | Pieces of leaf tissue and petioles, seed of *Betula*. Pieces of ??perianth segments of ??*Rumex*. 2 seeds of Carex (biconvex) |
| 72-112 cm. | |
| Field. | The peat though still rich in fibre and rootlets of *Phragmites* was no longer laminated. It became very rich in wood debris. The base of the peat had some sand. |
| Laboratory. | Seed of *Carex* (trigonous). Seed of *Betula*. |
| 112-120 cm. | |
| Field. | Fine sandy clay with considerable content of humus. |
| 120-125 cm. | |
| Field. | Sandy clay with rotted limestone and some accumulation of iron at the base. |
| 150 cm.+ | Boulder-Clay. |
| | An acorn lay at 90 cm. and roots including those of *Quercus* ran down into the clay below. |

Dr.T.Walsh, Dept. of Agriculture, was kind enough to visit this site and described the soil profile in more detail as follows ---

| | |
|---|---|
| 112-125 cm. | Eluvial Zone. Strongly leached grey coarse sandy medium loam with a poorly defined single grain type structure similar in several characteristics to the *A* horizon of a podsol. |
| 125-135 cm. | Illuvial Zone. Heavy coarse sandy loam with distinct enrichment with fine clay. Well defined angular blocky structure and some secondary enrichment of iron.<br>This zone because of its structure exerts considerable resistance to water penetration and its lower boundary marks the limit of weathering. It may be defined as a *BG* horizon although before gleying was probably a brown *B* horizon. |
| 135 cm. + | Boulder-Clay rich in calcium carbonate. |
| | The whole profile shows evidence of intense gleying under reduction conditions. |

Dr.Walsh considers that this profile was formed prior to bog development and that apart from gleying it has undergone little change due to the overlying peat.
In a profile at the Curragh, Co.Kildare, Dr.Walsh pointed out an apparently identical set of soil horizons now overlain with loam formed under grassland conditions. He says that no comparable soil formation is proceeding in Ireland at the present day, and believes that this relict soil formed under conditions of climate and woodland cover not now existing in this country.

## Note on the collection, preparation, and treatment of peat from Detailed Profile 1. 1955 for "Washing" analysis.

A column of peat from the profile under consideration was brought in sections to the laboratory and marked-off into 5 cm. thick blocks. 100 gm. were taken from each 5 cm. block and carefully examined and described (see below) during the process of being broken into small fragments for maceration with caustic soda. (see Appendix 2)

The samples were washed free of colloidal and other fine material. The residue on the sieves after this washing was examined in two fractions --- coarse, and fine. The coarse sieve was Mesh 40 (U.S. Sieve) with gaps of approximately 0.417 mm., and the fine sieve was Mesh 140 (U.S.Sieve) with gaps of approximately 0.104 mm. This latter sieve withheld all such small seeds as *Juncus* and *Calluna* while *Betula* etc. etc., remained on the coarse sieve.

The coarse fraction was examined by naked eye and the fine fraction under a dissecting microscope. The numbers of seeds of the different species present were counted. All identifiable remains were also recorded. The identifications were brought as far as was compatible with time, and of course, condition of the material.

Table of Identifications.

All identifications are given in the form of a tabular statement and this is included in the pollen-diagram folder. The Table itself shows the pollen zonation and stratigraphy for convenience of comparison.

Identifications are listed alphabetically according to their families. Unidentified remains and also those of Pteridophyta, Bryophyta and Fungi are listed at the right hand side of the Table. Depths in centimetres are shown at left and right hand sides of the Table and horizontal lines are drawn every 15 cm. for ease of reading.

The "Washing" sample numbers are given in Roman numerals and are not in sequence. The abbreviations, of which a list appears on the Table, are in part due to Jessen (Jessen 1949 p.192) and are part original.

On the Table, Betula sp. comprises B.verrucosa and B.pubescens. Both species were identified in most samples but due to their poor state of preservation a numerical differentiation was not possible.

Trigonous, biconvex, and other species of Carex were present and are totalled in the Table.

A total is also made of the Juncus species. J. effusus-conglomeratus, J. articulatus and/or J.acutiflorus and some unidentified species were present.

The Seed Diagrams.

Where seeds of any genus or species are present at several levels and in sufficient numbers, they are shown as a percentage of the sum of seeds at their particular level in a graph similar in form to the pollen graphs. This value is plotted on the curve at the mid-point of the 5 cm. block to which it refers.

Where less than 50 seeds were counted in any 5 cm. block there is no representation on the graph and presence is merely indicated by a plus sign. Seldom-occurring species are also not represented on the diagram though their numbers were used in the totals for the percent calculations.

While the tabular statement shows actual numbers of all seeds (term used in its loose sense) found, it should be remembered that the seed diagram shows percentages of only those genera or species quantitively prominent.

Columns one and two of the diagram show the pollen zonation and stratigraphy respectively.

The total numbers of seeds counted in each 5 cm. level are given even though all members of this total are not represented on the diagram. The depth and percentage scales are the same as for the pollen diagrams.

It may be repeated here that the "Washing" sample numbers given in Roman numerals are not in sequence throughout the profile.

Both Arboreal and Non-Arboreal species are represented on the same diagram and are treated alike in value calculations.

### *Description of the peat for "Washing" analysis, prior to treatment.*

*5-10 cm.* *Washing Sample XXIV*. Fresh dry moss peat with many rootlets and some fibre of *Eriophorum*.

*10-15 cm.* *Washing Sample XXIII*. Fresh dry moss peat with *Calluna* and tussocks of *Eriophorum angustifolium* fibre.

*15-20 cm.* *Washing Sample XXII*. Red-brown peat with abundant *Calluna*, also much fibre of *E. angustifolium*.

*20-25 cm.* *Washing Sample XXI*. Red-brown peat with abundant *Calluna*, some *Eriophorum* rootlets.

*25-30 cm.* *Washing Sample XX*. Red-brown humified peat, very rich in twigs of *Calluna*. Some *Eriophorum* and *Oxycoccus*. Thin lens of fresh moss.

*30-35 cm.* *Washing Sample XIX*. Red-brown peat with *Calluna* and *Oxycoccus*. Less *Eriophorum* fibre than in the following samples. Piece of bark.

*35-40 cm.* *Washing Sample XVIII*. Red-brown humified peat with *Calluna*, *Eriophorum*, and *Oxycoccus*. Large root of *Calluna*. Fine *Pinus* root.

*40-45 cm.* *Washing Sample XVII*. Red-brown highly humified peat with fibre and rootlets of *Eriophorum*. Also roots and rootlets of *Calluna* and *Oxycoccus*.

*45-50 cm.* *Washing Sample XVI*. Humified peat filled with fibre of *E. angustifolium*. Traces of *Calluna* and traces of *Phragmites*. Some large pieces of wood.

*50-55 cm.* *Washing Sample V*. Laminated peat with ??*Phragmites* and *E. angustifolium*. Very many leaves including birch. Also some twigs and horizontal roots. Seeds of *Menyanthes*. Immature pine cone or apex of cone. Several ??*Pinus* seeds.

| | |
|---|---|
| *55-60 cm.* | *Washing Sample VI*. Abundant *Eriophorum* fibre in top 2.5 cm. Little or none lower down. *Betula* leaves were present and some *Oxycoccus* leaves and stems. Also much fibre and stems of *Phragmites*. Some *Sphagnum* capsules and a ??rhizome of fern. Some bud scales. |
| *60-65 cm.* | *Washing Sample VII*. Laminated muddy peat very rich in remains of *Phragmites*, also leaves of *Betula*, bud scales and twigs. Seeds of *Potentilla palustris*. Seeds of *Carex* and *Menyanthes*. Leaf of *Potamogeton*. Rhizomes of *Equisetum*. *Sphagnum* capsules. |
| *65-70 cm.* | *Washing Sample VIII*. Laminated muddy peat with some layers very rich in leaf debris. Much fibre of *Phragmites* and some rhizomes of *Equisetum*. Seeds of *Carex*, *Menyanthes*, and *P.palustris*. Beetle fragments. |
| *70-75 cm.* | *Washing Sample IX*. Laminated *Phragmites* peat with *Menyanthes*, *Equisetum* leaves, twigs and moss capsules. |
| *75-80 cm.* | *Washing Sample X*. *Phragmites* peat with *Menyanthes*, not so strongly laminated and with fewer leaves. Twigs and beetle fragment. |
| *80-85 cm.* | *Washing Sample XI*. Brown peat with many yellow rootlets. Some fibre of *Phragmites*. Several large pieces of wood. |
| *85-90 cm.* | *Washing Sample XII*. Coarse fibrous peat with roots and rootlets. Some small wood, also ??moss stems and ??*Equisetum*. |
| *90-95 cm.* | *Washing Sample XIII*. As before but with some big wood including roots. Also *Equisetum* and *Phragmites*. Pieces of bark. |
| *95-100 cm.* | *Washing Sample XIV*. Denser peat with perhaps fewer rootlets and more amorphous material. Some large wood. Also *Equisetum*, bark, and roots. |
| *100-105 cm.* | *Washing Sample XV*. Firm brown peat with woody roots and rootlets. |
| *105-110 cm.* | *Washing Sample I*. Dark-brown crumbling peat with much wood and yellow rootlets. No obvious indication of *Phragmites*. Stem of *Fraxinus* 10 cm. in diameter in the sample, also oak wood and piece of a third wood. Many stems, twigs, a bud and bud scale. *Carex* seed. |

110-115 cm. Washing Sample II. Stem of Fraxinus noted above continued into this level. The material was a wood peat full of wood fragments and roots, also yellow rootlets. Fragments of Quercus and other woods were noted. Buds, beetle fragments and 1 seed of Carex.

115-120 cm. Washing Sample III. Dark-brown fine-grained peat with sand and small stones in base. Much debris of wood and bark. Many small yellow rootlets. Some fibre of Phragmites. Seeds of Carex and Potentilla. Part of Corylus nut.

120-125 cm. Washing Sample IV. Grey sandy clay with small stones. Considerable content of vegetable debris. Both wood and Phragmites.

The Pollen and Seed Diagrams.

As is apparent from the accompanying contoured map of the bog at Clonsast, there are troughs in various parts of the underlying moraine. Mitchell (Mitchell 1956 p.203 "Clonsast B") presents a diagram from such a hollow. Peat formation brought about a gradual filling of the depressions and eventually spread over all the lower-lying areas of the bog.

D.P.1.55 is a peat profile on higher ground which long remained above the influence of the enlarging bog. It lies just inside the 245 ft. (75 m.) contour and is in fact probably slightly higher than this as the ground slopes upwards towards the 255 ft. (77 m.) contour. (not shown on the map)

At the beginning of Sub-Zone VIIIb Quercus and Taxus were growing happily on this and other such slopes around the margins or on ridges protruding into the bog itself.
About 30 cm. of peat seems to have formed here before the "track" was constructed (D.B.2.56) and at the site of D.B.3.56 approximately 150 cm. of peat had formed when peat began to develope at D.P.1.55. It must be remembered that these figures given above and also elsewhere in the text are derived from measurements made on peat which has been subjected to differential shrinkage resulting from different intensities of drainage following the removal of the peat.

The bog rose gradually and conditions became increasingly difficult for the trees on the lower levels of the slopes.
That oak was growing on a dry soil is shown by the extensive root systems penetrating into the Boulder-Clay. The trees probably affected the soil which is visible in the deep drainage trenches cut into the moraine deposit by Bord na Mona. This soil has been

described in detail on pages 24 and 25 above.

The trees including Quercus, Taxus, and probably Fraxinus survived the changeover for a considerable period of time. An acorn lay above 10 cm. of peat and on a similar ridge in Trench 3 large numbers of Taxus seeds lay in the peat 4.5 cm. above the mineral soil. Conditions were of course still alkaline and there was a gradual change from increasingly wet woodland to a fen community with Phragmites, Carex, and Juncus.
All stages from wet woodland through increasing intensity of fen formation to mounting acid values on the deeper bog were present within quite a short distance.

The most interesting feature of the pollen diagram is undoubtedly the high value of 41% of Taxus pollen found at the base. This percentage is actually a minimum as any damaged grains which left even a small margin of doubt were not counted in the total.
This is a local maximum due to the proximity of yew trees on the ridges or rises producing ample pollen when the ground was wet enough to preserve the pollen without yet bringing about a reduction in its production due to the encroachment of unfavourable soil conditions and consequent loss of vigour in the trees.

It seems likely that Taxus trees succumbed before oak though there is no positive evidence to support this view other than that oak remains are to be found higher in the peat than those of Taxus. One thing certain however, is that Taxus never regenerated itself at Clonsast at any level divorced from the mineral soil. (also see "Taxus")

In this profile seeds of Alnus and Betula were preserved in the sandy clay between 115 cm. and 120 cm. By this time the oaks were probably feeling the effects of inundation fairly severely and sufficient light was reaching the ground through a diminishing canopy to allow the two above mentioned genera to gain a foothold on the ever-wetter forest floor.
Thorny species were growing in the area --- possibly Rosa sp. though more likely Rubus sp. Corylus was present or at least near at hand as evidenced by high pollen values at this level and the presence of a nut in the peat though no wood identified from this point belonged to the tree mentioned.

From 100 cm. to 110 cm. there is a brief falling-off in the amount of Phragmites remains. This is also reflected in the pollen curve for Gramineae which at this level shows a minimum.

Between 80 cm. and 100 cm. there is a sudden and, with the exception of one Betula value, total disappearance of seed remains of both Alnus and Betula. The Betula pollen curve but not that for Alnus

follows this drop. Cyperaceae seeds drop to minimum values though the Cyperaceous pollen curve is actually mounting to maximum values. The Juncus seed curve shows the same phenomenon which at 80 cm. approximately, ends as quickly as it began. (some "plus" values do however appear)
There is no pollen curve for Juncus as its pollen does not preserve.

Did Betula, and possibly Alnus, drop locally as a result of man utilising it in the construction of his "trackway" which is contemporaneous with this level ? More than likely, but that in no way accounts for the similar behaviour in the other seed curves.
Further, it would be quite unrealistic to suggest that the reduction in seed numbers is due to too much moisture as the species represented on the other curves have between them an extensive habitat range and a change unfavourable to one could be quite satisfactory to another.
Despite the fact that the large number of identifiable wood fragments at this level would appear to negative the idea, it must be assumed that conditions prevailing were not such as to favour the preservation of macroscopic material. Indeed the whole principle of representing seed frequency on curves is a doubtful proceedure. The chances of an equable dispersion of seeds is far less than for pollen as the heavier the seeds are, the sooner they reach the ground near their source of origin thus giving local over-representation. Further, the relatively small number of seeds produced by some species and often also their food value to animal life render numerical results unrealistic and unreliable.
Another and no less important disadvantage is the fact that humification intensities varying as they do, will play havoc with any attempts at such a representation. Pollen, it need not be emphasized, has powers of resistance beyond all comparison with those of seeds or indeed any other macroscopic plant remains.
Thus, at a particular level where there should be a superabundance of seed remains due to luxuriant growth, their numerical representation may show minimum values if soil conditions were such as to bring about rapid decomposition of all detrital matter.

In the Phragmites peat lying roughly between 50 cm. and 80 cm. in the seed diagram under consideration the higher percentages of Betula are due to two factors; firstly, to a normal increase in birch at this time as shown by the corresponding rises in the pollen curve for this tree, and secondly, to the better preservation in a peat less humified than that below.

That conditions were becoming wetter is indicated by increases in the seed remains of wet-habitat species. That these rises were factual may be confirmed in the appropriate pollen curves.

A peak in the Gramineae pollen curve is due to Phragmites which was soon to pass out of the scene.

The surface of the bog became very wet and its acidity had increased with growth away from the base rich mineral soil which now had an effective sealing layer of what before drainage must have been over a metre of peat. Rumex left the vicinity as shown by the curves for both seed and pollen, and a layer of Oxycoccus palustris spread itself extensively. The first rises in the Ericaceous pollen curve are doubtless due to this species. Curiously enough the seed evidence of its sojourn on the bog is disappointingly low. A special "Washing" sample taken from this layer is described as follows ---

> Layer with much Oxycoccus. Peat was a felted mass of stems with little red rootlets and leaves of Oxycoccus palustris. There was also a little Phragmites.

It contained leaves of Oxycoccus and of Erica tetralix and though seed preservation seems to have been good (Betula 61 seeds, and Carex 1) there were only 8 seeds of O.palustris in the sample.

The leaves of E.tetralix indicate that it was present also, and though no pollen differentiations were made in the Ericaceae, it is certain that this shrub assisted Oxycoccus in the initial expansion of the Ericaceous curve before Calluna took over.

The advent of Calluna, shown by the presence of its seeds indicates a progressive drying of the bog surface and this species is certainly responsible for the eventual rise to maximum in the Ericaceous pollen curve.
It was during, and as a result of this drying-out that Pinus proceeded to colonise a very large portion of the bog. (see "Pinus"
The layer of pine remains resulting from this colonisation can be traced over a wide area of the bog and is contemporaneous with Carbon-14 dated wood from a pine tree growing at about A.D. 365 (Mitchell 1956 p.202)

There are rises in the pollen curves for Pinus, Alnus, and Betula at 30 cm. Seing that the Pinus roots extend in this profile between 20 cm. and 40 cm. it may appear that the peak in the pine curve is thus not contemporaneous with the bog surface at the time of maximum growth (of pine), however, Godwin (Godwin 1956 p.277) points out that stumps may not sink as much as the surrounding peat due to the"strut-action" of the roots.
It would also seem likely that a certain amount of faunal transposition of material must take place in a humified horizon, giving at least the superficial layers a thorough mixing.

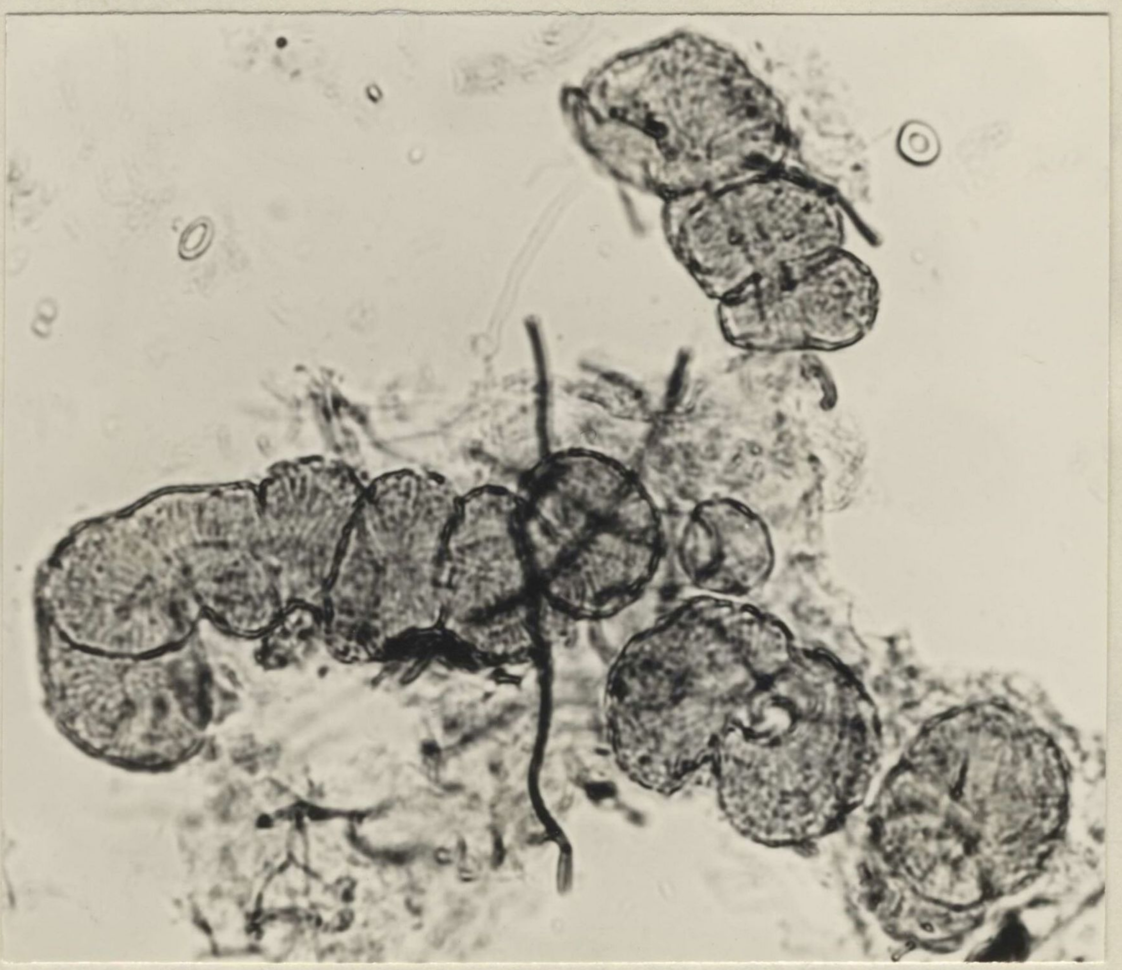
The VIIIb to IX zonal transition is located as usual where Ulmus drops to permanently low values. In D.P.1.55 it actually disappears from the curve at this point though in the overlapping D.B.1.55 it reahes a minimum without reaching zero.

Photo 10.

Photograph 10 shows an oak stem 7 m. long and about 70 cm. diameter lying in the "cutaway" of Trench 3.

The pollen sample at 105 cm. contained an object somewhat similar to the fungal fruiting-bodies described by Godwin and Andrew (Godwin and Andrew 1951) and Cookson (Cookson 1947). I am thankful to Dr.John Webster of Sheffield University for the following observations ---

> I am afraid I cannot help you much with the identification of the object. It is certainly fungal and might be a Microthyriaceous fruit body. However, I do not recognise it, and I know of no member of this group with confluent fruit bodies. Unfortunately there are no diagnostic features visible in the specimen, so I can go no further than this.



Fungal body from Sample 20 at 105 cm. D.P.1.55

x 400

## TAXUS BACCATA.

An interesting feature of the accompanying pollen diagrams is the strong representation of Taxus baccata. Stumps, stems, and seeds correlated with the pollen evidence, go to show that this tree was once widespread in the Clonsast area.

