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Studies of the Post-Glacial History of British Vegetation. X. Correlation between Climate, Forest Composition, Prehistoric Agriculture and Peat Stratigraphy in Sub-Boreal and Sub-Atlantic Peats of the Somerset Levels

H. Godwin

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STUDIES OF THE POST-GLACIAL HISTORY OF BRITISH VEGETATION

X. CORRELATION BETWEEN CLIMATE, FOREST COMPOSITION, PREHISTORIC AGRICULTURE AND PEAT STRATIGRAPHY IN SUB-BOREAL AND SUB-ATLANTIC PEATS OF THE SOMERSET LEVELS

By H. GODWIN, Sc.D., F.R.S., *Botany School, Cambridge*

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1. Decoy Pool Wood profile

It has already been shown that the site at Decoy Pool Wood gives very good evidence of two flooding episodes, each demonstrated by vegetation of a eutrophic character, and each succeeded by drier conditions in which oligotrophic communities recovered the bog surface (part VIII).

The pollen samples taken at intervals of only 1 in. (2·5 cm.) apart, yield a remarkable amount of information about the correlations of the two swamping horizons which they cross, and the alterations of climate, prehistoric agriculture and forest composition. It has already been shown that the pollen of local origin from plants growing on the bog surface reflects in detail the modification of the plant communities.

(*a*) *Dating*

Without at this stage prejudicing the issue, I may say that nothing in these newer studies suggests abandoning the earlier broad identification of the lower of the two flooding horizons on Shapwick Heath with the 'Grenzhorizont' of Weber, and the Recurrence Surface RY III of Granlund and Nilsson. This gives a date of about 500 or 600 B.C., according to current ideas, for the flooding of the old *Sphagnum-Calluna* peat, a dating supported by the Late Bronze Age correlations made at the Westhay trackway (see part IX).

There seems reason, in the smooth contour of the residual portions of the heath surface, to regard the surface of Shapwick Heath as having had no peat removed from it (at most of the sites that have been considered), before the period of contemporary peat exploitation, and the tree-pollen diagrams and stratigraphy indicate that at the Shapwick Heath boring DB 3, at Decoy Pool Wood, and the various Decoy Pool Drove sites the surface is of the same age. This point is of great importance for during a period between 1936 and 1939 no less than five late Romano-British hoards were found by peat cutters in the centre of Shapwick Heath. The pollen series DB 3 was taken beside one such site, and I was able to view the actual scene immediately after discovery. It was evident that the objects had been inserted into the bog from an horizon not far from the present surface, and since all the finds relate to the same period, the closing decades of the fourth century, this in all probability represents the date of the top of the Decoy Pool Wood profile. From the two limiting dates for the upper peat formation, given by the first flooding episode and the present surface it is possible, bearing in mind the different rates of formation of the different peat types present, to make a very rough guess that the age of the upper of the two flooding horizons is about A.D. 150.

(*b*) *Evidence of prehistoric agriculture*

Four of the non-tree pollen curves in figure 1 give evidence of prehistoric forest clearance and husbandry. These are the curves for:

(*a*) The large cereal type of grass pollen, to which attention was first called by Firbas (1937).

(*b*) The pollen of *Plantago lanceolata*, a species strongly characterizing open as opposed to closed woodland habitats.

(*c*) The pollen of *Artemisia*, which has been shown by Danish research (Iversen 1941) to accompany that of *Plantago lanceolata* in Neolithic and post-Neolithic forest clearance, and which is regarded as attributable to *Artemisia vulgaris*.

(*d*) The aggregate of pollen from the genus *Rumex*, and the families Compositae and Chenopodiaceae. This last category may be taken to a large extent as representing weeds of cultivation.

An extremely strong case has been made by Iversen for the employment of these pollen types as indices of prehistoric forest clearance, and his views have been supported by investigations in the Breckland of East Anglia (Godwin 1944).

The four index curves show a high degree of correlation with one another. Considered jointly they are present to a small extent before the first flooding horizon, and they show two maxima, the earliest small and the later larger. The first rise begins near the top of the old *Sphagnum-Calluna* peat, i.e. presumably in late Bronze Age time, reaches its maximum with the onset of the flooding and declines to low values through the flooding period. The second rise commences shortly after ombrogenous peat formation has been re-established: at first slow, it reaches its maximum in the period of formation of *Sphagnum imbricatum* peat, and declines steeply as the second flooding episode comes on. We might guess this second phase of agricultural activity to have lasted from 350 B.C. to A.D. 150, being especially vigorous in the last fifty years, which on any reckoning must fall within Romano-British times.

