# Historical and Palaeoecological Investigations of some Norfolk Broadland Flood-Plain Mires and Post Medieval Turf Cutting.

by

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CONTAINS

PULLOUTS

*Frontispiece.*

**The flood-plain mires of the Ant Valley, Norfolk from the air,** ***circa*** **1946.** The Catfield and Irstead fens are clearly discernible in the upper part of the photograph, adjacent to Barton Broad, while those of Reedham Marsh lie further south

# HISTORICAL AND PALAEOECOLOGICAL INVESTIGATIONS OF SOME NORFOLK BROADLAND FLOOD-PLAIN MIRES AND POST-MEDIEVAL TURF CUTTING.

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SUMMARY.

Plant macrofossil analyses of 5 peat cores obtained from undisturbed (i.e. not cut for peat) flood-plain mires situated in the Ant Valley in the Norfolk Broads have indicated the successional development of the vegetation over approximately the last 2000 years. These have been supplemented by analysis of diatom and foraminiferal content of some of the deposits together with the application of radiocarbon dating to give an approximate chronological framework within which to place macrofossil zones.

Macrofossil assemblages have been grouped into 5 major zones. These are interpreted as representing:

A: Carr woodland communities (pre-Roman)
B: Salt marsh communities formed during a marine transgressive phase (Romano-British).
C: Fen tussock/carr communities indicative of drier conditions (Early Medieval).
D: Aquatic communities indicative of wetter conditions (late/post Medieval).
E: Communities suggestive of present day vegetation influenced by human management (post Medieval-present day).

The zones have been interpreted largely in terms of the response of the vegetation to changes in sea-level, climate and management over the last two millenia.

Macrofossil analyses were also carried out on samples collected from a variety of former peat cuttings in the Catfield and Irstead Fens. Successional changes were deduced and compared with previous investigations.

Historical studies of archival documentary material have suggested that the post-Medieval use of peat as a fuel in Norfolk was largely a feature of the eighteenth and nineteenth centuries and that it was a commodity of major importance amongst the poor during this time.

Study of archive material specifically relevant to the Catfield and Irstead Fens has suggested that at least some of the former turf cuttings may have been dug in the first half of the nineteenth century but many may also date from the second half.

**Acknowledgements.**

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Finally especial thanks are due to the British Broadcasting Corporation for allowing me airtime to appeal for information about turf-cutting in Norfolk, and without whose excellent radio broadcasts the macrofossil and diatom analyses would have been much more onerous tasks.

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# CHAPTER 1. INTRODUCTION.

The landscape and vegetation of the Norfolk Broads present a paradox to the ecologist. In many ways the large expanses of impenetrable tangled fen and treacherous marsh make it the wildest place in lowland Britain. At the same time it is a landscape which has been subject to long and intensive exploitation by man for agricultural and industrial purposes and many of the wild places owe their existence to interference in the past.

The very "broads" after which the region is named, for instance, are now known to be the flooded excavations produced by early Medieval turbary (Lambert *et al.*, 1960). Many of the most interesting plant communities have developed over shallower peat cuttings of Victorian age. (Giller, 1982; Giller and Wheeler, 1986). Few, if any of the fens have not been affected at one time or another by economic exploitation whether it be peat cutting, management for litter, for hay, or sedge and reed for thatching (Jennings and Lambert, 1951).

Perhaps because of this situation and the consequent difficulty in finding relatively undisturbed sites, most previous stratigraphical studies in Broadland have either concentrated on investigating the nature of the interference (e.g. Lambert et al., 1960), or failed to record events from later deposits (Funnell, 1979), or have neglected them altogether (e.g. Alderton, 1983).

The present study is concerned with these later deposits and is an attempt to discover something of the environmental history of the Broads during this time by stratigraphical investigations of undisturbed fens and former turf [1] cuttings and by the study of historical material relating to the post-Medieval turf-cutting industry, whose activities affected so many areas in the Broads but of which very little appears to be known.

In the introduction which follows, the review of previous research will be confined mainly to that which is particularly relevant to the stratigraphical studies from the undisturbed sites.The sections of the thesis concerned with investigations into peat cuttings and historical studies will be served by separate introductions.

## 1.1 The Norfolk Broads.

The Norfolk Broads or "Broadland" are the names generally applied to that part of East Anglia lying between Norwich and Great Yarmouth and containing the lower reaches of five major river valleys; the Yare, Bure, Ant, Thurne and Waveney (fig.1.1). It is a low lying district with the valleys situated only slightly above present sea level and is famous for the series of shallow lakes (the "broads" themselves) which lie scattered about the flood plains of the rivers. Poor drainage has allowed the development of

1 In Norfolk, as in Eire, the word "turf" keeps its old meaning as in the German *torf* and the French *tourbe*. It is the equivalent of the word "peat" over most of the rest of the country (Estyn Evans, 1957).

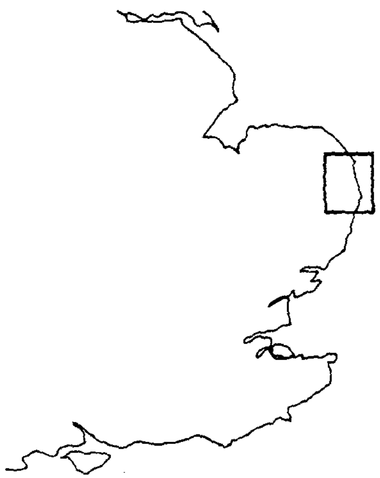
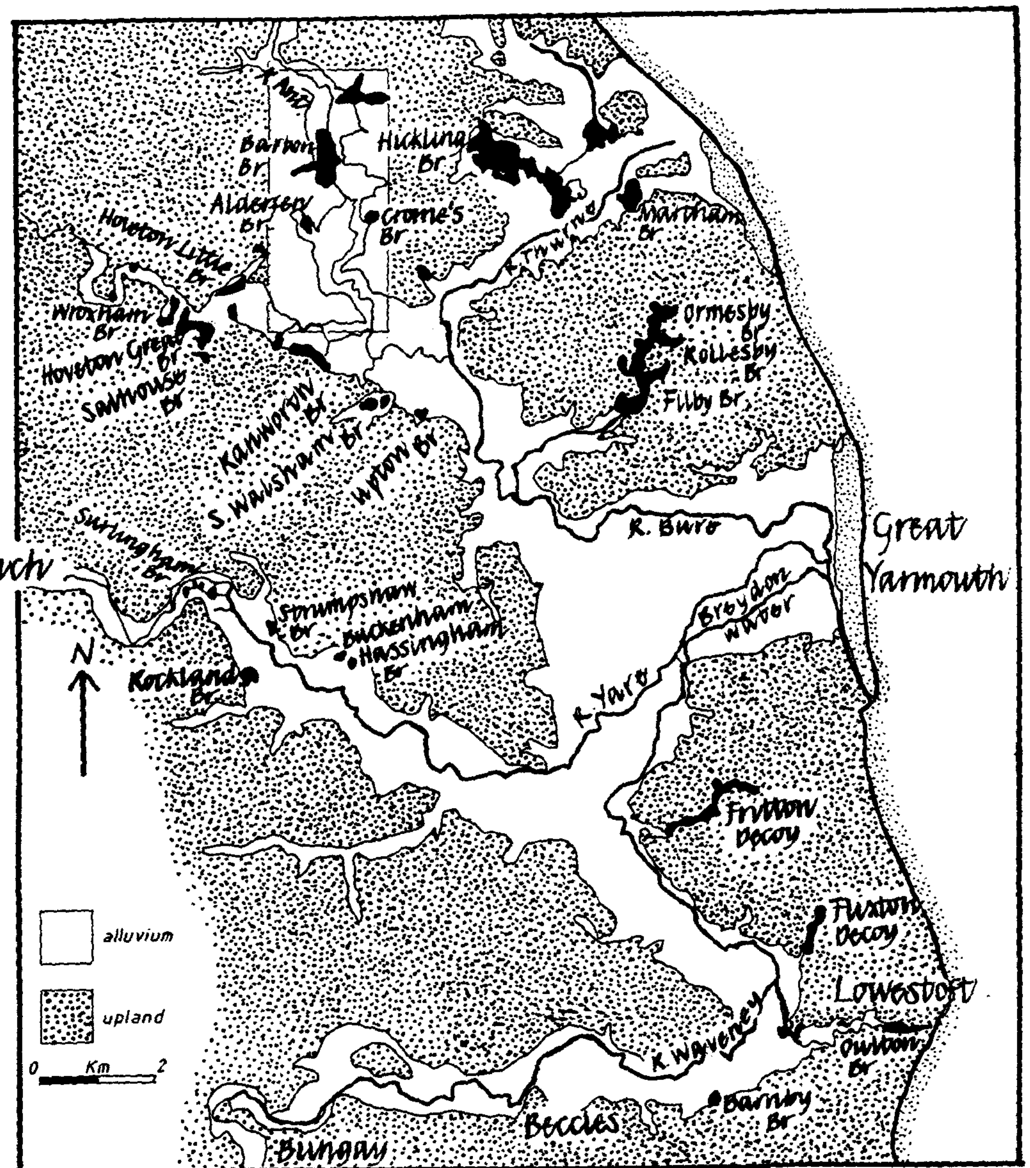
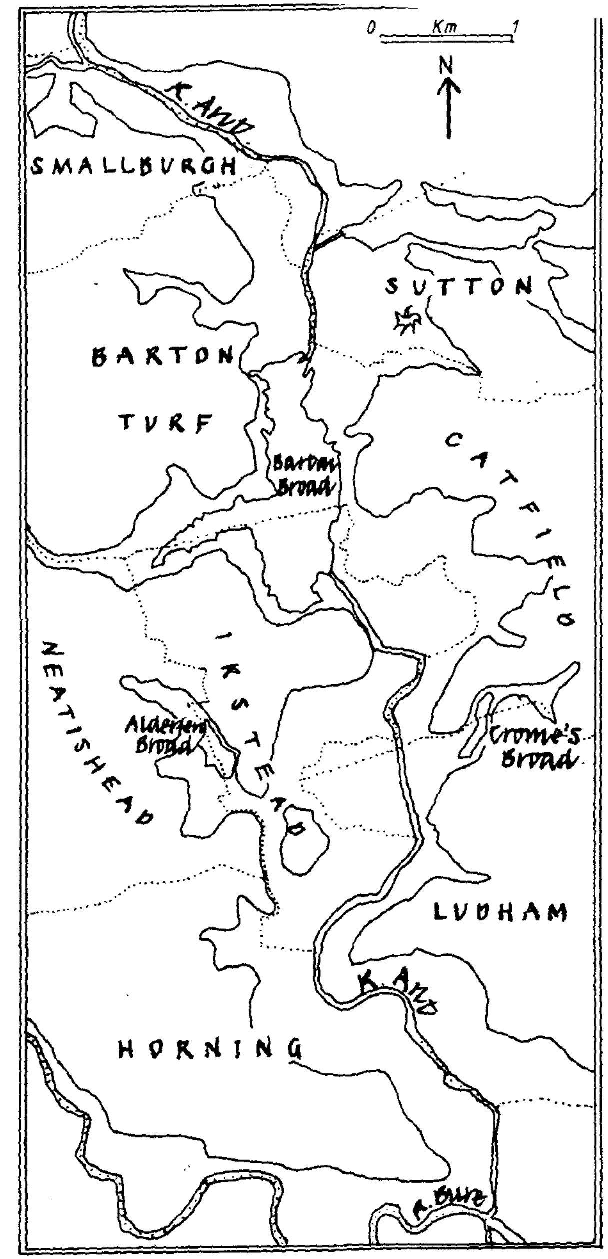


Fig 1.1.
Location maps.




The Broads.




The Ant Valley . showing parishes .

large areas of minerotrophic mire and these are highly prized areas for conservation (Ellis, 1965).

Despite the drainage activities extending over many centuries there are still large expanses of undrained mire remaining. Here is to be found the largest composite area of rich-fen in Britain,estimated to cover an area of c.3500 ha. (Ratcliffe, 1977).

### *1.1.1 Geology and Physiography.*

*Solid geology*

In east Norfolk the surface of the Upper Chalk lies above river level in the vicinity of Norwich but slopes downwards and eastwards until it lies at a depth of c.450 feet at Great Yarmouth. Above this lie beds of sands and clays similar to the Reading Beds followed by 300ft of London Clay. Pleistocene deposits cover most of the underlying rocks and are exposed in classic geological sections along the north Norfolk coast. (Sainty and Ellis, 1965).

As far as the Broads are concerned the most important deposits are all of Holocene age. All the broads lie entirely within alluvial deposits confined to river valleys which are bounded by areas of "upland" (in fact, rarely reaching more than a height of 60m O.D.) composed of Pleistocene drift deposits (fig..1.1). Norwich Brickearth predominates but chalky boulder clays are also found in the more southerly parts of the region (Chatwin, 1961).

*Alluvial deposits*

The alluvial deposits are characterised by a broad division. Mineral alluvium in the form of clay, sand and silt, predominates towards the seaward ends of the valleys. Sections further inland are distinguished by peat and organic muds. The latter deposits are intercalated in various places by clay bands representing differing relative positions between land and sea in the area which have occurred during the Flandrian (detailed in 1.3). The alluvium reaches considerable depths, being found down to 150ft below O.D.behind Yarmouth, 63ft below Acle Bridge and 41ft at Ludham Bridge (Jennings and Green, 1965).

The present day river systems are very sluggish due to a negligible gradient. This has led to the poor drainage of the valleys and the continued development of peat producing fen systems. Such systems probably once extended further down the valleys than they do now, but drainage and reclamation of land in the past has caused the peat cover to oxidise and waste away and these grazing marshes are now surfaced by the formerly underlying clays (Pallis 1911).

## 1.2 Previous studies of Broadland vegetation.

The vegetation of Broadland encompasses a diverse range of communities ranging from open water and reedswamp through to fen and carr. These are mixed in a patchwork caused by a combination of natural and anthropogenic factors.

*Early studies*

The wetland communities of the region attracted interest from an early date. Pioneering studies were those of Nicholson (1909) and Pallis (1911). The fact that the latter work was to remain the standard account of the east Norfolk river valleys for 40 years gives some indication of the strange lack of attention that the region has suffered compared to other areas, a sentiment echoed in Steers'(1950) comment that, "[the broads] are the best known and least investigated lakes in this country".

Pallis classified the vegetation into broad categories. She divided her "fen formation" into two main types,the Yare Valley type and the Bure Valley type. The former was characterised by , "a more eutrophic vegetation with much *Glyceria maxima*[2] and *Thalictrum flavum*". These were uncommon in the Bure Valley type.The vegetation of the Thurne and Ant Valleys was deemed to belong to the Bure Valley type. Pallis also divided carr into two kinds; fen carr and swamp carr. She envisaged the various communities to be different hydroseral stages in the terrestrialisation of a former estuary which had occupied the area covered by the alluvium of which the Broads represented the final open water seres remaining.

2.Nomenclature of vascular plants follows Clapham, Tutin and Warburg (1981). Nomenclature of mosses follows Smith (1978).

These coarse divisions were finally expanded in 1951 by Lambert (Jennings and Lambert, 1951) and developed further by the same author in 1965. Her classifications recognised many community types and she also overturned the previous assertion that the vegetation of the alluvial valleys could be ascribed to a single hydrarch succession. Instead, Lambert suggested that a primary distinction could be made between succession of communities on the loose, unconsolidated deposits of the broad basins and the more compact peat and clay deposits of the valley flats lying lateral to them. She additionally sub-divided these broad categories into several distinct successional sub-units.

*Recent developments*

The most comprehensive descriptive overview of Broadland vegetation types to date is included in Wheeler's (1980) publications on rich-fen communities in England and Wales. A modern approach using partially subjective computer generated classification units has allowed a more rigorous definition of community types to be achieved. Detailed descriptions of the vegetation of the Ant valley fens was published by the same author in 1978 and the most complete description of Broadland vegetation types yet attempted has been the study of the Catfield and Irstead fens by Giller (1982). Using the same approach as Wheeler (1980) he found that there was a significant difference between the communities developed over some turf-ponds[3] as compared with those uncut deposits–a notion discounted by Lambert (Jennings and Lambert, 1951).

**1.3 Previous stratigraphical and palaeoecological research.**

*The Broads–early speculation*

Initial interest in the superficial deposits of the Broadland valleys revolved around the problem of the origin of the Broads. Initial ideas involved glacial processes such as the formation of freshwater depressions caused by the wasting of relict ice-blocks (Fisher, 1866, cited in Jennings, 1952) or the scooping of hollows in underlying deposits by glaciers (Taylor, 1871). Both concepts were rapidly discarded as it became realised that the alluvial deposits of the broads region were linked to post glacial marine transgressive episodes. Taylor continued to maintain his original views and began some of the earliest stratigraphical investigations in the region, describing peat sections with freshwater faunas in the Yare valley in an attempt to discredit the new ideas about marine incursions.

3. The term "turf-pond" is used *sensu* Lambert & Jennings (1951) and Giller & Wheeler (1986), to refer to relatively shallow peat workings as opposed to the "broads" which represent older and deeper turbaries.

*Early stratigraphical studies*

The first studies taking a modern stratigraphical approach stemmed naturally from the research into present-day plant communities reviewed earlier. It was natural that after describing such communities,the reasons behind their development and maintenance should be sought. The concept of the hydrosere had been established early on in the development of ecology as a science (Clements, 1916) and its value in helping determine the reasons behind the present status and future fate of fen communities was soon realised when taken together with the property of such hydroseral systems to record their own history in the form of pickled plant remains.

Pallis acknowledged the possibilities of such studies but did not pursue the matter further than making some borings across the Yare valley alluvium allowing her to classify it into a tripartite division, as had already been established by Nicholson (1909). This division consisted of deep peat at the inland sections; "bluish unctuous ooze" (clay) in the middle sections and the seaward section floored by a "reddish loam" (silt). She did not mention the vertical relations of these deposits.

This aspect, however, was touched upon during an inevitable visit from the itinerant Erdtman (1928), who put down a line of bores at Woodbastwick Fen in the Bure valley to show a section containing *Phragmites* peat with *Cladium* remains and some shell marl overlying forest peat.On the basis of pollen samples, he suggested that the lowest peat he reached was not older than late Atlantic in age. Apart from this isolated rummage in the Broadland peat deposits, it was left to the post-war years and Lambert and Jennings to capitalise on the rich source of information buried beneath the fen surface.