Though its pollen is of course found in the deep peat as well as in the shallow peat above ridges and rises in the topography, it is with the latter locations that its macroscopic remains are invariably associated.

Under the heading "Soil and situation" Elwes and Henry (Elwes and Henry 1906 p.119) state ---

> Though the yew grows naturally most commonly on limestone formations in England, it will grow on almost any soil except perhaps pure peat and wet clay, and attains its largest dimensions on deep sandy loam. It grows better under dense shade than any tree we have, and may therefore be used for underplanting beech woods where bare ground is objected to, and where the soil is too poor or too limy for silver fir. In such situations however, it grows very slowly and produces little or no fruit.

In no place in the bog at Clonsast are stumps of Taxus to be found without mineral soil adhering to their roots, and Mr.T.Barry (Bord na Mona Research Station) states that he has never seen Taxus in any peat deposit other than with its roots having had contact with the mineral soil. He further observes (and the fact is commented on by Elwes and Henry, et.al.) that in Irish place names, the Gaelic word for "yew" (Iubhar) and a word descriptive of "hill" or "rise" are invariably associated.

Writing of this species Godwin (Godwin 1956 p.274) however, points out that ---

> .......it grows quite well planted upon fen peat, and its stratigraphic position along with Quercus, Pinus, Alnus, etc., in wood peats in East Anglian fens and in many "submerged forest" beds, show that it must formerly have held this status.

As the trees grow well when "planted" it must be assumed that drained fenland is referred to so that conditions of stagnant moisture may be presumed to be absent. It may also be observed that a tree may grow when planted in a particular site, but it does not follow that it will naturally regenerate itself in that site.

In other words, it requires man's interference to bring about its growth.

Godwin further states (Ib.p.275) ---

> .......and they are often clearly rooted in peat layers above older layers of stumps as at Wood Fen, near Ely, where male cones also indicate the contemporary ground surface.

and again, (p.275) ---

> It must be added that many records of Taxus growing in fen peats are from the Bronze Age during which time the marine retrogression, possibly assisted by climatic dryness, was keeping the marginal peat land well drained and encouraging its conversion to mesotrophic fen wood.

The observations from Clonsast are not necessarily at variance with those quoted above. The one is fen peat and the other acis bog, and it seems unlikely that at any time the fen peat, which preceded the acid peat at Clonsast,ever lasted long enough or became dry enough to allow of the seeding and development of Taxus.

A core of wood about 20 cm. long taken from the stem of a Taxus with diameters of approximately 64 cm.x 54 cm., which was found lying embedded in the peat just above the mineral soil of a ridge in the moraine deposit showed the following evidence of a moribund existence. What appeared to be the widest ring was just 3 mm. broad. One of the broadest 10-year periods measured 1.8 cm. while another group of 10 rings measured only 1.5 mm.
The outer 8 cm. (approximately) was made up of minute annual increments, and apart from any fall-off in increment which could be attributed to senescence, the rings showed that the tree succumbed only after a long-protracted battle for survival. (see also "cores" Appendix 3)
Unfortunately no figures for good Taxus growth are available though it must be pointed out that Taxus even under the best conditions is a slow grower.

In D.B.3.56 two seeds of Taxus were found at 155 cm. and correspond with a Taxus peak in the pollen diagram. This peak may be matched with the peak at 85 cm. in D.P.1.55. The seeds came from a tree growing, not on the deep peat but on the adjacent higher ground. It is quite possible that they were bird carried.
A further peak, at 100 cm. in D.B.3.56 corresponds with a peak at 25 cm. in D.P.1.55.
The curve for this species in the D.B.2.56 diagram bridges the period between the peaks referred to above in D.P.1.55 and D.B.3.56.

Taxus seeds were found elsewhere in the bog and a field note records-

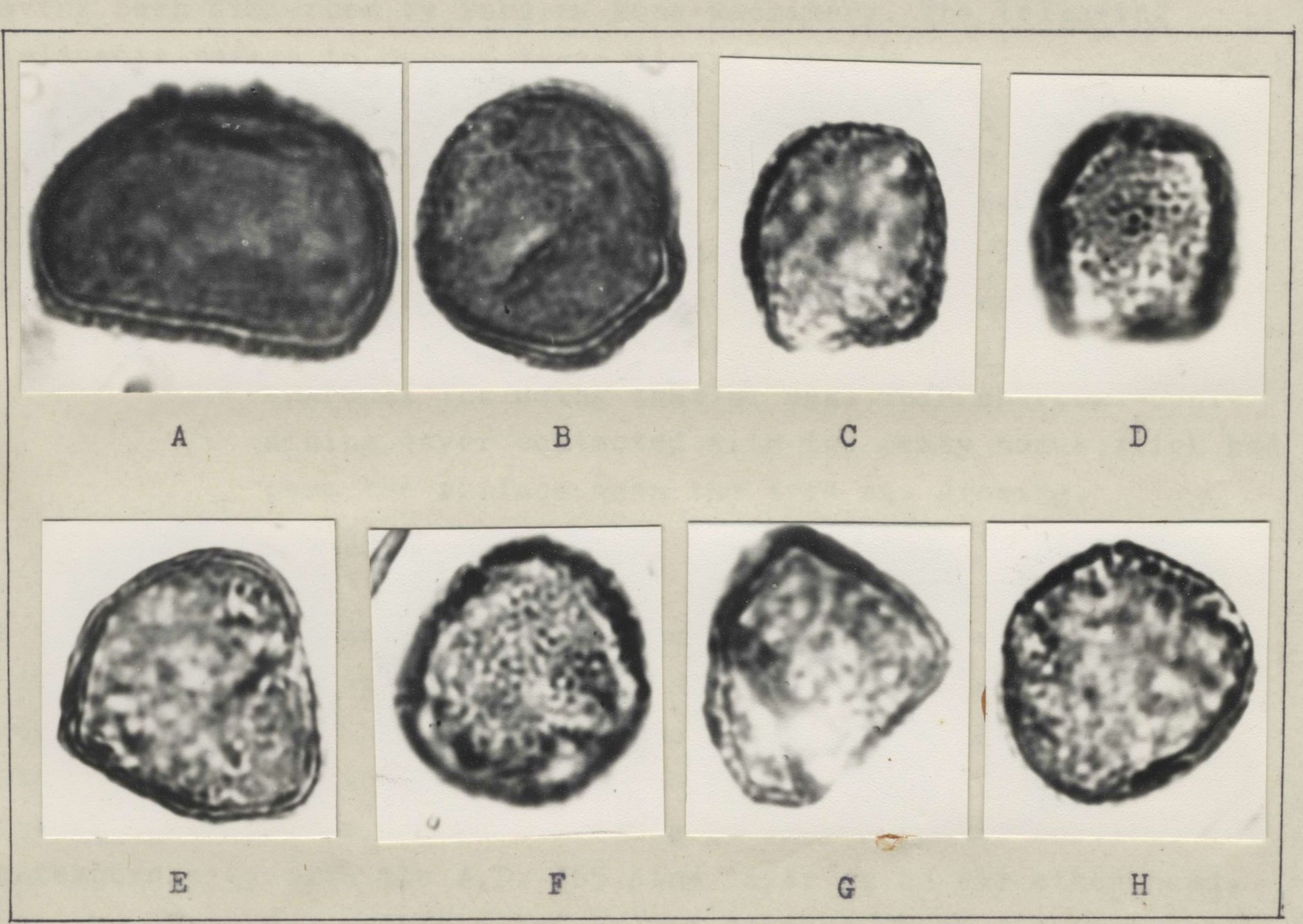
> Trench 3, on Boulder-Clay rise. Pinus and Taxus were apparently contemporaneous on top of the ridge.

A spread of charcoal occurred on the surface of the mineral soil. In the peat exactly 4.5 cm. above the mineral soil lay a Taxus seed and in its vicinity many more were found.

At 12 cm. above the mineral soil surface was another charcoal layer with which a large burnt log of wood was associated. On the disturbed peat surface lay many burnt stems but it was not possible to say whether they had been burnt in antiquity or by the peat workers.

The wood of Taxus is very distinctive (see "Timber Identification") and can usually be readily identified in the field.

The pollen of Taxus is described by Faegri and Iversen (Faegri and Iversen 1950 p.134) as being inaperturate, scabrate-gemmate, with projections crowded and sculpturing slightly irregular.



Pollen of Taxus baccata x 1680.

Taxus pollen Photomicrographs.

A and B are ordinary high-power (not oil-immersion) photomicrographs of sub-recent pollen. The material was treated by KOH and then acetolysis.

C to H are fossil pollen from a depth of 115 cm. in D.P.1.55. They were treated and photomicrographed in the same manner as the sub-recent material. Sizes ranged from 20 Mu to 26 Mu. in measurements made during counting. The usual size was about 22 Mu.

## PINUS SILVESTRIS.

Pine remains in peat deposits all over Ireland bear incontrovertible witness to the one time presence of woods of varying extent, age, development stage, and time of time of existence.
Clonsast is no exception to this generalisation, as the developers, Bord na Mona, know to their cost because the pine roots and stems hamper the operation of peat-winning machinery.

The layer of stumps left by the late Sub-Zone VIIIb pine colonisation gives clear evidence of the latest extensive pine growth in this bog.
During the course of visits to the bog, many large stumps of an older period were found in the vicinity of the locations from which material was obtained for pollen anlysis. These usually had mineral soil adhering to their roots. Of those seen, none were in-situ, having been disturbed by Bord na Mona machinery. The following field note refers to one of these stumps ---

> Pine stump, not in-situ, stem diameter 60 cm. at about 45 cm. above the roots. The massive root system had grown in mineral soil. The lower part of the stem was charred and was surrounded by a 15 cm. thick layer of peat containing Phragmites and much charcoal including that of oak. This charcoal-containing layer contacted with the peaty humus which had been the surface when the tree was growing.
> A Hedera stem adhered to the bark of the pine.

As time did not allow the carrying out of special investigations on such stumps it is not possible to state at what period they were growing. They may have been contemporaneous with the pine wood dated by Carbon-14 to B.C. 2195 (Mitchell 1956 p.204) or with the high Taxus values on the moraine ridges. They may have survived to contemporaneity with the A.D. 365 pine layer or on the other hand, they may have been exterminated by the peat on which the upper pine-layer was later to grow.

It would be most interesting if it were possible to say if the fires producing the charcoal mentioned in the field note above and also that mentioned in the section on Taxus were man-made or resulting from natural causes. If man-made, did they stem accidentally from cooking fires or was burning carried out to clear ground or drive out game ?

There is no reason to believe that these farmer people were not aware of the fact that a tree may be very easily killed-off by cutting a ring of bark from around the stem. Such experience would be early gained by a man chipping round a tree; tiring, and leaving his job half done and returning after some months to find the leaves withering. Trees thus treated, conifers in particular, would be in an ideal state for fire-clearance after a period of dry weather. Nevertheless, the suggestion that the fires were very often brought about by natural causes should not be too readily discarded. Potzger and Courtemanche (Potzger and Courtemanche 1955 p.111) reporting on work carried out in Northern Quebec state ---

> We were impressed with the abundant fire scars in forested areas far removed from human activity. At 55 Deg.27' N. 76 Deg.10'W we saw approximately 300 square miles of upper taiga forest in flames. Plane travel into uninhabited area, far beyond the sphere of human influence, emphasizes the importance of lightning as a cause of forest fires.

### The Suggested Disappearance of Pine.

There has been a tendency to accept as fact a suggestion made by Forbes that there was a break in the lineage of pine in this country in historic time. Forbes (Forbes 1933 p.176) writes ---

> "The reintroduction of pine is, of course, open to doubt. It may have survived as a native tree long enough to have been artificially propagated in nurseries, but the term "Scotch fir" universally applied to this tree rather throws doubt on the idea. There are several references to native pines existing at Cool na muck near Carrick-on-Suir about 1750, but the identity of the trees is rather doubtful.

While it is not intended to dispute the fact that very large quantities of pine seed and seedlings have been imported in, say, the last four hundred years, the evidence of the accompanying pollen diagrams shows that in reality no such break occurred.

An inspection of the Pinus curve in D.B.3.56 will show that the only break occurring is actually below the A.D. 365 colonisation of the bog surface with this species. The same applies to D.P.1.55 and it is interesting here to note that such gaps in a curve do not necessarily signify an extinction of a species, as the subsequent extensive expansion of pine shows.
Zone IX Pinus pollen gaps occur in D.B.1.55 and D.B.2.56 but these are overlapped by D.B.3.56 which, as mentioned, shows no break.

In contradiction to Forbes' view on the matter; it may surely be assumed with more certainty that the use of the term "Scotch fir" in

Ireland was merely and acceptance of the term used in the English language to enumerate a specific tree --- Pinus silvestris.

That pine had reached a low ebb is unquestionable and it may be presumed to have existed only around bog margins, "islands" in bogs and possibly lake islands, or in general, in inaccessible places. Elwes and Henry (Elwes and Henry 1906 p.579) give the following information ---

> Ray (Synopsis Methodica 1724 p.442) quotes Mr.Harrison as an authority for pine "growing wild in the mountainous parts of Kerry where the arbutus grows" about the beginning of the 18th.Century.
> Smith (State of the County Kerry 1761 p.372) writing in 1761 says that"these trees have been much destroyed in recent years; for, except a small shrub here and there among the rocks, there are none standing at present of any large size"
> Mackay (Catalogue of plants in Ireland 1825 p.83) mentions, in 1825, a solitary pine tree standing near the foot of Mount Nephin in Mayo, which was supposed to be the last remnant of the pine forest of that county. This tree, (Cybele Hibernica 1866 p.277) very large and very old was still living in 1866 and had been fenced in by the Earl of Arran. The exact location was an open bog at Deel Castle near Crossmolina, at the head of Lough Conn.

It is undoubtedly this tree to which Forbes (Forbes 1932 p.31) refers in the following quotation from his paper ---

> An interesting problem presents itself in connection with the disappearance of the pine as a native tree. It constitutes the most plentiful species in bog remains all over the country, and while oak and yew have survived until the present day, there is no authentic record of a pine which could be described as a natural descendent of the Irish stock. The most likely case of this kind was a tree reported to be a pine at Deel Castle, near Ballina. Recent enquiries, however, suggest that this tree was a yew, but was blown down about 40 years ago.
> Other references to reputed pines have turned out to be holly, yew, or arbutus seen from a distance, and the best authorities agree that no undoubted case of native pine can be found within the last hundred years at any rate.

It is unfortunate that Forbes does not give whatever evidence he had that this was a yew tree and not a pine. The fact that it grew on "the open bog" suggests that it was growing on peat, and presumably acid peat at that. If that was the case it seems unlikely that the tree was in fact yew; on the other hand it is hard to visualise a "very large and very old" tree withstanding the westerly winds with its roots only in peat, which suggests that it was rooted in the mineral soil and could therefore have been either Pinus or Taxus. What is probably more important however, is, how far can other old botanical identifications be trusted ?

The reports given above of the survival of pine in Kerry are substantiated by the presence of its pollen throughout a series of samples from the top of Carrantuohil analysed by Welten (Welten 1952 pp.92, 97.)

Presuming that Smith's (quoted above from Elwes and Henry) identifications were correct, his report is of considerable interest in so far that he says the trees were "much destroyed in recent years" To what purpose the timber was used is unfortunately not stated but the trees must have been of some reasonable dimensions if they were worthy of exploitation, even if only for firewood.

It is to be hoped that estate papers or other documents may yet come to light which will give some historical facts concerning its position to parallel the pollen evidence which can only show its presence.

The evidence of the accompanying pollen diagrams proves conclusively Mitchell's (Mitchell 1956 p.233) opinion that it is impossible to use the end of the Pinus curve for zoning purposes in the study of Irish pollen diagrams.

### The late Sub-Zone VIIIb pine-layer.

As already described in the separate diagrams, conditions became dry enough to allow Pinus silvestris colonise the surface of the bog That this colonisation lasted a very minimum of one hundred years is seen from the fact that a pinewood section from a stump in this layer showed just over one hundred annual rings. This section was cut not from one of the largest stumps which are often in bad condition, but from a medium sized stump whose wood was sound. Occasionally too, there is a tendency for smaller stumps to be rooted slightly above larger and presumably older stumps, as for example, the two stumps shown in Photo 9 p. 23. A distribution of ages would naturally be expected. (see also "Wood Sections")

The extent of this peatland forest was probably considerably more than two square miles. There appears to be considerable fall-off

in the numbers of stumps in the southern one-third of the bog. Growth seems to have been best and the stand densest on the peat overlying ridges in the Boulder-Clay deposit.
The number of stumps present falls-off with increase in distance away from the ridges but at practically all points it is possible to find thin tough pine roots protruding from the cutting face of the peat bank.

Photo.11.

Photograph 11 shows the view looking North on Trench 2 from the position of the Base-line on the map. The mineral soil is near the surface in the foreground. On the deeper peat in the background the amount of timber remains decreases.

Photo.12.

Photograph 12 shows in close view the tangle of pine roots and stems seen in the middle-left of Photo.11 above.
The timber has been disturbed by machinery but lies essentially in its original position.

Many of these stumps show what appear to have been healthy root-systems, often with the tap-root not rotted away; on the other hand it is possible to find stunted trees with their roots curving upwards so that they take on, roughly speaking, an appearance similar to an inverted umbrella-skeleton. This is due to the fact that the roots were seeking to attain the more aerated surface layers of the peat. It may be stated with equal chances of correctness that these latter remains represent individuals who colonised extra wet patches of the bog surface, and/or individuals which established themselves after the period of optimum dryness and whose development into trees was hindered by an ever-disimproving soil-moisture relationship. As peat development continued, the roots endeavoured to stay near the surface and in so doing left the crown ever-deeper below. It is to be wondered if the downward thrust of the weight of the tree into the soft peat plays any role in the formation of such root-systems ? In the cases in question it seems unlikely, as the stems were of such poor dimensions that their weight would have been relatively negligible.

The annual increments shown in sections cut from such stunted stems corroborate the evidence of their roots and show that their struggle for existence must have been a hard one. This is a case where an application of the principles of dendrochronology combined with careful stratigraphical examinations could throw much light on the development, life, and decline of a natural peatland forest.

Sections from what were, relatively speaking only, healthy trees, show invariably that there were periods of suppression of varying duration in different individuals before they succumbed to the drastic changes which took place in environment.
Some sections show evidence of gradual suppression followed by a period of increased vigour, in turn succeeded by further decrease in increment. This is normal behaviour in a dense stand of trees. With increase in size of the members of the stand there is increased root and light competition; a neighbour dies for one reason or another --- maybe suppression or windthrow --- and the surrounding trees make use of the root space left and the increased light available. Increment builds up only to fall-off again when the space which had been made available is used up by the expansion of the local trees.

That fire was not responsible for the destruction of this upper pine-layer is obvious from an examination of the stumps which show no traces of burning. It is possible, of course, that other portions of contemporaneous forest not examined in the course of this research may show evidence of burning. A fire often runs through a forest burning one portion and leaving a contiguous area untouched. This would be all the more likely where patches of wet bog occur.

It need hardly be pointed out that man did not bring about the destruction of the forest by utilising the wood --- the trees lie there as evidence that he did not.

The only other explanation is that pointed to by the evidence of the pollen curves, by the stratigraphy of the peat, and by the tree remains themselves; namely, that a climatic deterioration took place. Such a conclusion falls in line with the accepted findings of palaeobotanists over the last several decades.
The horizon here might possibly be a recurrence surface corresponding to that occurring in southern Sweden which has been dated by Granlund to A.D. 400.

The bog surface became wetter, seemingly as a result of increased precipitation but probably also assisted by decreased evaporation due to lower air temperatures. A root-suffocating growth of Sphagnum began and the trees became suppressed and died-off.

The lack of smaller branches and twigs preserved in the peat would seem to indicate that the stems stood rotting and gaunt long enough for the decomposition of the smaller wood which when it fell was not heavy enough to embed itself into the growing Sphagnum but remained on the surface where it rapidly decomposed.
In the larger wood the quickest decay took place at the point of emergence of the stem from the bog surface where maximum bacterial activity could proceed. The heavier stems eventually snapped at this point and embeded themselves in the wet peat, rapidly becoming covered and thus preserved. The lighter stems, like the branch wood, had largely rotted away before they became surrounded by peat.

The best preserved trees would appear to be those which were windthrown either before or soon after they died.
There is good reason to believe, by analogy with present day forests on peaty soil, that much wind-throw occurred as a result of the loosening of root hold due to softening of the rooting medium by increased moisture.
People working on the bog are of the impression that 90% of complete stems found in the peat were lying in a South-East to North-West direction. No indication can be given as to whether these trees were already dead when they fell but an investigation should be capable of yielding criteria such as bark condition, presence of branches etc., in the surrounding peat which would enable some inference to be drawn.

* * *

## AFFORESTATION.

### Silting-up of drainage outlets.

There can be no doubt that man and his animals have, by their continuous interference with the soil and vegetation of the country, greatly assisted the formation of peat. There is a continual and insidious loss of soil from the tilled fields of hill and plain lying naked to the rains, and from the bare-nibbled uplands suffering the incessant trampling and cutting action of the hooves of grazing animals. A glance at one of the silting-up canals disused only since the advent of road transport is ready evidence of the enormous soil shift which man inadvertently causes.

This silting-up of drainage outlets causes a progressive rise in the water-table of many catchment areas making possible continued peat formation. Unfortunately (from a palynological and not an agricultural viewpoint ) lake and river deposits in which evidence of this soil movement could be traced back have either disappeared or have been so severely altered by the drainage works of the last hundred years or so, that no reliable results in this field of investigation seem attainable.

Following these drainage works, much of the silt was spread on the local fields or was washed away; lake levels dropped, their banks eroded, and wholesale re-deposition of palaeobotanical material took place.

That the results obtained from palaeobotanical research are of value to the ecologist, archaeologist, and climatologist is at once apparent; but that these knowledges are of importance to the science of forestry is not so obvious, even to many foresters.

### Forestry and peatland.

Ireland is a country whose statistics show a minimum of productive woodland cover. The authorities in whose charge it lies to rectify this position are faced with an ever more-difficult task --- the acquisition of land for planting.