The two phases of agricultural activity may therefore be provisionally referred to (i) the middle to late Bronze Age, (ii) the middle and late Iron Age to middle Romano-British.

It is particularly striking that each phase was apparently terminated by the conditions of wetness which produced flooding of the raised bogs. We might suppose this to have followed either directly by the flooding out of agriculturalists from all land in the floor of the Levels, or by climatic deterioration making tillage of heavy clay soils of the upland so much more difficult. We may note that the inhabitants of the Meare Lake Village and the Glastonbury Lake Village had abundant cereals and that the prevalence of sheep-bones and of the materials of the weaving trade indicates that large flocks of grazing animals were maintained in more or less disforested areas (cf. Clark 1947). The level of their habitations is such that they could only have been occupied between the flooding episodes of

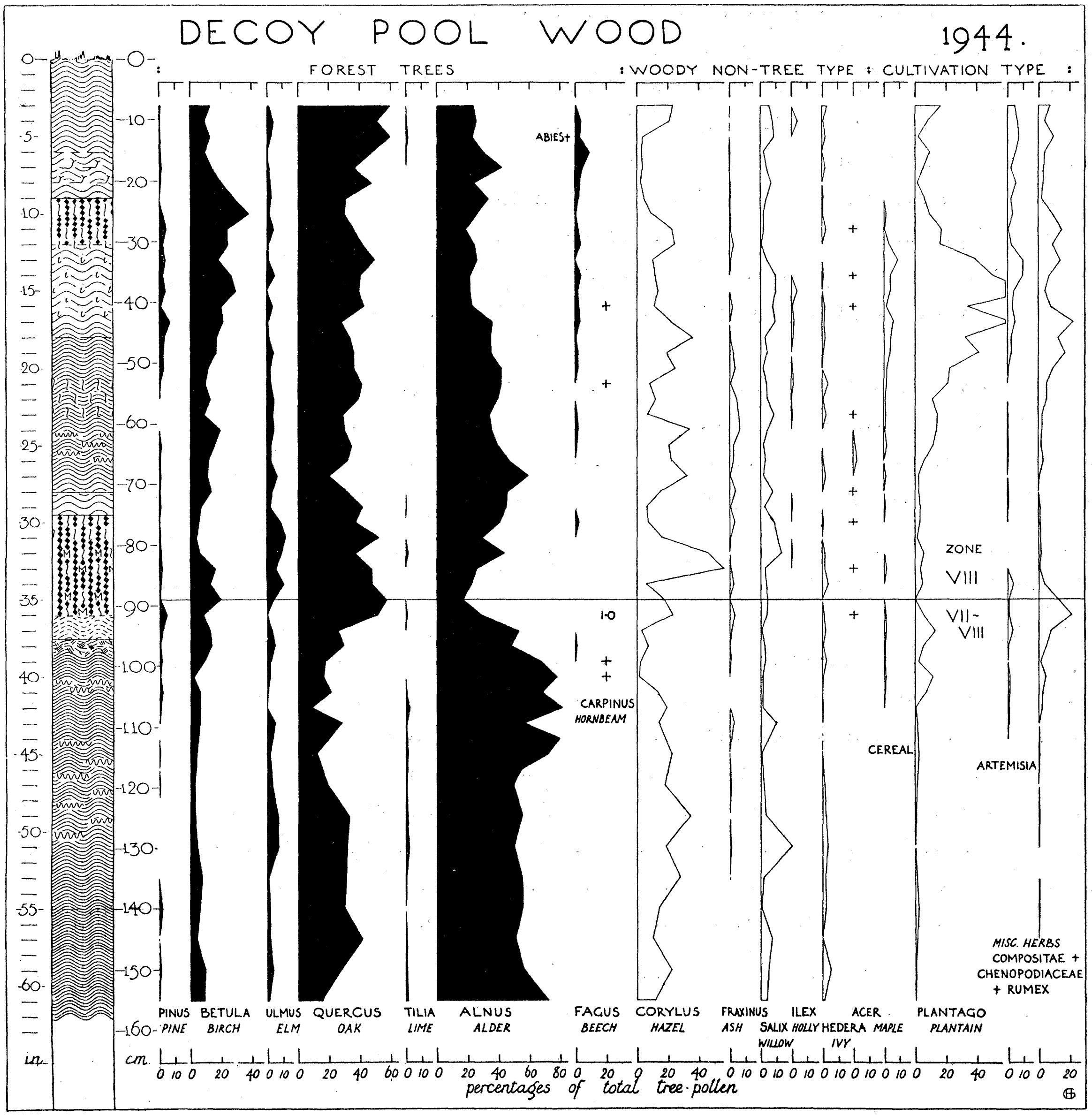

Figure 1. Composite pollen diagram at Decoy Pool Wood (cf. figure 8, part VIII). The tree-pollen types it has hitherto alone been customary to reckon in tree-pollen counts are shown in black, and the other pollen types are expressed as a percentage of this total at each level. These other pollens include two categories: (*a*) shrubs and trees of low frequency, (*b*) plants indicative of agricultural activity, namely cereals, *Artemisia*, *Plantago lanceolata*, and miscellaneous herbs, probably chiefly weeds. Peat symbols as in figure 4, part VIII. The lower flooding horizon (90 cm.) corresponds with big changes in the tree-pollen curves, and terminates a minor phase of agricultural activity; the upper flooding horizon (30 cm.) corresponds with small changes only in the tree pollen, but terminates a phase of much greater agricultural activity.

which I am speaking: the period between 350 B.C. and A.D. 150 would, however, cover the total occupation of the lake village sites. It is not necessary to emphasize the fact that there is evidence of numerous and flourishing Roman occupation in the region of the Somerset Levels.

(*c*) *Evidence of forest composition*