*The 1950's*

Lambert was initially interested in the uppermost deposits as providing evidence for the successional development of wetland plant communities but the studies became progressively more orientated towards the outstanding problem of the origin of the broads. The 1951 publications were the results of investigations in the Bure valley. They constructed a threefold stratigraphical division of the upper alluvium of the valley. The relative positions of the deposits varied depending on location within the valley as did subtle differences in the deposits themselves.

The general picture which emerged from these investigations was of a fairly pure saline clay often occupying a considerable depth beneath the central channel which thinned as it wedged outwards laterally, gradually changing in character with distance away from the channel to a clay more encumbered by organic remains of plants, particularly *Phragmites*. This rested on a brushwood peat and was overlain by a peat rich in remains of *Phragmites* (fig 1.2).

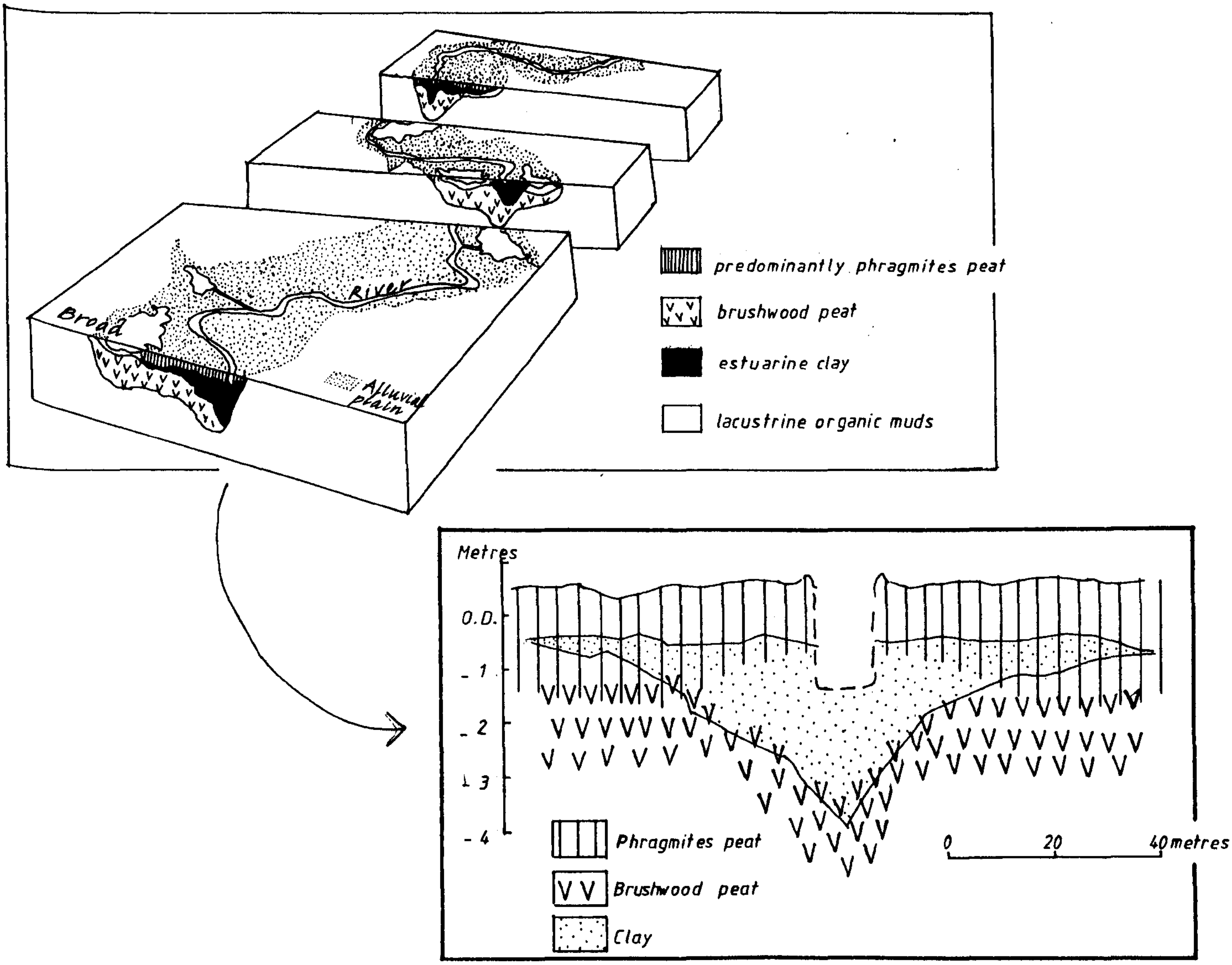



Fig. 1.2. Idealised diagrammatic representation of Broadland upper alluvial stratigraphy. (based on Jennings 1952).

The relative depths and thickness varied depending on location within the study area but on the whole the clays were more important in the lower third of the valley while peat was the major deposit in the upper third.

Of particular relevance to the present study are the findings from stratigraphical investigations in the Ant valley presented by Jennings in 1952. He showed a similar tripartite division of the major deposits of the upper alluvium of the valley as had been proved for the Bure. Particularly interesting was the confirmation that the course of the River Ant had been artificially altered at some time in the past. The estuarine clay deposits were thickest along the course of the old "Hundred Stream" [4] which follows the course of the boundary between the parishes of Catfield and Irstead (fig.1.1) thus proving the notion that the Ant had once flowed along it. The study was also notable for being the first one in which any serious attention was paid to seed macrofossils found in the peat. This was not, however, done in a quantitative manner and Jennings merely noted the presence of various seeds such as *Nuphar lutea, Carex sp., Rubus sp., Potamogeton sp.* and also,interestingly, *Corylus* (The latter from the brushwood peat underlying the estuarine clay).

The 1952 study concluded that the Broads were of fundamentally natural origin but it was acknowledged that

4 The "Hundred Stream" is so-called because it marks the boundary between the Hundreds (shire administrative units) of Tunstead and Happing as well as the parishes mentioned above.

they may have been modified by artificial means in some cases. The theory favoured to explain their formation involved the deposition of estuarine material and its consequences.

Reduced to its basic form, the theory postulated the ponding back of fresh water by the laying down of the estuarine clay. It was suggested that by this mechanism, shallow lakes were impounded to the sides. The height of the clay banks along with better growth of *Phragmites* on them causing higher peat accumulation rates was supposed to have maintained the lakes and even caused them to deepen. Despite the definitive nature with which this elegant theory was presented, after only eight years it was completely undermined by a multidisciplinary study involving further stratigraphical investigations combined with rigorous reappraisal of historical documentary evidence.

*The Broads explained*

The Making of the Broads (Lambert *et al.*, 1960) finally stated what had been suggested for some of the Broads as long ago as 1834 (by Samuel Woodward); that they owed their origin to a completely artificial cause, namely peat cutting. One of the main objections to the idea that peat cutting might have been responsible for these water bodies had been the immense amount of material that would necessarily have had to have been removed and the consequent problems of drainage. Prior to 1960 such an enormous industrial undertaking was thought to have been beyond the resources of early Medieval society. Careful research of the account rolls of the abbey at St.Benet's and Norwich Cathedral (Smith, 1960) revealed that huge amounts of peat were being used for domestic heating purposes in medieval times and the conclusion drawn was that such a large amount of peat could only be accounted for by the presence of the water filled holes known as the Broads. Further stratigraphical study and re-interpretation of extant evidence confirmed this opinion and the objection due to problems of drainage became less important as evidence from palaeoclimatic studies began to indicate that the early medieval period had been much drier and warmer than the present (Lamb, 1965). The fact that this also seemed to have been followed by a rapid deterioration and increase in wetness provided a convenient explanation for the subsequent flooding and abandonment of the turbaries.

With the origin of the broads apparently explained, the region seems to have been regarded as having had its interest exhausted and it became an unfashionable place for palaeoecological studies, remaining in the backwaters of research in the subject for nearly two decades.

*The rediscovery of Broadland*

The first studies designed to investigate more general problems of stratigraphy than the specific one of the origin of the Broads were those of Coles (1977) and Coles and

Funnell (1981). They attempted elucidation of the sequence of events leading to the formation of the Holocene deposits of the Yare valley by the use of evidence provided by sub-fossil assemblages of foraminiferids and thecamoebans within the deposits. This enabled estimates to be made of the extent of episodes of marine and freshwater influence in the past while the application of radiocarbon dating allowed the construction of the following chronology of events:

| | | |
|---|---|---|
| Upper Peat | <1500 | b.p. |
| Upper Clay | 2000-1500 | b.p. |
| Middle Peat | 4500-2000 | b.p. |
| Lower Clay | 7500-4500 | b.p. |
| Lower Peat | pre 7500 | b.p. |

This study was followed by Alderton (1983), who looked into the succession of marine transgressive and regressive overlap sequences from the Waveney valley. Using evidence mainly from diatom and pollen sources combined with extensive radiocarbon dating she constructed a chronology for the events represented by the marine clay and peat intercalations up to the upper clay. This provided a test of the general applicability of Coles and Funnell's (1981) scheme for the rest of Broadland. Her results were broadly comparable but she found the "lower peat" to be diachronous.

*Palynological studies*

Although East Anglia was one of the centres of original studies in the vegetational history of the British Isles (Godwin, 1978), pollen analyses from sites in east Norfolk and the Broads in particular have been relatively few. Apart from limited analyses by Alderton the only ones actually from the Broads are still Jennings and Godwin's (1952) and Lambert and Jennings'(1960) studies. These investigations, from sites at Fenside-Irstead, Barton Broad and Ranworth Broad and based primarily on arboreal pollen trends, recognised a sequence similar to other regions of the country with the identification of zones VII and VIII with a sub-zone of "VIII-modified" introduced to describe the rapid rise in pollen of planted species such as *Pinus* recognisable in the latter stages of all the diagrams. What was not immediately recognised was the possibility that the profiles may have been subject to disturbance (caused by medieval turbary activity) as any possible peat digging had been presumed up to then to be post-Medieval or later in date and so the existence of marked and systematic changes in pollen content through quite substantial thickness of mud were used to argue against the artificial origin of the broads. It was only when the greater antiquity of the actual excavations was discovered that reinterpretation of the palynological evidence revealed that the changing profiles could be accounted for without requiring continuous deposition from Romano-British times (Lambert and Jennings, 1960).

The most recent palynological study encompassing Norfolk is that of Sims (1978). The study is concerned with regional trends over the whole of East Anglia and is based on findings from Hockham Mere and Seamere, both well to the west of the Broads. Using a modern approach of narrow sampling intervals, high pollen counts, absolute pollen frequencies and radiocarbon dating, the study takes a generally anthropocentric approach in interpreting the pollen evidence and identifies several phases which it relates to agricultural activities during various prehistoric and historic episodes. It also takes a novel approach in using high concentrations of spores of thermophilous actinomycetes as forest clearance indicators. Evidence is highlighted suggesting Mesolithic anthropogenic interference with vegetation in Norfolk around 7600-7450 b.p. Other changes are mainly interpreted in terms of differing land use strategies related to changing economic pressures caused by Neolithic and Bronze Age population expansion, Roman occupation, Saxon immigration and, more tentatively, Danish raiding.

The zone from the Dark Age to the present day is ignored because of complications caused by local pollen components.

## 1.4 Aims of the present study

Palaeoecological studies, then, have provided a considerable amount of data about the Broads region. Most of this body of evidence relates to the period before the last 2000 years. There were, therefore, two major aims to the present study.

The first was to try to fill some of the gap in knowledge about vegetational history relating to the last 2000 years in Broadland by investigating the upper deposits of a fen thought never to have been cut for peat. This also served as a reference point with which to compare results from another part of the study which was to look in detail at successional development in historically recent peat cuttings surrounding the Catfield site. These were investigated to try and see if the stratigraphical record of these features might gives some clues as to the reasons why different fen communities occupy them today. Studies of historical documentary evidence were also pursued in relation to the latter objective with an eye to dating the inception of the peat-cuttings more accurately and to try to find out about the actual mechanics of Broadland peat digging in the recent past. This was later widened to incorporate study of all aspects of recent turf-cutting in the Broads-a subject about which surprisingly little is known.

Macrofossil, diatom and foraminiferal analyses were the principal methods chosen to attempt the stratigraphical investigations as the study was intended partly as a detailed investigation of the development of a relatively localised area chosen both because of its present day botanical interest and because of its undisturbed nature. Because of this, pollen analysis was not attempted due to the regional derivation of much of the pollen rain in such sites compared to the localised nature of much of the material comprising macrofossil deposits from fens (GreatRex, 1983; Collinson, 1983). The pollen record, albeit limited, was also felt to be adequately covered by the studies mentioned above. The other aim of the study, the attempt to discover something of the post-Medieval turf-cutting industry in Broadland, lent itself to an historical approach.

Such a multidisciplinary study was felt to be consistent with the traditions of Broadland research and to be the most effective way of expressing something of the story behind the last 2000 years of Broadland environmental history.

# CHAPTER 2: METHODS.

## 2.1 Fieldwork.

### *2.1.1 Site selection.*

Two areas were studied,both part of the floodplain mire system occupying the middle reaches of the Ant Valley (see Chapter 3). Three cores were located in the Sedge Marsh portion of Catfield Fen adjacent to Barton Broad and placed to ensure coverage of deposits overlying estuarine clays as well as pure peat. Two further cores were taken from Reedham Marshes situated approximately 2 km to the south of the latter site. Here, deposits were completely underlain by estuarine clays and it was hoped that investigation of these cores would indicate whether features noted from the Catfield samples might be of local or more general significance.

### *2.1.2 Sampling.*

Two kinds of coring devices were used to obtain material for the study. A piston sampler of Livingstone type (Livingstone, 1955) was employed to obtain material for plant macrofossil analysis and radiocarbon dating and a Hiller type chamber sampler was employed to recover samples for conductivity studies, cation analysis and foraminiferal analysis. The advantage of the Livingstone was that it enabled enough material to be recovered for macrofossil analysis in a single complete core as the amount required for a detailed quantitative study is relatively large (Watts and Winter, 1966). This also avoided the need to combine material from adjacent cores necessary when using devices of smaller dimensions and so eliminated the possibility of errors which may occur when attempting to match stratigraphical horizons. It had a diameter of 5cm and enabled the 2m sampling depth to be reached in two drives.One of the disadvantages of using a piston-type sampler in peat deposits is the possibility of compaction of the material in the initial drives. During the first drives of all the cores the peat was found to have been compacted in the Livingstone Corer to varying degrees. This is a problem encountered by other workers using piston samplers in peat sediments (e.g. Alderton, 1983) and is caused when a compressive force is applied to relatively unhumified peat due to its being forced against a relatively dense and inelastic medium such as clay. It is similar to the process of autocompaction suffered by peats when they become buried,particularly under a dense clay layer (Bloom, 1964) although in the present case the process is speeded up due to the causal force being provided by the piston drive, rather than by gradual weight accumulation on top of the peat. When interpreting the relative depths of stratigraphical features from such compacted cores it was assumed that compression had been uniform along them and actual depths were calculated using a simple correction factor based on the ratio of drive length:core length. This was found to be satisfactory for almost all of the analysis and was checked for major error by comparison with material recovered from the same depths by other coring devices.

At a later date, a Hiller-type chamber sampler was used to obtain material for conductivity studies,cation analysis and foraminiferal analysis. Far less peat and clay was required for these purposes; hence the more easily operated and transported Hiller was used.

Using the Livingstone corer, two complete cores, situated less than a metre apart, were taken from each sampling position. One of the cores from each position was used for plant macrofossil analysis (series "A" cores), while the additional core (series "B" cores), was used for radiocarbon dating from two of the sites (Sedge Marsh One and Sedge Marsh Three). In addition, the macrofossil cores from positions SM1 and SM3 were also sampled for diatom analysis.

Immediately after sampling.the cores were wrapped in a protective "sandwich" consisting of a layer of "clingfilm" light polythene followed by industrial aluminium foil and finally sealed in heavy duty polythene. They were transported back to Sheffield on plastic guttering and the carefully labelled packages were stored until examination in a dark cold room at a constant temperature of 6 °C.

The material obtained with the Hiller corer was put into thick polythene bags,labelled and stored in the same conditions as the cores.

*2.1.3 Recording stratigraphy.*

Prior to sub-sampling for macrofossil analysis, the cores were unwrapped and the surface scraped clean with a sharp blade. Drawings of the stratigraphy were made and recorded and the sediment types characterized using a deposit element system based on Troels-Smith (1955). All stratigraphical boundaries were measured to the nearest half centimetre and noted as either sharp or diffuse. Abbreviations follow Troels-Smith with the addition of the colour notation of Munsell Colour Charts.

*2.1.4 Stratigraphical diagrams.*

These are shown as part of the plant macrofossil diagrams with explanatory keys. The peat types encountered can be broadly categorised into:

1. *Turfa herbacea* (Th): herbaceous peat, mainly composed of *Phragmites* and *Cladium* fragments.
2. *Substantia humosa* (Sh): undifferentiated humified herbaceous peat material.
3. *Limus detrituosus* (Ld): fine detritus mud.
4. *Argilla steatodes* (As): clay.
5. *Turfa lignosa* (Tl): wood peat.

The degree of humification of peats within each category and proportion of deposit element is recorded conventionally;the former by means of numerical superscript attached to the deposit element symbol and the latter by a number placed after the symbol with both values on a scale of 1-4.

## 2.2 Analysis of macroremains.

### *2.2.1 Sub-sampling and preparation.*

The cores were divided up into equal sized blocks every 10 cm down the core using a sharp knife which was carefully cleaned after each incision in order to avoid contamination. Each block was then wrapped in thin "cling- film" polythene and placed in a thick polythene bag which was sealed. The bag was labelled with the depth the sample was from and with an indication as to the upper and lower ends of the peat block. The cores thus sectioned were returned to cool storage until the next stage of preparation could be carried out. This consisted of taking individual blocks of core material from the polythene bags and obtaining 100 cm3 of material from each block, measured by displacement of water in a measuring cylinder. Usually the material was removed from the top portion of the block but if this meant an obvious stratigraphical horizon would be incorporated within a single sample then the sample was taken from a position within the block so as to avoid mixing deposits from the two deposit elements.