Planting has now gone on for many decades and naturally units of land of dimensions suitable to economic forest establishment are increasingly difficult to obtain, particularly as the prices offered for such land are anything but attractive to the owners.

The result is that the forester is being pushed more and more to the areas of both mountain and lowland peat.

While a large amount of experience has been gained in the afforestation of certain peat types, many young forests are still very much

in the experimental stage.
Forest operations in many peat areas are only possible following the comparatively recent development of caterpillar traction and various drainage ploughs. This machinery can work with maximum economy on large areas of peatland which can usually be acquired fairly cheaply. This more or less meets the requirements of all concerned. The forest authorities can at low rates acquire large areas capable of cheap forest establishment thus showing good acreages for money allocated. This in turn pleases the politicians in power, who like everyone else, like to see unproductive acres being turned to good use.

So far so good. Most of the areas already planted show every prospect that with proper silvicultural treatment they will yield satisfactory results. However, there are two vastly different locations and peat types now coming under the attention of the forest authorities ---

(a)the large"cutaway" areas left in the wake of machine development, e.g. Clonsast.
(b) the Blanket-bog areas of the West.

Some of the problems arising out of any attempt to carry out the afforestation of such areas are enumerated below. Their solutions are not. Only experience and research can supply them.

Before proceeding it is necessary to point out the monetary implications of successful forestry.
A forest crop to be a successful financial enterprise must carry at compound-interest all the capital involved in its production from the day of acquisition of the land till the day the harvest is sold to the timber merchant. That means the costs of the land, of establishment, of maintenance, and of silvicultural operations.
To these must be added all "overheads" such as office expenses, rates, etc. These costs are normally offset to some extent by the income received from the sale of thinnings etc. In an inaccessible area there may be no such income.
The importance of the economics of land cost, establishment, and maintenance will be seen when it is realised that at 5% compound-interest, capital doubles itself in 15 years. The implications of this are apparent if it is remembered that the crop rotation may be expected to be anything between 50 and 70 years and maybe more.
So-much for the financial considerations. What of research on, establishment, and silviculture of, the areas mentioned above ?

(a) "Cutaway" peatland.

Extensive areas of "cutaway" peatland are becoming available in various parts of the country following the large scale utilisation of the peat. The areas, in which there is varying depth of peat depending on the topography of the mineral soil, lie derelict awaiting further development. The most likely economic future for such areas would appear to be their use for afforestation. It seems a great pity that properly controlled scientific experimentation is not at once initiated to determine the likelihood of the successful establishment of forest crops on these areas. They are of necessity well drained and if it could be shown that a timber crop is likely to succeed, it would be quite a simple matter for those developing such deposits to leave the "cutaway" in a suitable condition for planting before colonisation with vegetation hostile to tree establishment takes place.

Photo. 13.

Photograph 13 shows a general view of "cutaway" peatland.

An annual or biennial programme of planting equivalent to the area of one or two years peat clearance would result in a gradation of the crop which would be desirable on the deeper peats in view of the danger of wind-blow on such a soft rooting medium. (in many places a considerable depth of peat is left in the "cutaway" due to uneveness of the ground topography.)

There is no reason to believe that peat formation would re-start in such planted "cutaway" bogs if periodic attention is paid to main drainage outlets. The only danger might be the eventual subsidence of the peat following transpiration by the trees in topographical basins from which no drainage outlet exists and the later inundation of such hollows following, for example, a few successive years of extra heavy rainfall with consequent loss or suppression of the crop growing in such places.

(b) Blanket-bog areas of the West of Ireland.

What of areas of active peat formation ? Areas of climatic peat like the West of Ireland where peat piles up under seemingly incessant precipitation practically independently of drainage. What are the prospects here? The question is at present totally unanswerable but certain inferences can be drawn, more in the economic field rather than as to whether trees can or cannot be made to grow there. If a forest, given assistance involving the expenditure of a readily determinable economically permissible amount of money, does not produce commercial timber in a certain number of years which may also be specified, it obviously ceases to be a profitable undertaking and is best forgotten.

1500 years ago trees grew on the bog at Clonsast. The climate got wetter and the resulting water-logging and Sphagnum growth killed-off the trees. A similar fate seems to have befallen the upland forests. Here were established forests, and in the case of the mountains at least, the drainage facilities must have been reasonably good; nevertheless, the trees succumbed. The forester now seeks to reclothe these hills and mountains. His efforts are being aided enormously by a wide choice of different exotic tree species available and by machinery to help make the planting sites more suitable rooting media. Herein lie the main hopes of success. The native flora of timber-producing species is totally inadequate to the demands of present day industry and economy. Different uses require different timbers. The day of slow-grown, narrow-ringed timber has passed with the virgin forests.
It is to these exotic species --- practically all conifers --- that the forester pins his hopes. So far they have been successful, but the western province provides the greatest challenge. It remains to be seen if species can be found which will stand up to the salty Atlantic winds and the continual rain.

When peat is to be planted, systems of surface drains and main drains are cut. These drains usually require maintenance until such time as the transpiration of the trees takes over the work of at least the surface drains. If however, the trees are not capable of taking over a goodly portion of the removal of moisture and all the drainage system must be painstakingly maintained for the whole rotation of the crop, or indeed beyond a certain number of years, the costs of this coupled with all the other necessary financial outgoings will render the enterprise a failure. It must be remembered that once the trees are planted heavy machinery can no longer move about without doing damage, and hand work on such a large scale would be prohibitive in cost.

An absolute necessity in relation to the establishment of such forests would be the formation of a peatland-forest research team

capable of carrying out experiments and making observations on the reaction of the growing trees to different treatments.
If such forests were established on a large scale, constant and thorough supervision and inspection by qualified experts would be absolutely necessary.

An important function of such a team would be the carrying out of experiments aimed at determining the relationship between canopy, soil-moisture, and stand-density, and from that, the best thinning regimes to follow.

A most interesting case of the relationship existing between stand density and transpiration has been observed by Mr.T.Clear, Lecturer in Forestry, N.U.I. He states (verbally) that a peat area at Castlepollard, Co.Westmeath, which had been forested with a mixture of Pinus and Picea (about 50% of each numerically though the Picea timber volume was much greater) had the latter removed as it was of marketable dimensions. With the original planting, drains had been cut but soon the water requirements of the trees took over the work of the drains. On removal of the Picea crop however, the water-table rose as a result of the vastly reduced rate of transpiration and the pine trees and also an understorey of Rhododendron became suppressed and died-off as a result of root suffocation.
It is possible of course that the understorey, and the pine trees too, to some extent, suffered also from the unaccustomed increase in light intensity.
The area was cleared, the drains were reopened and replanting was carried out, but the drainage system soon became clogged again due to the light now reaching the forest floor leading to fast growth of vegetation. This shows strongly the effect man's interference can have on a vegetational unit.

To summarise; Forestry is a financial business and a highly technical science and must therefore not only observe the principles of economics but must carry out its own research into the problems peculiar to its region of operations and not rely on experiments of scientists in other regions carried out with different though vaguely similar aims.

* * *

# DENDROCHRONOLOGY.

## The Dendrochronological Method.

The dendrochronologist seeks by means of changes in the annual increment or ring widths of timbers to build up a calendar of the past climate as recorded by the one-time living tissue of the tree, starting with trees growing at present and working backwards through the years.

The method has had its main applications in the dry regions of South-West America where its early development took place.

Ring-widths showing differences resulting from alternating drought and wet periods of varying duration are graphed and by means of successive overlaps the dating is carried back in time so that timbers from archaeological sites can be matched up on the graphs and thus accurately dated.

On first consideration an application of the principles of dendrochronology to bog-grown timbers would not appear to be a fruitful proposition due to the fact that the climatic extremes in the temperate regions are not great enough to cause significant differences in the annual ring-growth.

This view is worthy of reconsideration though it is obvious that no conclusions could be reached without a careful examination of large numbers of timbers from as many bog areas as possible.

The examination of sections recorded below was merely exploratory and the numbers are too few to be of any analytical value. (see Appendix 3)

Investigations in this field of research were carried out by Gwyneth Harrington (O'Neill-Hencken, 1936 p.235) on timbers from Ballinderry Crannog No.1. Pieces of Fraxinus wood in different parts of the Crannog she states, definitely came from the same tree and possible correlations over a limited number of years, also in Fraxinus, were obtained. Thus the results of her investigations were not entirely negative but she comments that much more work would have to be done before definite statements could be made.

Conifers are regarded as being more "sensitive" in recording climatic variations than broadleaved trees. Ample Pinus and Taxus remains lie in Irish bogs.

Dendrochronologists regard it as undesirable to include in their calculations trees whose roots have had permanent access to an abundance of moisture. This is perfectly understandable as the method is, generally speaking, based on the fact that deviations from the normal annual ring-width indicate drought periods if thin and increase in moisture if broad.

It must be remembered when examining bog-grown timber that the roots probably had a superabundance of moisture and that the reverse process, namely a drying-out of the peat or soil as opposed to an occasional increased supply of moisture in arid localities, lead to improved conditions of growth.

It seems likely however, that whereas in arid regions a year of drought can be instantly recorded by the tree, the reverse process of drying-out of a wet locality due to a drought would be far slower and would require more than one year to make its effect felt by the tree.

Without a large scale investigation of bog timbers it is merely a matter of conjecture as to what reliance could be placed on data collected, of necessity, in a limited locality such as one bog. Tree growth on a bog will be affected by such a wide variety of factors,both local and climatic, that the sorting of them out would be an extensive piece of research.

At very least such an investigation would for a given locality provide a picture of the rise, struggle for existence, and decline of a peatland forest. Such information would be of as much interest to the forester faced with the plantation of bogland as to the palaeobotanist.

Significance of the shape and size of annual rings.

Diminishing ring-widths, apart from those due to senescence, indicate some change in environment or climate whereby conditions became inimical to the species under consideration. They may indicate, for example, an increase in wetness due to climate or merely due to increased water-logging following either silting-up of regional drainage outlets (possibly resulting from man's interference with the natural vegetation cover) or increased local moisture-retention due to growth of the peat deposit.

Diminished growth may also be a result of fungal or insect attack to which poorly growing trees are particularly susceptible; to persistent cold winds and/or drop in average air temperature.

Hartig states (quoted here from Büsgen and Münch p.164) that cold wet years seriously depress the increment.

Suppression may be due to overcrowding of the trees, or in general, to any one or more of the above factors unfavourable to the trees' well-being.

Büsgen and Münch (Büsgen and Münch p.164) state that ---

> Diameter growth is diminished in years of seed production the seed requires so much assimilated and reserve material.

Sometimes years remain unrecorded and the same authorities also state (Ib.p.158) that ---

> Cases in which several rings appear during one year are not altogether rare and on the other hand there are cases, e.g. in the lower and middle parts of the stem, as well as in the lower branches of trees growing under unfavourable conditions where no ring is formed for years.

In relation to the form of the bole Toumey (Toumey 1947 p.248) states the following ---

> Form of the bole in cross section is determined both by environmental conditions and inherent characteristics. Most trees are naturally circular in cross section. Many, however, show an inherent tendency towards irregularities, as shown in hornbeam and red cedar and in many tropical species. Irregularities in cross section are more frequent at the base of a tree, as exhibited in buttresses. Damage resulting from death of the cambium on one side of the tree may cause eccentric growth. Twisted grain may cause an eccentric cross section. Trees on side hills have an oval or ovate cross section, due to the greater growth on the lower side. Trees exposed to constant winds have an irregular bole with the greatest growth on the leeward side. Increased growth occurs just below a branch and hence the cross section is less regular.

False rings may arise due to frost or defoliation causing a stoppage of growth during the growing season, resumption of growth causing a double ring.

Increased increment will follow any improvement in the conditions favouring growth such as improved soil-moisture relationship, suppression of hostile vegetation,(though this latter is of more concern to the seedling trying to establish itself) the dying-off of a neighbour leaving more root space and light, and in general, any improvement in the climatic factors mentioned above.

The 11 year solar-cycle is capable of manifesting itself in the ring-widths.

## Wood Sections.

### The collection of sections for examination.

If possible, stumps or boles which are in-situ should be selected in preference to those which have been disturbed during peat cutting or drainage works, firstly as there is danger that the timbers may have been mixed if there is more than one forest layer, and secondly it is desirable to orientate the stem before removing it from the stem. If it be desired to obtain very large sections a cross-cut saw will be necessary but for the more common type of bog timber a Swedish "Bushman" saw is ideal provided it has a good "set" to the teeth as otherwise it will jam in the wet wood. These latter saws give a clean cut and are light to carry.

The rotted top of the stump is first sawn off and then using a compass the North point is marked on top of the stump. The section should be taken as low as possible commensurate with the avoidance of butt-swell. Its height above ground or root level should be recorded. The number of rings shown in the section naturally diminishes with increase in height above the ground. The section, 1.5 cm. or 2 cm. thick is then sawn off from the stump and labelled. Thinner sections will tend to split and this, needless to say, does not aid examination. Knotty and deformed stumps should be avoided.

The condition of the surface of the stem should be noted, i.e. whether part of the outside is rotted away or whether it still has its bark.
Measurements of stems from which no sections are being taken may also be made and some idea of the stand density should be formed and noted.
The topography of the locality and possible drainage outlets at the time of growth should be noted if this is apparent
The soil or deposit in which the stumps are rooted and also any subsequently formed deposits should be described,and if any pollen samples have been taken the tree layer should be located in the description of the stratigraphy.
The condition of the roots should also be noted down --- is the tap-root present or absent ? Do the roots show by their development that soil conditions were suitable for tree growth or do they show that conditions were very wet with the result that they are curved upwards evidencing their attempt to remain in the superficial soil or peat layers ?

## Examination of Sections.

The surface of the section should be prepared with a razor or plane in order to render the rings more readily visible. This may not be necessary where the rings are wide but it is essential where there are very narrow rings.
Where there is eccentricity of growth the rings may usually be counted more easily along the radius passing through the greatest eccentricity. More accurate results will be obtained by counting a whole diameter. Where possible, doubtful rings should be traced all the way round the section.
Counting is expedited by drawing a radius or diameter on the section. Starting at the centre the rings are counted outwards towards the circumference. For a simple age count each 10 annual rings may be

marked on the radius and totalled on completion of the count.

If it be desired to ascertain the lenght of periods of good growth and bad growth or the widths of individual rings, the principle can be varied accordingly.

Examination may be carried out by naked eye, hand lens, or low-power microscope. In the case of minute increments best results are obtainable by dissecting microscope.

It is advisable to keep sections at least as moist as they were when collected or shrinkage and consequent cracking will take place. The growth of mould on the sections may be avoided by dipping them in a solution of formalin.

The wood of broad-leaved trees taken from the bog is usually brittle and where possible is better snapped-off than sawn.(oak is an exception) Such wood must be kept in water as otherwise an almost completely irreversible shrinkage will take place.

Appendix 3a contains photographs, ring-counts and measurements of some pine sections fron Clonsast Bog.

Timber Cores.

An increment borer is an implement designed to remove a core of wood from a tree stem or other large block of timber so that the annual rings can be examined.

It is driven in at right angles to the direction of growth and the core obtained shows the increment ring for each year.

The borers are manufactured in various sizes and the augur is of necessity of very high quality steel as a very considerable torque is exerted on it in driving it into timber.

Photo 14.

Photograph 14. The implement comprises (A) a handle/container, (B) an augur and (C) a wedge to withdraw the core from the hollow augur. (D) is a glass rod for containing cores.

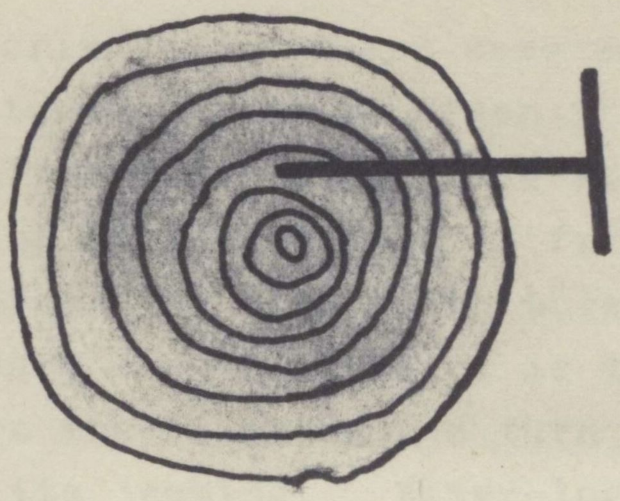
When the borer has been driven into the centre or as far as is required, the wedge is driven in and the borer given a turn to detach the core. The wedge and core are then withdrawn. Containers for cores may be conveniently made from glass tubing cut to the augur length of the borer being used. ( see "D" photo 14)

### Collection of cores.

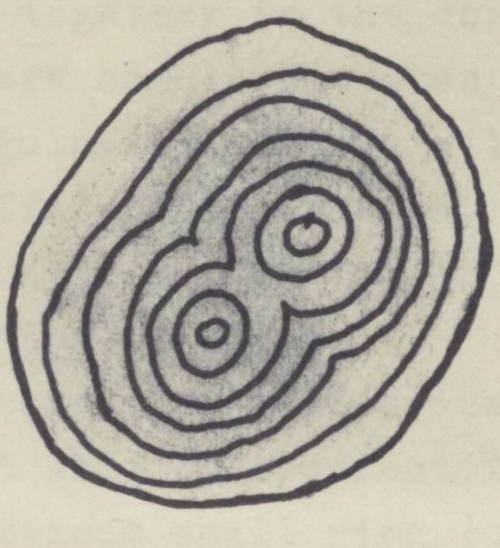
Broadly speaking, the same rules that apply to the collection of timber sections should be observed when taking cores.
If the species is not positively identifiable in the field a sample of the wood should be taken and analysed in the laboratory.

It is desirable that cores be taken in a standard direction, for instance, the borer may always be driven in from the North side of *in-situ* timbers. With stems not *in-situ* it may be recorded where the core has been taken in relation to the greatest root development or any other feature apparent.(curves, branches, etc.) Distance of the boring point from the root crown should be noted where possible.

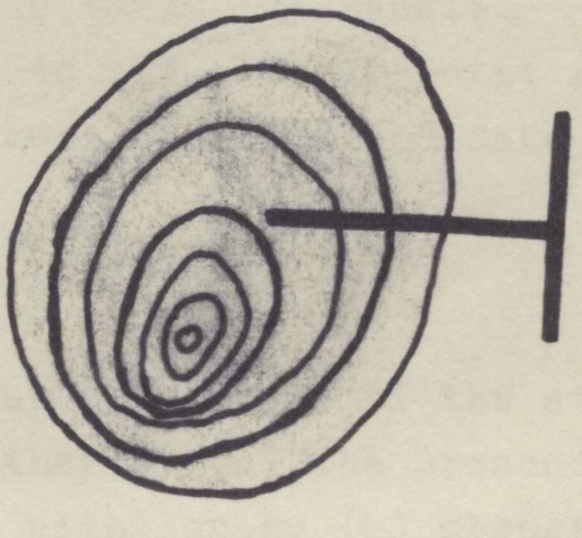
Cores which are to be brought to the laboratory for examination should receive at least a cursory examination in the field, otherwise it may be found that for one reason or another a useless core has been collected. For example, the borer may not have been driven in straight, or growth may be completely eccentric or possess a double centre. Also, it is very easy to miss the last few rings towards the centre of a stem. The effect of these faults is shown diagrammatically below.



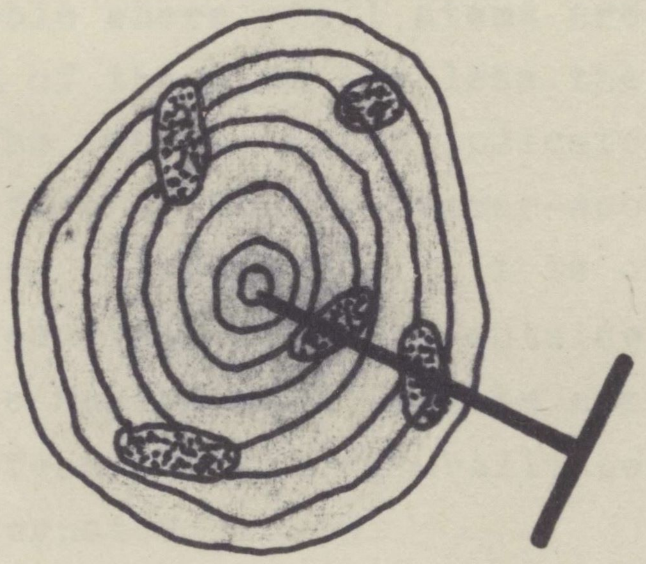
Borer misses the centre. Apart from missing some of the rings there will be distortion in the size of the central rings.



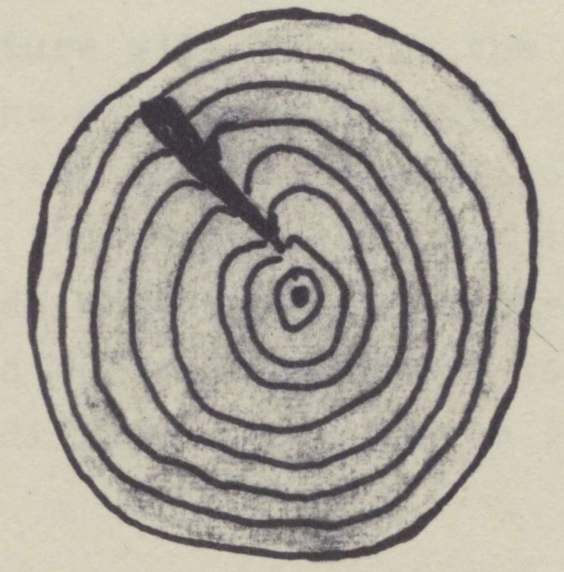
Double centre.



Eccentric ring-growth.