It is apparent that the level of the first flooding horizon corresponds with a greater disturbance of the tree-pollen curves than is found elsewhere. *Alnus* shows a big fall, *Quercus* a large rise, *Tilia* ceases about this level and *Fagus* begins, *Ulmus* begins a temporary rise and *Betula* begins a persistent and considerable increase. These features are those which characterize the opening of zone VIII of the pollen zone sequence for England and Wales and which have been ascribed to general climatic control. There has recently developed a tendency, from the work of Iversen upon forest clearance, to regard the increase of *Betula* (and perhaps the other tree changes also) as a consequence merely of forest clearance and the improved opportunity which this would afford for trees with powers of rapid colonization and high light requirements. The data here given allow this hypothesis to be tested.

Since early agriculture and stratigraphy have been shown to be correlated, and we now see forest history and stratigraphy correlated, agriculture and forest history must evidently also be correlated, but it remains to consider whether the agricultural clearance or climatic change is responsible for the pronounced modification of the tree-pollen curves.

1. Many reasons support the view that the control was climatic. The fall in *Alnus* is too big and too sudden for an anthropogenous effect: it might be conceived that this tree suffered selective felling, for the wood is easy to work and is often found in Late Bronze Age utensils, but in fact *Alnus* increased in amount after agriculture had begun (120 to 110 cm.), and moreover there is so large a proportion of *Alnus* in the diagram that the amount of disforestation needed to produce the observed drop in the *Alnus* pollen curve cannot be envisaged. It might be suggested that *Alnus* was largely growing on the valley floors and margins and that rise of the flood-waters killed it out, but although this may have been true in part the proportion in which *Alnus* occurs at the base of the series makes it most probable that this tree was a normal constituent of the forest, and that what we are here concerned with was a shift in upland forest composition.

2. *Alnus* is only slightly repressed, if at all, at the second flooding phase, although the agricultural intensity is much greater than before.

3. The drop in *Tilia* is most unlikely to have been due to selective felling, for there would have been great difficulty in extracting large timber from the upland hill forests.

4. The increase in *Fagus* is very difficult to conceive as determined by any factor save climatic.

5. The large rise of *Quercus* and the smaller rise of *Ulmus* could not quantitatively be explained merely by differential cutting out of *Alnus*, and presumably they are therefore climatic responses.