In order to disperse the sediment it was found that soaking in tap water for about a day proved sufficient for most samples. Samples containing clay or *Phragmites*-clay could be dispersed by using hot water or the addition of small amounts of 10% KOH. When completely dispersed the samples were washed through two sieves with mesh sizes of 500 and 178 microns. Tap water was used to wash the material, care being taken that the water jet used was not so strong as to damage the plant material but strong enough to cause small mineral particles to pass through the sieves. When the water passing through the sieves was clean, the washing was finished and the material from both sieves was transferred to separate beakers.

*2.2.2 Separation of fossils.*

Before identification and counting the different fossils needed to be segregated.This was achieved by placing small amounts of material on a petri dish which was covered with a thin (c.2-3mm), film of water. Under a Nikon low-power microscope using a magnification of between 8-16 times, the material was pushed from one end of the dish to the other with a spatula and all identifiable plant remains were picked out with a delicate brush or tweezers and placed in another dish. A pipette was found to be ideal for transferring very small items such as *Chara* oospores or foraminifera without damage.

*2.2.3 Identification of fruits and seeds.*

All macroremains were identified using a combination of comprehensive keys, illustrations and reference material.

The main reference collection used was housed at the Botany School, University of Cambridge. Several visits were made to consult the specimens contained in the collection in order to determine uncertain fruits and seeds and to confirm the identification of others. Occasional use was also made of the collections housed at the York Archaeological Unit based at the Dept. of Physics, University of York. A limited collection of material was also made by the author and used at Sheffield but the most useful tools employed in between visits to more comprehensive reference collections were the publications by Beijerinck, 1947; Berggren, 1969, 1981a,b; Jessen, 1955; Katz *et al.*, 1965; Godwin, 1975; Nilsson and Hjelmqvist, 1967. Specimens retained for future comparison with reference material were preserved in a mixture of 90% alcohol, formalin and glycerol and stored in plastic tubes. After definite identification they were added to the author's own reference collection and used in subsequent determinations. Representative examples of *Chara* oospores from the Reedham and Howhill cores were sent to Dr.J.A.Moore at the British Museum (Natural History) where a scanning electron microscope study was made of the oospore surfaces by Ms.D.Green in an attempt to identify the specimens more accurately. This met with a modest amount of success. (The methods used were similar to those described in John. D.M. and Moore, J.A., 1987.)

*2.2.4 Identification of remains other than fruits and seeds.*

Identification of vegetative remains such as rhizomes, stems, leaves etc., was made with the aid of reference material available at Sheffield and also collected by the author and with the assistance of opinions from people experienced in field determinations of vegetative remains. Reference to literature such as Jennings and Lambert (1951) was also of value.

The foraminifera collected from the deposits were sent to Professor B.M.Funnell at the Dept. of Environmental Sciences, University of East Anglia for identification. Unfortunately the results of this analysis are unavailable for use in this thesis but provisional results from an initial small scale investigation are presented in Appendix B.

It was felt that the identification of coleopteran fragments would be too time consuming to be pursued thoroughly and so only the numbers of such fragments were recorded from each level.

The numbers of mollusc and snail shells are recorded in the same way.

Details of the diatom analysis from two of the cores are given in chapter 6.

*2.2.5 Presentation of results.*

Pull-out figures are enclosed relating to chapters 4 and 5 and showing the changes in macrofossil content from the cores. As in most previous studies of this kind, the results have been presented as a series of histograms indicating numbers of seeds and some vegetative remains from each level.

In the diagrams and descriptions the word "seed" is used to describe both fruits and seeds in order to simplify the presentation. The appearance of a taxon name on the diagrams without qualifying additional information indicates the representation of totals of seeds found referable to that particular taxon.

The example of Watts and Winter (1966) is followed in the way in which the relative certainty of determination of the macrofossils encountered is presented. Thus, where a species name is used without qualification it means that species and no other appeared to match the fossil.

Where a genus or family name is followed by "sp."(species), the generic or family determination is certain but the lower taxon is indeterminate. Where a species name is followed by "type", the fossil matches not only this species but also others; here the selection of the species name is based on ecological or geographical reasons. The use of "cf."(*confer*–compare) connotes uncertainty because of poor preservation, inadequate reference material or ill-defined morphology.

Most recognisable vegetative remains are displayed using a qualitative 4-point scale, *viz.*:

XXXX abundant; fills field of view most of the time.

XXX common; encountered most of the time.

XX frequent.

X present.

Diagrams similar to those of Watts and Winter, (1966); Birks (1976), etc., have been drawn. The stratigraphy of each core is also shown to the left along with a depth scale which indicates distance from the fen surface. The series of histograms display the total number of fruits, seeds, leaf fragments, beetle remains, etc., found in 100 cm3 from each 10 cm segment down the core. A scale indicating such values is located at the base of the diagram for each taxon. Individual histograms are arranged such that taxa having similar stratigraphical occurrences are grouped together, as far as possible. It was felt that detailed statistical treatment of the results was unnecessary. The diagrams have also been divided by eye into macrofossil zones where major assemblage boundaries occur. These are indicated by thick horizontal black lines running across the diagrams and given a prefix based on an abbreviation of the site name at the right side. Thus Sedge Marsh is abbreviated "SM";

HowHill,"HH" and Reedham Marsh, "RM". They are recorded from the base upwards. The zones are discussed in detail in chapters 4 and 5.

## 2.3 Diatom analysis.

There are several ways of presenting diatom data but it is the salinity tolerance of diatoms which is the most significant parameter when investigating episodes of marine influence.

Diatoms have been used in many studies to indicate changes in salinity and water depth in palaeoenvironments (Berglund, 1971; Devoy, 1979; Miller, 1964; Tooley, 1978; Shennan, 1980; Alderton, 1983). This has been done by interpreting changes in assemblages thought to represent the movement of the study site relative to tidal cycles and connection with the open sea.

Two salinity classifications are commonly used. Hustedt(1957), using the system devised by Kolbe (1927), developed the *halobian diagram* which comprises five salinity groups. Each of these salinity categories is further differentiated into planktonic, benthonic and epiphytic groups.

Van der Werff & Huls (1958-66) divide species into seven groups dependent on the chloride content of the water favoured by them. Van der Werff's approach uses the analysis of species by summing the number of species belonging to each salinity class and calculating this as a percentage of the total number of species counted.

Other methods of representing individual species or groups vary. Evans(1969) and Haworth (1976) calculate individual species frequencies as a percentage of the total valves counted. Berglund (1971) uses a selected sum of valves for the denominator similar to the way arboreal pollen sum can be used in pollen analysis. Devoy (1979) uses the halobian spectrum for groups of planktonic, epiphytic and benthonic species calculated as a percentage of the total valves counted.

The majority of recent diatom studies most concerned with palaeoenvironmental change in coastal or past-coastal areas have favoured the salinity classification of Van der Werff (Alderton, 1983; Devoy,1979; DuSaar, 1978 in Tooley 1978; Jansma, 1981 in Brothwell and Dimbleby 1981; Shennan, 1980). This classification, sometimes called the "M-B-Z"or "M-B-F" system (Marine-Brackisch-Zuss; Marine-Brackish-Fresh) and which is detailed overleaf, has also been used in the present study.

M-B-F grouping

| | | |
|---|---|---|
| M : Marine | >17000 | mg Cl/l |
| MB : Marine/brackish | 10000-17000 | mg Cl/l |
| BM : Brackish/marine | 5000-10000 | mg Cl/l |
| B : Brackish | 1000-5000 | mg Cl/l |
| BF : Brackish-Fresh | 500-1000 | mg Cl/l |
| FB : Fresh/brackish | 100-500 | mg Cl/l |
| F : Fresh | <100 | mg Cl/l |

Unlike some studies (e.g.Tooley, 1978), the relative percentages of the various groupings have been expressed as percentages of total frustules occurring rather than percentage species as it is felt that the latter method may give a distorted picture of the salinity grouping composition of the samples.

Because there is yet no general agreement over the method of grouping diatom species on a salinity scale (Shennan, 1980) the present study follows that of Alderton (1983) by using the Halobian system, as well as Van der Werff.

*Halobian grouping*

This is based on Kolbe's classification (1927), outlined by Foged (1954) and Evans (1969). It defines the range of the chloride content of the water in which the diatom is normally found.

(a) **Oligohalobous forms**-mainly widespread in freshwater, i.e. water which contains less than 5% salt.

(i) *Halophobous forms*-these are found in water particularly deficient in chloride.

(ii) *Indifferent forms*-freshwater forms proper.

(iii) *Halophilous forms*-mainly widespread in freshwater, but thrive in slightly brackish conditions.

(b) **Mesohalobous forms**-brackish water forms, mainly widespread in water which contains 5-20 % salt.

(c) **Polyhalobous forms**-marine forms which have their optimum development in water containing 30-40 % salt.

The pH preferences of the various diatom species recorded, based on the system originated by Hustedt (1937-39) were also noted where possible and a percentage diagram constructed. The diatoms were divided into five categories according to their individual pH tolerances as follows:

pH grouping

*alkalibiontic*, occurring at pH values>7;

*alkaliphilous*, occurring at pH values about 7 and with widest distribution at pH>7;

*indifferent*, occurring equally on both sides of pH=7;

*acidophilous*, occurring at pH values about 7 with widest distribution at pH<7;

*acidobiontic*, occurring at pH values under 7 with widest distribution at pH=5.5 or under.

It must be stressed that the preferences allocated by authors to many taxa are based on limited observations from the field and are not strictly defined limits. Not enough detailed observational and experimental work has been carried out to produce a more refined body of data.

The diatom analysis used material from two of the cores also used for macrofossil study (cores SM1 and SM3).

### *2.3.1 Sub-sampling*

The cores were initially sampled for diatom analysis whilst still intact. A spatula of material was removed every 10 cm down the core after first scraping clear the surface to remove any contamination of the sides. This was put into small plastic tubes and stored at low temperature until preparation for analysis.

*2.3.2 Preparation and counting.*

Preparation of samples for diatom analysis followed the methods employed by Alderton (1983) and the laboratory schedule is detailed in the appendix. Diatom counts were made using a Vickers microscope at x750 or above and using an oil immersion objective. Counting was carried out along continuous traverses a millimetre apart to avoid overlap. Care was taken to include equal proportions of near edge and centre to allow for possible sorting which may have occurred due to evaporation while preparing the sample. Counting followed the standard procedure in regarding the basic unit as the valve with complete frustules counting as two. Fragments of valves were included in the count by adopting a system that excluded the possibility of double or multiple counting,as far as possible. Taxa possessing single characteristic features of the valve such as distinct centres could be counted as single units when this was recognised. For valves without this advantage an alternative approach was to count only those fragments with a valve end and to divide the total by two. The total minimum number of valves counted from each sample was 300. This figure was decided on as a reasonable compromise between the conflicting suggestions offered by the main workers in this field. Battarbee (1986) recommends a sum of 300 to 600 valves,increased when there is a dominance of a few species, Devoy, (1977, 1979), analyses a minimum of 600 whereas Shennan(1980) counts only 200. Tooley (1978) keeps his sum secret.

*2.3.3 Presentation of results.*

M-B-F diagrams from the two sites have been constructed to indicate the prevailing trends in relative salinity displayed by the diatom assemblages. In addition, the data have been presented in the form of a species percentage diagram similar in form to those used in the presentation of palynological results. In the latter diagrams, the various species have been grouped according to their respective pH preferences,where these are known, using the system proposed by Hustedt outlined earlier.

The diatom nomenclature follows Hartley, 1986.

**2.4 Foraminifera analysis.**

Foraminifera were initially found in deposits indicative of a marine transgressive overlap during the original macrofossil investigations. At this first encounter no attempt was made to identify the specimens found due to the difficulty of determination and the very large numbers encountered (sometimes in excess of 2000).Subsequent to this, a kind offer to help identify the organisms was made by Professor B.M.Funnell of the University of East Anglia. Unfortunately the final results are as yet unavailable for use in this thesis. Preliminary identifications which were originally made of limited numbers from selected samples are therefore included in appendix B as an indication of the estuarine conditions suggested by the various species occurring.

### *2.4.1 Preparation and counting.*

The samples were initially prepared in a manner similar to that described for the macrofossil study (*see 2.2.1*). The foraminifera were picked from the deposit left in the finer sieve (178 microns) placed on a petri dish and examined a portion at a time. They were put into robust plastic screw-top tubes containing water, labelled and sent to the University of East Anglia where Professor Funnell identified and counted them.

## 2.5 Radiocarbon dating.

Four samples were taken from each of the series "B" cores extracted from the SM1 and SM3 sites. The samples were taken from the boundaries of major lithological units but precise positioning of the samples was impossible due to the fact that even with a 5 cm diameter core, samples up to 10cm thick are necessary to provide enough carbon for the dating process. Other authors have suffered problems of this kind (e.g. Birks,1976). The largest amount of material was required from the estuarine clay deposits as these contain the least organic material. The widest margin for error, therefore, was encountered in the dating of the clay horizons.

### *2.5.1 Dating Technique.*

All radiocarbon dating and sample pretreatments were performed by the Godwin Laboratory staff of Dr.V.R.Switsur at the Botany School, University of Cambridge.

The dates derived from the analyses have been calibrated by Dr.Switsur using the internationally agreed calibration curve based on dendrochronologically dated tree rings which was established at the 1986 Trondheim Radiocarbon Conference (Switsur, 1986; Pearson, 1987).

### *2.5.2 Diagrams.*

All radiocarbon dates associated with the cores are recorded on the macroremains diagrams.

Deposition rate curves are drawn for each core dated (figs.7.4, 7.5) with a vertical axis of centimetres depth and a horizontal axis of calibrated radiocarbon years before present. Each date is given a tolerance bar of two standard deviations representing the range in which that date has a 95% probability of falling. The thickness of the peat/*Phragmites* clay sample is indicated by the ends of the tolerance bar.

# CHAPTER 3: THE SITES INVESTIGATED.

## 3.1 Sedge Marsh; Catfield and Irstead Fens.

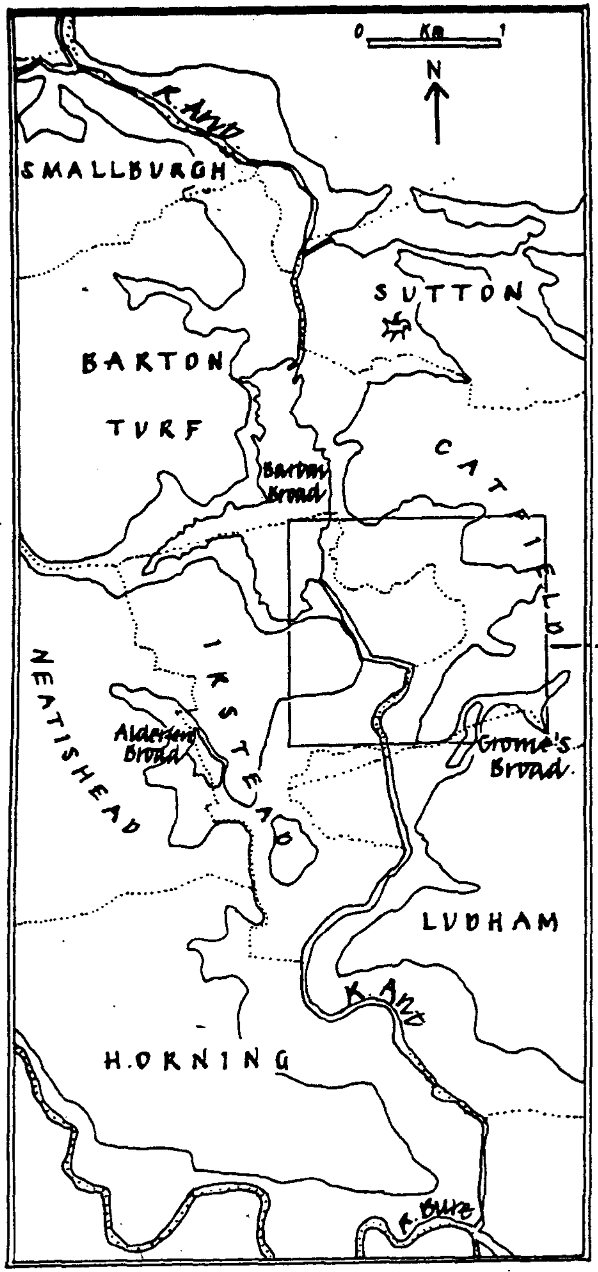
The Catfield and Irstead Fens are an extensive (c.150 ha.) and low lying <1m O.D.) flood-plain mire complex situated in the middle reaches of the River Ant valley. They lie about 20km north-east of Norwich and are situated to the south-east of Barton Broad (Fig.3.1). The western part of the site is bordered by the present course of the River Ant which flows from the southern end of the broad. The river was diverted sometime before the eighteenth century and used to flow through the centre of the site along the winding ditch known as the "Hundred Stream " which marks the boundary between the parishes of Catfield and Barton Turf and Happing and Tunstead Hundreds (Jennings, 1952). The eastern and northern borders of the site are formed where the peat deposits abut against the "upland". The peat deposits of the site are underlain by the *Norwich Brickearth*; a drift material of decalcified and weathered boulder clay deposits (Chatwin, 1961).