Galleries due to borers



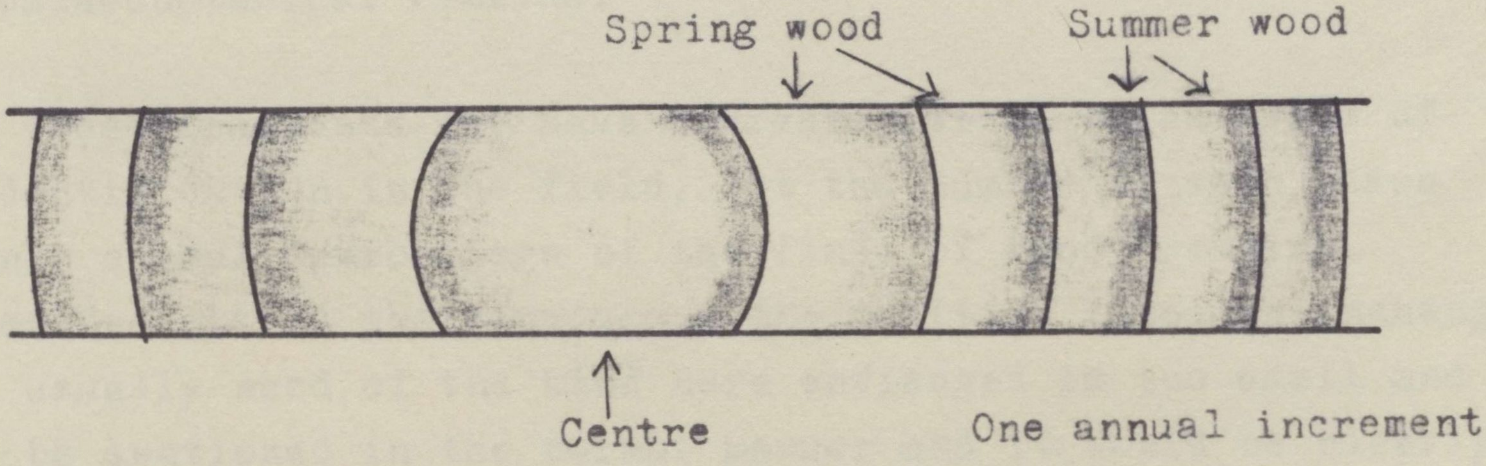
Knots due to branches may upset the core ring count.

The galleries made by wood-boring larwae may be of various sizes. The larger ones (e.g. due to <u>Sirex</u>) may cause considerable trouble in the core. The cavities or galleries are usually filled either with peat or with the frass of the grub. They may cause what appear to be only small gaps or breaks in the core, but this gap may have become smaller as a result of the forcing in of the extracting rod or wedge of the increment borer. Alternatively, the filling material may fall out of the gap in the core during transfer to the glass tube, later giving the impression that the core has merely broken whereas in reality a piece of the sequence is missing. The same will apply to pockets of rot which are particularly often found running down stems or stumps standing upright in peat deposits. All such occurrences must be carefully noted or serious discrepancies may arise.

When boring bog timbers care must be exercised to keep the increment borer turning because often if it is left for as little as half a minute the borer may become stuck fast with resultant chance of breaking it when trying to free it.(a 15" borer costs £7.)
The larger the stem being bored --- and thus the larger the borer necessary --- the greater is this risk. It may be found helpful to turn the borer back a turn after every couple of forward turns to avoid its jamming. Water-logged but hard timber such as <u>Taxus</u> is particularly bad in this respect.
Needless to say, the borer should be thoroughly dried before being screwed together in the container which also forms its handle.
Every care should be taken to avoid damage to the cutting point as an irregularity in this will cause it to score the core and make it more difficult to examine.

<u>Examination of Cores</u>.
If the borer has been driven in further than the centre of the stem the fact will be apparent from the core either by (a) the presence of an obvious small ring (or in some cases pith) or by (b) change in the radius of curvature of the rings though this is usually only

reliable where small stems are being dealt with as the greater the girth of the stem the less the curvature will show in the thin core. (c) The most reliable indicator is the change in density of the wood from Spring to Summer-wood with the abrupt termination on the outside of each ring. It is obvious that when examining the core progressively from the outside inwards that once the centre is passed the Spring-wood will be approached before the Summer-wood. This feature will naturally be more difficult to observe in timber of stagnated growth.



Diagrammatic representation of the centre part of a core.

Great care should be taken where cores are broken to see that they always have their parts placed in the correct sequence and do not become mixed. Mixing is particularly easy where a core has become broken into many pieces.
It is sometimes possible if the core is not too brittle, to join the pieces together with an office paper-stapler. If staples are driven in from both sides they should be "staggered" so that they will not cause a new break in the core.

Cores may be gently trimmed by razor on the transverse surface if the rings are not readily visible. If they are removed from their tubes and let air-dry the rings usually become more visible.

Measurements may be easily carried out by placing the core on a sheet of millimeter-paper . See Appendix 3b.

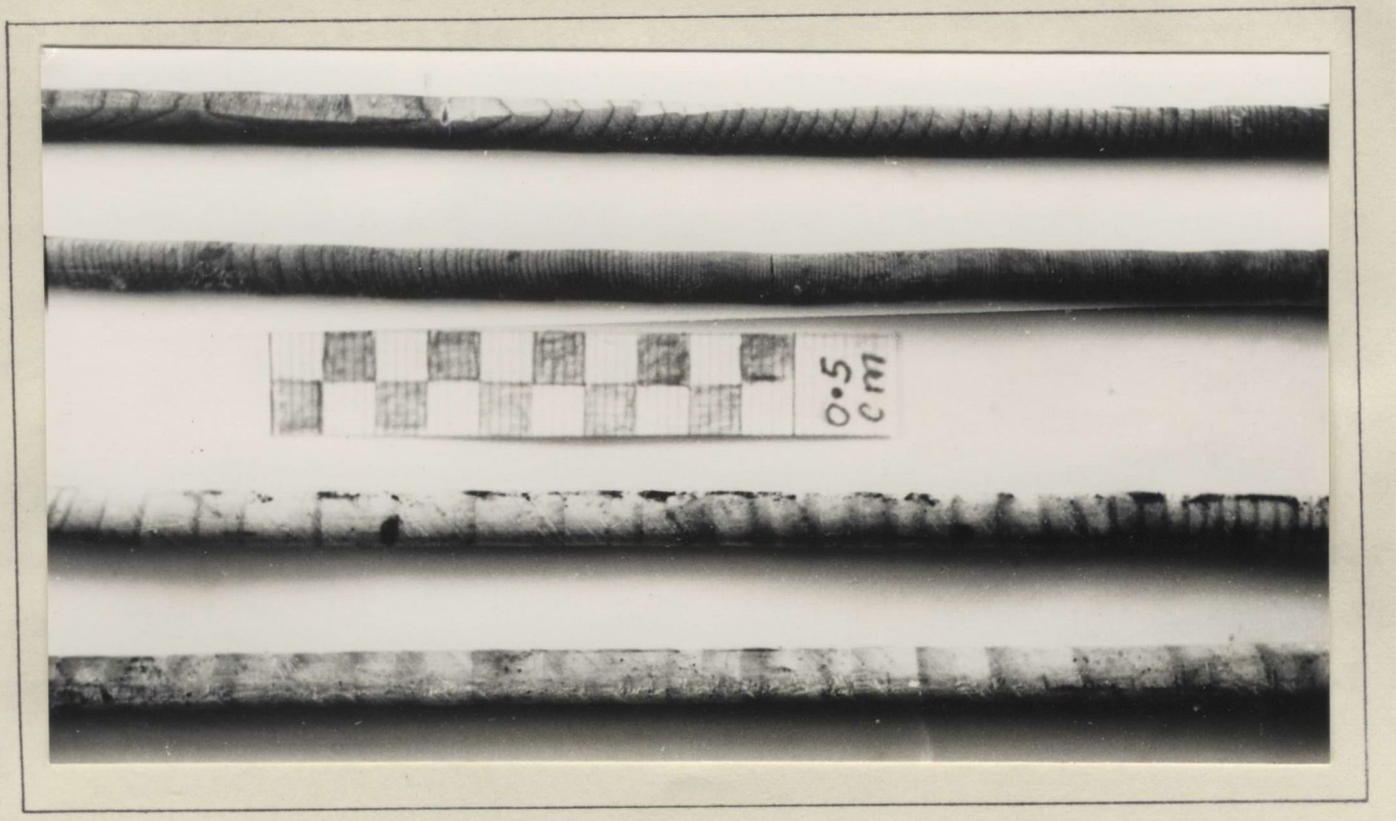


Photo.15.

Photograph 15 shows two cores of Taxus above and two of Pinus below.

## TIMBER IDENTIFICATION.

### Maceration.

Apart from the larger and more obvious timber remains which are usually apparent in the bog, small pieces of woody growth in the form of twigs, rootlets, and fragments of once larger timber present a constant challenge when one is dealing with the identification of palaeobotanical remains.

Some of these fragments may have characteristics which allow of their identification in the field, but the number of such cases forms only a small percentage of the finds of woody remains.
Even when brought to the microscope the position is often unchanged because usually wood of the kind here envisaged is too small and too soft to be sectioned in the normal manner and it would be clearly quite impossible to set about the impregnation of such vast numbers of pieces as turn up during any ordinary peat-profile investigation.
It was therefore endeavoured to develope one of the standard maceration treatments to cope with such material.

Firstly a set of type specimens was produced, the idea being that these could be used in conjunction with standard sections so that by comparison it could be estimated just how the dispersed macerated elements fitted into the structure characteristic of the species.
With this end in view, wood of all the species likely to be met with in the course of the investigation of unknown samples from a bog were collected.
Wood of all these species was then cut or broken into fragments no larger than half a matchstick in size and placed in test-tubes, care be taken to avoid the inclusion of bark tissue. Each test-tube was engraved with a serial number by glass-cutter.
Into each tube was poured a mixture of equal parts of glacial acetic acid and hydrogen peroxide (20 volumes). The tubes were corked and placed in 400 ml. beakers which form convenient water baths and hold 12 to 14 test-tubes each.
Theoretically the samples should then be cooked at 60 Deg.C. for 48 hours, however, most samples prepared in the course of this work were left to macerate on an ordinary domestic anthracite-burning cooker --- not on the hot plate but on the back of the cooker.
Apart from the occasional blowing out of corks this method proved very convenient, efficient, and economical. The time required for the maceration varied from overnight to several days depending on the temperature of the cooker, the species and condition of the wood (Taxus took longest) and the age of the hydrogen peroxide.

With a little experience it can be judged when the wood has reached the optimum stage of maceration. Broadly speaking, this is when the wood has become whiteish in colour and the maceration liquid has become water-clear. Usually too, fibres start to fall off the outside of the sample.

If the maceration has not gone on long enough it will not be possible to tease the elements apart for examination. On the other hand, too much cooking will result in total disintegration. The fibres should only fall apart on vigorous shaking.

When maceration is complete the macerating liquid should be drained off and replaced by distilled water. After some time this water is drained off and replaced with fresh distilled water. The tubes may then be sealed and the type-material used as required.

Type specimens were prepared as outlined in Appendix 4 and mounted in Canada balsam. It was only realised when the set was practically complete that the method though speedy was actually unsatisfactory for the following reasons, i.e. some of the stages involved shaking the macerated material in centrifuge-tubes with only small amounts of liquid filling at most, quarter of the volume of the centrifuge tube. The necessary shaking of the contents then left the smaller wood elements adhering to the side of the centrifuge-tube wall while the larger tracheids went to the bottom of the tube and from there to the microscope slide with resultant over-representation of the larger wood-elements. Further, as dispersion is total due to shaking-up, some woods are left in a condition in which they can no longer be identified, e.g. Salix and Populus are only seperable on the grounds of possessing heterogeneous and homogeneous rays respectively. Clearly after the treatment given these type specimens such a feature is quite destroyed. The difficulty can of course be overcome by treating a piece of the desired sample on a slide and not teasing it out till it is ready for mounting in balsam though this process takes more time.

In actual fact, later work proved it quite convenient to prepare fresh type slides from the serially labelled tubes of type material as required. This merely necessitated washing the material well with distilled water, staining with 1% aqueous safranine, again washing it and then mounting it in glycerine.

Semi-permanent mounts can be prepared in similar fashion using glycerine jelly instead of glycerine. The wood is gently teased apart on the slide so that while the elements separate, they lie more or less in the position to which they belong.

Much valuable information is contained in "The preparation of wood for microscopic examination" Leaflet no.40 of the Forest Products Research Laboratory, Princes Risborough.

Treatment of Unknown Samples.

Where possible, unknown samples should be identified using the features visible with a 10 x hand lens. If the wood cannot be identified in this manner it should, condition allowing, be sectioned and examined by microscope.

Only in cases where timber is too soft, or possibly too compressed to examine in the ordinary manner should maceration be resorted to. Very valuable samples are better treated with Celloidin or by some other standard botanical impregnation method used for soft tissue.

Having regard to time and material it will be found advisible to collect a large number of samples and then carry the identifications through in one operation. Pending treatment, samples should not be let dry out.

Each piece of woody material it is intended to analyse should have all macroscopic features and its dimensions noted. A space may then be left in the note book so that features upon which identification is based can be recorded also.

The unknown sample is placed in a tube upon which a serial number is scratched so that it cannot become eradicated. It is quite a simple matter to evolve a system whereby these tubes can be re-used without danger of mixing results, e.g. samples can have their serial number cancelled as soon as they are identified leaving the maceration tube free for further use. Tubes and their corks should be well washed before re-use.

A word of warning is necessary with regard to the use of cleaning tissues of the paper-handkerchief type in the laboratory where wood identification is being carried out. These tissues are usually made from wood pulp and for obvious reasons must not be used where work on timber identification is being done.

It will be found convenient to have an array of about a dozen watch-glasses and a wax pencil to number them. Samples placed on these glasses may be conveniently examined under the dissecting microscope in order to remove any bark tissue which interferes with identifications. Dissecting needles are effective for this job. The sample may then be stained with 1% aqueous safranine, washed free of excess stain, transferred to a slide, teased and mounted in glycerine and examined.

Over 100 identifications were carried out using this method. The smallest material identified were twigs or roots of approximately 1 mm. in diameter. Alnus, Betula, and Corylus were the commonest remains found.

## Bog Timber and its Treatment.

When timber which has lain embedded in peat is collected for identification it should not be let dry out as shrinkage will only add to the difficulties of identifications.
The pieces of wood may be labelled with aluminium or copper tags bound on with copper wire and placed in a water-filled receptacle of suitable dimensions.
Where possible identification should be made from the features visible in transverse, radial, and tangential fractured surfaces using either a hand lens or a dissecting microscope. Identification is often aided by arranging the light so that the beams are parallel to the surface being examined. This emphasizes features such as perforation plates, to be seen in the fractured surface.

If the timber cannot be identified by the above means it will be necessary to section it. As the proceedure for the preparation of sections is standard and is given in all text-books dealing with the subject of timber identification it will not be repeated here. A few observations will however be made.

The wood may or may not require preliminary boiling to bring about softening. Quercus, Pinus, and Taxus being hard and durable are liable to require softening though it is not usually necessary to have to section these timbers in order to identify them as they each have distinctive macroscopic characteristics. On the other hand, woods like Corylus and Betula though normally soft after their sojourn in the bog are often compressed and distorted. Boiling will help very slightly in expanding them.

Sections can be more easily expanded than blocks of wood but although satisfactory results may be obtained in the expansion of transverse sections it is not quite so simple with radial and tangential sections as these will have their elements cut in their distorted form with the result that it is extremely difficult to see the identifying features.
A private communication from the Forest Products Research Laboratory at Princes Risborough states ---

> Sections of bog timber are often dark in colour and the tissues may be distorted owing to compression whilst in the bog. Proprietary bleaching agents (e.g. "Durazone" "Parazone") have been found useful in such cases for clearing and swelling the tissue.

A transverse section of very compressed wood from lake mud, probably a pile, in which the vessels appeared as only small jagged holes was treated with pure "Parazone", washed with distilled water and again treated with "Parazone". This process was repeated several times.

Finally the section was well washed with distilled water and stain-with 1% aqueous safranine. The previously compressed vessels were completely expanded and the section looked in fact like a section of sub-recent timber.
Such satisfactory results were not obtained with radial and tangential sections, though if a number of each are prepared sufficient identifying features are usually present among the distorted tissue. Several tests were made with a view to expanding compressed sections. They were merely exploratory and no significant results were obtained. They are recorded in Appendix 5.

## CHARCOAL.

Only a limited number of experiments were carried out on the identification of charcoal as the small amount found was immediately identifiable on macroscopic features.

Wood charcoal is the residue of the incomplete combustion of timber or wood in the absence of air. Type specimens may be prepared by placing wood of the species required in a tin or other suitable metal container upon which a loose cover is placed to restrict the free access of air. The container may then be heated over a bunsen burner in a fume-cupboard until the wood is charred through. The time required for this will vary with the size of the sample and its moisture content. The samples may be marked with notches or metal tags. The container and sample should be allowed to cool before removing the cover or further combustion will result on the access of air.

As with ordinary wood samples, it is best to try and identify the specimen without any treatment. A set of type samples may be prepared as outlined above and used for comparing with the unknowns. Transverse, radial, and tangential fractures are made and the sample illuminated by light beams parallel to the surface being examined and preferably passed through a sheet of opaque glass. This method of lighting brings into relief many identifying features which might ordinarily be missed under direct illumination. This is a standard method commonly applied in research laboratories.

If it is not possible to carry out a straightforward macroscopic identification, methods of impregnation must be resorted to. Impregnation is necessary as it is impossible when dealing with untreated charcoal to cut sections thin enough to identify as the structure merely crumbles before even the sharpest blade.

Fossil material is usually more fragile than that produced in the laboratory as type specimens.

Impregnation with paraffin wax (see Appendix 6) gave identifiable sections but the wax clearing-agent here used (xylol) was found to dissolve the wax at such a rate that currents were set up which disturbed the thin, very fragile, identifying elements. Doubtless the use of a more suitable clearing agent could improve matters in this respect.

Friable-rock impregnation methods applied to charcoal.

If certain porous and friable rocks could be impregnated with a binding agent to enable thin sections to be prepared it seemed reasonable that such a process could be applied to charcoal. Rowland and Lewis (Rowland and Lewis, undated offprint) give the following outline of the process as applied to rocks ---

> The object of impregnation is to fill the cracks and cavities in the specimen with a material that will bind it together during grinding operations. It must not pick up any of the abrasives and, as much of the impregnating material will remain in the section when it is completed it must have an R.I. equal to that of Canada balsam (1.540) or, in exceptional cases, very close to it.

Three methods for the impregnation of friable rocks were tried on charcoal, two of them given by Rowland and Lewis (quoted above)

One method involved the use of Damar Gum. (see Appendix 7a) Some good slides were produced by this method though impregnated blocks of charcoal left for some hours flaked into small fragments due to cracking up of the gum probably as a result of overheating during the impregnation process thereby driving-off the solvents and leaving the gum in a very brittle state.

A second impregnation technique involved the use of a proprietary brand of wax --- "Lakeside 70" (see Appendix 7b) This method although requiring the same stages as the Damar-Gum technique was quicker and gave more satisfactory results.

Both the above methods are given by Rowland and Lewis.

A third method tried out involved impregnating the charcoal with Canada-balsam (see Appendix 7c) This produced good results though possibly less satisfactory than the "Lakeside 70" impregnation.

In all three methods the impregnated charcoal sample is ground down with silicon carbide to the required orientation --- radial, tangential, or transverse, mounted on a slide and further ground to an identifiable thickness just as rock sections are prepared for microscopic examination. (see Appendix 7d)

Difficulties inherent in these rock-type impregnation methods are firstly, the difficulty of grinding the charcoal block to the exactly correct orientation for mounting on the slide, as if not true (i.e. skewed away from radial, etc.) identification may not be possible. Secondly, it is very difficult to split a small piece of charcoal into the three pieces which are necessary for the production of transverse, radial, and tangential sections.
Thirdly, it is quite easy to overgrind or otherwise spoil a section so that unless the unknown sample was large enough to have reserved some of it from the process --- and this is not often the case --- all the evidence will have been destroyed.

Charcoal should be let dry slowly at room temperature as excess heat seems to bring about splitting-up of the sample. Samples placed to dry on a hot-plate fell apart.

Photomicrograph of a transverse section of Quercus charcoal (sub-recent) showing the large Spring-wood and smaller Summer-wood vessels. x 330.
The section was produced by the "Lakeside 70" impregnation process.

o

## TIMBER IDENTIFICATION and PHOTOMICROGRAPHS.

A series of photomicrographs of type-specimens of woods of genera found in the peat at Clonsast has been prepared for this thesis. These are not intended to take the place of a standard timber identification key but rather to illustrate the points by which macerated (and also some sectioned) woods were identified.
A most useful key to identifications is that prepared by M.H.Clifford (Godwin 1956, Table 1)

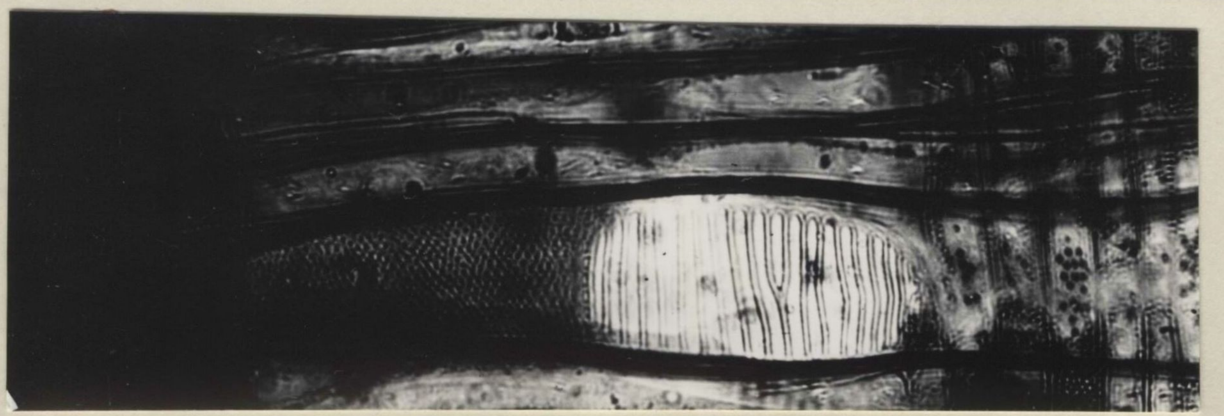
For purposes of uniformity of illustration it was considered better to make photomicrographs of sections rather than macerations though some of the latter are included.
The standard section surfaces were photomicrographed, i.e. transverse, radial, and tangential, though the first of these of course is no use in maceration work. In this connection, certain features have been included in the general description which are valueless to the identification of macerated wood. These have been limited as far as possible.