6. The rise of *Betula*, which shows a rather close inverse correlation with *Alnus*, might be taken to imply merely replacement of one species by the other in the woodland seral

stages. If it were to be regarded as a colonist of cleared areas, it increases very little during the first flooding horizon, in comparison with *Quercus*. Thus even for *Betula* the evidence suggests climatic control rather than anthropogenous disturbance as the cause of its altered status, and this view is supported by the very widespread character of the *Betula* rise in Britain in this period, and by the very close correlation found by Eneroth and von Post (von Post 1946) between *Betula* pollen and recurrence surfaces in Swedish bogs.

7. In the sequence of anthropogenous effects disclosed by Iversen's work on Neolithic forest clearance, the *Corylus* curve shared the general displacement and was one of the earliest trees to recover: here the effect of rise is delayed until after *Quercus* and *Ulmus* have risen. It must of course be recognized that the curve is suspect in that it depends upon the separation of *Corylus* grains from a much larger bulk of *Myrica* grains.

8. A further argument of weight is supplied by comparing the effects of the two flooding phases, the first associated with sudden and severe flooding but small agricultural activity, the second showing less severe flooding but far more agriculture. The large and sudden movements of the tree-pollen curves at the earlier flooding phase are repeated only in slight degree at the second, and other things being equal we should therefore expect the forest composition changes to have been caused rather by the factors responsible for the flooding than by agricultural effects.

All these arguments strongly support the view that the shifts in the tree-pollen curves at the lower flooding horizon, like the flooding itself, were determined by climatic change. This, naturally, is of great importance in the general theory of pollen analysis applied to Britain as a whole.

In drawing these conclusions I have made no pronouncement as to the probable cause of the upper flooding horizon. It may have been climatic and it certainly was followed by some small degree of alteration in the tree-pollen curves. At the same time it has to be remembered that in Romano-British times there took place a substantial marine transgression in which was laid down the tidal belt of clay land on which Bridgwater, Huntspill and Highbridge now stand. This event buried some Romano-British sites, and it seems highly probable that there was backing up of fresh water behind the coastal clay belt. I lack evidence as to whether the upper flooding horizon was due to this or to a climatic cause, but the dating I have suggested is not incompatible with linking it to the marine invasion.

It must be recalled in this connexion that there is a purely oligotrophic expression of the upper flooding horizon at Willis's Piece and at Westhay. This would perhaps be rather unlikely to follow blocking of the lowland drainage by rising sea-level, although it could be imagined that such an event would make for higher water-tables in the highest and still emergent raised bogs.

It remains to consider the pollen curves of the following woody plants: *Ilex* (holly); *Hedera* (ivy); *Acer* (hedge maple); *Salix* (willow), and *Fraxinus* (ash). The first four play a rather minor role in high forest and although *Fraxinus* is probably of greater importance, it tends (save in certain limestone areas) to be a plant of seral stages, and has not been reckoned as part of the total tree pollen.

The pollen of *Salix* and of *Hedera* is not strikingly changed in amount through the series.

Ilex and *Acer* are present in small amount only, but agree in behaviour with one another, being more or less restricted to the period between the two flooding phases. It might have been expected that these plants would show some increase with the onset of forest clearance, but there is little evidence of this causal relationship here.

Like *Acer* and *Ilex*, *Fraxinus* has its best development in the period between the two flooding phases, and like them may have been associated with woodland clearance, but its expansion begins sooner and lasts longer than theirs, perhaps an expression merely of its greater frequency. On the Liassic Limestone and clay soils of the Polden Hills to-day *Fraxinus* is abundant and it certainly would be a plant likely to establish itself freely there after opening of the natural woods.

It is of great interest to consider the curves for *Hedera* and *Fraxinus* in relation to the behaviour of the curves for Denmark and the climatic implications attached thereto by Iversen. *Hedera* is found in Denmark to have been relatively frequent in the Atlantic period and to have decreased sharply at the change to the Sub-Boreal, a decline naturally associated with the decline of the oceanicity which geographical distribution and ecological observation suggest strongly to favour the species. In the much more oceanic longitude of Somerset it is not surprising to find the ivy present alike throughout Sub-Boreal and Sub-Atlantic times and in substantially greater amounts than in Denmark.

At the other end of the scale we have the pollen of mistletoe (*Viscum album*) common in late Boreal and Sub-Boreal layers in Denmark, whilst no single grain of it has been observed in the Somerset series even though a large part lies in layers of Sub-Boreal age.

