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Introduction: Quaternary research and mires

Those, who, like myself, get intense pleasure from visiting the solitary unspoiled stretches of our British countryside will recognise that few landscapes have been less affected by human interference than the water-logged peat bogs, especially the acidic mires so poor in mineral nutrients and so badly drained that they offer little inducement to cultivation, pasture or afforestation. Remote and guarded by legends of unfathomable morasses and malign spirits, they have retained a loneliness which is a welcome safeguard to the wild creatures native of them. To those of us anxious to discover the quality of the natural landscape and the behaviour of its natural plant and animal communities, these acidic mires correspondingly attract our deep interest, and under wide skies where one hears nothing beyond the call of the curlew down the wind, one comes to regard them with instinctive affection.

I have little doubt that such reactions played their part in persuading me in 1935, whilst continuing research in the East Anglian Fenland, to extend both ecological and stratigraphical research to the acidic bog lands of the north and west. Thus began a delightful involvement with what might light-heartedly be called bog-trotting, although heaven knows, there can be few natural communities less adapted to sustain trotting than those of the squelchy rain-fed mires.

Already by 1935, five years of field and laboratory research, done in conjunction with the Fenland Research Committee, had made it apparent that there now presented itself the chance to enter an almost virgin field of study. This was to become known as 'Quaternary research', a title invented to cover the very wide range of scientific and historical interest involved in the study of events and processes of the Quaternary Epoch, that is, the geological period covering the waxing and waning of the great glaciations, the mild intervening periods and the intensely important Flandrian period that has succeeded the latest of the major glacial stages.

The events leading to this conviction I have already described in *Fenland: Its Ancient Past and Uncertain Future* (1978). What I hope now to recount is how the switch to the great western peat bogs as a central area of research provided such stimulus and reinforcement to my conviction that the conclusions derived in the following twenty-five years or so became very closely bound up with the story of Quaternary study as a whole. Accordingly, to recount what these years reproduced is possibly to serve a more general historical purpose, and especially so if one can recapture the excitement and pleasure of the day by day discovery and progress of our work.

In a memorandum to the University of Cambridge in 1938 I set out the case for its establishing a research organisation for the encouragement of coordinated research from diverse scientific angles, into the events of the Glacial and Post-glacial periods. The war having naturally halted any such development, the case was restated in 1943, and eventually led to the creation in 1948 of a 'Sub-department of Quaternary Research' administratively tied to the Faculty Boards of Biology 'A', Geography, Geology, and Archaeology and Anthropology. I was made Director of it, a post I held until 1966. The Sub-department has accordingly now enjoyed upwards of thirty years of activity, during which time, not only here within Cambridge precincts, but throughout the world, Quaternary research has attracted enormous popularity and successful development, and many scientists of great distinction are engaged upon it and constantly are achieving fresh successes in exploring its possibilities.

These circumstances make it essential that I declare at once that this book is no more than an account of my own purely personal involvement with Quaternary studies and their ecological background, and that it barely extends beyond 1960, although the time-space 1935–60 enables me to attempt some reconstruction of the environment in which the young subject of Quaternary study was being first defined and applied. The year 1955 could no doubt be regarded as of critical significance for the young Sub-department. Dr Donald Walker (later to become Professor in Canberra) had returned from National Service to take up his post of Senior Assistant in Research, Dr Richard West (later to be head of the Sub-department and Professor of Botany in Cambridge) had just taken the more junior post of Assistant in Research, and Dr Eric Willis had designed, built and brought into commission our own radiocarbon dating laboratory. They and numerous research workers of less permanent grade comprised an extremely active centre of expanding advance, as is very well shewn in the successive reports published each year in the *University Reporter*.

Finally by 1956 I had completed and published the comprehensive *History of the British Flora* that gave an organised presentation of all the detailed evidence made available by the methods of Quaternary research, and gave a summary of what those methods were and the main conclusions to which we had been led. It was not long before election to the Chair of Botany (1960) and the Presidency of the Xth International Botanical Congress (1964) were to provide such considerable involvement with administration and paper-work that personal concern with field or even laboratory work dwindled to a small, though persistent stream.