Alnus, Betula, Corylus, and Myrica are grouped together due to certain similarities.
Salix and Populus (though not found in the course of the work here presented) are included to illustrate a point made in the section on maceration technique, i.e. to show that by carefully teasing macerated wood, identifying features which depend on the position of component elements may be preserved. In this way too, seriation of the rays is occasionally visible in macerations.
Fraxinus, Ulmus, Quercus, Taxus, and Pinus are included though each of these is readily identifiable on macroscopic features if specimens large enough are found.
Macerated Ericaceous woods are also shown.

Due to the size of the photomicrographs it was not possible to include the descriptive notes on the page alongside the illustrations, therefore descriptions have been placed on the page preceeding the photomicrographs of the genera concerned. They are numbered 1-41 inclusive, and in the descriptive text when bracketed with the letters Phm. they indicate that the feature to which they are appended is visible in the photomicrograph of that number.
In all the timber photomicrographs the magnification over the original is x 330.

The presence of a particular element may prove the identifying factor in a sample, but its apparent absence should not be taken as an indication that the sample is of another species, e.g. a sample may show uniseriate rays and no barred perforation plates, Salix or Populus might then be suspected; however, for one reason or another bars are sometimes not apparent --- possibly they become broken away due to poor state of preservation --- and may only be found after an exhaustive search involving many maceration preparations or sections of the unknown sample.

Too, in the counting of bars in scalariform perforation plates, bars which are forked should only be counted as one bar. This fault may not be apparent where only the "stumps" of the bars are left. As many perforation plates as possible should be examined.



Photomicrograph showing scalariform perforation plate of Betula sp. with forked bar. x 330.

## Index to Wood Photomicrographs.

T.S. = Transverse Section. Ta.S. = Tangential Section.
R. = Radial Section. Mac. = Maceration.

1 Alnus T.S.
2 Betula sp. T.S.
3 Corylus T.S.
4 Myrica T.S.
5 Alnus R.S.
6 Betula sp. R.S.
7 Corylus R.S.
8 Myrica R.S.
9 Alnus Ta.S.
10 Betula sp.Ta.S.
11 Corylus Ta.S.
12 Myrica Ta.S.
13 Salix T.S.
14 Populus nigra T.S.
15 Salix Ta.S.
16 Populus nigra Ta.S.
17 Salix R.S.
18 Populus nigra R.S.
19 Salix Mac.
20 Populus nigra Mac.
21 Calluna Mac.
22 V.myrtillus Mac.
23 " "
24 Ulmus montana T.S.
25 " " Ta.S.
26 " " R.S.
27 " " Mac.
28 F.excelsior T.S.
29 F.excelsior Ta.S.
30 " R.S.
31 " Mac.
32 Quercus T.S.
33 " Ta.S.
34 " R.S.
35 Taxus T.S.
36 " Ta.S.
37 " R.S.
38 " Mac.
39 Pinus T.S.
40 " Ta.S.
41 " R.S.

All are magnified x 330

## ALNUS.

Photomicrographs 1, 5, 9,
Diffuse porous, radial multiples of pores present.
Medullary rays uniseriate. (Phm.9)
Perforation plates scalariform with 12-32 bars. (Phm.5)
Intervessel pitting (Phm.5) orbicular to oval, larger than in Betula and smaller than in Corylus.
Rays homogeneous (Phm.5)

## BETULA.

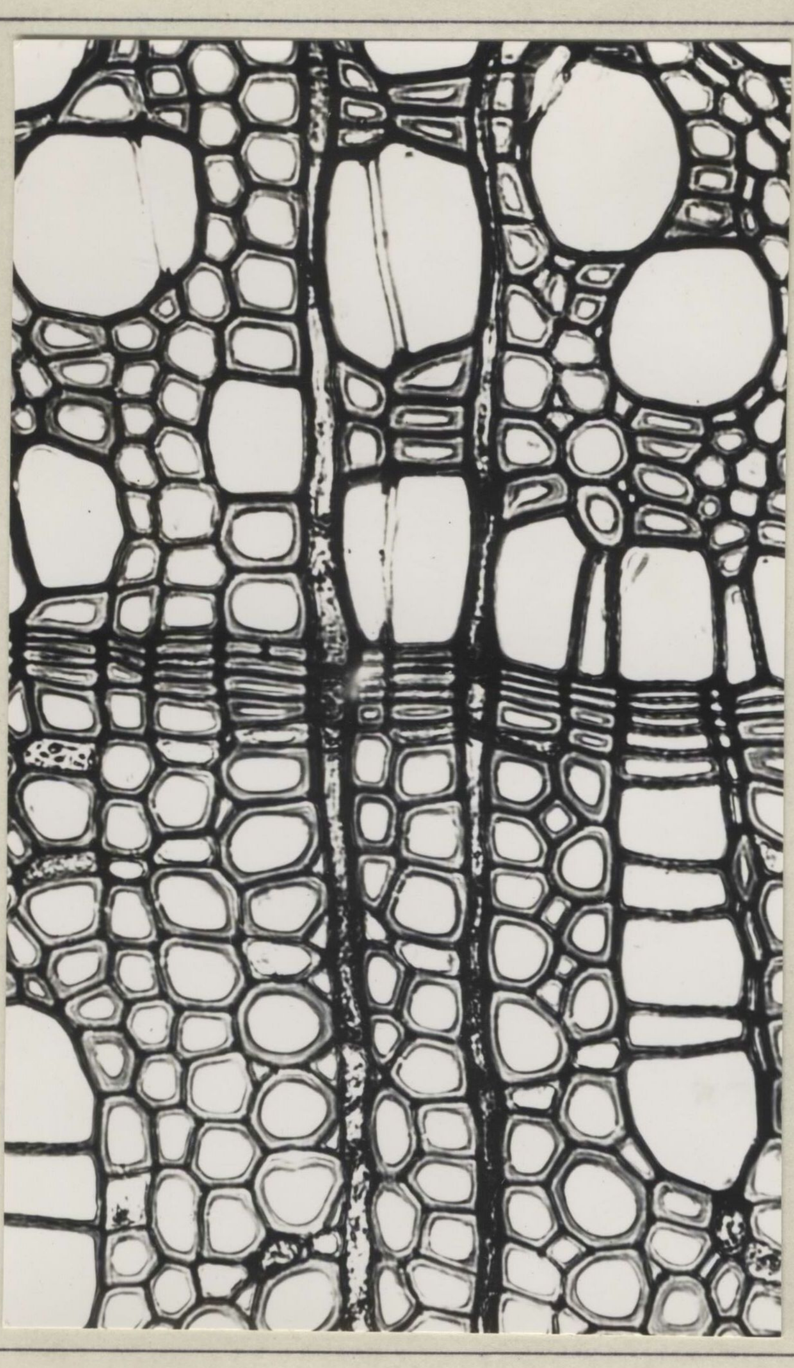
Photomicrographs 2, 6, 10, and page 65.
Diffuse porous.
Medullary rays usually 1-5 seriate. (Phm.10)
Perforation plates scalariform with 12-25 bars. (Phm.6)
Intervessel pitting small and having a latticed appearance.(Phm.6)
Rays homogeneous.

## CORYLUS.

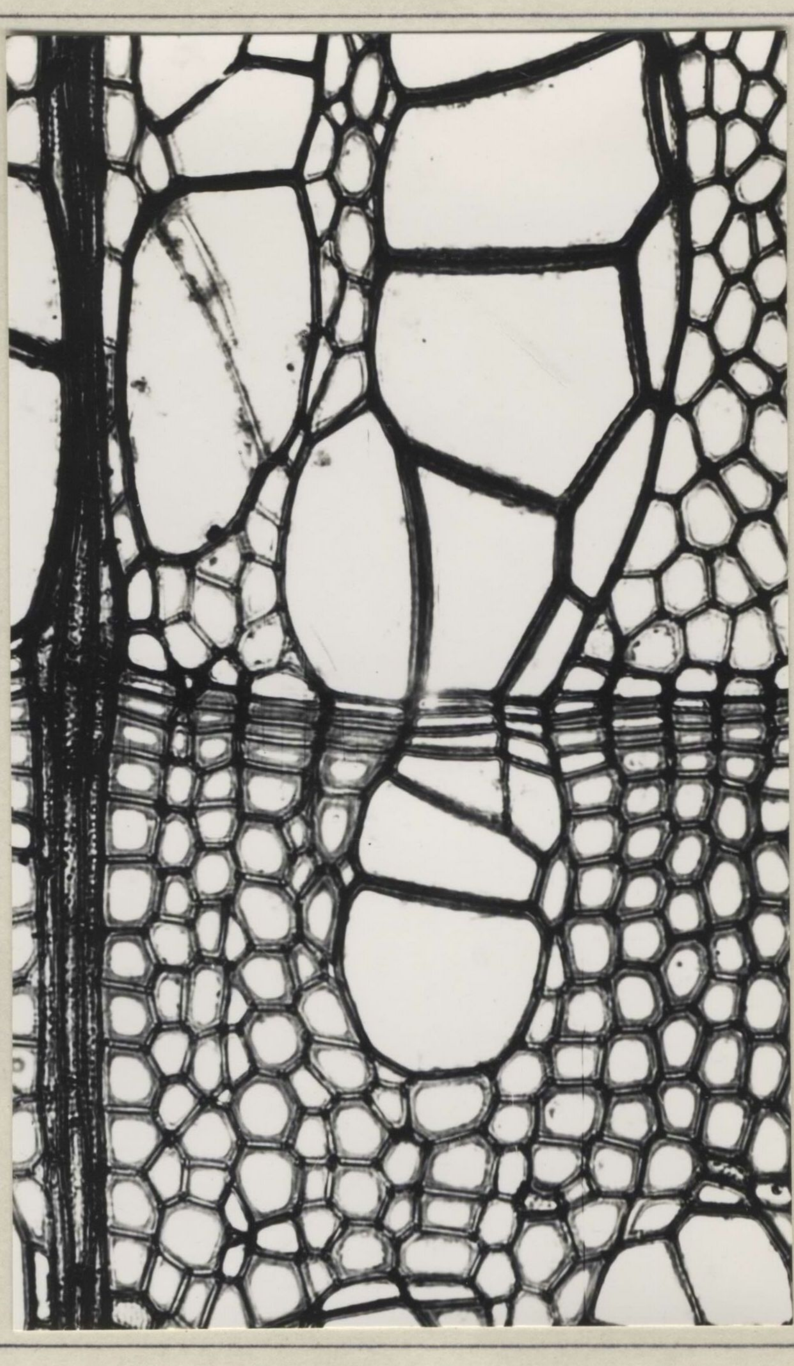
Photomicrographs 3, 7, 11.
Diffuse porous, radial multiples of three or more pores.(Phm.3)
Medullary rays uni- and bi-seriate.(Phm 11)
Perforation plates scalariform with 4-10 bars. (Phm.7)
Intervessel pitting,large, orbicular to oval. (Phm.7)
Rays heterogeneous.

## MYRICA.

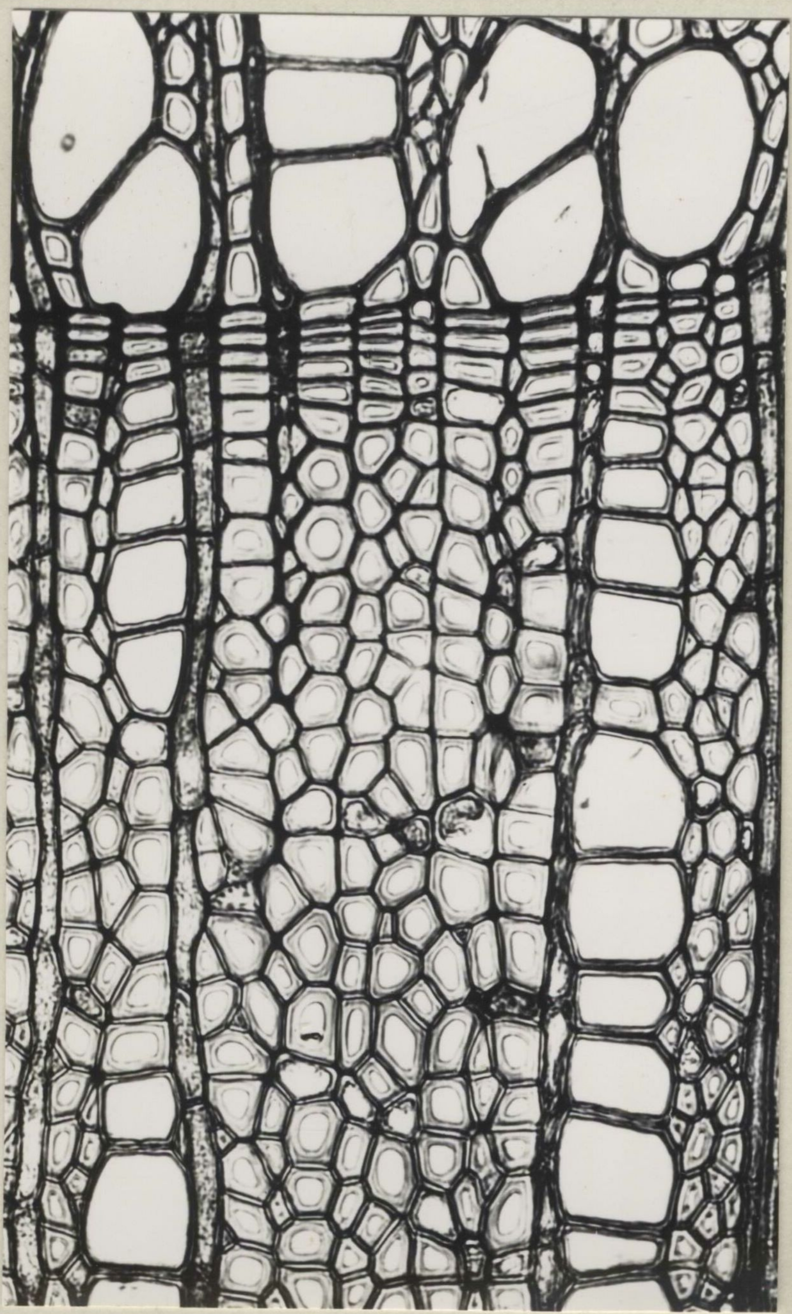
Photomicrographs 4, 8, 12.
Ring porous,(Phm.4) radial multiples of pores present.
Medullary rays uni- and multi-seriate. (Phm.12)
Perforation plates scalariform with 5-11 bars. (Phm.8)
Intervessel pitting (Phm.8) smaller than in Corylus. Some vessels have pitting similar in "lattice" appearance to that of Betula though the latter are smaller.
Hetero- and homogeneous rays present.



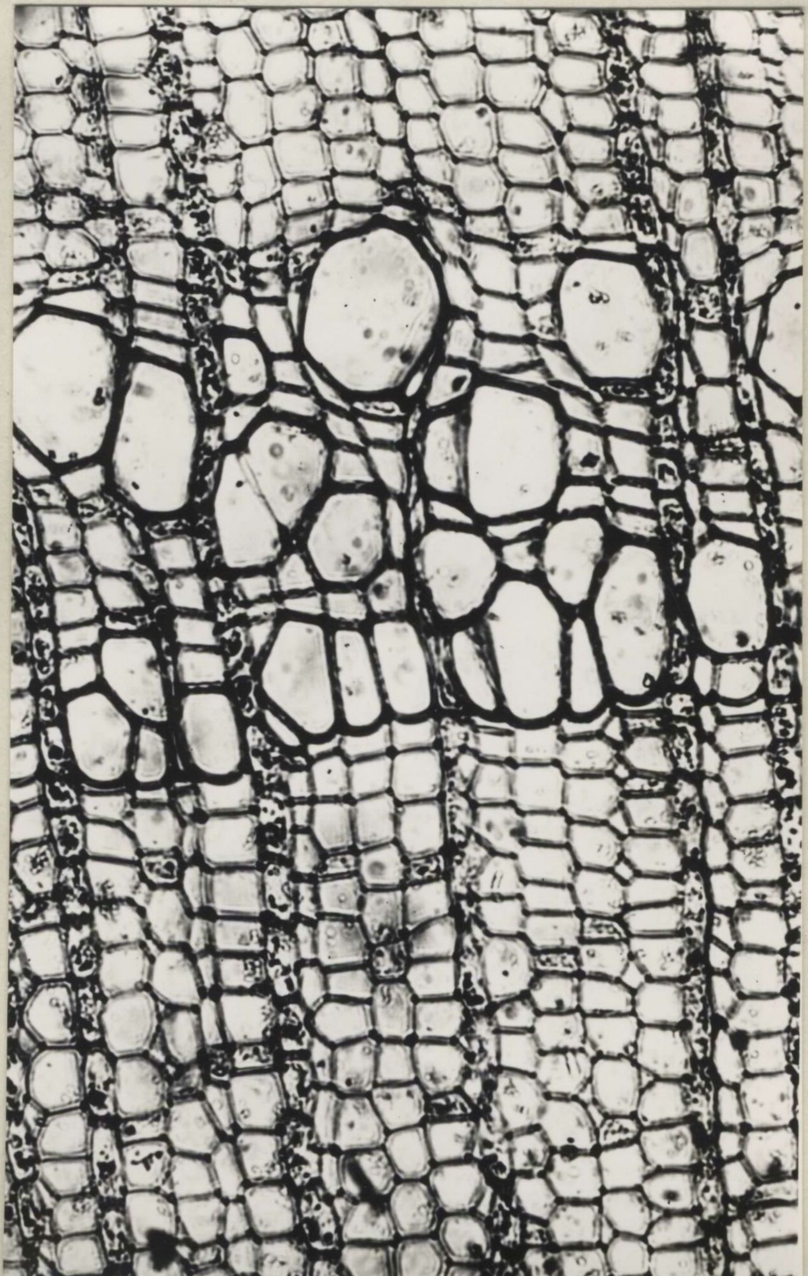
1. ALNUS (T.S.)



2. BETULA (T.S)



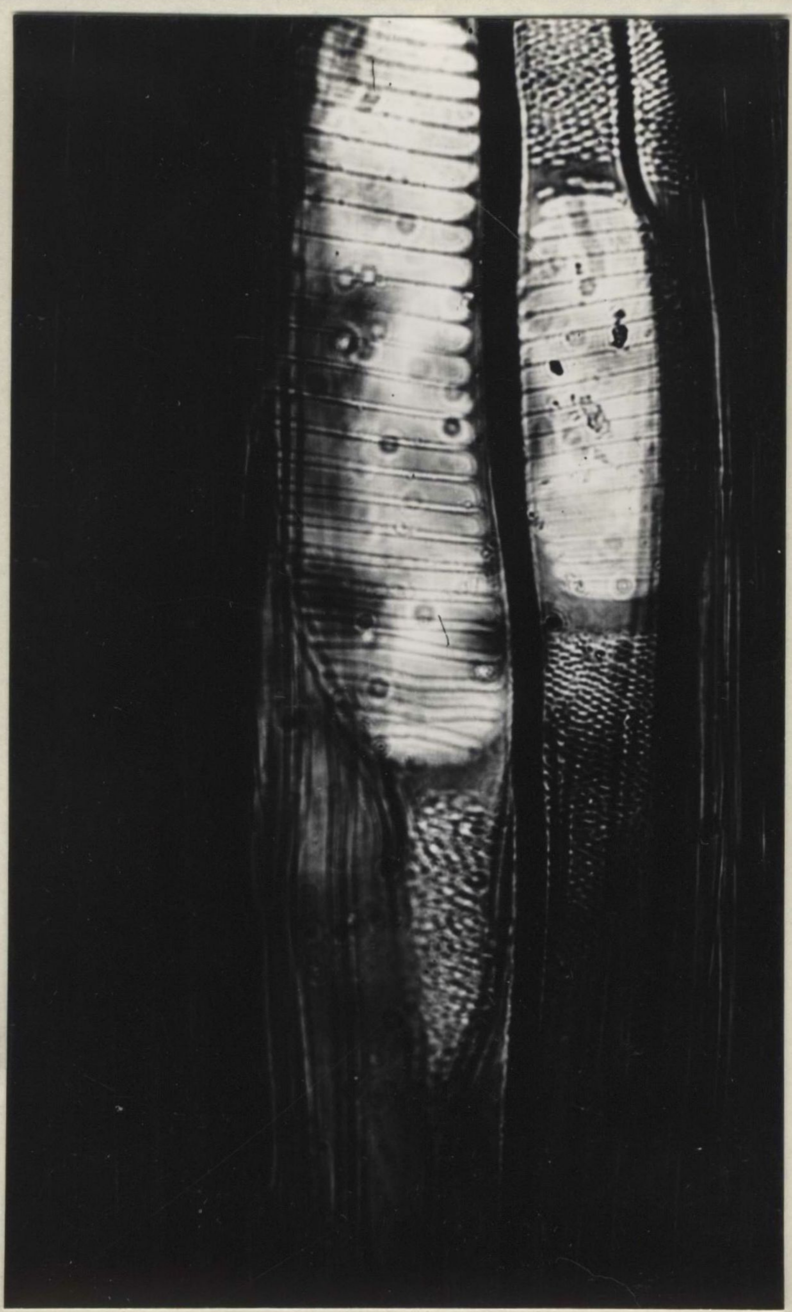
3. CORYLUS (T.S.)



4. MYRICA (T.S.)

MAGNIFICATION X 330

5. ALNUS (R.S.)



6. BETULA (R.S.)

7. CORYLUS (R.S.)

8. MYRICA (R.S.)

MAGNIFICATION X 330

9. ALNUS (Ta.S.)

10. BETULA (Ta.S.)

11. CORYLUS (Ta.S.)

12. MYRICA (Ta.S.)

MAGNIFICATION X 330

## SALIX.

Photomicrographs 13, 15, 17, 19.
Diffuse porous.
Medullary rays uniseriate. (Phm.15)
Perforation plates simple.
Intervessel pitting large. (Phm.17)
Rays heterogeneous, i.e. possessing both procumbent and upright cells. (Phm.17) This feature is visible in carefully macerated samples, see (Phm.19) which shows part of a heterogeneous ray.