In the Danish curves *Fraxinus* is shown by Iversen to exhibit a pronounced rise at the transition from the Atlantic to the Sub-Boreal period, the horizon of decrease in *Ulmus*. Both movements he regards as climatically determined, as also is the decline of *Fraxinus* in the succeeding Sub-Atlantic. The Decoy Pool Wood series does not quite extend through to the opening of the Sub-Boreal period, but *Fraxinus* values appear to increase only towards the end of this period, and rise further in the Sub-Atlantic. Thus the movements of this tree here seem to be at variance with its behaviour in Denmark.

2. Recurrence surfaces, pollen-zone correlations and the onset of climatic deterioration

The phenomenon of a sudden superposition of pale unhumified *Sphagnum* peats on dark, much humified peats formed under drier conditions, gives a sharp contact horizon to which the term Recurrence Surface has been given, to indicate the restoration of active bog growth. The 'Grenzhorizont' is the most conspicuous, as it was the first described of such surfaces. It is now apparent, especially through the work of Granlund in southern Sweden, that the phenomenon is multiple and repetitive, and that a number of recurrence surfaces of varying intensity of development occur consistently in the raised bogs of that region. He identified five such surfaces and by pollen-analytic means, and archaeological correlations, dates them as follows: RYI, A.D. 1200; RYII, A.D. 400; RYIII, 600 B.C.; RYIV, 1200 B.C.; RYV, 2300 B.C. Of these RYIII is the original Grenzhorizont. More recently Nilsson (1935) has been able to recognize no less than nine recurrence surfaces between 3500 B.C. and the present day, among them the five identified by Granlund.

These recurrence surfaces in general indicate the replacement of relatively dry oligotrophic raised-bog communities by infra-aquatic communities or active hummock-building *Sphagna*, still oligotrophic in character, as in the sequences described for Willis's Piece. There is no general flooding by base-rich water and explanations other than climatic alteration seem improbable. It is naturally of the greatest interest to determine how far the swamping horizons of the Somerset levels can be correlated with the Scandinavian and for this purpose it is essential to consider the results of independent zonation of the pollen diagrams.

In considering the tree-pollen curves at Decoy Pool Wood, (p. 277) it was pointed out that the base of the *Cladium* zone corresponded with substantial changes in almost all the tree-pollen curves, and it was suggested that these changes must be supposed the response to general climatic change. By reference to the pollen diagram of Shapwick Heath DB 3 (figure 5, part VIII), it will be seen that the base of zone VIII is drawn at the level where swamping effects are first evident and is based upon the same changes of tree pollen, particularly the falling *Alnus*, rising *Betula* and *Quercus*. At Decoy Pool Drove (Shapwick Heath trackway: figure 20, part IX) once more the base of the *Cladium* layer corresponds with the base of zone VIII, as indicated by the same coincident changes of the tree-pollen curves: the correspondence with Decoy Pool Wood is particularly close.

At Meare Heath trackway (figure 16, part IX) the base of zone VIII falls again just beneath the *Cladium* zone, but its determination depends rather largely upon the reciprocal movement by the *Quercus* and *Alnus* curves. At Westhay trackway (figure 26, part IX), similarly, the base of zone VIII corresponds with the lower part of the *Cladium* layer.

This co-ordination in the five sites considered bears out the view, which stratigraphy has suggested, that the lower *Cladium* layer is of similar age throughout this region. The climatic change which caused it and also the change in forest composition can hardly be other than the general climatic 'deterioration' which gives rise to the 'Grenzhorizont' throughout the raised bogs of Western Europe, which is Granlund's RYIII and which is there dated to the opening of the early Iron Age. This assumption we already made on p. 275.

The investigations by Hardy (1939) in Shropshire and Flint Maelor showed multiple recurrence surfaces in the raised bogs there. One was found at the top of zone VII–VIII, presumably corresponding to RYIII, and below it, at the base of zone VII–VIII was another, known on archaeological grounds to be of Middle Bronze Age, and therefore probably corresponding with Granlund's RYIV.