All the same, to limit oneself to this early phase of Quaternary research has its advantages. The pioneer is concerned, as at no later time, with the most general and basic conceptions: he is not embarrassed by preconceived notions, but has (in the wise words of a great American inventor) 'the advantage of beginning from total ignorance'. It is also certainly true, as Lord Zuckerman writes concerning his war-time research, that in most fields of scientific enquiry the cream of the new intellectual adventures is skimmed off in the first year or two after starting! We were a little slower. It is especially of such early phases of research that one can say 'a good hypothesis is worth a ton of facts', whilst accepting that of course a good hypothesis is no alternative to the organising of established proof, but a great stimulus to the effective collection and testing of relevant information. The discoveries and implications of this early phase of Quaternary research, in Cambridge and elsewhere, certainly caused all kinds of further enquiry to be started, much of course by one's own students following promising leads and applying generalisations from one area to another. Such enquiries were part of a wave of enthusiastic development of Quarternary study everywhere, but it would be quite contrary to my present intention to attempt any presentation of this mass of active research or to try to evaluate the present state of knowledge in this vast scientific field. Only in completion of important arguments already developed have relatively recent results been mentioned, as in Chapters 12 to 14.

In the first years of my botanical career, even then a convinced ecologist, I took advantage of the nearness to Cambridge of a widely known nature reserve, Wicken Fen, to engage upon a series of field studies, observations and experiments. In these I sought to make out the factors relating the major plant communities to one another, and especially I tried to discern the natural processes by which, as peat accumulates in conditions of maintained water-logging, a consistent process of vegetational succession inevitably takes place.

This sequence, the so-called hydrosere, begins with the slow deposition of organic detritus in the open water of flooded valleys or basins. Progressive shallowing in time allows invasion by submerged water-

Plate 1. Fen vegetation at Wicken, Cambridgeshire. The calcareous waters support lilies and marginally reeds and reed-mace. The emergent alkaline peat supports dense bush growth, especially of sallow and buckthorn, that later develops into fen-wood with ash and oak.

plants (such as the pond-weeds and water-lilies) upon the bottom mud and subsequently by the tall erect stems of the reed-swamp dominated by bulrush (*Scirpus lacustris*), common reed (*Phragmites communis*), various small reeds and sedges, and particularly the giant sword sedge (*Cladium mariscus*). Peat growth, speeded up by the addition of the underground parts of these vigorous plants, now allows the establishment of such shrubs as the sallow (*Salix cinerea*) and hairy birch (*Betula pubescens*), and later of alder (*Alnus glutinosa*), with even oak (*Quercus robur*) and ash (*Fraxinus excelsior*), eventually to form fen-woods. We established the general nature of these successional (seral) relationships and were able to show how human cropping of the vegetation had often modified it.

At Wicken Fen we were concerned with a category of peat land and peat land vegetation that can be recognised very often in low-lying, constantly flooded areas. This main type of peat land (now conveniently referred to as 'mire' in conformity with the Swedish usage 'myr') is known to all English-speaking ecologists as 'fen'. Its first essential quality is that it has a *topogenous* (i.e. landscape dependent) origin. The water-logging responsible for its occurrence is induced by the convergence in one limited valley or basin of the surface drainage of a bigger area. Thus in the East Anglian Fenland the great river systems of Witham, Welland, Nene and Great Ouse (with its large westward-running tributaries) all discharge into the wide lowlands that surround

The Wash: here drainage is hindered by the building up of tidal silts at the seaward side, ponding back the abundant inflow from the rivers. It was in such conditions that deep peat (still 10 ft (3 m) or more at Wicken) was able to form throughout the 'Black' Fens. The second essential 'fen' quality arises from the constant importation with the river water of dissolved mineral salts that provide high concentrations of inorganic nutrients, important alike to the submerged plants of the early seral stages and to all those that follow. The conditions and the plant communities are in consequence spoken of as *eutrophic* (i.e. of good nourishment). Even where the drained landscape is one of thin soils and acidic rocks this *eutrophication* is recognisable (although to a minor extent) in the increased variety and richness of the flora in the drainage basins, an effect that is also passed on, naturally enough, to the quality and variety of animal life dependent for nutrition on the plants. The streams, however, that drain into the East Anglian Fenland traverse a landscape of quite another kind, made of soft sedimentary rock of relatively recent geological age, including big stretches of the Chalk and substantial exposures of Jurassic limestone. Moreover, the several advances of ice in past glaciations have scraped and eroded exposures of these formations, leaving the ground mantled everywhere with a highly calcareous till. Thus the river waters have been fully charged with soluble calcium bicarbonate and the accumulating peat throughout its depth has been made alkaline in reaction. So long as the flat fen surface remains within reach of the calcareous flood-water, the natural tendency of decaying vegetative matter to become acidic upon oxidation is fully compensated. Finally, as is always the case, the vegetation, by its response to the environmental conditions, itself directly indicates the specific fen type. It is dominated in all the middle hydroseral stages by a great variety of monocotyledons (sedges, grasses and rushes in a great range of species and often of large size), with equally vigorous dicotyledonous plants able to co-exist with the monocots (such for example as *Angelica*, hemp-agrimony (*Eupatorium cannabinum*), purple loosestrife (*Lythrum salicaria*), yellow loosestrife (*Lysimachia vulgaris*), milk-parsley (*Peucedanum palustre*), marsh thistle (*Cirsium palustre*), and very many more). In the later hydroseral stages, as I have said, woody plants right up to the stage of mature fen-wood are entirely typical of this mire type. Where the trophic (nutritional) condition of the drainage water is less extreme, as over the base-poor hard igneous rocks, a mire type that may be called 'acid fen' can develop, but for such development we need to look to the mountains of the north and west of this country.