### *3.1.1 Upper deposits and fen divisions.*

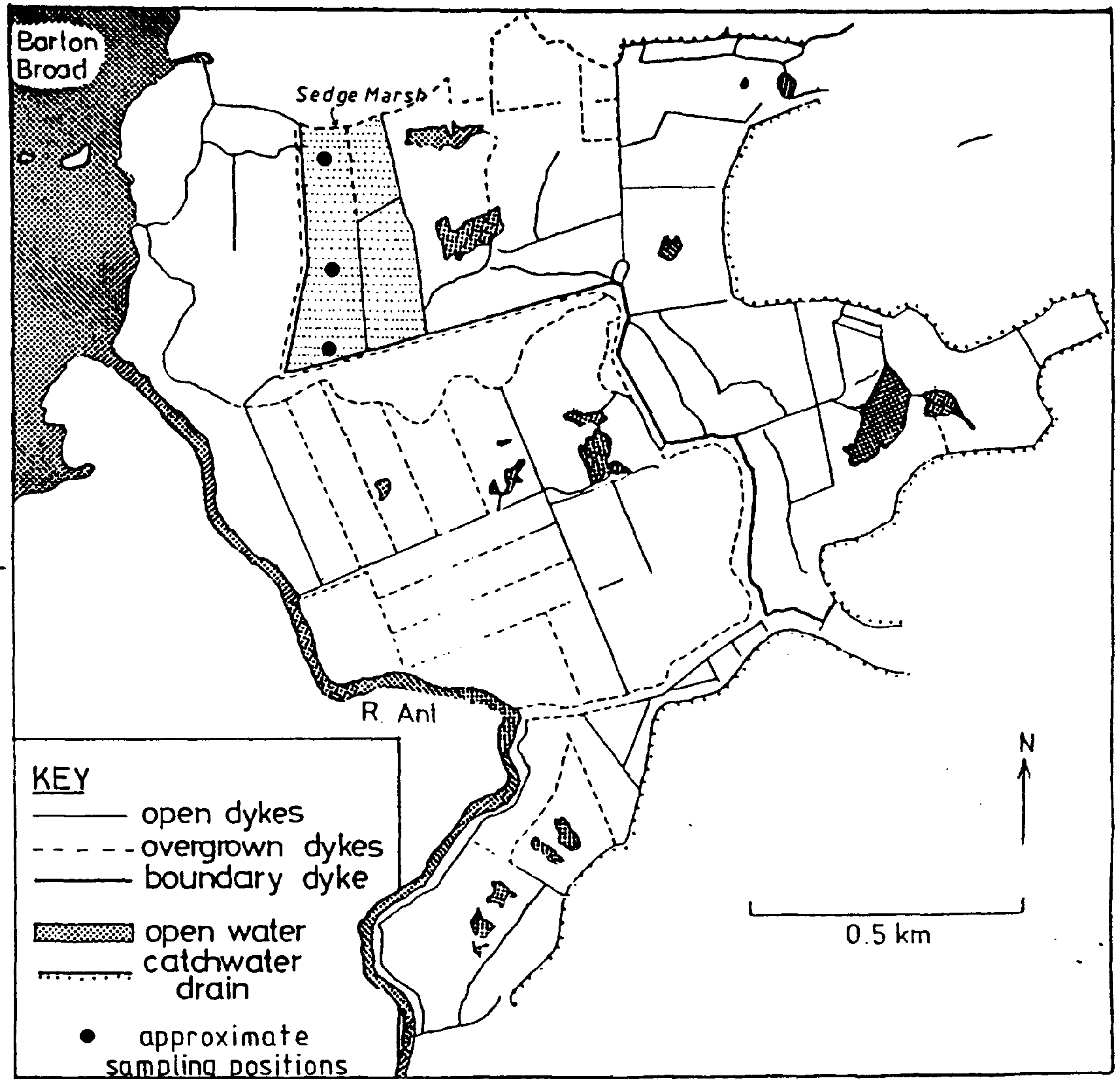
The upper peat deposits of the fen complex incorporate deposits laid down during a marine transgressive overlap episode c.1600-2000 years ago; the so-called "Romano-British Marine Transgression" (Coles and Funnell,1981). In many places the deposits take the form of a blue-grey estuarine

Fig. 3.1 Catfield and Irstead Fens.

showing sampling positions of Sedge Marsh cores.




The Ant Valley. showing parishes.



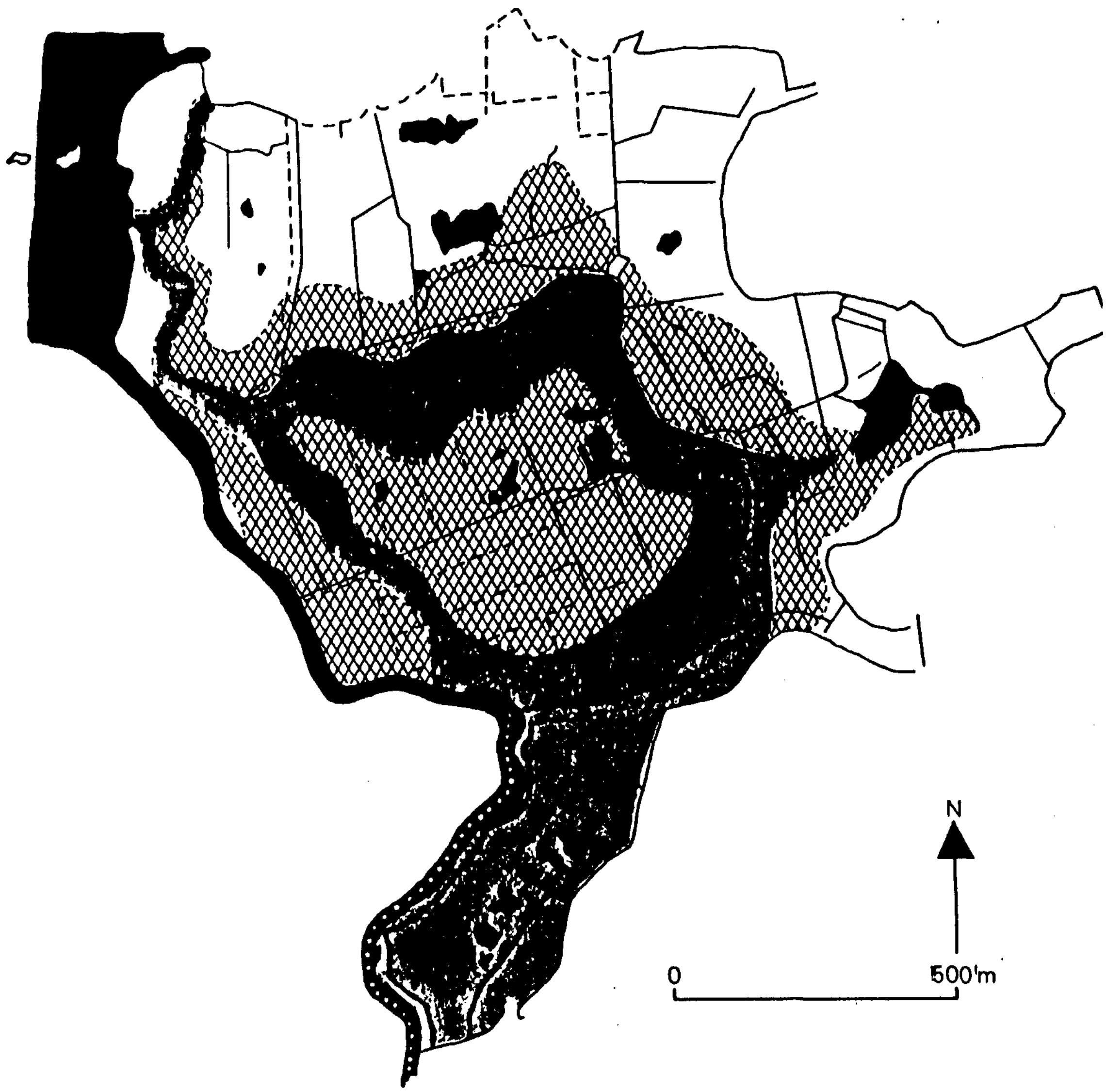
clay or a *Phragmites* clay (*sensu* Giller and Wheeler, 1986) containing organic material.

Such clays tend to be present at depths of around 80-180 cm below the surface although the levels vary. The approximate sub-surface distribution of these clays has been mapped by Giller and Wheeler (1986) who suggested that they are most prominent in the southern part of the complex while areas further north contain pure peat deposits (Fig. 3.2).

The site is divided by a network of dykes into a series of irregularly shaped compartments (Fig.3.3). These compartments have often tended to have had different individual ownerships and consequently land use histories frequently differ from compartment to compartment. This may in part explain the very diverse range of present day fen communities which now occupy the site (Giller, 1982).

There appear to be many reasons for the diverse nature of the vegetation but one of them is due to the shallow peat cutting which was carried out extensively in recent centuries (Fig.3.3). The cuttings produced shallow water areas known as "turf ponds" which allowed secondary hydroseral succession to take place. Because of a range of factors as yet incompletely understood, succession in these cuttings has led widely differing fen communities to occupy their surfaces (Giller, 1982; Giller and Wheeler, 1986).

The demand for turf appears to have been so great that relatively few compartments were left untouched by cutting. One of such area is Sedge Marsh, a rectilinear compartment




Cross-hatching represents organic *Phragmites* clay; grey area represents pure, blue-grey clay; unshaded areas represent uninterrupted peat deposits.

Fig. 3.2. Distribution of upper clay deposits (≈ 80 - 150 cm below peat surface) in the Catfield and Irstead fens. (After Giller and Wheeler, 1986.)

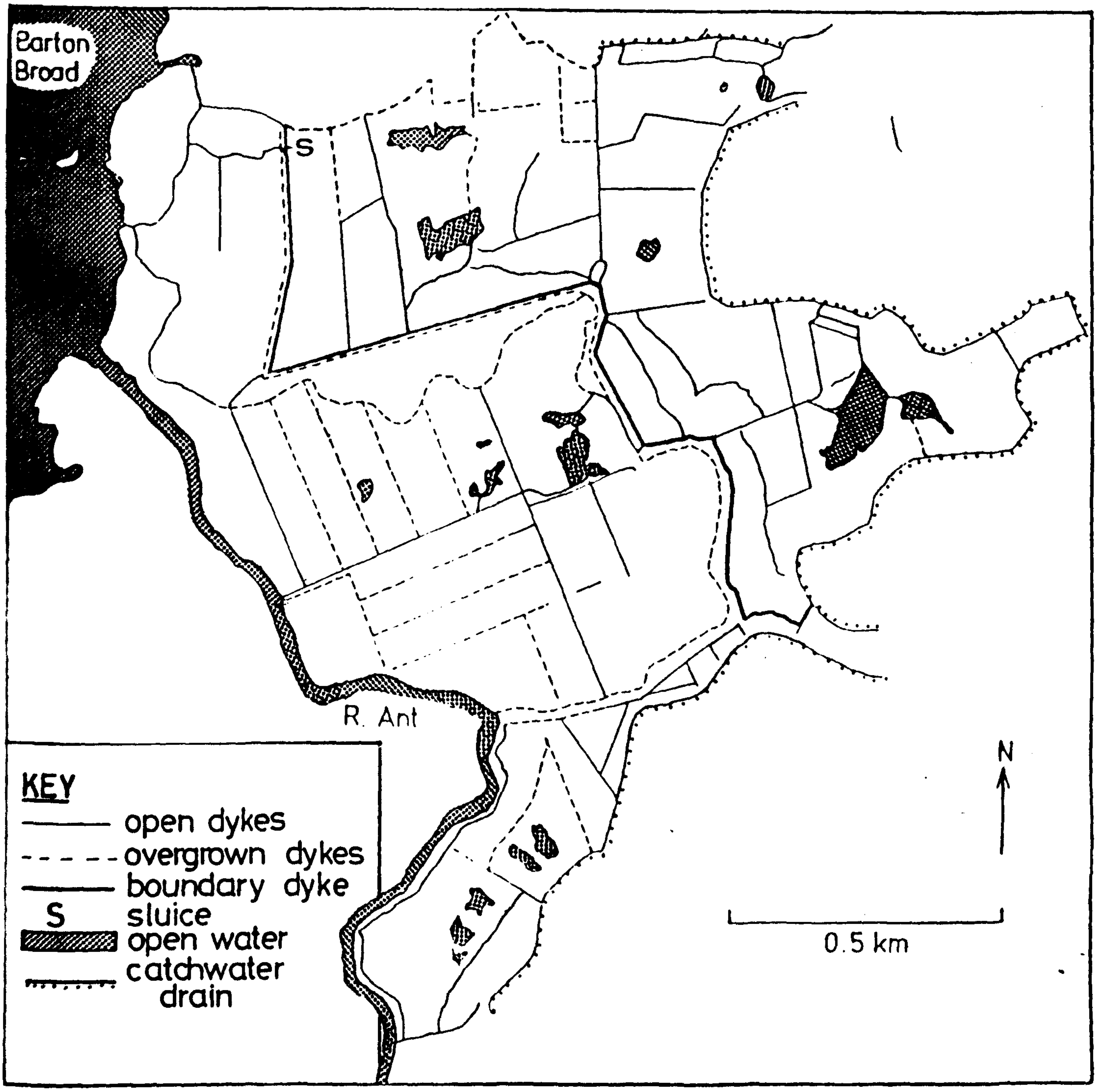



Fig. 3.3 Map showing distribution of dykes and fen compartment divisions within the Catfield and Irstead fens, Norfolk.

One of such area is Sedge Marsh, a rectilinear compartment in the north west sector of the Catfield and Irstead Fen complex which is flanked on three sides by former turf cuttings (Fig.4.1; Plate 1).

The undisturbed nature of the compartment was first identified from using evidence from old maps and stratigraphical observation (Giller, 1982.; Giller and Wheeler, 1986). The upper 60-80cm of the peat filling a former turf pond is usually relatively unconsolidated and generally fails to remain within the chamber of a coring device (this corresponds to the average depth of most historically recent cuttings in Broadland and is related to the length of the most commonly used peat spade of the time; the "becket"-Giller and Wheeler, 1986). The peat from the Sedge Marsh compartment is relatively consolidated up to the last 20-30cm or so indicating an unbroken sequence of deposition.

Part of Sedge Marsh has been affected by a small amount of cutting in the past in the form of a curious long linear cut which bisects it in a north-south direction. The feature seems to be the grown over remains of a former dyke which was dug possibly between 1838 and 1885. Its function remains unknown but it is thought possible that it may have been used as a water way along which to transport reeds or turf by boat (Giller, 1982).

Plate. 1. Panoramic view of northern section of Sedge Marsh, Catfield Fen, Norfolk. Photographs taken from approximate sampling position of core SM 2.

*3.1.2 Present day vegetation.*

The present day vegetation of Sedge Marsh is predominantly classified as the *schoenetosum* subassociation of the *Peucedano-Phragmitetum* community (Wheeler, 1980a).

This is dominated by *Cladium mariscus* and is characterised by the presence of *Molinia caerulea* and *Schoenus nigricans*. It may contain many other species and Sedge Marsh is considered to be one of the most species-rich examples of the type with 29 species recorded (Giller, 1982).

Northern, eastern and southern fringes of Sedge Marsh are occupied by communities classified as *Peucedano-Phragmitetum myricetosum*-a subassociation characterised by dense growth of *Myrica gale*.

**3.2 Reedham Marsh.**

Reedham Marsh is situated about 1.5km south of Sedge Marsh and forms part of the continuation of fen complexes bordering the River Ant which extends down to Turf Fen just to the south (Fig. 5.1). The River Ant forms its eastern border while the western one is met where the peat deposits abut the adjacent "upland" at Irstead Street. To the north lie further fens divided from the marsh by a WSW-ENE running dyke whilst to the south further dykes partition the site from Turf Fen. As with Catfield Fen, the course of the River Ant has been altered at some time in the past and once again the line of the Hundred Stream marks the old course.This takes a big bight through Reedham Marshes and closely follows the west side of the valley.

*3.2.1 Upper deposits.*

The whole of the valley occupied by the site is underlain by a thick deposit of estuarine clay. This is part of the same series of deposits including the clays and *Phragmites* clays mentioned at Catfield due to the marine incursion of c.1600-2000 B.P. The top of the clay varies in its depth below the surface,lying closest to it near to the hundred stream at about 80-90cm but lying deeper further away; typically 100-130 cm below the surface (Wheeler, 1983).

In the areas selected for study the clay is topped by a continuous column of solid peat representing an uncut surface. Over most of the surface, however, there is evidence for turf cutting down to a level of about 80cm (Wheeler, 1983).

*3.2.2 Present day vegetation.*

As at Catfield, the present day vegetation is composed of a complex mosaic of communities. These have yet to be described to the same degree of detail as those of the Catfield and Irstead fens but Wheeler (1983) records a transect across part of the marshes which he considered to be representative of the range of vegetation. This included *Phragmites-Typha* wet fen; *Phragmites-Juncus subnodulosus* fen

(*Peucedano-Phragmitetum typicum*); *Phragmites-Juncus* fen with some *Cladium*; managed *Phragmites-typicum* sedge beds and *Phragmites-Juncus* fen developed over probable former litter-fen (*Peucedano-Phragmitetum typicum*).

# CHAPTER 4: SEDGE MARSH.

## 4.1 Introduction and superficial stratigraphy.

The cores taken from Sedge Marsh were located in such a manner as to give a representative biostratigraphical view across the rectangular compartment of fen from which they were extracted (Fig. 3.1). The cores were taken from the section of the compartment lying to the west of the former dyke mentioned in 3.1.2 and were located in the northern, approximate central and southern sections of the fen at TG 367 203 (*Sedge Marsh 1*), TG 367 201 (*Sedge Marsh 2*) and TG 367 200 (*Sedge Marsh 3*). By spacing the cores in this way, it was intended to investigate an area thought to be developed over pure peat (SM1), an area over *Phragmites* clay (SM3) and an area estimated to be on the approximate boundary, or "feather edge" of the clay flange (SM2).

The broad stratigraphy of the upper deposits of the site had been previously investigated by Giller and Wheeler (1986). Their description was from a levelled transect across the Sedge Marsh from north to south (Fig.4.1) and showed a uniform *Cladium/Phragmites* peat extending from the surface down to about 1.6m-1.8m followed by *Phragmites* clays and more pure clays in the southern part of the fen from 1.6m-1.8m to about 1.9m-2.0m. Northwards, the *Phragmites* clay graded laterally into a layer of peat containing greasy, grey-green organic muds. They were present in decreasing amounts up to about 100cm.