At Shapwick Heath, DB 3 and Decoy Pool Wood there is no evidence of the onset of swamping of the bog surfaces before the opening of zone VIII, but at the Shapwick Heath trackway (figure 20, part IX) some 45 cm. of *Myrica-Hypnum-Calluna-*(*Cladium*) peat precedes it, and at Meare Heath trackway (figure 16, part IX) some 30 cm. of similar material. In each instance we have tentatively identified this peat layer which directly overlies the trackways as indicative of the early stages of swamping.

At the Westhay trackway similarly there are 20 cm. of aquatic *Sphagnum* peat and dense *Eriophorum* beneath the *Cladium* layer and overlying the trackway.

These facts suggest at once: (*a*) that the effects of the climatic degeneration were already evident before the opening of zone VIII; (*b*) that they were felt only in certain sites; (*c*) that where they were felt the prehistoric trackways mark their presence.

At Westhay trackway (figure 26, part IX) there is even an indication of the onset of wetter conditions some 25 cm. beneath the base of the prehistoric trackway.

In the Shapwick Heath DB 3 pollen diagram (figure 5, part VIII) although there was no evidence of earlier flooding of the bog surface there, at 200 cm. was drawn in the base of zone VII–VIII, which we had delimited as a zone transitional between the Sub-Boreal and Sub-Atlantic, and established chiefly by comparison with the Fenlands and with Shropshire. In the other pollen diagrams there has been barely sufficient evidence to permit a precise insertion of the base of zone VII–VIII, and it has been therefore indicated tentatively by a broken line. At Meare Heath trackway and Shapwick Heath trackway sites the base of zone VII–VIII lies at the trackway level corresponding with the first indications of swamping. At the Westhay trackway the base of zone VII–VIII lies very near to the minor recurrence surface constituted by replacement of the old humified *Sphagnum-Calluna* peat by much fresher *Sphagnum* peat and then by *Eriophorum vaginatum*. There is some archaeological evidence that the trackway is of late Bronze Age construction and this suggests that the base of zone VII–VIII here, as in Shropshire, may correspond with RY IV, and supports further the view that the top of the zone corresponds with RY III.

It would appear therefore that early and mild indications of increasing wetness were shown in some localities in the Shapwick region in Middle Bronze Age times, the period of RY IV: conditions became wetter but the substantial and general swamping took place at the end of the Bronze Age, the period of RY III.

It has been pointed out elsewhere (Godwin 1946) that this compound or protracted impact of the climatic deterioration which ushered in the Sub-Atlantic period has important consequences for quaternary studies in Britain. It indicates particularly of course that there is some considerable chance, under varying climatic and varying topographic conditions, that the main flooding horizon or recurrence surfaces may be of somewhat dissimilar ages.

3. Drainage and cessation of bog growth

It has been pointed out in part VIII that at Shapwick Heath and Willis's Piece there seems to be an undisturbed raised-bog surface from which peat has not been removed, and at Westhay this surface is closely approached. The parallel stratigraphy and pollen analyses suggest that this surface is of the same age everywhere and this is of the greatest interest since it seems that the late Romano-British hoards on Shapwick Heath were buried from a level very close to this surface. In other words, active bog growth would seem to have ceased (in this restricted area at least) in late Romano-British times. It is naturally necessary to collect what confirmatory evidence is possible, and what evidence exists for parallel effects elsewhere in the levels.

It is difficult to suppose that this cessation of growth can have been entirely caused by climate, since raised bogs in Wales and in Ireland continued very active uninterrupted growth. The most obvious alternatives are evidently drainage effects. It is possible on the one hand that the Romans who responded to the worsened conditions induced by marine transgression in the East Anglian Fenland, by a prodigious development of drainage works, did so equally in the Somerset Levels where the marine transgression was of similar character. If they did so these drainage works are yet undetected, but equally those in the Fenland have come to light very recently.

On the other hand, even given adequate drainage in Roman times to stop bog growth (a very large matter for ombrogenous peat bogs), the drainage works must surely have fallen into disrepair with the decay of Roman power, so that bog growth would have been expected to revive.

If we accept then the likelihood that it was not too much drainage that caused cessation of bog growth, the possibility remains that it was the contrary, that is to say the subjection of the raised bogs to flooding (not necessarily continuous) by base-rich or even by brackish water, which stopped their growth. To this day the susceptibility to flooding of the Glastonbury Levels is notorious, and Shapwick Heath is moreover still the home of a small number of surviving species characteristic or indicative of marine (salt-marsh) habitats. Among these are *Scirpus maritimus* and *Carex divisa*, *C. disticha* and *C. diandra* (in lit. W. Watson).