We may note, *en passant*, how its hydrographic nature makes the fen mire to a very large extent independent of climate, for even in regions of

Plate 2. Fen-wood in valley of River Beaulieu, Hampshire. The many-stemmed alders have largely killed out the herbaceous vegetation of the preceding fen stage and the mattress it formed is breaking up.

low rainfall, local water-logging is induced essentially as a consequence of the local topography and local concentration of the stream and river drainage.

The second great group of peat lands (mires) is that of the bogs or mosses. Although these English colloquial terms have a wide application and the term 'moss' extends of course to the lowly cryptogamic plants, the Bryales, nevertheless in their central areas of usage the terms coincide well enough with the category of ombrogenous mires, that is to say, those dependent for sustained water-supply merely upon direct precipitation either as rain or snow. Such mires will necessarily be dependent upon climate, being favoured on the one hand by high precipitation and on the other by a low evaporation rate, in short by increased oceanicity, and it is no accident that they occur most abundantly in the atlantic west of the British Isles, as in north-western Europe generally. Since the water-supply comes entirely from the sky it is naturally poor in plant nutrients, receiving only air-borne dust, traces of salt derived by long-distance carriage from sea-spray, and traces of ammonium washed from the air. It makes a poor diet for an extensive plant carpet, and certainly such mires and their plant communities are qualified to be classed as *oligotrophic* (of meagre nourishment). A portmanteau term sometimes used is *ombrotrophic*: the English equivalent – rain-fed – seems specially evocative. In such mires the growing bog surface with its acidic products of humification lacks

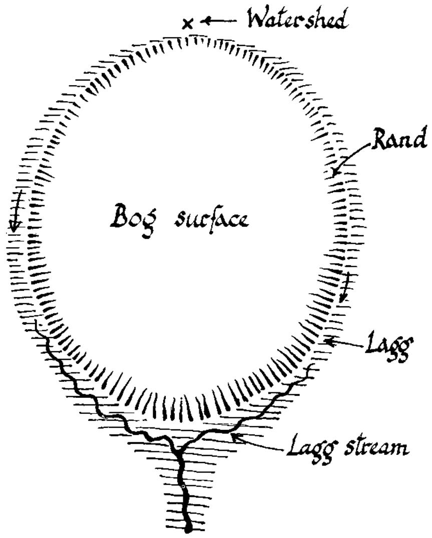

Fig. 1. Diagram to shew idealised raised bog occupying a flat valley floor. When drainage from the bog meets that of the hillside a wet lagg is formed that gets wider downstream: because it is richer in mineral bases its vegetation is then more fen-like and it inhibits invasion by the *Sphagna* of the bog. Thus the bog margin (rand) is highest and steepest downstream and least pronounced upstream where almost no lagg separates the bog from the gently sloping hillside. (After Osvald.)