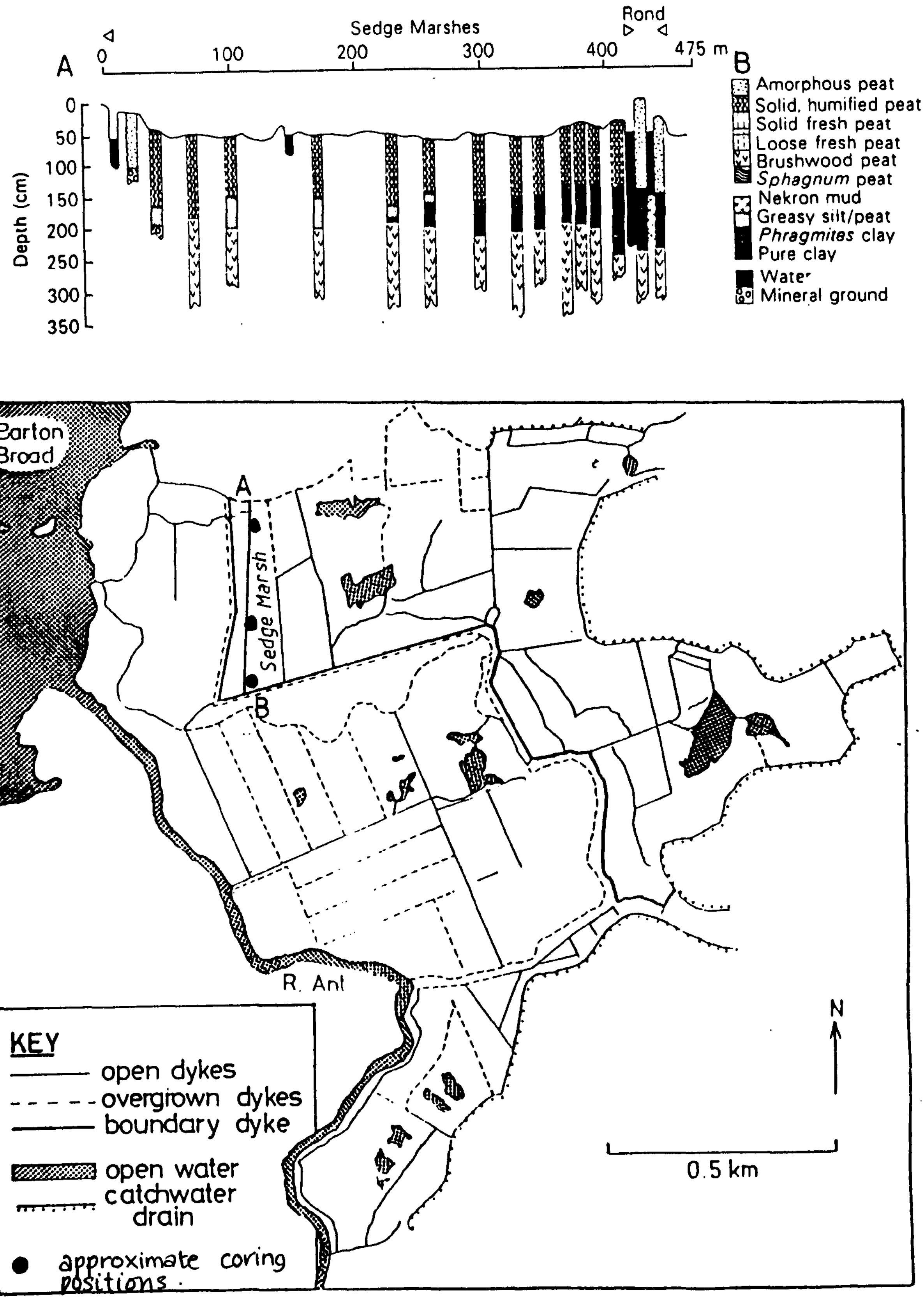



Fig. 4.1. Stratigraphical transect across Sedge Marsh, Catfield and Irstead Fens. (After Giller and Wheeler, 1986).

Below this was brushwood peat. In broad terms the superficial stratigraphy of the cores from the present study exhibited similar features.

Sedge Marsh 1 (SM1) was largely composed of *Cladium/Phragmites* peat down to 90cm but there was a noticeable change from fresh, slightly humified peat to a more humified variety at 30cm. From 90-148cm a greasy *Phragmites*/organic mud was recorded followed by a return to a *Phragmites/Cladium* peat to 212cm.

A thin band of brushwood peat occurred at 212-218cm followed by more *Phragmites/Cladium* peat below this.

Sedge Marsh 2 (SM2) displayed the same humification change in the *Phragmites/Cladium* peat at around 30cm but the greasy *Phragmites*/organic mud episode appeared to extend down to 168cm. A *Phragmites/Cladium* peat followed this down to 200cm when the core ended with brushwood peat.

Sedge Marsh 3 (SM3) showed a humification change at 20cm and contained a *Phragmites/Cladium* peat down to 130cm. From 129cm -213cm was a clay, the upper 10cm of which contained a high proportion of plant material while the remainder was more pure.This was underlain by brushwood peat below 213cm.

By means of macrofossil analysis it was hoped to discover the meaning of these boundary changes in terms of past plant communities. In addition it appeared that Sedge Marsh lay on the fringe of the marine influence caused by the "Romano-British" Trangressive Overlap dated to around

1600-2000 B.P. (Coles and Funnell, 1981). The change from clay deposits at the southern end through to more organic mud deposits from similar stratigraphic levels represented a gradation of influence of that trangression across the site (Giller and Wheeler, 1986). With this in mind the foraminifera of the deposits from the appropriate levels were looked at in an attempt to quantify this gradation in a little more detail. Unfortunately the results are unavailable for inclusion in this thesis but a summary of some provisional findings is presented in Appendix B.

The diatom assemblages were also analysed from two of the sites at each end of the fen (SM1 and SM3). This aspect of the investigation is explored in chapter 6.

Finally, samples of peat were taken from the Series "B" cores from SM1 and SM3 and radiocarbon dated to test the synchroneity of the stratigraphic boundaries and to attempt to construct a chronology for the events represented by the deposits.

## 4.2 The Zoning of the Macrofossil Diagrams.

### *4.2.1 SM1 (Fig.4.2)*

**Zone A (220 - 130 cm)**

*Description:* Characterised by a large peak in *Juncus subnodulosus* seeds at 170-180cm and the constantly high numbers of seeds of *Schoenoplectus lacustris* from 180-130cm. The zone is notable for the occurrence of macrofossils from

Fig. 4.2. Sedge Marsh One
Catfield Fen, Norfolk.

# MACROFOSSIL DIAGRAM

tree and shrub species such as *Alnus glutinosa, Salix sp.* and wood fragments.

*Carex paniculata* seeds are present throughout as are the vegetative remains of *Cladium mariscus* and *Phragmites australis.* A number of species are represented by relatively low numbers of seeds scattered at various levels within the phase and include *Carex pseudocyperus, C.diandra, C.elata, C.panicea, Ranunculus sp., Glyceria maxima, Hydrocotyle vulgaris* and *Oenanthe aquatica.* Some species are represented by low numbers of seeds at or around the 70-180cm level including *Cirsium palustre, Rumex hydrolapathum, Galium palustre, Mentha aquatica* and *Senecio sp.* The upper part of the phase is marked by the occurrence of relatively large numbers of *Cladium mariscus* seeds along with the occurrence of *Chara sp.* (oospores), seeds of *Carex acutiformis, Carex rostrata, C.riparia, Eleocharis palustris, Sagittaria sagittifolia, Menyanthes trifoliata, Typha latifolia* and the remains of *Scorpidium scorpioides.*

*Contacts:* The lower boundary is the base of the core and the upper follows the decrease in macrofossils of *Cladium mariscus, Juncus subnodulosus, Schoenoplectus lacustris and Chara sp.*

*Radiocarbon Age:* -95 to 100 Cal.AD (68% probability); -200 to 200 Cal.AD (95% probability).

*Interpretation:* The assemblage initially represents a facies of vegetation indicating a drier environment than those which follow it. The presence of wood fragments and macrofossils from tree species together with the constant presence of seeds of *Carex paniculata*, suggest that initially a possible swamp carr community may have existed nearby. The appearance of macrofossils from species such as *Schoenoplectus lacustris*, *Chara*, *Menyanthes*, *Carex rostrata* etc., suggests that this community began to be replaced by a vegetation reflecting anincrease in the overall wetness of the site in the last stages of the phase around 140-130cm.

**Zone B (130 - 90 cm)**

*Description:* The phase is distinguished by the large numbers of foraminifera present along with *Scirpus maritimus* and *Juncus gerardii*. Glumes of *Phragmites australis* are present as are seeds of *Atriplex patula*, *Zannichellia* sp. and *Rumex longifolius*. There are scattered occurrences of seeds belonging to *Carex elata* and *Eleocharis palustris*. *Betula pubescens* seeds are found in small quantity at the beginning and end of the phase. *Cladium mariscus* and Phragmites australis vegetative remains are also present.

*Contacts:* The lower boundary is placed where the the numbers of macrofossils of *Juncus gerardii* and foraminifera begin to increase and the upper boundary is marked by the sudden decrease in these and also seeds of *Scirpus maritimus*,

*Radiocarbon Age:* 125 to 320 Cal.AD (68% probability); 80 to 405 Cal.AD (95% probability).

*Interpretation:* The phase appears to show an episode of marine influence with the macrofossil assemblage representing a community indicative of very brackish conditions. The zone probably represents the development of upper salt marsh as *Juncus gerardii* and *Scirpus maritimus* are often prominant members of the later stages of salt marsh succession (Chapman, 1976). The presence of seeds of the nitrophile *Atriplex patula*, may indicate the former existence of a nearby driftline.

**Zone C (90 - 80 cm).**

*Description:* This phase, although short, is notable for the sudden increase or appearance of seeds belonging to *Alnus glutinosa, Betula pubescens* and *Carex paniculata*, along with wood and *Salix* leaf fragments. Other species represented include *Cladium mariscus, Phragmites australis, Stellaria sp., Galium palustre, Mentha aquatica, Hydrocotyle vulgaris, Eleocharis palustris, Carex pseudocyperus, C.rostrata* and *Chara sp.*

*Contacts:* The boundaries follow brief rise and decline of macrofossils of *Carex paniculata, Alnus glutinosa, Betula pubescens and Stellaria sp.*

*Radiocarbon Age:* 980 to 1050 Cal.AD (68% probability); 885 to 1225 Cal.AD (95% probability).

*Interpretation:* The assemblage seems to indicate that drier conditions became established fairly rapidly after the preceding trangressive episode. The presence of wood fragments together with macroremains of tree species and *Carex paniculata* indicate that some form of *Carex paniculata* tussock fen (*sensu* Lambert, 1951[Jennings and Lambert, 1951]) and carr may have become established nearby for a short period. The occurrence of aquatic species might be accounted for by the presence of secondary pools developed between Carex paniculata stools (Lambert, 1965; Wheeler, 1978).

**Zone D (80 - 40 cm)**

*Description:* Marked by a large increase in the macrofossils of aquatics such as oospores of *Chara sp.*, seeds of *Eleocharis palustris, Potamogeton sp., Carex rostrata, C.elata* and *C.riparia.* The first part exhibits peaks of seed numbers of *Carex pseudocyperus, C.acutiformis, C.diandra, Sagittaria sagittifolia, Hydrocharis morsus-ranae, Ranunculus (Batrachium) sp.* and *Menyanthes trifoliata.*

Remains of *Scorpidium scorpioides* are present throughout the phase as are vegetative remains of *Phragmites australis* and *Cladium mariscus.* The seeds of the latter are present from all levels save 50-40cm. Seeds of other species occurring sparingly include *Typha sp.* and *Hydrocotyle vulgaris.*

*Contacts:* The lower boundary is taken at the increase in macrofossils of *Chara sp., Eleocharis palustris, Potamogeton sp.* and *Scorpidium scorpioides.* The upper follows the decline seen in the same species.

*Interpretation:* The presence of large numbers of oospores belonging to *Chara sp.* together with the appearance of relatively large numbers of seeds belonging to species characteristic of wet fen or swamp conditions such as *Potamogeton sp.,Eleocharis palustris, Carex rostrata,* etc., all indicate an abrupt shift to much wetter conditions with areas of open water after the relatively dry episode which appears to have preceded it. The boundary between zones C and D at 80cm is particularly marked and may suggest a very rapid alteration in the conditions inducing the corresponding vegetation change.

**Zone E (30 - 0 cm)**

*Description:* There are large increases in numbers of seeds of *Cladium mariscus, Juncus subnodulosus, Betula pubescens* and the vegetative remains of *Phragmites australis,* together with seeds of *Molinia cærulea, Glyceria maxima, Carex elata* and the glumes from *Calamagrostis sp.* as well as leaf fragments of *Myrica gale.* Seeds of other species present include *Carex rostrata, C.riparia, Hydrocotyle vulgaris* along with remains of *Scorpidium scorpioides.*

*Contacts:* The lower boundary is placed at the decline of macrofossils belonging to the aquatics of the previous zone and at the first stages in the increase in macrofossils of *Cladium mariscus* and *Juncus subnodulosus.* The upper boundary is the top of the core.

*Interpretation:* The assemblage reflects the *Cladium mariscus/Phragmites australis* dominated vegetation of the present day with a prominent *Juncus subnodulosus* representation.

*4.2.2 SM2 (Fig. 4.3).*

**Zone A (200 - 160 cm).**

*Description:* Macrofossils of *Carex paniculata* are prominent together with smaller numbers belonging to *Myrica gale, Juncus subnodulosus, Carex acutiformis, Hydrocotyle vulgaris, Betula pubescens, Lychnis flos-cuculi, Lycopus europaeus* and *Rumex longifolius.* Vegetative remains of *Cladium mariscus* and *Phragmites australis* are present throughout the zone as are wood fragments. The end of the zone witnesses a rise in the numbers of *Eupatorium cannabinum* seeds and the appearance of relatively small numbers of foraminifera.

*Contacts:* The lower boundary is the base of the core. The upper is placed at the sudden decline in macrofossils belonging to *Carex paniculata* and *Juncus subnodulosus.*

*Interpretation:* Remains representing a community indicating relatively dry conditions. The presence of wood fragments, seeds of tree and shrub species and of *Carex paniculata* suggest the possibility of some kind of *C.paniculata* "tussock" fen with some carr development.

Fig. 4.3.
Sedge Marsh Two.
Catfield Fen, Norfolk.

# MACROFOSSIL DIAGRAM

**Zone B (160 - 100 cm).**

*Description:* Marked by the occurrence of very large numbers of foraminifera along with constant representation of seeds of *Juncus gerardii and Atriplex patula. Scirpus maritimus* seeds are also well represented and there are smaller numbers of seeds belonging to *Glaux maritima, Sparganium sp.,Typha latifolia, Potamogeton sp., Carex riparia, Eleocharis palustris, Betula pubescens, Carex paniculata, Myrica gale, Juncus subnodulosus* and *Cladium mariscus.*

Remains of *Drepanocladus aduncus* and *Scorpidium scorpioides* are also present as are *Chara sp.*(oospores), leaf fragments from *Salix sp.* and some wood fragments. The initial section of the zone contains occurrences of seeds of *Eupatorium cannabinum, Rumex hydrolapathum, Apium graveolens* and *Ranunculus sceleratus.* Vegetative remains of *Carex paniculata* and *Phragmites australis* are present throughout.

*Contacts:* The lower boundary is placed at the point where numbers of foraminifera begin to increase dramatically together with the rise in macrofossil numbers due to *Juncus gerardii, Atriplex patula* and *Schoenoplectus tabernaemontani.* The upper boundary is placed where remains of these organisms decline.

*Interpretation:* The most prominent macrofossil contributors in this zone point to brackish conditions with indications of upper saltmarsh development in the vicinity (e.g.*Juncus gerardii, Glaux maritima*). The occurrence (although in low numbers) of macrofossils of many species indicative of freshwater and more terrestrial conditions (e.g. *Myrica gale*, *Salix sp.*, wood fragments, *Carex paniculata*) might indicate the localised nature of marine influence in the area with contributions from a mosaic of brackish and freshwater communities forming the macrofossil assemblage. This lends support to the idea that the Catfield and Irstead fens were situated at the limit of the extension of estuarine influence during the transgressive episode (Giller and Wheeler, 1986).

**Zone C (100 - 60 cm)**

*Description:* Foraminifera and *Juncus gerardii* decline and disappear to be replaced by a rapid rise in *Myrica gale*, *Juncus subnodulosus*, *Carex paniculata* and *Typha latifolia*. Also present are glumes of *Calamagrostis sp.*, seeds of *Betula pubescens*, *Lychnis flos-cuculi*, *Rumex longifolius*, *Chenopodium sp.* and *Mentha aquatica*. Wood fragments are present frequently and the upper stages of the zone are marked by the appearance of small numbers of seeds of *Lycopus europaeus*, *Potamogeton sp.*, *Eleocharis palustris*, *Hydrocotyle vulgaris* and *Ranunculus(Batrachium)sp.* Remains of *Scorpidium scorpioides* are present from one of the samples in the zone. *Cladium mariscus* and *Phragmites australis* vegetative remains are both present throughout.

*Contacts:* The lower boundary is placed at the rise in macrofossils of *Myrica gale* and *Juncus subnodulosus*. The upper boundary occurs where *Myrica gale* declines and the seeds of aquatic species start to rise.

*Interpretation:* The zone signifies the resumption of freshwater conditions. The prominence of *Myrica gale* seeds suggests extensive shrub colonisation pointing to a degree of dryness of the surface. The presence of wood fragments and seeds of *Betula pubescens* supports this interpretation. The appearance in the upper portion of the zone of Carex paniculata along with species suggestive of wetter conditions (*Eleocharis palustris, Potamogeton sp.* etc.) might indicate a gradual moistening of conditions during the later phases of the zone.

**Zone D (60 - 40 cm)**

*Description:* A sudden appearance of oospores of Chara sp. along with seeds of *Schoenoplectus lacustris, Carex rostrata, Carex acutiformis, Anagallis sp., Cladium mariscus* and *Mentha aquatica.* Seeds of *Eleocharis palustris* rise briefly and *Carex riparia* seeds are present in the last section of the zone. The initial portion exhibits seeds of *Carex paniculata* before their disappearance and also present in small quantities are *Salix sp.* leaf fragments, glumes of *Calamagrostis sp.*, wood fragments and remains of *Drepanocladus aduncus.* Seeds belonging to *Juncus subnodulosus* gradually increase in small numbers through the zone and the vegetative remains of *Cladium mariscus* and *Phragmites australis* are present throughout.

*Contacts:* The lower and upper boundaries follow the respective appearance and disappearance or decline of *Chara sp.*(oospores), *Schoenoplectus lacustris* and *Carex rostrata*.
*Interpretation:* Open water communities appear and indicate a marked shift in conditions from the previous relatively dry episode.

**Zone E (40 - 0 cm)**

*Description:* Numbers of seeds of *Cladium mariscus* and *Juncus subnodulosus* rise markedly and seeds of *Myrica gale* and *Betula pubescens* reappear. Wood fragments and *Carex riparia* seeds are present in the middle part of the zone and *Carex paniculata* appears in the first half. The initial stages display low numbers of seeds belonging to *Hydrocotyle vulgaris* and *Carex rostrata* together with the presence of remains from *Scorpidium scorpioides*. Remains of *Drepanocladus aduncus* are scattered through most of the zone whilst vegetative remains of *Cladium mariscus* and *Phragmites australis* are plentiful.
*Contacts:* The lower boundary is taken where the rise in *Cladium mariscus* and *Betula pubescens* seeds begins and the upper is the top of the core.
*Interpretation:* A *Cladium mariscus/Phragmites australis* dominated vegetation with significant tree/shrub component corresponding to present day communities at the site.