The possibility has been considered that the upper of the two flooding horizons at Shapwick Heath was caused by the marine transgression, and it is possible that the continued ombrogenous bog growth above this was due to some measure of protection by Romano-British drainage schemes.

4. Relic species

In the upper peat of the Shapwick area it is not remarkable that there should be found a rather large number of species characteristic of growing raised bogs, which now, in the much exploited and dissected remnants of the peat bogs, are no longer to be found. Some few only of the most xeric members of the bog communities persist on the dried bog surfaces, and a few of the least exigeant of the aquatic forms are represented in the colonization of peat cuttings. Of especial interest are the three species: *Scheuchzeria palustris*, *Sphagnum imbricatum* and *Dicranum Bergeri*. *Scheuchzeria palustris* is described by Rübel (1930) as characteristic of the transition between Flachmoor and Hochmoor, along with *Rhyncospora alba* and *R. fusca*, *Carex chordorrhiza* and *Lycopodium inundatum*. Similarly, Steffen (1931) also describes this species as characteristic of the 'Schwingzwischenmoore' appearing in *Sphagneto-Caricetum rostratae*, and along with abundant *Sphagnum amblyphyllum*, *S. recurvum* and *Calla palustris*, in the *Sphagneto-Rhyncosporetum* which derives from the former association more especially through the extension of *Rhyncospora alba*. The *Scheuchzeria* is regarded by Steffen as belonging to the category of meso- to oligotrophentic species, and is grouped for moisture preferences with *Carex chordorrhiza*, *C. dioica*, *C. limosa* and *Caltha palustris*.

Scheuchzeria occurs regularly and abundantly in the pools ('Schlenken') of the Regeneration-Complex of the raised bogs in East Prussia (Steffen) and similarly at Komosse in southern Sweden (Osvald 1923). In these regions the pools are large and remain water-filled throughout the year, and *Scheuchzeria* forms marginal half-floating mats in them. It recurs similarly in the larger 'Blänken' (lakes), and in the drainage streams or becks ('Rüllen').

In view of the habitat requirements thus indicated it will be evident why layers of *Scheuchzeria* peat so regularly and strikingly form the precursor peat at the Early Iron Age recurrence-surface in the Danish raised bogs and occurs in such abundance at the two flooding surfaces in these Somerset raised bogs, where the base status of the water is sufficiently low.

Scheuchzeria palustris is to-day a relatively rare species in Britain, occurring very sparsely in the north of England and Scotland, and having its most southern locality in the Midlands. It must have been exceedingly abundant in the Somerset bogs in Roman times, and it has been found in abundance also in Sub-Atlantic or recent peat at Fenn's Moss, Shropshire and at Risely Moss, Lancashire. No doubt its remains will in time be recognized in many other now inactive bogs. Drainage and the cessation of bog growth offer an immediate and plausible explanation for its great diminution, but although in southern and midland Britain almost no growing raised bogs have been allowed to survive, in the north and west this explanation can hardly suffice and we may justifiably look for a more general, perhaps climatic, cause such perhaps as brought about widespread drying of bog surfaces. The absence of the plant from Ireland may be a chance historical matter (it has not been reported by Jessen or Mitchell as present in Irish peats), but it may also have to do with some intolerance of Atlantic conditions.

Sphagnum imbricatum is one of the tussock-building *Sphagna* of the raised-bog surface, and takes a medial station in the regeneration cycle. Its abundant presence in the Sub-Atlantic peat of Somerset commands attention chiefly because it falls so clearly into line with the phenomenon already commented upon (Godwin & Conway 1939, p. 357), that this species very widely over Britain and Holland constitutes a large part of the bulk of the upper peat, whilst remaining exceedingly rare or infrequent as a living component of the bog surface at the present day. This has been interpreted as the consequence of a climatic modification towards decreasing oceanicity, recent in date although not necessarily continuing to the present moment.