virtually all neutralisation by bases, so that the peat is acidic throughout. Thus in all ombrogenous mires we find ourselves contemplating plant communities dominated by the same highly characteristic range of species that are oxylophytes (of acidic soils), even possibly calcifuges (lime-hating), that tolerate base-poor, water-logged, or at least very wet conditions and correspondingly often favour moist climates. Of this assemblage the key genus is the bog moss *Sphagnum*, whose many species occupy various ecological niches in the vegetation of these acidic mires, many of them indeed playing a primary role in building up the bog peat. They occupy this central role to a large extent by virtue of their remarkable powers of water-retention within large empty porous cells that constitute a large proportion by bulk of their leaves and stems, and that convert the adjacent shoots of the *Sphagnum* hummock into an extremely effective sponge, capable of sustaining the plant colony through dry periods of considerable length. Other extremely characteristic oxylophytes of the bog surface are the various members of the calcifuge heath family, the heathers (*Erica tetralix* and *E. cinerea*), ling (*Calluna vulgaris*), cranberry (*Vaccinium oxycoccus*), bilberry (*V. myrtillus*) and *Andromeda polifolia*, a plant that has no English name in common usage. Also, from other families, we have the crowberry (*Empetrum nigrum*) and cloudberry (*Rubus chamaemorus*). Such species, mostly shrubby, tend to occupy the higher areas of the bog surface along with sheathed cotton-grass (*Eriophorum vaginatum*), deer grass (*Scirpus caespitosus*) and purple moor grass (*Molinia caerulea*), whilst in the wetter hollows are the beaked sedges (*Rhynchospora alba* and *R. fusca*), bog-

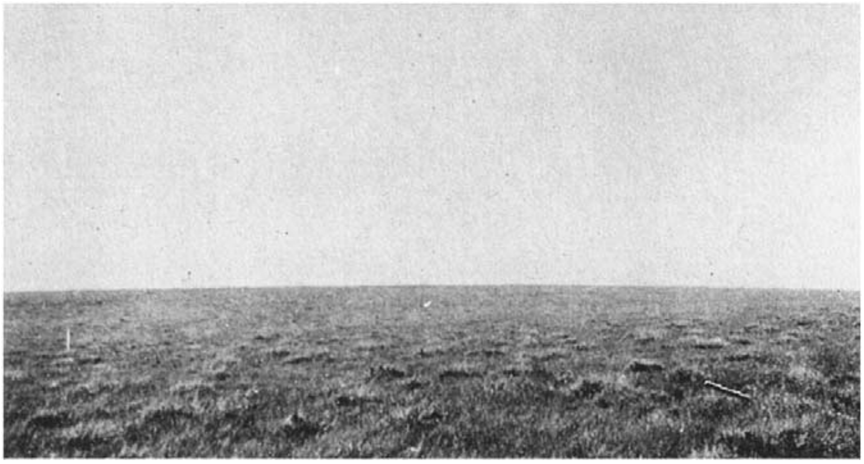

Plate 3. Raised bog in County Athlone, Ireland, shewing the natural gentle dome of the uncut central surface of the mire. (1935)

asphodel (*Narthecium ossifragum*), the many-headed cotton-grass (*Eriophorum angustifolium*), and, more marginally, the three British sundews (*Drosera rotundifolia*, *D. anglica* and *D. intermedia*). How strongly such a plant assemblage contrasts with that which characterises the eutrophic fens, and how forcibly this contrast makes the point that the plant communities themselves, responding individually and collectively, are the best ultimate indicators of the prevalent habitat conditions and thus also of the major mire types! This conclusion would be only strengthened were we to extend mention to include in our consideration the great wealth of mosses and liverworts that also characterise, at ground-level, the living carpet of the bogs.

The ombrotrophic mires are divided into two major groups, the raised bog and the blanket bog, part of the terminology, along with 'mire' itself, hammered out by Professor A. G. Tansley, Hugo Osvald and myself during our meetings in 1935, and subsequently brought into general use. The raised moss or raised bog develops in the less extreme conditions of oceanicity and takes the form of a gently domed cushion of peat, often of considerable lateral extent (very often a mile (1.6 km) or more across) and a height of several feet (up to 5 m or more) above the immediately surrounding landscape. It is the equivalent of the German *Hochmoor* and the Swedish *Högmosse*, both terms indicative of the shape of the mire. The centre of the raised bog is very nearly flat, so that the attempt to popularise the architectural term 'cupola' for the bog centre is, I think, ill-advised. The margins of the raised mass of peat slope downwards relatively steeply and are cut by little drainage streams from the bog surface. These, at the foot of the 'rand', as the sloping margin is known, meet the collected drainage from the adjacent mineral soil to form a slightly eutrophic fen known as the 'lagg', which on the downslope side may include a small stream that deepens progressively in its lower reaches. It is the base content of this lagg drainage that inhibits lateral growth of the *Sphagnum* peat, so that where the lagg is deep and more eutrophic the rand of the bog remains high and steep: the acid mire develops most readily upstream where the lagg is at its feeblest (Fig. 1).