*4.2.3 SM3 (Fig. 4.4)*

**Zone A (220 - 210 cm)**

*Description:* Composed almost completely from wood fragments.
*Contacts:* The lower boundary is the base of the core whilst the upper is placed where there is a sudden rise in macrofossils of *Juncus gerardii, Glaux maritima* and foraminifera.
*Radiocarbon Age:* (for end of zone); -20 to 95 Cal.AD (68 % probability); -50 to 110 Cal.AD (95 % probability).
*Interpretation:* A brushwood peat indicating extensive carr development.

**Zone B (210 - 140 cm)**

*Description:* Seeds of *Juncus gerardii, Glaux maritima* and foraminifera are prominent. Also present in smaller numbers are seeds of *Apium graveolens, Oenanthe aquatica, Myriophyllum sp., Ranunculus sceleratus, Alnus glutinosa* and *Carex paniculata.* Vegetative remains of *Cladium mariscus* and *Phragmites australis* are present throughout.
*Contacts:* The lower boundary is taken with the rise in foraminifera and the upper one follows the decline of these and the disappearance of *Juncus gerardii.*
*Radiocarbon Age:* 5 -225 Cal.AD (68 % probability); -95 to 370 Cal.AD (95% probability).
*Interpretation:* An assemblage indicating brackish water conditions. The presence at low level of macrofossils belonging to species of predominantly freshwater habit

Fig 4.4.
Sedge Marsh Three.
Catfield Fen, Norfolk.

# MACROFOSSIL DIAGRAM


Analysis: C.E. Wells
1985-6.

suggests again the possibility of localised mosaics of fresh and brackish water habitat during this episode or perhaps the rapid swamping of preceding freshwater communities (see *4.1.2*, zone B). A possible driftline is indicated again by the presence of seeds of *Atriplex patula.*

**Zone C (140 - 70 cm)**

*Description:* Sudden appearance and prominent representation of macrofossils of *Juncus subnodulosus, Carex paniculata, Alnus glutinosa, Rubus idaeus* and *Betula pubescens. Salix* sp. leaf fragments are also present initially as are wood fragments. *Ranunculus sceleratus* and *Mentha aquatica* seeds are also present in significant numbers. Scattered through the zone are sporadic occurrences of seeds of several species in small numbers including *Stellaria palustris, Galium palustre, Potamogeton pusillus, Apium sp.,Carex riparia, Chara sp.,* (oospores), *Eleocharis palustris, Potamogeton sp.,Carex acutiformis, Apium graveolens, Lycopus europaeus, Hydrocotyle vulgaris, Myriophyllum sp.* and *Sium latifolium.* Vegetative remains of *Cladium mariscus* and *Phragmites australis* are present throughout.

*Contacts:* The lower boundary is taken at the appearance and rise in macrofossils of *Juncus subnodulosus, Carex paniculata, Alnus glutinosa and Rubus idaeus.* The upper boundary is placed where these disappear or decline.

*Radiocarbon Age:* 1015 - 1085 Cal.AD (68% probability); 995 - 1165 Cal.AD (95% probability).

*Interpretation:* An assemblage indicating the predominance of relatively dry,freshwater conditions. The presence of macrofossils from tree species along with the prominent representation of seeds from *Carex paniculata* suggest some form of shrubby "tussock fen" (*sensu* Lambert,1951) to have been present. The prominance of seeds of *Alnus glutinosa* and *Carex paniculata* together with the presence of *Salix sp.* leaf fragments are suggestive of the present day *Alnus glutinosa-Carex paniculata* Community, a seral stage in the development of swamp carr from open tussock fen of which these species are the characterising taxa.

*Rubus idaeus*, however, is more more characteristic at the present day in better developed carr communities, particularly those of *Betula pubescens* and *Myrica gale* (Wheeler, 1978). These are often communities of birch "islands" or scrubbing- up fen. From these indicators,it is clear that the episode represented by the macrofossil assemblage was one of drier conditions than had appertained previously leading to increasing terrestrialisation of the site.

**Zone D (70 -30 cm)**

*Description:* A sudden increase in the numbers of oospores of *Chara sp.*, seeds of *Eleocharis palustris, Potamogeton sp., Carex acutiformis* and *Schoenoplectus lacustris.* Also appearing in smaller amounts are the seeds of *Menyanthes trifoliata* and the remains of *Scorpidium scorpioides* and present in small quantity are seeds of *Lycopus europaeus, Myriophyllum sp., Alnus glutinosa* and *Rubus idaeus.* Vegetative remains of *Cladium mariscus* and *Phragmites australis* are present throughout as are seeds of *Juncus subnodulosus* at a slightly reduced level than in the preceding zone. Towards the end of the zone seeds of *Cladium mariscus* begin to rise and those of *Carex paniculata* and *Betula pubescens* reappear.

*Contacts:* The lower boundary is formed by the dramatic rise in oospores of *Chara sp.*, the seeds of *Eleocharis palustris,Carex acutiformis and Potamogeton sp.*The upper boundary is placed where these species decline.

*Radiocarbon Age:* 1250 - 1270 Cal.AD (68% probability);1225 - 1340 Cal.AD (95% probability).

*Interpretation:* The drier conditions of the preceding zone appear to end abruptly and are replaced by an assemblage indicating the presence of aquatic communities with much open water.

**Zone E (30 - 0 cm)**

*Description: Chara sp.* oospores decline to insignificant numbers, the seeds of *Cladium mariscus* rise and there is the appearance or reappeaance of several species including *Myrica gale, Molinia caerulea, Carex panicea, Hydrocotyle vulgaris, Epilobium hirsutum and Lycopus europaeus. Betula pubescens* seeds are present intermittently along with those of *Juncus subnodulosus* and the vegetative remains of *Cladium mariscus* and *Phragmites australis* are both plentiful.

*Contacts:* The lower boundary is taken where the *Chara* declines and the group of species previously unrecorded begins to occur. The upper boundary is formed by the top of the core.

*Interpretation:* The increase in vegetative remains of Cladium mariscus and *Phragmites australis* together with the rise in seeds of the former suggest a vegetation with these plants as dominants. The remainder of the species complement does not conflict with an interpretation of the assemblage as representing a community similar to that found at the site currently.

**4.3 Comparison of biostratigraphy between the sites.**

All three sites exhibit evidence of five significant macrofossil zones which indicate major changes in environmental pressures, namely; a fen carr community (Zone A); a saltmarsh/brackish water community, (Zone B); a "tussock" fen/carr community (Zone C); a community indicating very wet/open water conditions (Zone D) and a community similar to that of the present day managed vegetation (Zone E).

The macrossil complement varies between them to a greater or lesser degree but in each case it tends to point to similar episodes in terms of environmental conditions such as relative wetness of the surface and water quality.

GreatRex (1983) has shown that due to the dispersal characteristics of many fen plant seeds, reconstructions of past plant communities from the assemblages in a single sample may apply only to the immediate vicinity of that sampling point. The coincidence of the zones from widely spaced cores can therefore be taken to confirm the widespread nature of the episodes across the Catfield site as a whole.

Most of the zones are similar with regard to the depth at which they occur to within about 10-20cm but there are several exceptions to this.

Particularly noticeable differences exist in the length and position of Zone C between the three sites. In SM1 it occurs between 80 and 90 cm; in SM2 it isfound between 60 and 110 cm, and in SM3 between 70 and 140 cm. There is thus a difference in length of 10 and 70 cm between the shortest and longest sections in which the episode is recorded. It is possible that the apparent compression in SM1 may be due to compaction of sections of the upper core material during sampling. As noted in chapter two, compaction of peat may occur when using a piston sampler due to compression forces particularly when peat is forced against a relatively inelastic sediment such as clay. The initial drive to collect the upper section of core in SM1 incorporated a major portion of the level containing a deposit recorded as an organic deposit which, although not a clay, had a greasy clay-like texture and was comparatively inelastic.

Cores from the two other sites were able to be collected without crossing the equivalent stratigraphical boundary with the initial (upper) drive and as a result any compaction effect appears to have been obviated. If the compression of the zone in SM1 is in fact a function of compaction, it appears to have been restricted to that particular zone as those above do not display such a feature.

It may be that the nature of the peat formed during this apparently wetter phase of the site is more prone to compaction perhaps because of greater water content.

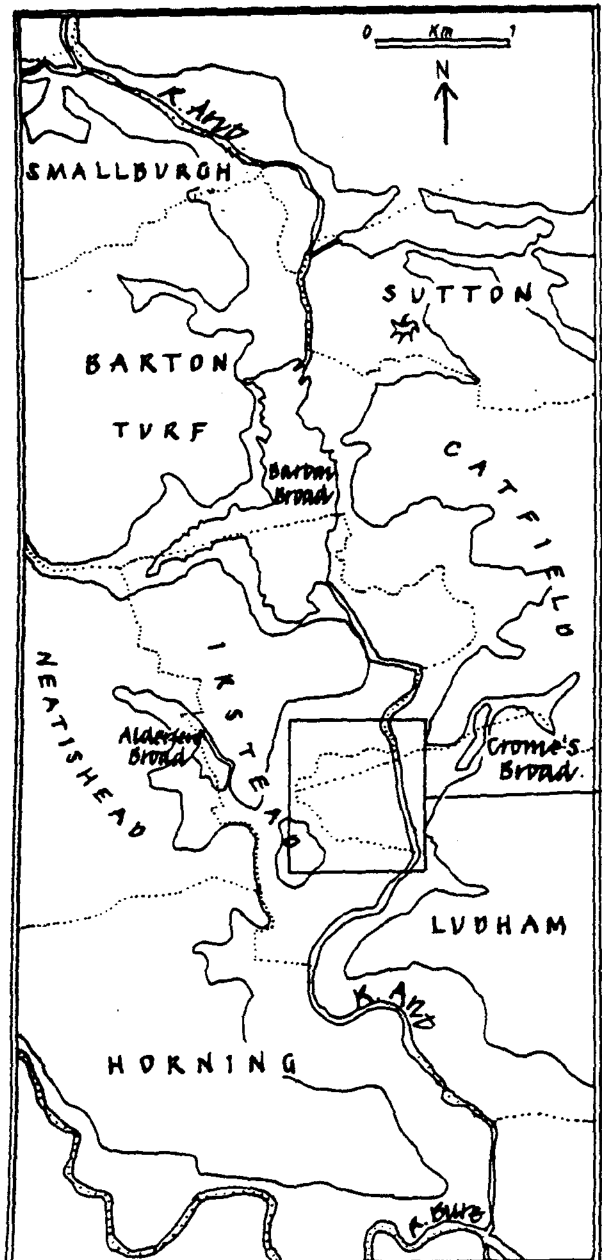
A feature of note is the presence of upper saltmarsh communities recorded from SM1B and SM2B. In both these cases the gross stratigraphy shows little indication of such development save for the presence of a greasy *Phragmites/Cladium* peat occupying the same levels. A definite clay component more characteristic of such sediments appears to be absent although the macrofossil complement seems to suggest an estuarine environment and loss-on-ignition values show notable reductions in samples from the corresponding levels (see Appendix A, 1.6 and Fig. A3). It may be that these deposits, characterised by Giller and Wheeler (1986) as a, "greasy, grey-green organic mud", are better thought of as highly organic estuarine mud deposits as the areas in which they occur still seem to have been subject to considerable marine influence.

# CHAPTER 5; REEDHAM MARSH

## 5.1 Introduction and superficial stratigraphy.

Two cores were taken from Reedham Marsh. The easternmost is referred to as the "Reedham" core while the easternmost is named the "How Hill" core as it lies on the side of the marsh just across the river from the HowHill Estate (Fig. 5.1). In order to place the cores in their general stratigraphical context, a transect across the marsh from the river on the west to the upland at the eastern side was taken using a Hiller borer to describe the gross stratigraphy (Fig. 5.2). Following the example of Giller and Wheeler (1986) at Sedge Marsh, the present transect was levelled relative to the depth of standing water at a time when most of the area was continuously flooded.

The investigation showed the site to be underlain completely by a pure blue-grey clay deposit with its upper boundary occurring at varying depths ranging from c.60 cm to c.80 cm. Lying above this in many places was a *Phragmites* clay whose upper surface varied in its position from c.50 cm to 60 cm. Above this the deposits tended to vary, with some cores displaying a woody peat, others a *Phragmites* silt and some amorphous *Phragmites* peat. The upper boundary of this episode generally occurred around 40cm below the peat surface. Above this was commonly found




The Ant Valley . showing parishes .

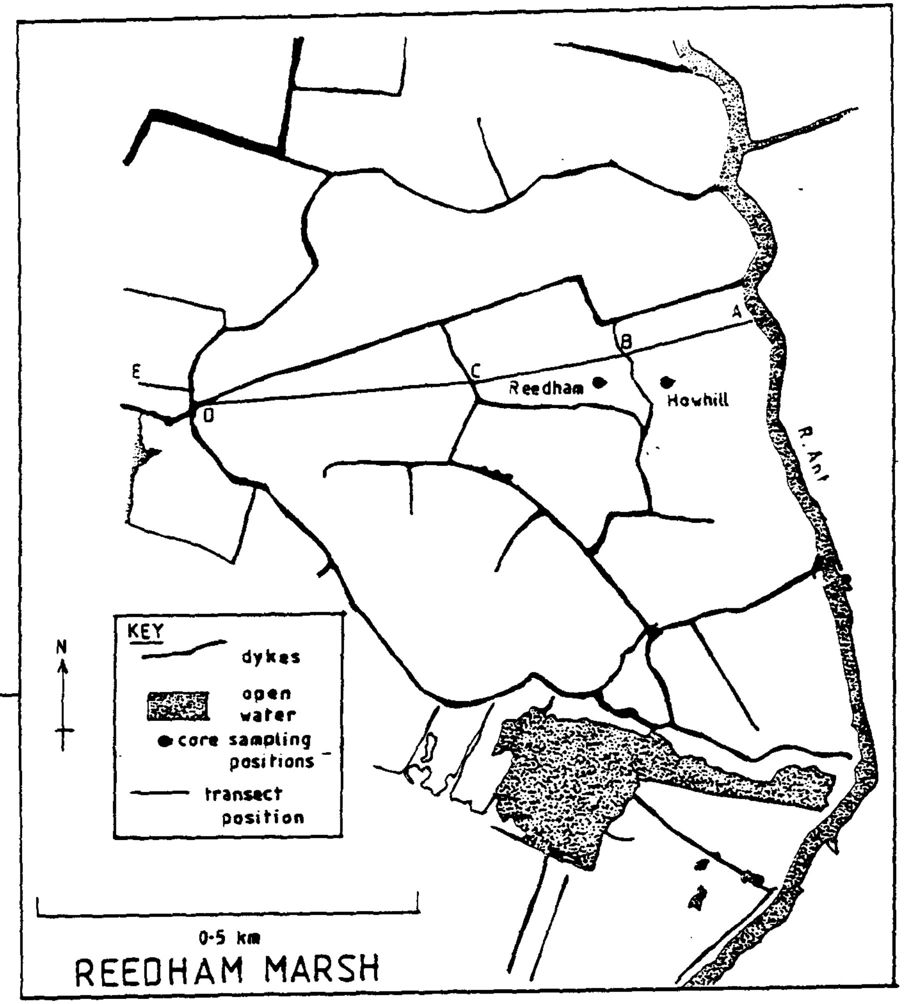
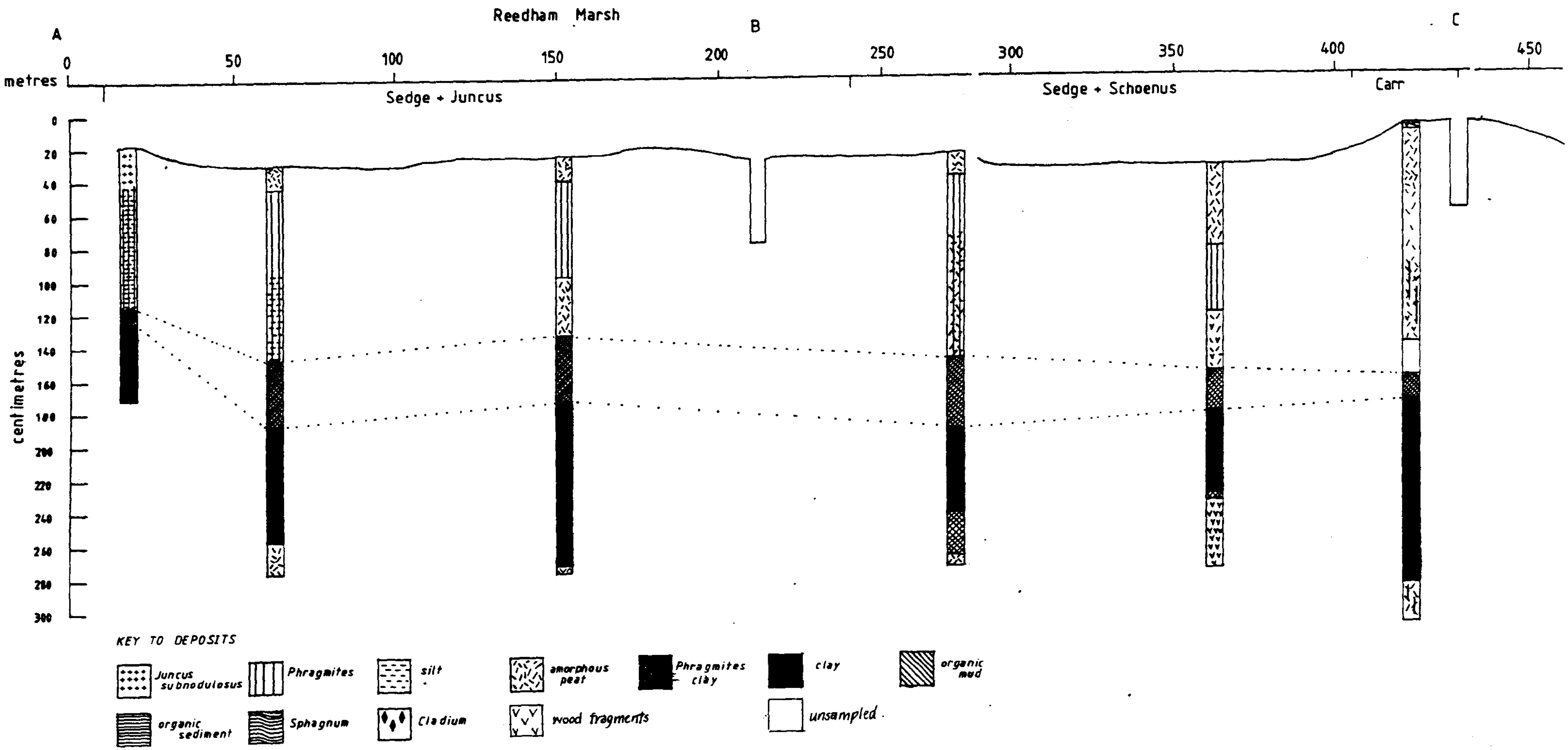



Fig 5.1. Location of Reedham Marsh showing positions of stratigraphical transect (A–E) and macrofossil core sample points .