## POPULUS.

Photomicrographs 14, 16, 18, 20.
Diffuse porous.
Medullary rays uniseriate.(Phm.16)
Perforation plates simple.(Phm.18)
Intervessel pitting large.(Phm.16 and Phm.18)
Rays homogeneous, i.e. possessing procumbent cells only. (Phm.18)
This feature is visible in carefully macerated samples.(Phm.20)

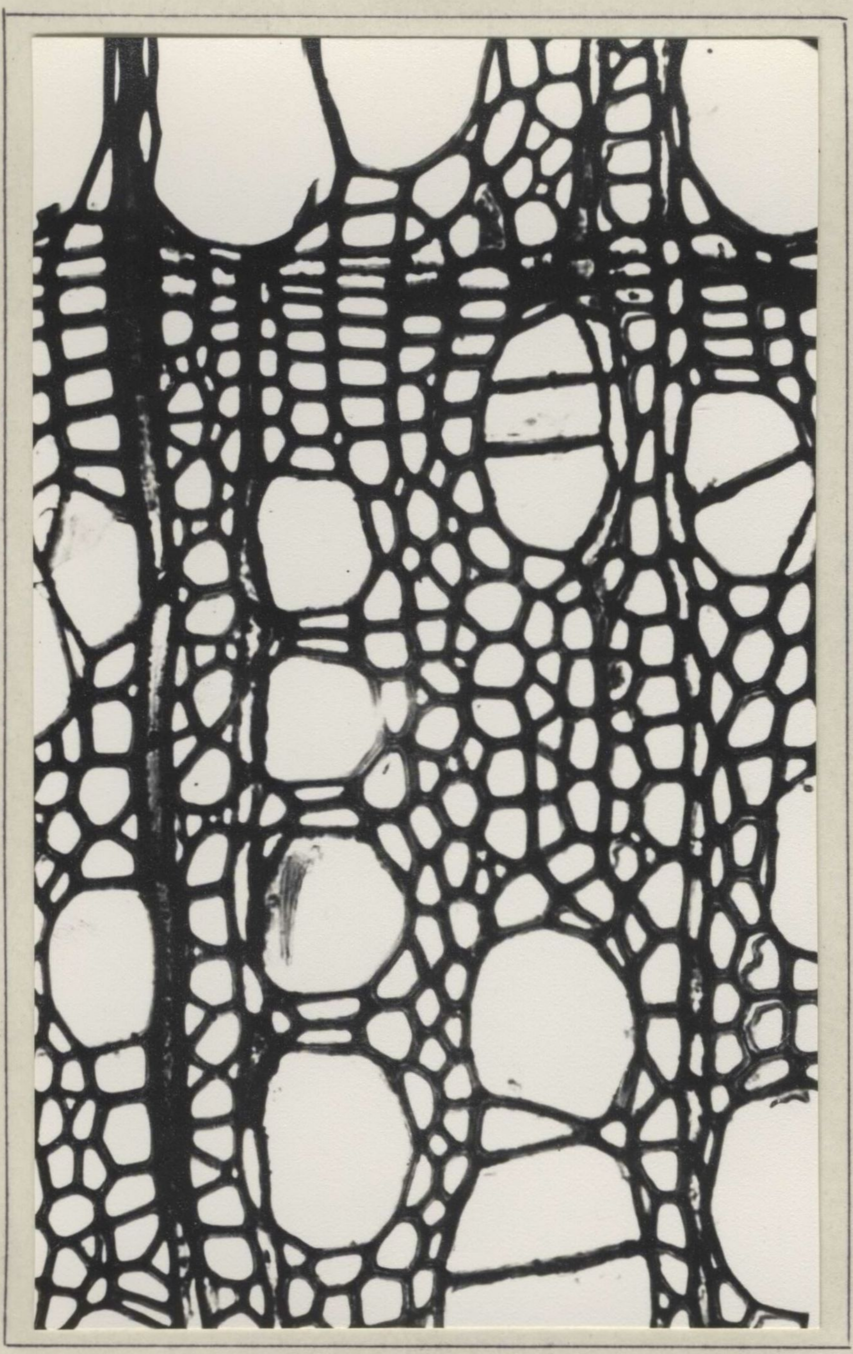
## "ERICACEOUS" WOOD.

Photomicrographs 21, 22, 23.
Unfortunately no sections of Calluna or other Ericaceous wood were prepared so no section photomicrographs are available for comparison.

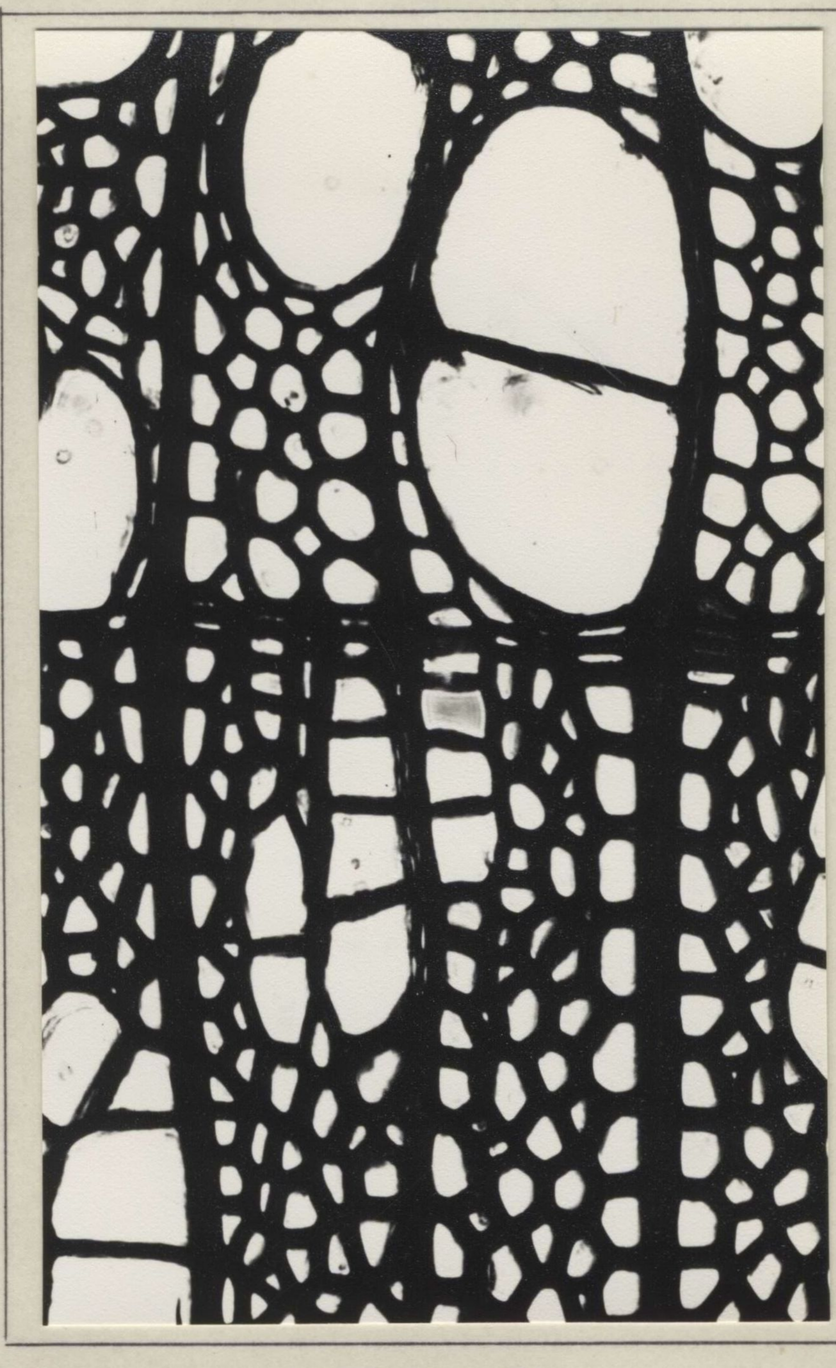
In the course of peat-analytical work macerated samples of unknown twig or rootlet wood were identified as "Ericaceous" by comparison with type-material macerations.

From the following photomicrographs Phm.21, Phm.22, Phm.23, it will readily be seen that the fibres and vessel segments of Calluna and Vaccinium (myrtillus) are much smaller than those of, say, Betula or Corylus.

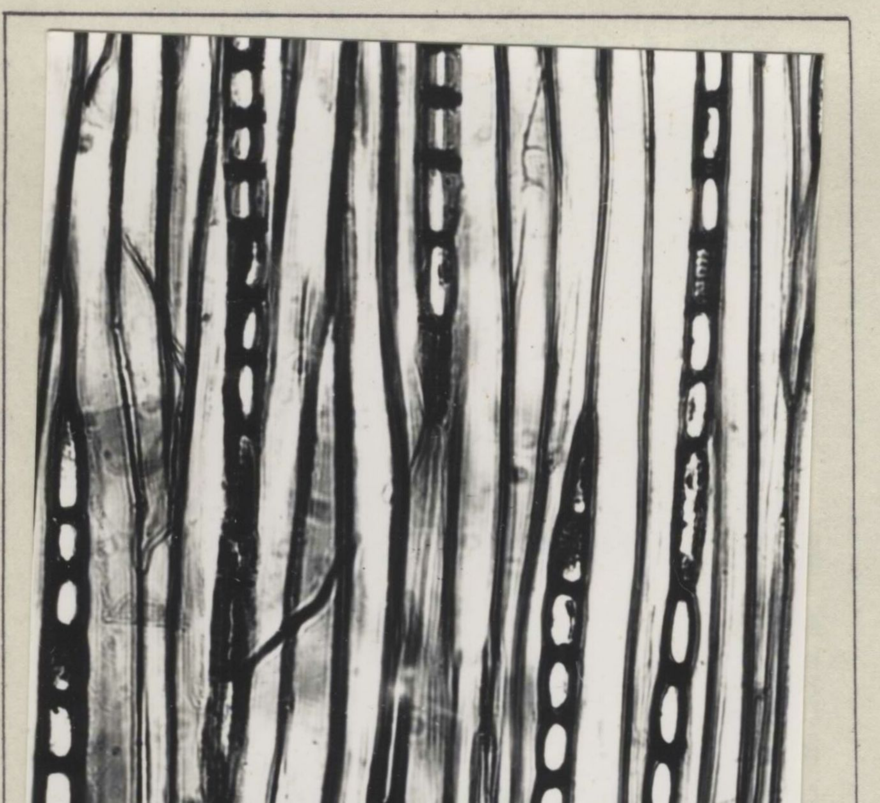
It appears from the limited amount of type material examined that Calluna (Phm.21) has simple perforation plates and that Vaccinium (Phm.22 and Phm.23) has mainly scalariform perforation, but also simple and foraminate perforation plates.



13. SALIX (T.S.)



14. POPULUS (T.S.)



15. SALIX (Ta.S.)

16. POPULUS (Ta.S.)

MAGNIFICATION X 330

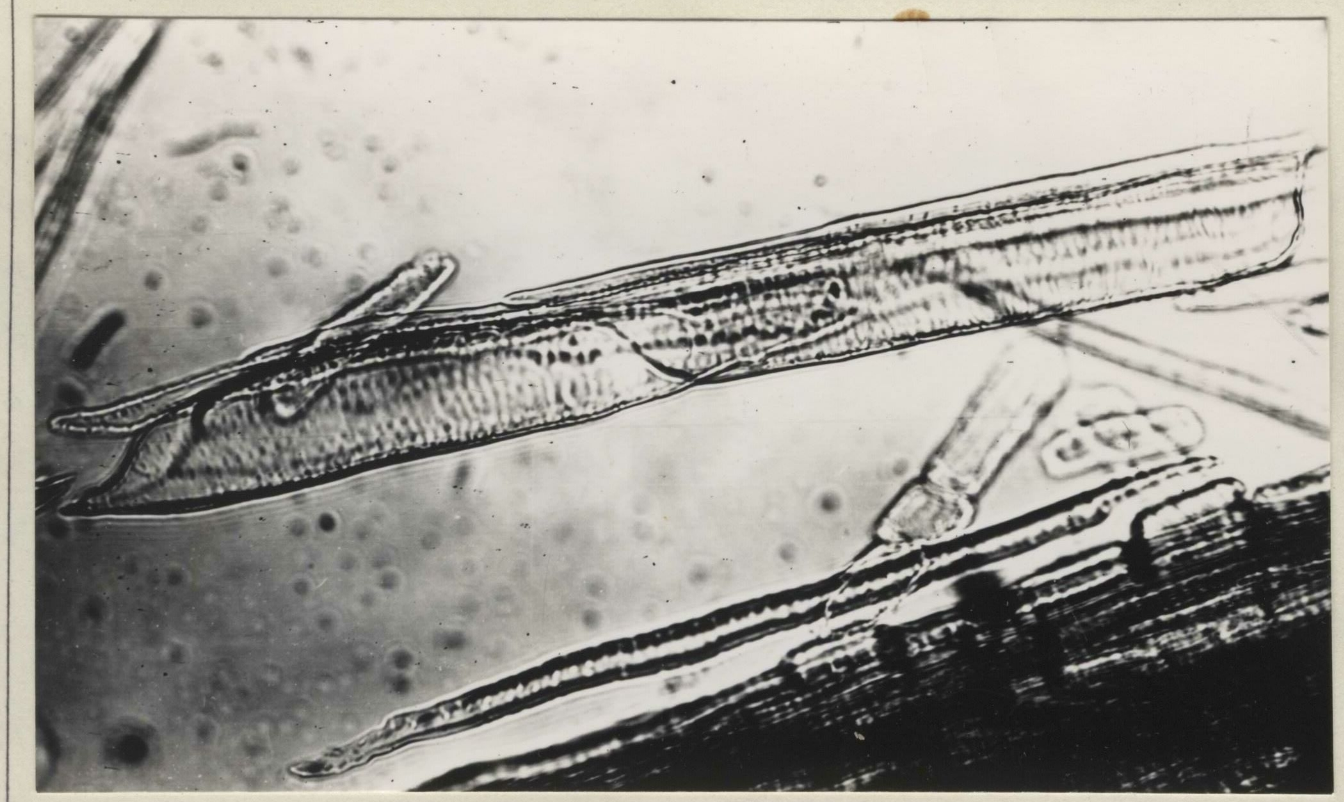
17. SALIX (R.S.)

18. POPULUS (R.S.)

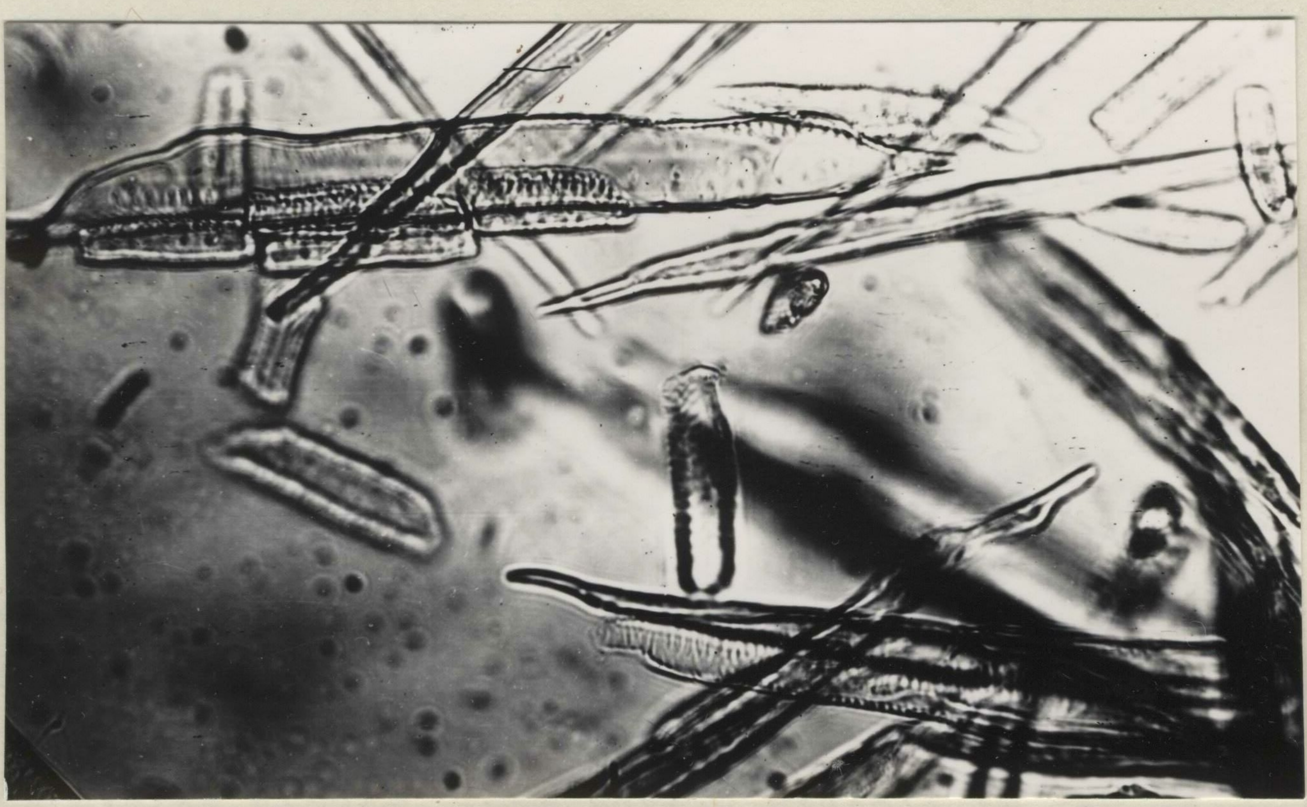
19. SALIX (Mac.)

20. POPULUS (Mac.)

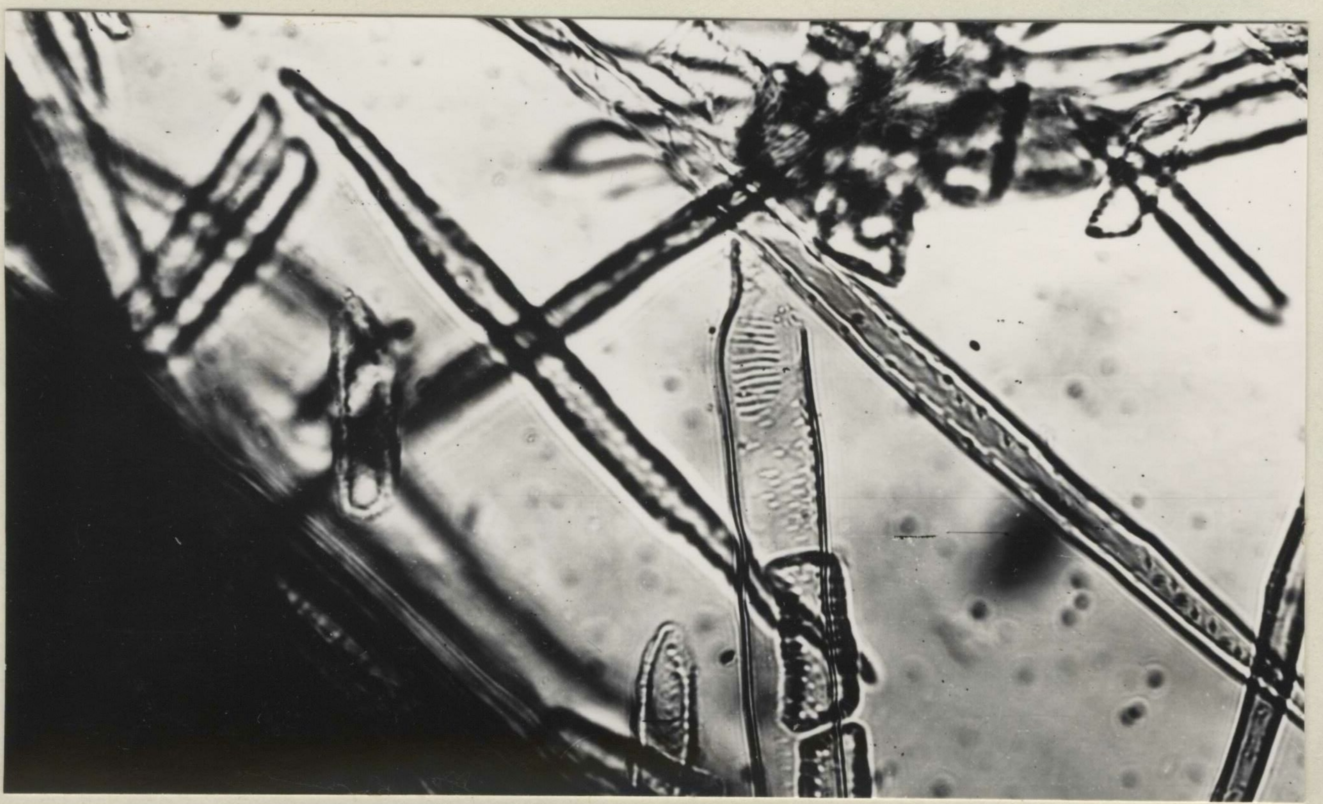
MAGNIFICATION X 330



21. CALLUNA (Mac.)



22. VACCINIUM (Mac.)



23. VACCINIUM (Mac.)

MAGNIFICATION X 330

## ULMUS.

Photomicrographs 24, 25, 26, 27.
Ring porous, tyloses present.(Pore clusters and tangential parenchyma are very apparent features in macroscopic transverse view)
Rays mainly multiseriate (Phm.25) and homogeneous
Has spiral thickening which in macerations distinguishes it immediately from Fraxinus or Quercus. Photomicrograph 27 shows macerated vessels with spiral thickening.