Dicranum Bergeri has now been recognized by Dr P. W. Richards in the upper peats at the Decoy Pool Wood site. This species is one of a small group of northern mosses, now with a very restricted distribution in Britain, which seem to have survived in certain undrained bog localities. The discovery of another moss of similar character, *Meesea triquetra*, in a fossil state at Puriton, near Bridgwater, has already been reported (Godwin & Richards 1946).

It is interesting to discover that these relic northern species persisted in the Somerset raised bogs until so late as Roman times for it indicates that in the raised-bog habitats at least they probably survived the post-glacial climatic optimum.

5. The Shapwick boat

In September 1906 there was found, 209 ft. southwards from the railway gates at Shapwick Station and in the ditch bordering the east side of the road, a prehistoric monoxylous boat. The circumstances of its discovery were recorded by Dr Bulleid (1906). He stated that the bow of the boat appeared to have lain beneath 4 ft. of peat where it met the ditch, whilst the stem which lay under the edge of the road was said to be beneath 12 to 16 ft. of peat. Nothing was found in the boat except peat and a thin layer of soft blue clay (like that underlying the peat throughout the moor) lying next to the wood. Dr Bulleid concludes by writing that it is 'difficult to give even an approximate date as nothing was found associated with it' although 'it is possible that the boat was made with iron tools'. The investigations described here upon the nature of the upper peat do, however, seem to permit a quite close estimate of the boat's probable age.

So long as the upper peats of Shapwick Heath were conceived as being of the purely oligotrophic *Sphagnum-Calluna* type, then the presumed condition of raised bog must have prevailed throughout Atlantic, Sub-Boreal and Sub-Atlantic times, and no one could imagine an 18 ft. boat employed on the surface of a typical raised bog. The peat depth under the road was uncertain and likely to have been in part due to building up of the roadway: that at the ditch suggested a natural depth of some feet at least from the bog surface. It cannot be supposed that the boat lay in the old *Sphagnum-Calluna* peat, but either of the two flooding episodes now described as affecting the Shapwick bogs could have provided conditions for the usage and incorporation of a sunken boat. The depth would certainly suggest the earlier flooding phase as the more likely, and this could make the boat of early Iron Age, a view consonant with Bulleid's note that it could have been made with iron tools.

The alternatives to this explanation are either that there was here some river channel cutting through between the raised bogs (and surface contour, local stratigraphy, and old maps do not offer the least support for this), or that the boat was so deep as to have laid in the lower *Phragmites* and *Cladium* peat. In the latter case it must have been of early Neolithic or Mesolithic age.

The difference in the two possible ages to which the boat may be referred is so considerable, and the tree (and non-tree) pollen spectrum so different at the two periods, that it would be expected that pollen analysis of peat adherent to the boat would easily decide between them.

Mr H. St George Gray kindly sent from the Taunton Museum a small peat fragment taken from the boat: it contained some particles of buff-coloured calcareous silt and others of dark humified peat. On preparation with hydrofluoric acid and the chlorination and hydrolysis processes, sparse pollen grains were recovered, many in a state of rather advanced decay. These gave the following analysis:

	total	%		total	%
Betula	8	13·5	*Fagus*	1	2
Pinus	0	0	*Corylus*	9	15
Ulmus	3	5	*Myrica*	94	160
Quercus	18	30·5	Ericoid type	118	200
Tilia	0	0	*Sphagnum* spores	36	56
Alnus	29	49	*Lycopodium* spores	4	7

Judging from the tree pollen alone allocation to zone VII *a* is excluded by the low values for *Ulmus* and *Tilia*, by the presence of *Fagus* and the high proportion of *Alnus*. The high values in the non-arboreal pollen for the types characteristic of the ombrogenous raised bog (ericoid pollen, *Myrica* pollen, *Sphagnum* spores and *Lycopodium* spores) indicate that the peat sample must have formed later than zone VII *a*, for ombrogenous growth established itself generally in the levels only after that time.

These analyses certainly point strongly to the later of the two alternative dates for the boat, namely Early Iron Age, for the tree-pollen spectrum can be fairly well matched at the period of the first flooding episode. On the other hand, it must be recognized that the peat sample gives no indication that it was formed under aquatic conditions, and its own exact age relationship to the boat is therefore cast in doubt, save that it cannot well be older. The silt already mentioned probably comes from the 'clay' layer described as lying inside the boat when found.

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