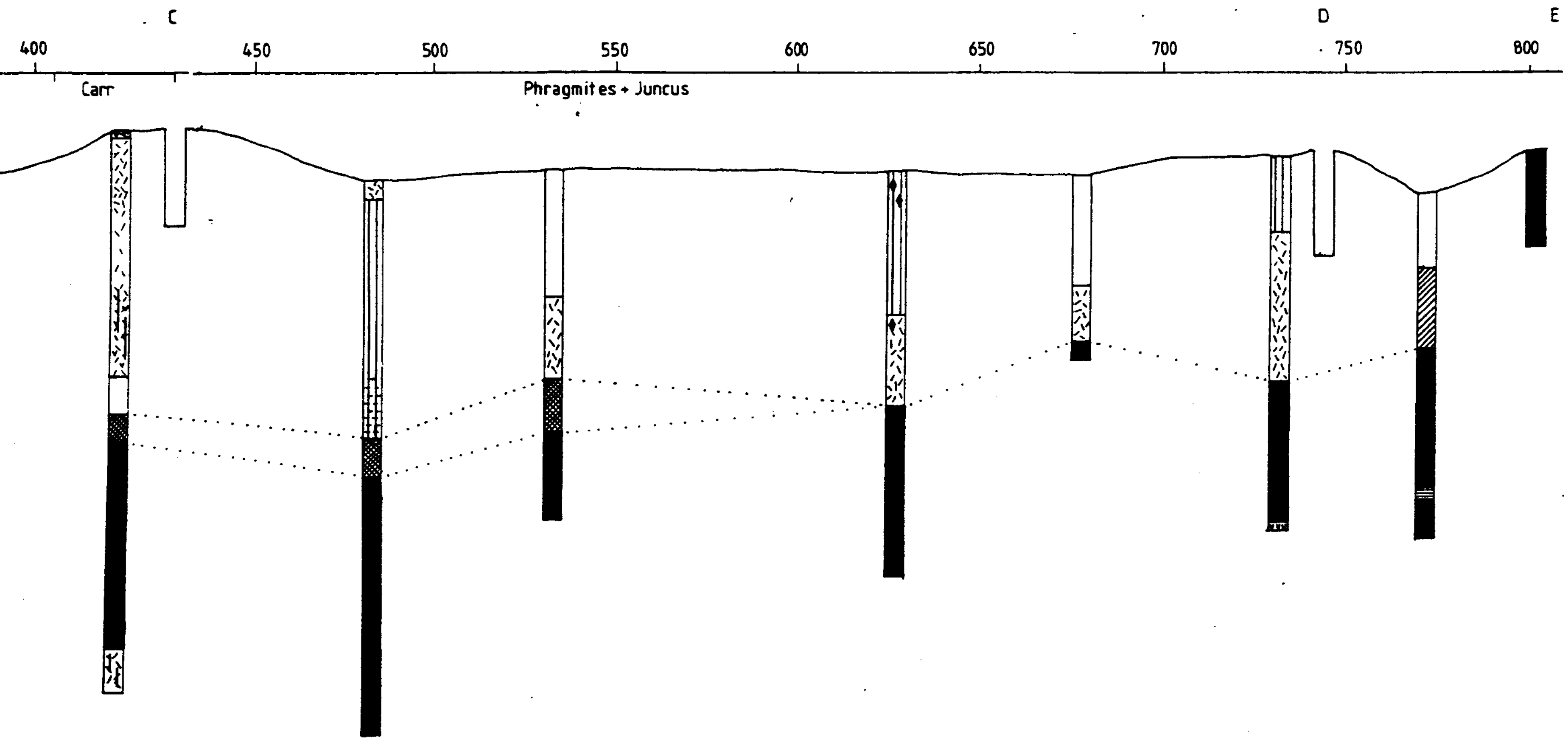
**Fig. 5.2a, b.**
Stratigraphical transect across Reedham Marshes.

FIG. 5.2a



Reedham Marsh
A
B
C
0
50
100
150
200
250
300
350
400
450
metres
Sedge + Juncus
Sedge + Schoenus
Carr
centimetres
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
KEY TO DEPOSITS
Juncus subnodulosus
Phragmites
silt
amorphous peat
Phragmites clay
clay
organic mud
organic sediment
Sphagnum
Cladium
wood fragments
unsampled

FIG. 5.2 b


C
D
E
400
450
500
550
600
650
700
750
800
Carr
Phragmites + Juncus

a *Phragmites* peat which continued almost to the peat surface in many cases. The upper 10 cm was generally composed of a dark brown humified peat.

The How Hill core exhibited a gross stratigraphy similar to the foregoing generalised transect description. A relatively unhumified *Phragmites australis/Cladium mariscus* peat was present from the surface down to c.34cm which was followed from 34-93cm by a more humified version of the same peat. The section from 34-52cm was possibly a fraction more humified than the remainder and exhibited a slightly "sloppy" texture.

From 93-133 cm, following a diffuse boundary, the peat remained similar in composition but acquired a greasy nature, indicating a small clay element.

From 133-180cm a blue-grey clay incorporating a small amount of organic material up to about 156cm was present. A brushwood peat was found from 180cm to the bottom of the core.

The Reedham core's top 31cm was composed of a coarse fibrous *Phragmites/Cladium* peat which was followed from 31-79cm by a similar but more humified version of the same deposit. From 79-130cm following a diffuse boundary was a Phragmites clay which in turn was followed by a pure blue-grey estuarine clay occupying the levels from 130-170cm. From 170-220cm the deposit gradually became a clay with a significant organic component, mostly *Phragmites* rhizome fragments.

## 5.2 The Zoning of the Macrofossil Diagrams.

### *5.2.1 How Hill Core (HH) (Fig.5.3)*

**Zone A (200 - 170 cm)**

*Description:* The most noticeable macrofossils are the remains of bark fragments of *Betula* and the leaf fragments of *Myrica gale*. Single seeds belonging to the latter species and *Betula pubescens* also occur in the final sample included in the zone. The upper section includes frequent wood fragments and there are isolated occurrences of seeds belonging to *Sparganium minimum, Schoenoplectus lacustris* and *Typha* sp. Vegetative remains of the latter are present in small quantity in the final sample. Seeds of *Potamogeton* sp. are present throughout the zone and the vegetative remains of *Cladium mariscus* and *Phragmites australis* are present sparingly.

*Contacts:* The lower boundary is the bottom of the core while the upper boundary is drawn below the rise in species characteristic of the succeeding zone.

*Interpretation:* A brushwood peat indicating the development of carr woodland. The presence of Potamogeton and Sparganium seeds suggests the existence of wet hollows within such a community.

**Zone B (170 - 100 cm)**

*Description:* Marked by a sudden appearance and rapid rise of macrofossils of brackish water species and foraminifera.

Fig. 5.3.
Howhill Core,
Reedham Marsh, Norfolk

# MACROFOSSIL DIAGRAM

Analyst: C.E. Wells
1980–1987.

The latter gradually increase to peak at 110-130cm after which their numbers decline rapidly. The initial section of the zone is dominated by seeds of *Atriplex patula* but this soon declines and the most prominent macrofossils become those of *Scirpus maritimus*, *Juncus gerardii* and *Triglochin maritima*. *Samolus valerandi* seeds are frequently encountered and there are large numbers of mollusc shells present in the middle section of the zone.

Other species present with macrofossil representation at relatively low level in the first section include *Phalaris arundinacaea*, *Typha* sp., *Carex paniculata*, *Eupatorium cannabinum*, *Schoenoplectus tabernamontanii*, *Sparganium minimum* and *Oenanthe* sp. *Rumex hydrolapathum*, *Rumex sp.*, *Carex paniculata*, *Rubus fruticosus*, *Eupatorium cannabinum*, *Carex diandra* and *Artemisia* sp. are all represented in the last samples.

Wood fragments are also recorded sparingly at the beginning and end of the zone and the vegetative remains of *Cladium mariscus* and *Phragmites australis* are found intermittently through it.

*Contacts:* The lower boundary is placed where the numbers of foraminifera and seeds of *Atriplex hastata* begin to rise and the upper boundary follows the point at which foraminifera begin to decline rapidly along with macrofossils of *Triglochin maritima*, *Scirpus maritimus* and *Juncus gerardii*.

*Interpretation:* The assemblage strongly suggests the development of saltmarsh, perhaps reaching its peak at around 110-130 cm. The vegetation appears to have had a large *Triglochin maritima* component as the seeds and vegetative remains of this plant dominate the upper section of the zone.

The initial development of the zone suggests that the marine influence began in a gradual manner causing conditions to become wetter, but not necessarily very brackish as the macroremains of species which are relatively intolerant of such conditions and species characteristic of mildly brackish water are found from these levels, e.g. *Atriplex patula, Carex paniculata, Sparganium minimum, Typha sp. and Schoenoplectus tabernaemontani.* Giller (1982) seems to have recorded a similar feature from the Main Reed Marsh section of the Catfield and Irstead fens when he reported that; "The *Phragmites*/clay was separated from the brushwood peat by a less sticky *Phragmites*/nekron mud". He attributed this to, "increasing water levels causing the replacement of fen carr by Phragmites dominated vegetation before water levels rose high enough to cause the deposition of the clay."

Salt marsh development appears to have advanced rapidly after this with *Scirpus maritimus* and *Juncus gerardii* the dominant macrofossils initially followed by eventual predominance of *Triglochin maritima* at the probable peak of marine influence as suggested by the large number of foraminifera at the same point. The increase in *Triglochin* macroremains up the zone is suggestive of increasing marine foraminifera at the same point. The increase in *Triglochin* macroremains up the zone is suggestive of increasing marine influence, as the species is regarded as generally occurring at slightly lower levels in salt marsh systems compared to *Juncus gerardii* and *Scirpus maritimus* (Chapman, 1976).

*Comparisons:* The deposits are reminiscent of the "*Triglochin* clays" recorded by Swinnerton (1931) from the Lincolnshire coast and estimated by him to be of late Bronze Age/early Iron Age in date based on artefacts found associated with the deposit (probably around 1000 B.C.). Although characterised by the plentiful remains of *Triglochin maritima*. and sharing the presence of remains of *Phragmites* and foraminifera, the Lincolnshire deposits appear to differ in the way that relatively abundant remains of *Armeria maritima and Limonium vulgare* were contained within them.

Swinnerton also records that his "*Triglochin* clays" were of a purple colour whereas the Reedham clays display a very distinctive green/grey colour when *Triglochin* forms a prominent component.

**Zone C (100 - 70 cm)**

*Description:* Prominent macrofossils in this zone include wood fragments, seeds of *Carex paniculata, Rubus fruticosus, Apium inundatum, Carex cf. elata, Potamogeton pusillus, Carex pseudocyperus, Carex riparia, Alisma plantago-aquatica* and *Menyanthes trifoliata. Betula* bark fragments, leaf fragments of *Myrica gale* and unknown leaf fragments also *aquatica, Schoenoplectus tabernaemontani, Rorippa sp., Eleocharis cf. uniglumis, Epilobium hirsutum, Barbarea stricta, Hottonia palustris, Apium nodiflorum, Alnus glutinosa, Sium erectum, Carex panicea, Ranunculus sceleratus, Polygonum cf. hydropiper, Chenopodium sp., Eupatorium cannabinum, Sparganium erectum, Rumex hydrolapathum, Myrica gale, Juncus subnodulosus, Juncus subnodulosus* (flowerhead fragments), *Potamogeton* sp. and *Typha* sp. Also present are the remains of mosses.

*Contacts:* The lower boundary is placed where foraminifera and brackish water species decline or disappear and where *Carex paniculata, Rubus fruticosus* and many other species rise or appear for the first time. The upper boundary is placed where wood and leaf fragments begin to decline

*Interpretation:* The assemblage represents the withdrawal of marine influence and a return to freshwater conditions. There are also indications that the site experienced a relatively dry episode during this time as evidenced by macrofossils of *Rubus fruticosus, Alnus glutinosa, Myrica gale* seeds and leaf fragments, *Betula* bark fragments and wood fragments. Together with the prominence of seeds belonging to *Carex paniculata* this suggests the establishment of carr and tussock fen communities in the vicinity. In the Ant Valley at the present day, *Rubus fruticosus* is generally commonest in well established *Betula-Myrica* communities (Wheeler, 1978) which, " often form the vegetation occupying the central core of birch "islands", or, " may form more extensive stands in areas of scrubbing-up fen."

In present day *Carex paniculata* communities which are developed on floating rafts of *Phragmites rhizomes*, the formation of secondary pools may occur as tussocks increase in size, the pools forming between the *Carex paniculata* stools (Lambert, 1965). Wheeler (1978) states, "In these intertussock spaces the main species are usually *Phragmites australis, Carex riparia, Typha angustifolia* and *Sparganium erectum*". Macrofossils from all these species occur in the zone. Lambert (1965) further notes that, "the mixed tussock-fen community is relatively rich in species". It is perhaps interesting in this respect that the samples comprising zone C contained the largest numbers of taxa in the core.

The assemblage may therefore indicate that a mosaic of carr and tussock fen communites was present during this period with secondary pools developed in the latter.

**Zone D (70 - 30 cm)**

*Description:* Marked by a very large rise in the numbers of oospores of *Chara globularis* and *Nitella cf. flexilis* together with seeds of *Ranunculus (Batrachium) sp., Eleocharis palustris and Carex rostrata.*

*Cladium mariscus* vegetative remains become very abundant while those of *Phragmites australis* become relatively uncommon. Remains of mosses are present

*Cladium mariscus* vegetative remains become very abundant while those of *Phragmites australis* become relatively uncommon. Remains of mosses are present throughout and other species found commonly include *Hydrocotyle vulgaris, Schoenoplectus lacustris, Menyanthes trifoliata, Alisma plantago-aquatica, Mentha aquatica, Sparganium erectum, Sparganium minimum, Myriophyllum alterniflorum, Sagittaria sagittifolia* and *Potamogeton sp.*

The initial section of the zone contains of seeds of *Carex elata, Carex paniculata, Apium inundatum, Rubus fruticosus, Eupatorium cannabinum, Polygonum c.f. P.hydropiper* and *Juncus subnodulosus.* The final stages contain seeds of *Carex acutiformis, Peucedanum palustre* and *Myrica gale.* There are also small numbers of macrofossils of *Potamogeton natans, Potamogeton pusillus, Carex pseudocyperus, Carex riparia, Chenopodium sp.*, wood fragments and *Betula* bark fragments.

*Contacts:* The lower boundary occurs where there is a marked rise in *Chara* and *Nitella* oospores and the upper boundary is placed where these decline together with seeds of *Eleocharis palustris* and *Carex rostrata.*

*Interpretation:* A sudden rise in the remains of species characteristic of open water suggests a dramatic increase in the wetness of the surface.

**Zone E (30 - 0 cm)**

*Description:* The most prominent macrofossils are those of *Cladium mariscus, Phragmites australis, Juncus subnodulosus* and *Carex elata.* In the early stages of the zone, *Schoenoplectus lacustris* exhibits a strong representation. Other species present in the zone include *Betula pubescens, Typha sp., Peucedanum palustre* and indeterminate moss remains.

*Contacts:* The lower boundary is placed where numbers of macrofossils of *Cladium mariscus, Phragmites australis, Carex elata* and *Schoenoplectus lacustris* rise. The upper boundary is the top of the core.

*Interpretation:* An assemblage suggestive of a *Cladium mariscus- Phragmites australis* dominated vegetation similar to that of the present day.

### *5.2.2 REEDHAM CORE (R) (Fig. 5.4)*

**Zone B (240 - 110 cm)**

*Description:* Foraminifera are abundant, rising rapidly from 230cm onwards and reaching a peak at 150-160 cm thereafter declining markedly.

The early stages of the zone are also marked by numerous mollusc shells, snail shells and shell fragments of indeterminate nature. These are followed by the predominance of *Triglochin maritima* macrofossils.

Fig. 5.4. Reedham Core, Reedham Marsh, Norfolk. MACROFOSSIL DIAGRAM

Associated with these are seeds of *Samolus valerandi* and *Scirpus maritimus.* There follows a series of samples approximately contemporaneous with the peak of the foraminifera from 160-130cm which are relatively poor in organic remains. The upper half of the zone from 130-110cm sees an increase in the amounts of vegetative remains of *Cladium mariscus* whilst later stages are marked by the appearance of seeds belonging to *Juncus subnodulosus* and also flowerhead fragments of the latter; seeds of *Mentha aquatica, Ranunculus (Batrachium) sp., Alisma plantago-aquatica, Sparganium erectum, Ranunculus sceleratus, Artemisia sp., Chenopodium sp., Chara globularis, Eleocharis palustris, Carex rostrata, Menyanthes trifoliata, Alnus glutinosa, Carex riparia, Hydrocotyle vulgaris, Juncus sp.,* and remains of *Scorpidium scorpioides* and *Drepanocladus aduncus.*

*Contacts:* The lower boundary is placed at the level marking the bottom of the foraminifera-bearing deposits and the upper boundary is taken at the point where the foraminifera decline rapidly and species such as *Eleocharis palustris, Alnus glutinosa* and *Carex paniculata* begin to increase.