In considering the ombrogeneity of the raised bog I like to contemplate the notion that if a billiard table were left out of doors in a suitable climate, such as that of central Ireland, lowland Cumbria or Wales, it would, if long neglected, grow a raised bog upon its level surface! I have in fact observed something akin to this in County Sligo, where a tall stack of Mountain Limestone stood detached from the main escarpment: its flat surface, only a few square metres in extent, was altogether prevented from receiving any water-supply save that from the sky and yet it was capped by a considerable depth of acidic peat and carried a typical bog flora. No doubt to some degree the surface of the limestone had been sealed by the residues of solution and the peat was unaffected by the chemical properties of the underlying rock. This Sligo site is in fact on the atlantic side of the climatic boundary, possibly around the 40 in (100 cm) annual rainfall line, that is taken to mark the transition from the region of raised bog to that of blanket bog. As the rainfall, or better the rainfall–evaporation ratio, increases, it appears that direct

Plate 4. Blangsmosse, central Sweden, shewing the edge of an unspoiled raised bog. Left, the sloping rand of the bog covered in dwarf shrubs, small pine and birch; right, coniferous woodland (spruce) on rising mineral soil; centrally, the flat lagg kept wet and fenny by drainage water from both sides and dominated by sedges. (1958)

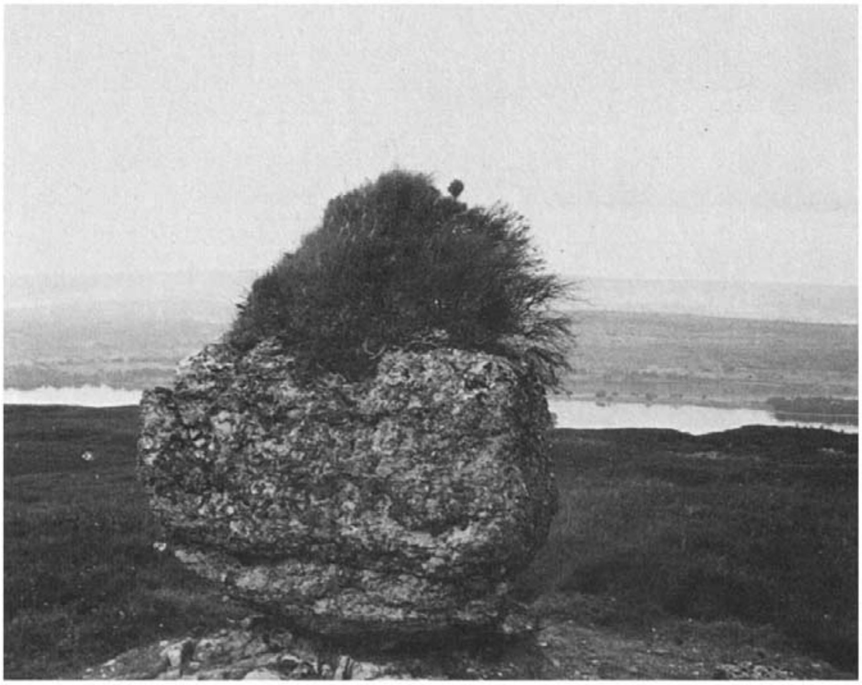

Plate 5. The perfect demonstration of an ombrogenous (rain-fed) mire, Carrowkeel, County Sligo, western Ireland. On the flat top of this perched limestone block there is a considerable depth of acidic peat that supports such lime-intolerant plants as *Calluna* (ling). The weathering of the limestone is advanced and the block must have been long detached: the atmosphere alone must be source for the water that sustains peat growth on this island bog. Lough Arrow and drumlin landscape in background. (1949)

Plate 6. Escarpment of the Carboniferous Limestone at Carrowkeel, County Sligo, with acidic peat bog sitting directly upon the limestone. The bog margin sustains abundant tall bushes of *Calluna* and the peat face shows some buried timber. The very high annual rainfall of this region (over 1000 mm) naturally conduces to ombrogenous bog formation. (1949)