## FRAXINUS.

Photomicrographs 28, 29, 30, 31.
Ring porous, some tyloses present. (Has vasicentric, aliform parenchyma)
Medullary rays multiseriate.
Perforation plates simple.(Phm.31 maceration)
Macerations distinguishable from Ulmus in having no spiral thickening in the vessels, and from Quercus by having smaller intervessel pitting and narrower vessel segments. (see Quercus below)

## QUERCUS.

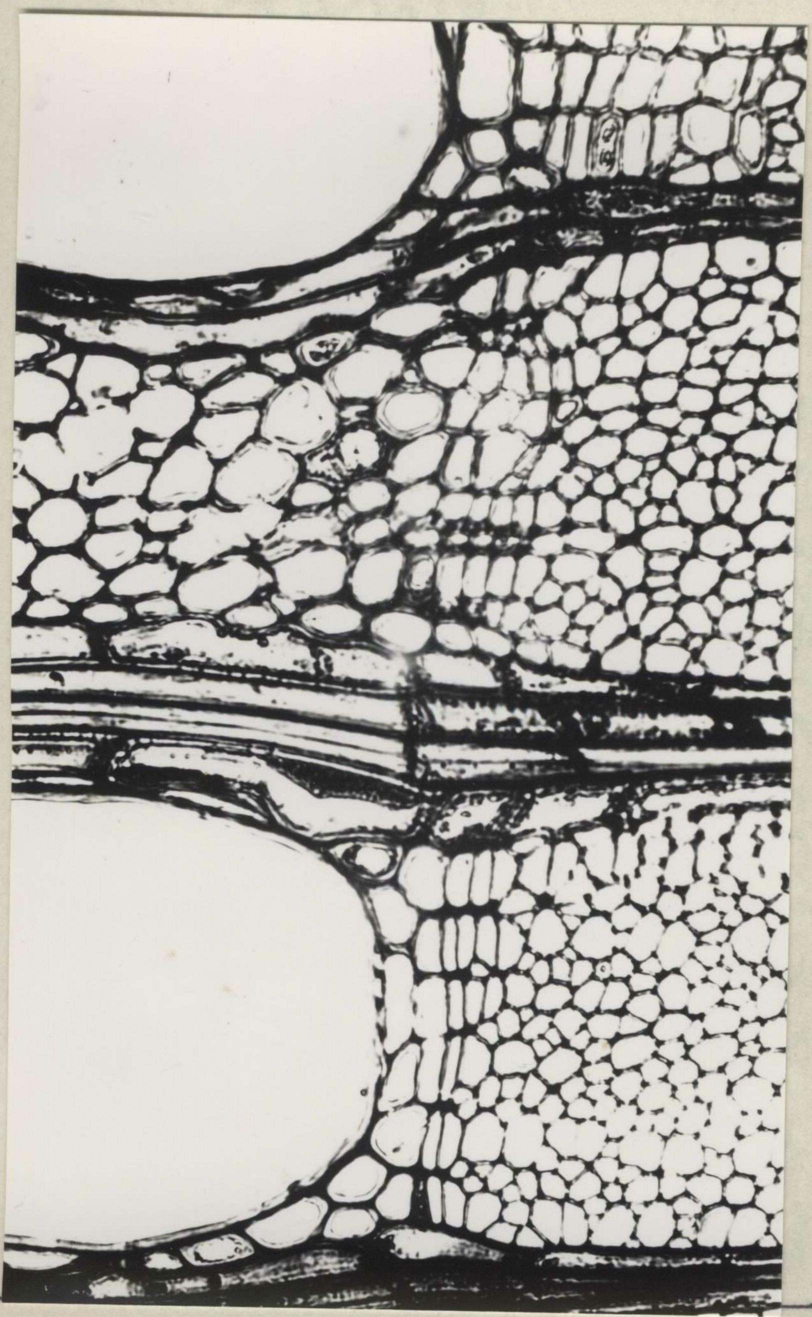
Photomicrographs 32, 33, 34.
Ring porous, abundant tyloses, (Phm.32)
Medullary rays uni- and multiseriate. (Phm.33)
Perforation plates simple. (One barely visible in Phm.34)
Rays hetero- and homogeneous.
Intervessel pitting (Phm.34) larger than in Fraxinus. Some vessel segments will be comparable in size with those of Fraxinus but the large ones are much greater in diameter than those of Fraxinus. Note part of the circumference of a Spring-wood pore in(Phm.32).
No spiral thickening in vessels.

## TAXUS.

Photomicrographs 35, 36, 37, 38.
No resin ducts in transverse or tangential sections. Ray tracheids absent. Bordered pits present. (Phm.37)
Pronounced spiral thickening. (Phm.36, Phm.37, Phm.38.

## PINUS.

Photomicrographs 39, 40, 41.
Resin ducts in transverse section. (Phm.39) Horizontal resin ducts in tangential section. (Phm.40) Dentate ray tracheids,(Phm.41) large cross field pits, 1 or 2 per cross field. Pronounced bordered pits.



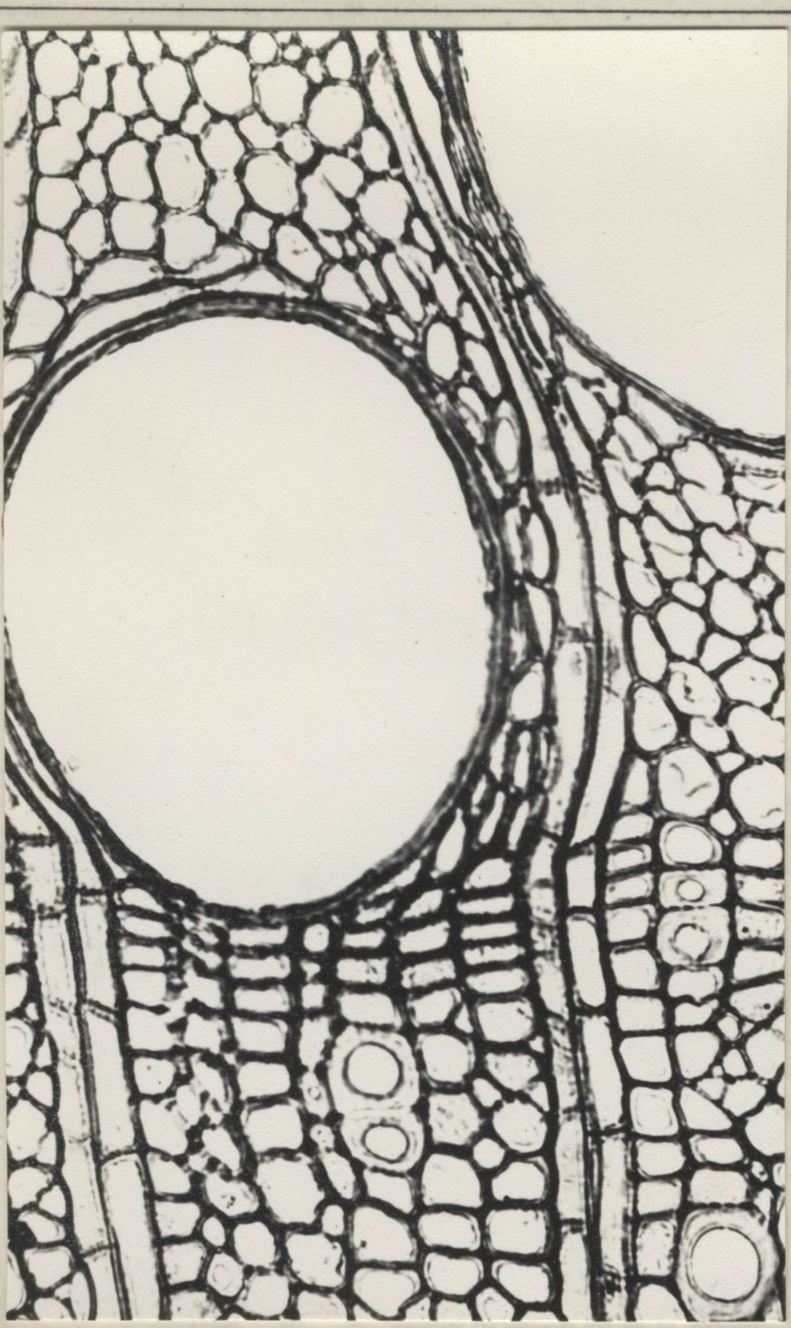
24. ULMUS (T.S.)

25. ULMUS (Ta.S.)

26. ULMUS (R.S.)

27. ULMUS (MAC.)

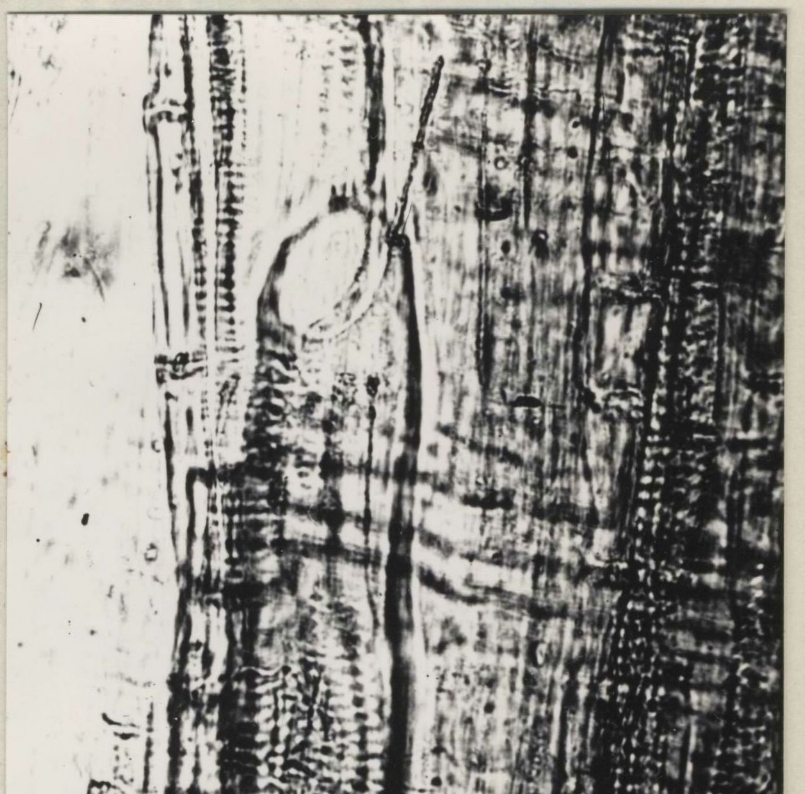
MAGNIFICATION X 330



28. FRAXINUS (T.S.)

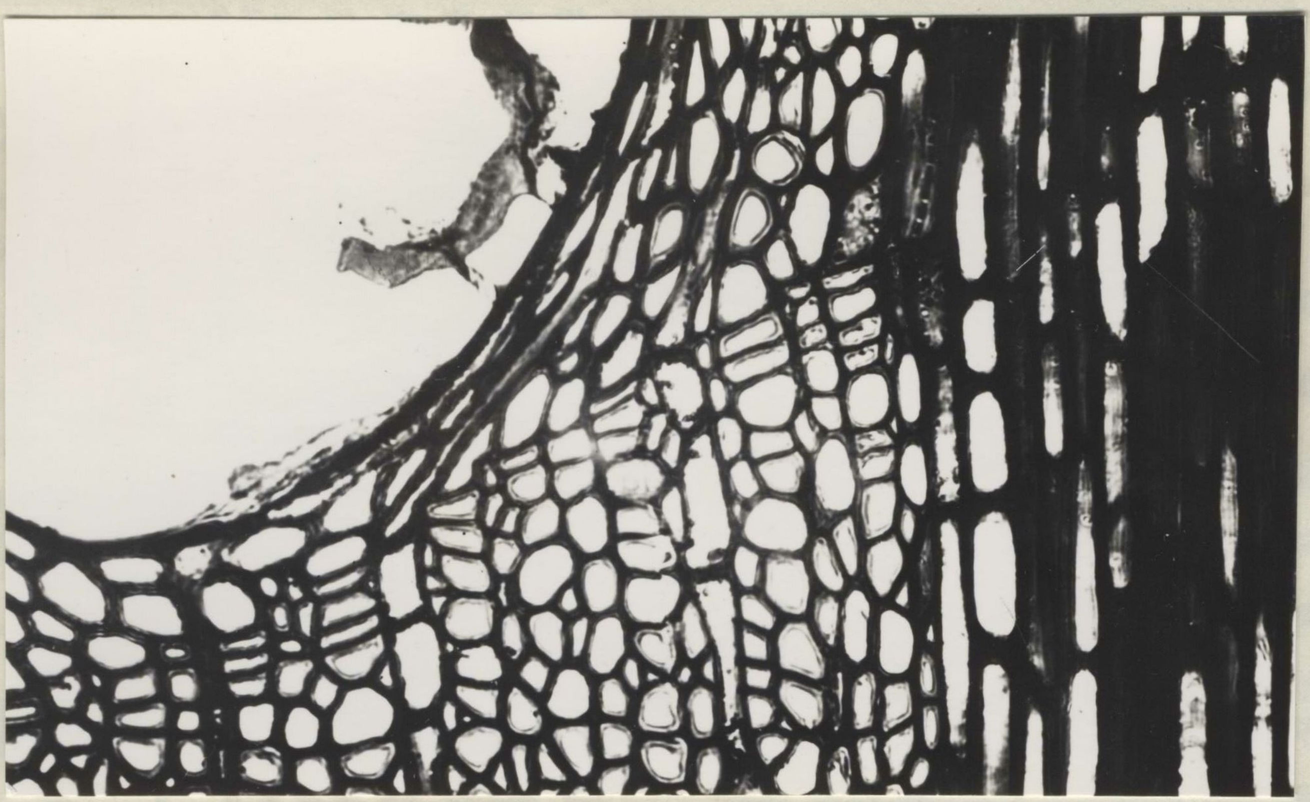
29. FRAXINUS (Ta.S.)

30. FRAXINUS (R.S.)



31. FRAXINUS (Mac.)

MAGNIFICATION X 330

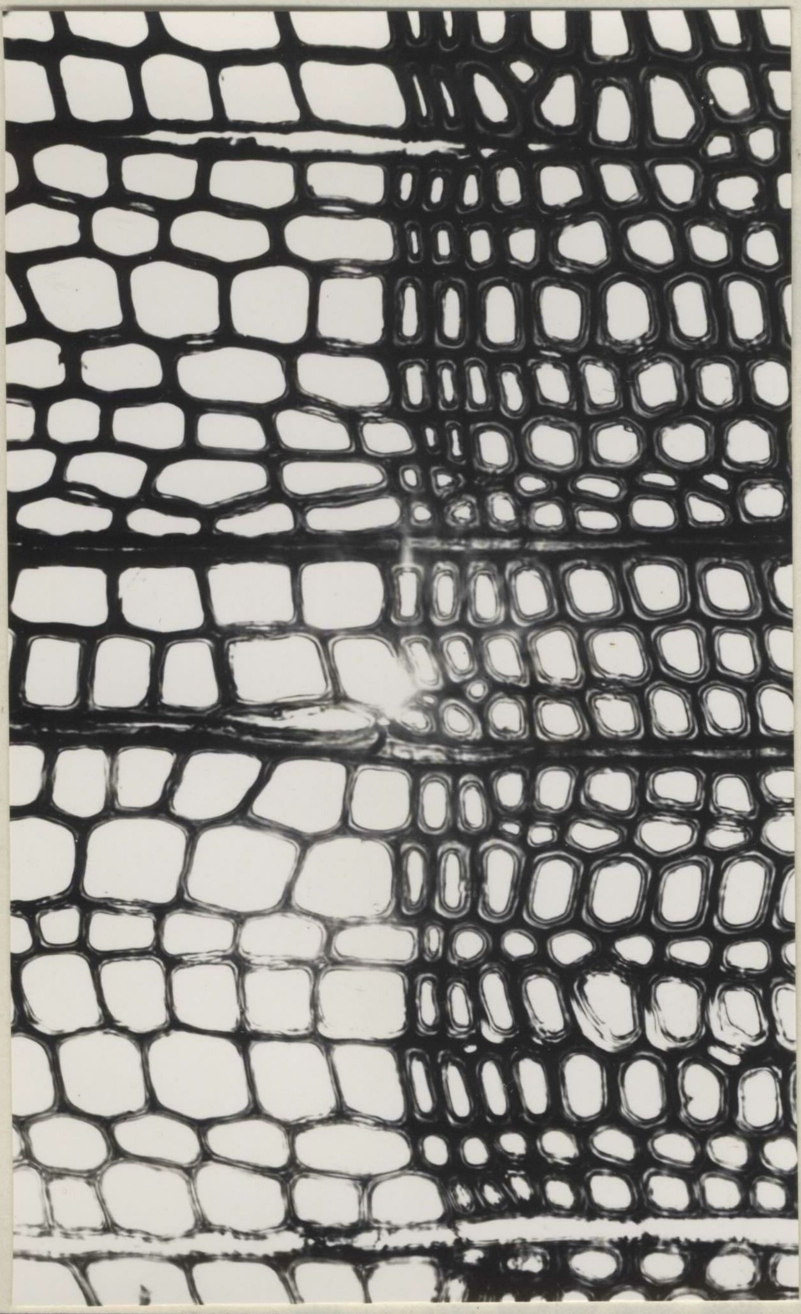


32. QUERCUS (T.S.)

33. QUERCUS (Ta.S.)

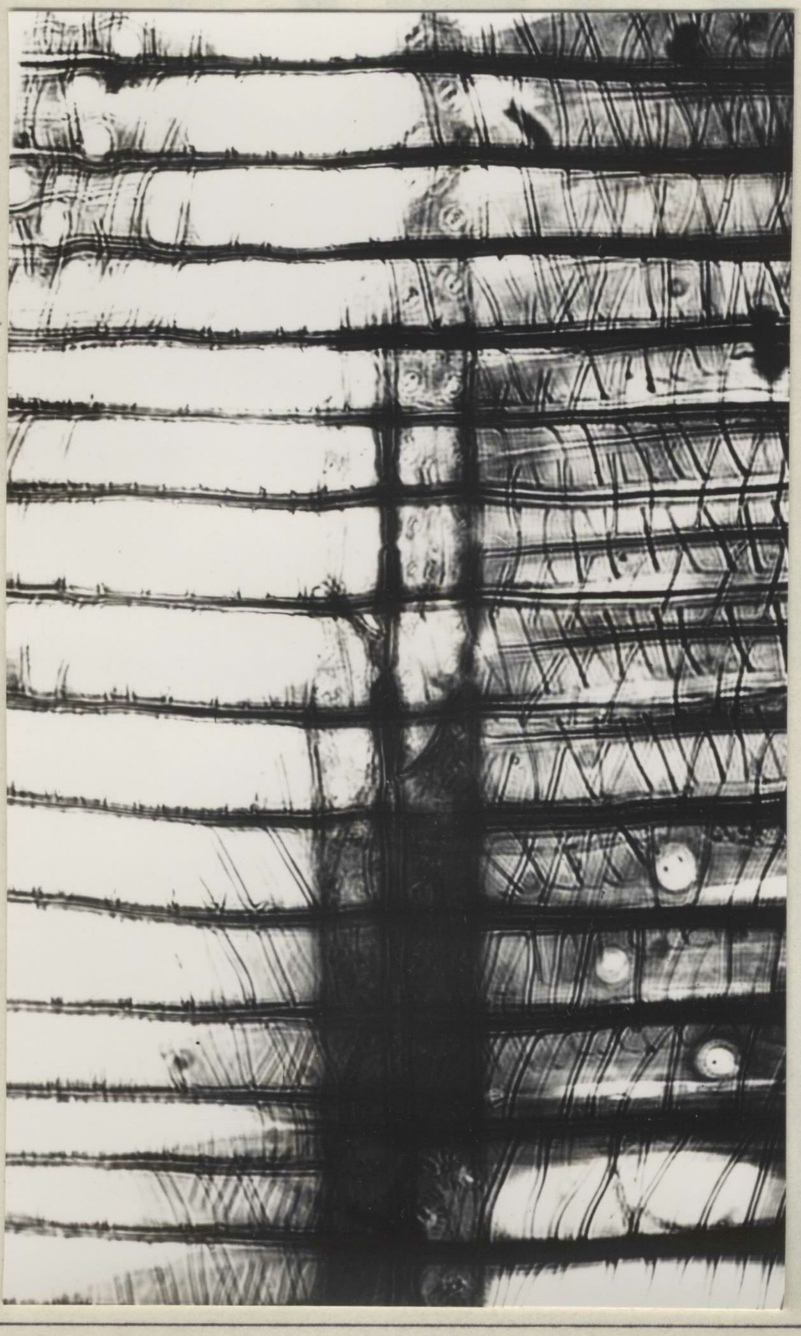
34. QUERCUS (R.S.)

MAGNIFICATION X 330

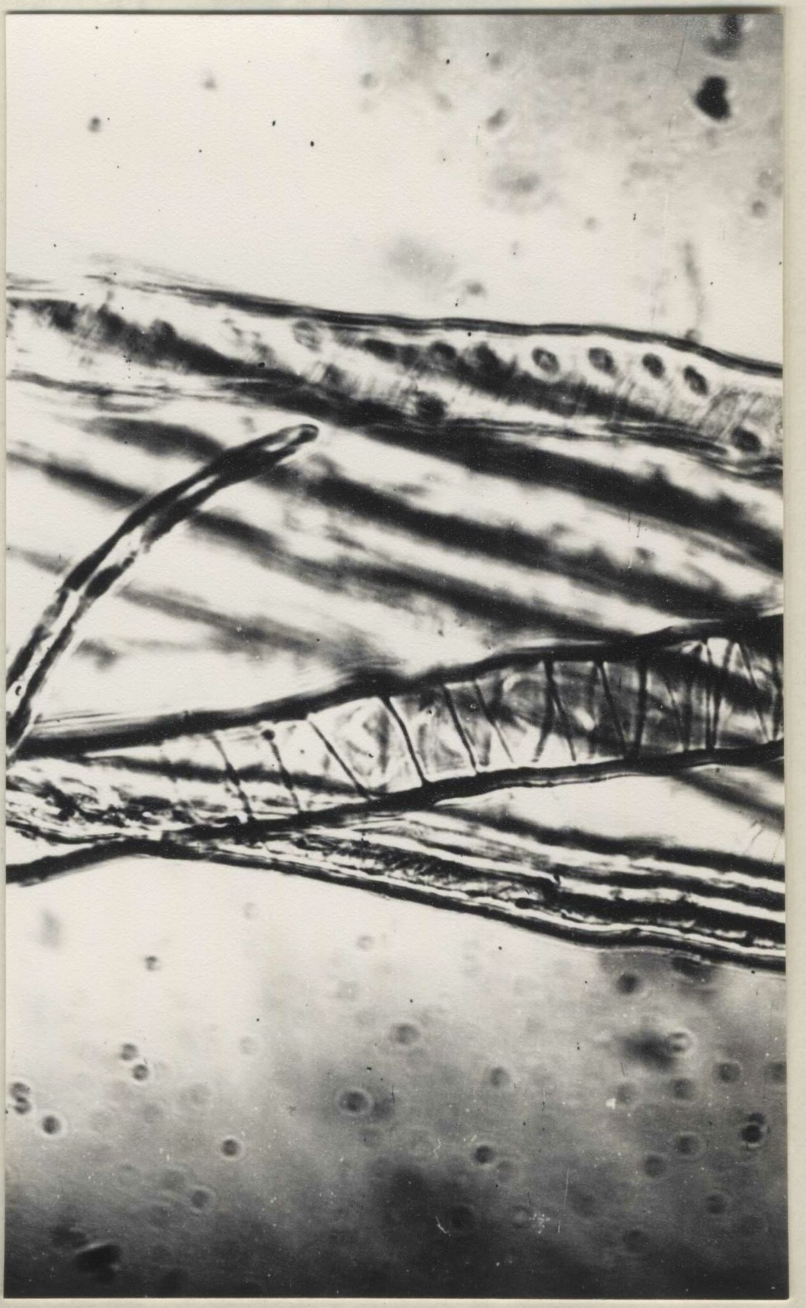


35. TAXUS (T.S.)

36. TAXUS (Ta.S.)

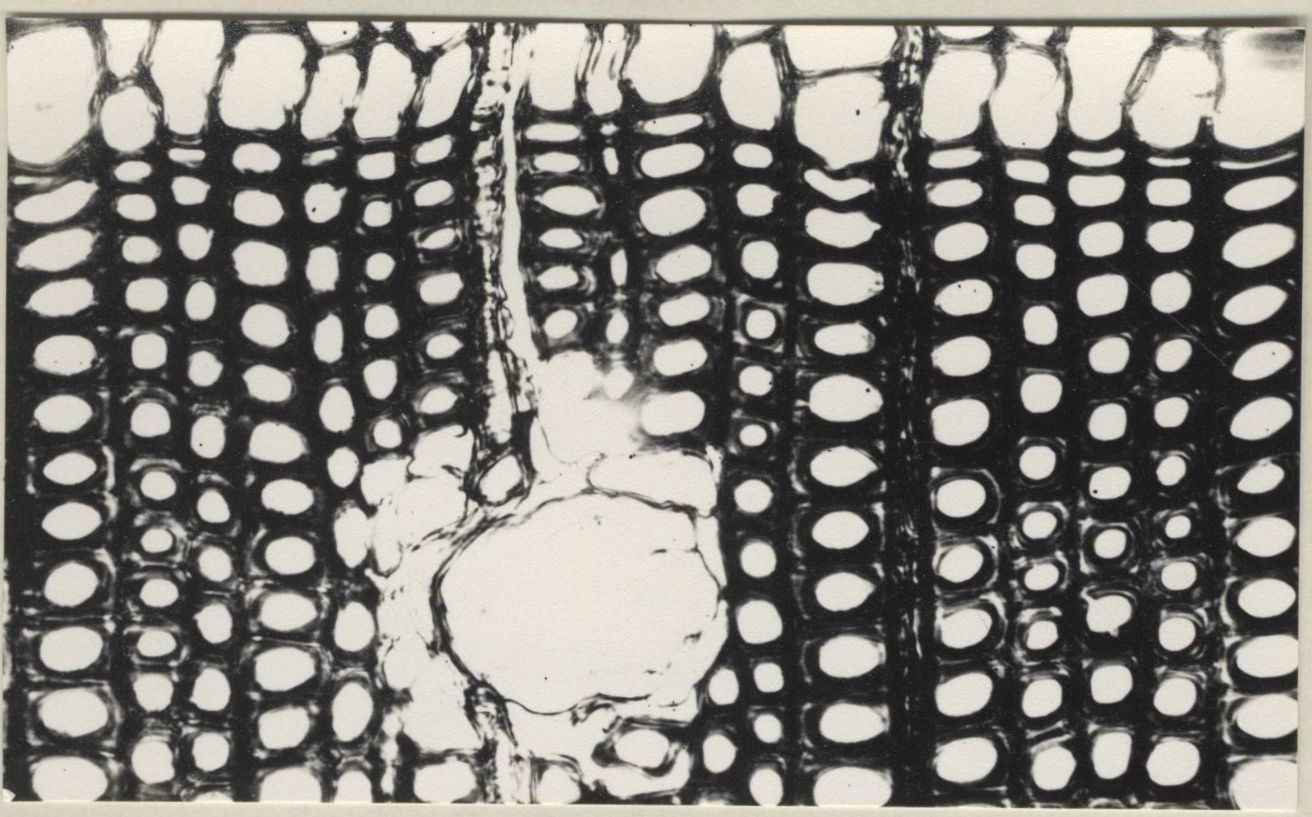


37. TAXUS (R.S.)



38. TAXUS (Mac.)

MAGNIFICATION X 330



39. PINUS (T.S.)

40. PINUS (Ta.S.)

41. PINUS (R.S.)

MAGNIFICATION X 330.

## APPENDIX 1

### Pollen concentration - Oxidation and Acetolysis.

Oxidation.

1. To the sample add 4 cc. glacial acetic acid, 5-6 drops of $NaClO_3$ (30% solution) Let bleach for a maximum of 60 seconds and centrifuge.
2. Wash with water, (always distilled) centrifuge.
3. Dehydrate with glacial acetic acid, centrifuge.
4. Add 9 cc. acetic anhydride and 1 cc. $H_2SO_4$ (conc.) Heat to boiling point in a water bath. Centrifuge.
5. Wash with glacial acetic acid, centrifuge.
6. Wash with water, centrifuge.
7. Stain with safranine, centrifuge.

* * *

## APPENDIX 2.

### Preparation of peat for "Washing-Analysis"

The peat was broken into small pieces and 100 gm. from each level was placed in a 400 cc. beaker with a teaspoonful of caustic soda and sufficient water to cover all the material. The samples were then let stand for about two weeks, water being added to replace that lost by evaporation. Before being examined the material was gently brought to the boil, stirring all the time so that no lumps remained. The samples were then washed on the sieves mentioned, under running water. If very much stringy monocotyledonous remains are present it sometimes expedites examination to remove this by using a coarse sieve which will let all other material through but retain this.

* * *

## APPENDIX 3a.

### Pine sections.

The following sections were all cut from *Pinus* stumps which were still in situ in the peat of the upper pine-layer in Trench 2 at Clonsast.

The stem diameter measurements were made under bark. In each case the the sections were measured along two diameters --- the greatest and that at right angles to the greatest. The total number of rings

counted is given. All counts were made starting at the centre and working outwards.
Other sections (and cores in Appendix 3b) which were in poor condition have not recorded.

Section I.

Diameters 20.8 x 17.0 cm. Total number of rings counted = 60

| | | | |
|---|---|---|---|
| 1st. 10 years | 1.5 cm. | 4th. 10 years | 1.6 cm. |
| 2nd. " | 2.0 " | 5th. " | 1.45 " |
| 3rd. " | 2.1 " | 6th. " | 1.85 " |

Section II.

Diameters 13.2 x 12.8 cm. Total number of rings counted 101. Ring 10 and also ring 33 were apparently double and were counted each as one ring. Between rings 76 and 77 there was a very fine dark band which was not counted.

| | | | |
|---|---|---|---|
| 1st.10 years | 1.2 cm. | 7th. 10 years | 0.70 cm. |
| 2nd. " | 0.85 " | 8th. " | 0.90 " |
| 3rd. " | 0.46 " | 9th. " | 0.40 " |
| 4th. " | 0.60 " | 10th. " | 1.50 " |
| 5th. " | 0.60 " | Last ring | 0.10 " |
| 6th. " | 0.50 " | | |

Photograph of Section II in which holes due to borers are visible.

Section III.

Diameters 14.5 cm. x 12.9 cm. Total number of rings counted 86, of which maybe one or two were missing. Rings 38, 39, 40, formed a fine-ringed band.

| | | | |
|---|---|---|---|
| 1st.10 years | 1.5 cm. | 5th. 10 years | 0.85 cm. |
| 2nd. " | 1.6 " | 7th. " | 0.65 " |
| 3rd. " | 1.75 " | 8th. " | 0.60 " |
| 4th. " | 0.85 " | Last 6 years | 0.30 " |
| 5th. " | 0.50 " | | |

Section IV.

Diameters 9.15 cm. x 8.7 cm. On one radius ring 7 shows a complicity of false-ring bands but on the opposite radius it is apparently a true ring. Total number of rings counted was 42 on one radius and 39 on the opposite radius.

| | | | |
|---|---|---|---|
| 1st. 10 years | 1.10 cm. | 3rd. 10 years | 1.20 cm. |
| 2nd. " | 1.34 " | 4th. " | 1.0 " |

The above photograph shows Section IV. The tree grew little over 40 years.

Section V.

Diameters 19.5 cm. x 14.9 cm. These measurements were made through the middle (but not growth centre) of the section. Growth was very eccentric. The stump from which it was cut had its root expanse to the West and was curved to the East. The wood had been attacked by wood borers such as possibly Sirex. Infestation was greater on the upper side of the section, i.e. higher up the stem.

| | | | |
|---|---|---|---|
| 1st.10 years | 1.70 cm. | 4th. 10 years | 3.30 cm. |
| 2nd. " | 1.65 " | 5th. " | 2.75 " |
| 3rd. " | 2.55 " | 6th. " | 1.20 " |

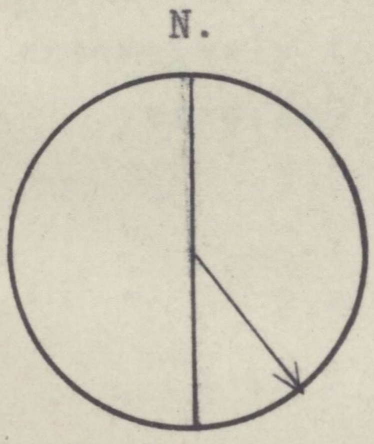
The photograph shows part of Section V.

Section VI.

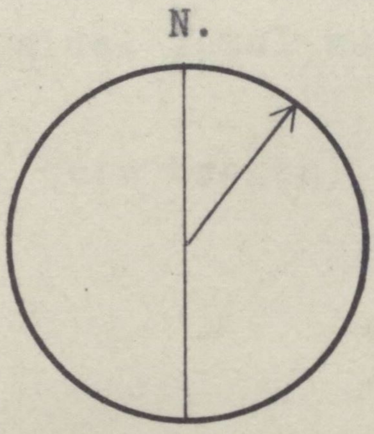
Diameters 11.5 cm. x 8.9 cm. Total number of rings counted = 104. The Summer wood of ring 12 was abnormally thin, lying between two thicker rings. Rings 39 and 40 fell in a band of very narrow rings and were in fact the first rings of the ensuing poor growth. Ring 89 was false and was not counted in the total.

| | | | |
|---|---|---|---|
| 1st. 10 years | 0.8 cm. | 7th. 10 years | 0.25 cm. |
| 2nd. " | 1.0 " | 8th. " | 0.35 " |
| 3rd. " | 1.1 " | 9th. " | 0.35 " |
| 4th. " | 0.85 " | 10th. " | 0.30 " |
| 5th. " | 0.27 " | Last 4 years | 0.21 " |
| 6th. " | 0.70 " | | |

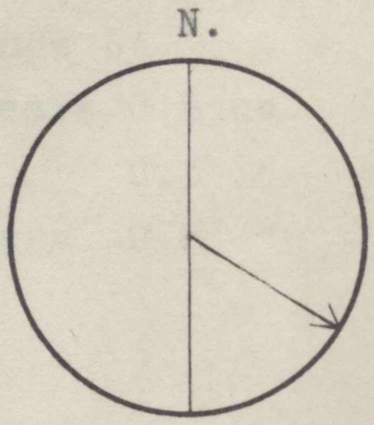
The following is a diagrammatic representation showing the direction of the greatest growth (i.e. longest "radii") in the above sections. Theoretically the greatest growth should be on the side of the tree away from the prevailing wind. (which at the present time is from the South-West) However, topographical factors and local shading and sheltering by other trees will play a large part in causing deviations from this rule.



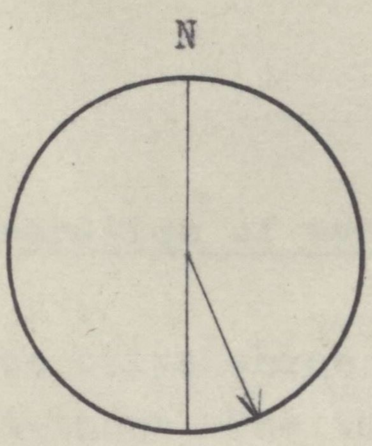
Section I.



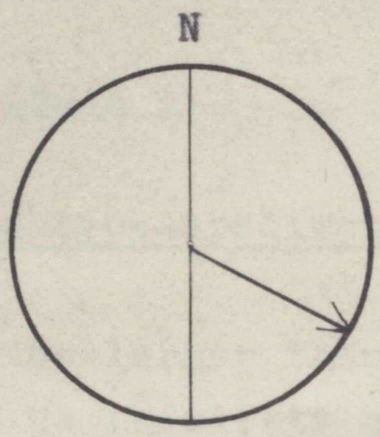
Section II



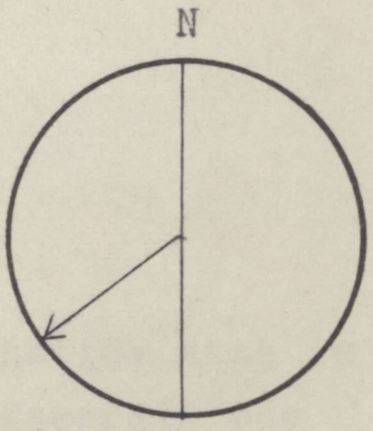
Section III



Section IV



Section V



Section VI.

* * *

## APPENDIX 3b.

### Cores.

### Core 1

This core was taken from a Taxus stem 62 cm. x 54 cm. approximately, which was lying embedded in the peat over a rise in the moraine in Trench 2.
The core showed 341 rings. Some of the rings may have been false; on the other hand the core did not show the centre rings. The total length of the core was 20 cm. The innermost rings were, due to skewing, apparently broader than they actually were.

### Core IV.

This core was also Taxus and was taken from an in-situ stump about 36 cm. in diameter. It was taken from the side facing South.
The core showed 67 rings and then there was a break due to rotting so it is not possible to say how much was missing. The other part of the core had 56 rings.
The 67 rings occupied 9.4 cm. of core and the 56 rings occupied 8.0 cm. of the core.

### Core III.

This core was taken from an in-situ Pinus stump in Trench 2.
The borer was driven in from the North side. The roots stretched out extensively to the South side. Total number of rings 64.

| | | | | |
|---|---|---|---|---|
| 1st. 10 years | 4.9 cm. | | 5th. 10 years | 0.8 cm. |
| 2nd. " | 3.2 " (approx. core broken) | | 6th " | 0.3 " |
| 3rd. " | 2.7 " | | Last 4 years | 0.2 " |
| 4th. " | 2.5 " | | | |

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## APPENDIX 4.

### Preparation of macerated wood type-specimens.

Place chips which should not be larger than half matchstick size in test-tubes. The tubes should be indelibly numbered. Macerate the chips in equal parts of glacial acetic acid and hydrogen peroxide (20 vols.) at about 60 Deg.C. in a water bath until the elements start to fall apart. The tubes should be corked.
When maceration is complete drain out the macerating mixture and wash twice with distilled water.

## Preparation of permanent type slides.

This method is not recommended, see text p. 58.

Place a small fragment of the sample in a centrifuge-tube and shake-up with distilled water. Add 4 or 5 drops of 1% aqueous safranine, leave to stain for a few minutes and then centrifuge.

Wash with distilled water; centrifuge.

Wash with 95% alcohol; centrifuge.

Wash twice with absolute alcohol, centrifuging each time

Add a few drops of clove-oil and leave for 5-10 minutes.

Wash with xylol; centrifuge.

Mount in Canada-balsam.

* * *

## APPENDIX 5.

## Tests made to expand compressed timber.

The tests involved soaking sections with various chemicals under view of a dissecting microscope. The sections which were in water had excess moisture removed before being treated.

1. HCl (conc.) put on section. Some slight expansion.
2. Section dehydrated with glacial acetic acid and acetic anhydride. On adding a drop of $H_2SO_4$ (conc.) there was fairly rapid expansion and some charring.
3. Section soaked in HCl (conc.), excess acid removed. Drop of $H_2SO_4$ (conc) added. Very rapid expansion took place but this was not as thorough as that obtained elsewhere (pp.60, 61) using "Parazone" Measurements were made on a tangential section treated in this way -

   Water soaked section 552 Mu wide
   After addition of HCl, 566 Mu wide
   After $H_2SO_4$ --------- 966 Mu wide.

4. Section treated with glacial acetic acid followed acetic anhydride. Very little expansion after 10 minutes.
5. Soaking in glacial acetic acid followed by HCl (conc.) gave some small expansion.
6. Carbon tetrachloride alone caused some slight expansion only.

The idea was to find some means of expanding crushed vessels for the purpose of identification after which the section could be discarded.

* * *

## APPENDIX 6.

### Paraffin wax impregnation of charcoal.

The dry charcoal sample (e.g. 1 ccm.) is placed in xylol till evolution of air ceases, then removed to gently heated molten paraffin wax where it is left till the xylol is replaced by the wax and no further reaction takes place about the sample. Wood with small pores will require longer to become impregnated than that with large pores. The sample is let cool as quickly as possible because slowly cooled wax is said to be more brittle and therefore less satisfactory for sectioning.

Standard wood-sectioning faces are then prepared and transverse, radial, and tangential sections are cut. These are best cut with a safety-razor blade which can be discarded as charcoal sectioning will ruin any botanical razor edge.

The sections will curl during cutting. They should be placed on a slide a slight distance apart and in such a position that they may tend to open out flat rather than collapse folded one end over the other. (It will be found that with practice the amount of curling of the section in cutting can be minimised.)

A small drop of xylol is added and the sections will immediately uncurl. A cover-slip is placed on top and identification immediately carried out because the xylol dissolving the wax tends to displace many of the finer identifying features.

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## APPENDIX 7a.

### Rock-type impregnation methods applied to charcoal.

#### Damar-Gum.

The sample, which must be dry, is placed in xylol until all the air is excluded, i.e. until it fails to float any longer. It is then transferred to Damar-gum which has been very gently melted and brought to boiling point. It is left in the gently boiling gum for 10 minutes after effervescence has ceased, removed from the gum, let cool and then ground ( see Appendix 7d.) Mounting on the slide may be carried out with "Lakeside 70"

The Damar-gum may be re-used but it soon becomes discoloured by the charcoal.

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## APPENDIX 7b.

"Lakeside 70" impregnation method.

The dry charcoal sample is placed in xylol until all the air is replaced by xylol and the specimen no longer floats.

Some pieces of "Lakeside 70" are melted in a crucible or evaporating dish. The charcoal sample is then placed in the molten "Lakeside 70" and boiled until impregnation is complete. The time this takes will depend largely on the size of the sample.

The sample is then prepared for mounting as outlined under Appendix 7d. It may be mounted on the slide in either "Lakeside 70" or in Canada balsam.

The "Lakeside 70" will get progressively thicker as the solvents are evaporated-off in cooking. Alcohol must be added.

* * *

## APPENDIX 7c.

Canada Balsam impregnation method.

The dry charcoal sample is placed in xylol till all the air is replaced. It is removed to a vessel containing gently heating Canada balsam which has been well diluted with xylol. The heating is continued till the sample is fully impregnated and all the xylol has been driven-off. It is then removed from the balsam and let cool before grinding.

The balsam may be re-diluted with xylol and used again. Care must be exercised in using the xylol as it is very inflammable. If the heating balsam and xylol lights it is usually easily blown out.

* * *

## APPENDIX 7d.

The preparation of ground sections from charcoal treated by the above impregnation methods is the same for all three processes.

Before impregnation, samples may be scraped gently with a knife or rubbed carefully on fine sand- or emery-paper till the required section-orientation is more or less smooth. This may save a certain amount of grinding after impregnation. Unimpregnated samples should not be ground on the silicon carbide grinding plates as they become wet and the pores become occluded with the grinding powder.

It is better if the sample can be split into three pieces transversely as it is very difficult and usually wasteful of the sample if it must be split longitudinally in order to obtain fragments from which to grind transverse, radial, and tangential sections.

Sections of the impregnated material are prepared for microscopic examination just as are minerals and rocks. The process consists of grinding the specimen on smooth glass plates of about 1 sq,ft. area upon which has been spread some "Carborundum" silicon carbide and a small drop of water. Silicon carbide is obtainable in several different grades so that the sample can be quickly reduced by grinding with a coarse grade and then more finely and more controllably with a fine grade of powder. Grades No.360 and 700 were found suitable. The section should be repeatedly examined during grinding and care should be taken that large pieces of extraneous matter do not contaminate the grinding plate or the sample may become scored. This is particularly important during the fine grinding stage. (fragments of impregnated material sometimes become detached from the edge of the sample)
Charcoal will grind down much more readily than minerals and it is not desirable that the section be brought to too thin a stage on the coarse grinding plate as some of the finer elements may then become damaged or eradicated.
The grinding should be carried out with a gentle even pressure and care should be taken to see that the specimen grinds down evenly, particularly when the surface of the fragment is being prepared for mounting on the slide. The mounting surface must be perfectly flat and no air space should be present between the sample and the slide. If the surface is flat a gentle pressure will ensure this.
During the process of grinding,the section should be continually examined under a low power microscope as the last stages of grinding are crucial. It is in fact better to endeavour to identify the sample before even the final desired thinness of section is obtained. The preparation may be covered with a drop of Canada balsam and a cover-slip

As with other fossil timbers the specimen should be identified positively only on the features present. "Negative attributes" should not be used.

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