*Interpretation:* The zone might be further divided into three subphases. The first of these from 220-160cm is dominated by macrofossils of *Triglochin maritima* and probably represents a salt marsh vegetation dominated by this plant. The next sub-phase from 160-130cm appears to mark the peak of marine influence with a low organic content

in the estuarine clay laid down at this point. The final sub-phase,from 130-110cm indicates the regression of relatively strong marine influence with the rapid decline in numbers of foraminifera and the appearance of predominantly brackish water plants such as *Chara globularis* together with the first appearance of predominantly freshwater species.
*Comparisons:* The initial section of the zone appears similar to the assemblage recorded by Swinnerton (1931) from Lincolnshire and detailed in the Zone B description.

Zone C (110 - 70 cm)

*Description:* Marked by a rise in numbers of seeds of *Juncus subnodulosus, Alnus glutinosa, Carex riparia, Apium graveolens, Eleocharis palustris, Menyanthes trifoliata,* together with the appearance and rise in abundance of macrofossils of *Carex paniculata, Myrica gale* and wood fragments. Also present are seeds of *Betula pubescens, Potamogeton sp., Carex rostrata, Ranunculus(Batrachium)sp., Lycopus europaeus, Hydrocotyle vulgaris, Rumex hydrolapathum, Oenanthe aquatica, Oenanthe sp.* and *Juncus sp.* The remains of *Scorpidium scorpioides, Drepanocladus aduncus, Drepanocladus fluitans* and other mosses are also present. The uppermost sample of the zone contains a few *Chara* oospores.

*Contacts:* The lower boundary follows the point at which seeds of *Alnus glutinosa, Carex riparia* and *Juncus subnodulosus* all rise. The location of a satisfactory

upper boundary is rather difficult to determine but is placed where the three species mentioned above all begin to decline together with a lessening in the abundance of wood fragments and where *Chara sp.* oospores begin to increase.
*Interpretation:* The assemblage indicates the completion of the change from brackish conditions to those of freshwater. The presence of tree and shrub species indicate a relatively dry environment with a species complement suggesting the possibility of carr and tussock fen communities containing secondary pools (as discussed for HH Zone C).

**Zone D (70 – 30 cm)**

*Description:* Marked by a rapid rise in the oospores of *Chara globularis* and *Chara pedunculata.* Seeds of *Ranunculus (Batrachium) sp., Eleocharis palustris, Carex rostrata, Lycopus europaeus, Menyanthes trifoliata, Alnus glutinosa, Carex riparia, Carex paniculata, Juncus sp.* and the remains of mosses are all relatively constant and there are more scattered occurrences of macrofossils of *Potamogeton sp., Potamogeton pusillus, Cirsium palustre, Galium palustre, Iris pseudacorus, Apium graveolens, Myrica gale, Hydrocotyle vulgaris, Oenanthe fistulosa, Oenanthe sp., Carex elata, Rumex hydrolapathum* and wood fragments. Seeds and vegetative remains of *Cladium mariscus* begin to rise towards the end of the zone as do those of *Typha* sp and the seeds of *Schoenoplectus tabernaemontani.*

*Contacts:* The lower boundary is placed where there is a rise in *Chara* oospores and the upper is taken at the point where there is a sharp decline in these along with seeds of *Ranunculus (Batrachium)* sp. and moss remains.

*Interpretation:* The overall indications are of a change to wetter conditions with some open water as suggested by the presence of *Chara* oospores and the seeds of *Potamogeton sp., Carex rostrata, Eleocharis palustris* and remains of mosses. There are indications, however, that carr and tussock fen communities may have lingered well into the later stages of this zone, as evidenced by the presence of seeds of *Alnus glutinosa, Myrica gale* and wood fragments in many of the samples included within it. The number of oospores belonging to the two *Chara* species recorded appear notably reduced when compared to equivalent zones from the other sites. This may imply that the increase in wetness that appears to be associated with Zone D may have been relatively subdued for some reason at this particular site.

**Zone E (30 - 0 cm)**

*Description:* Distinguished by a marked rise in the abundance of macrofossils of *Cladium mariscus* and *Phragmites australis* together with *Carex elata and Juncus subnodulosus* and the appearance for the first time of *Calamagrostis sp., Carex pseudocyperus, Schoenoplectus lacustris, Carex acutiformis, Glyceria maxima, Oenanthe lachenalii, Peucedanum palustre, Myosotis scorpioides, Carex diandra,* *Hydrocharis morsus-ranae, Ranunculus lingua* along with the vegetative remains of *Thelypteris palustris.* Also present are seeds of *Betula pubescens, Alnus glutinosa, Oenanthe fistulosa, Oenanthe sp., Typha sp., Ranunculus(Batrachium) sp., Potamogeton sp., Lycopus europaeus, Carex riparia,* leaf fragments of *Rumex sp.* and the vegetative remains of mosses. There are initially a few *Chara* oospores present but these soon disappear.

*Contacts:* The lower boundary is placed where *Cladium mariscus, Phragmites australis* and *Carex elata* macrofossils all rise markedly. The upper boundary is the top of the core.

*Interpretation:* An assemblage which indicates a *Cladium mariscus/Phragmites australis* dominated vegetation similar to that of the present day.

**5.3. Comparisons between Reedham Marsh and Sedge Marsh Cores.**

The material analysed from the cores display four biostratigraphical zones in common; namely zone B, suggestive of saltmarsh/estuarine conditions; zone C, indicating a drier episode in the fen development; zone D indicating an episode of greatly increased wetness, and zone E suggesting a similar vegetation to that existing at the site today. Zone A of Howhill, which is indicative of carr development,is not recorded from the Reedham core because the brushwood deposit lay below the drive of the corer at the point of sampling at this particular location. There is a possible difference in the salt marsh zone B between the Reedham marsh and Sedge Marsh sites. The latter site possesses macrofossil assemblages predominantly indicating the establishment of the later stages of salt marsh succession while the former contain abundant remains of *Triglochin maritima* , which may be taken to represent a zone of salt marsh subject to slightly higher salinity levels (Chapman, 1976).

Overall, however, the zones recorded from Reedham Marshes seem to be very similar in nature to those from Sedge Marsh. The fact that such zones can be shown to be identifiable from undisturbed flood-plain mires in parts of the Ant Valley other than the Catfield and Irstead area reduces the the chances that the analyses might be recording events of only localised importance and lends weight to the notion that the zones are signalling responses of vegetation to environmental changes on a broader scale.

# CHAPTER 6. THE DIATOM ANALYSES.

## 6.1 Introduction.

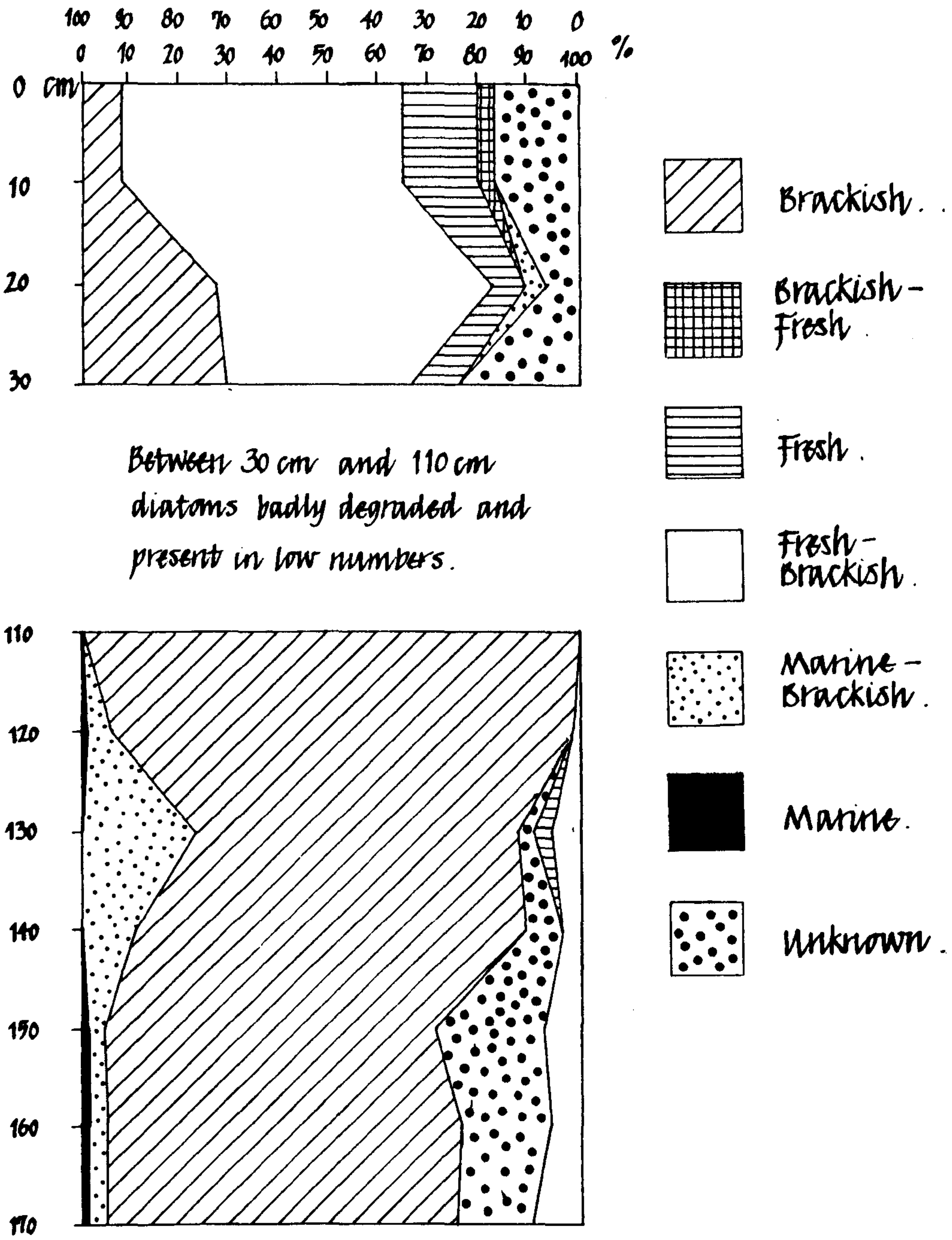
Fossil diatom assemblages have been used in many palaeoecological studies as indicators of past environmental conditions, particularly with regard to salinity of water at time of deposition and the pH value (e.g. Tooley, 1978; Haworth, 1976). Most studies to date have been from lake muds or clay deposits and relatively few have been attempted using peat material. Poor preservation in such deposits, particularly those from alkaline peats, has generally discouraged investigation of such deposits (this phenomenon is discussed in more detail below).

It was decided to examine the diatom assemblages from the Catfield site initially, as these deposits incorporated a significant clay component which was likely to be diatom-rich. In addition, the studies of diatoms by Alderton (1983) from the more southerly Waveney Valley had proved successful and it was thought that investigation of upper peat deposits from the Broads(which she ignored) might provide interesting additional palaeoecological information about the region. The main reason for the diatom analysis, however, remained the desire for further information about the environmental conditions existing during the various vegetational episodes indicated by the macrofossil record.

The methods and rationale behind the analyses are explained in the methods section (chapter 2.)

Fig 6.1.
Diatom analysis M - B - F.

# Sedge Marsh One. Catfield Fen, Norfolk.




Between 170 cm and 230 cm diatoms badly degraded and present in low numbers.

## 6.2 Results.

The results are presented as a series of graphs. Figs. 6.1, 6.2 and 6.3 refer to the respective M-B-F diagram, Halobian Diagram and Relative Species Petcentage Diagram for the Sedge Marsh One Site while figs.6.4, 6.5 and 6.6 show the same information respectively from the analyses of the Sedge Marsh Three Core. In the relative species percentage diagram the species are grouped according to their pH preference groups, as far as these are known.

The diagrams from both sites exhibit large sequential gaps caused by a combination of bad preservation and low numbers of frustules. In Sedge Marsh One the samples from 30-110 cm and below 170 cm were disappointing in this respect and in Sedge Marsh Three the levels from 0-60 cm and below 180 cm were found to be largely barren of countable diatoms.

### *6.2.1 Sedge Marsh One.*

**M-B-F Diagram.**

*Description:* The samples from 170-110 cm exhibit a dominance of forms characteristic of brackish water conditions although there is a suggestion of a subtle change from slightly less brackish conditions in the lower 30 cm of the diagram (evidenced by the small but significant representation of fresh-brackish forms) to a more saline condition between 140-120 cm (marked by a peak in marine-brackish species), before the complete domination of brackish forms above this.

The levels from 30-0 cm exhibit a dominance of fresh and fresh- brackish types but still with a smaller but significant brackish water component.

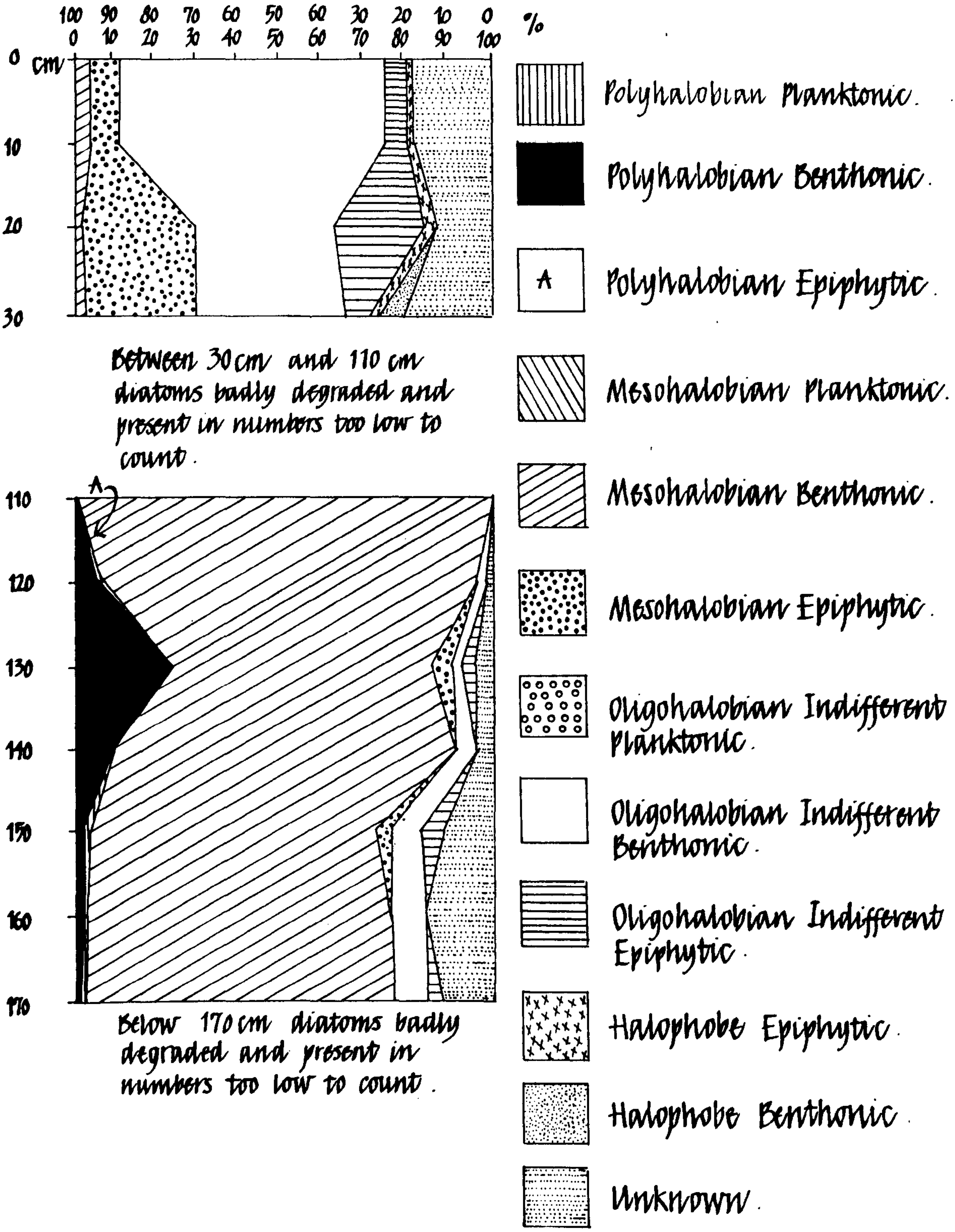
*Interpretation:* The lower part of the core appears to have been subject to brackish water conditions during deposition, with a possible peak in saline influence indicated at 130 cm whilst the upper 30 cm have been formed during a period of predominantly fresh-brackish water conditions.

**Halobian Diagram.**

*Description:* The levels from 170-110 cm are largely dominated by mesohalobian forms with smaller percentages of polyhalobes which peak at 130 cm and a small percentages of oligohalobes which gradually decline to insignificance as the upper section of the diagram is reached. From 30-0 cm oligohalobes form the most prominent component of the assemblage but there is also a sizeable component represented by mesohalobes. There is additionally a small but constant representation of halophobes present in this section.

The samples from 170-110 cm are almost completely dominated by benthonic forms with only very small percentages of planktonic and epiphytic types occurring.

Fig. 6.2.
Diatom Analysis: HALOBIAN DIAGRAM.
Sedge Marsh One. Catfield Fen, Norfolk.



The upper section between 30-0 cm exhibits almost equal representation overall between benthonic and epiphytic forms.

*Interpretation:* The lower section of core appears to have been deposited during very brackish water conditions with a possible peak in salinity at around 130 cm while the upper 30 cm were laid down during a much less saline episode, although still of a moderately brackish nature.

**pH Groupings:** Alkaliphilous forms dominate the assemblage although acidophilous and indifferent forms are more prominent in the upper levels, albeit at rather low percentages with the exception of the indifferent *Pinnularia viridis.* Overall the indications are that at the diatom rich levels, the system has always tended towards the higher levels of pH with a possible slight lessening of alkalinity in the upper 30 cm of the deposit.

**Summary**: The salinity groupings produced by using the two classification systems closely concur in the two sections of this core where analysis was possible. The indications are that very brackish conditions predominated in the lower part from 110-170 cm while the upper 30 cm indicate that much fresher water condition obtained by the time the peat there was deposited. Alkaline conditions appear to have predominated throughout the profile where the diatoms occur,

Fig. 6.3.
Diatom Diagram: Sedge Marsh One. Catfield Fen, Norfolk.

with a possible slight lessening in alkalinity in more recent deposits.

*6.2.2 Sedge Marsh Three.*

**M-B-F Diagram.**

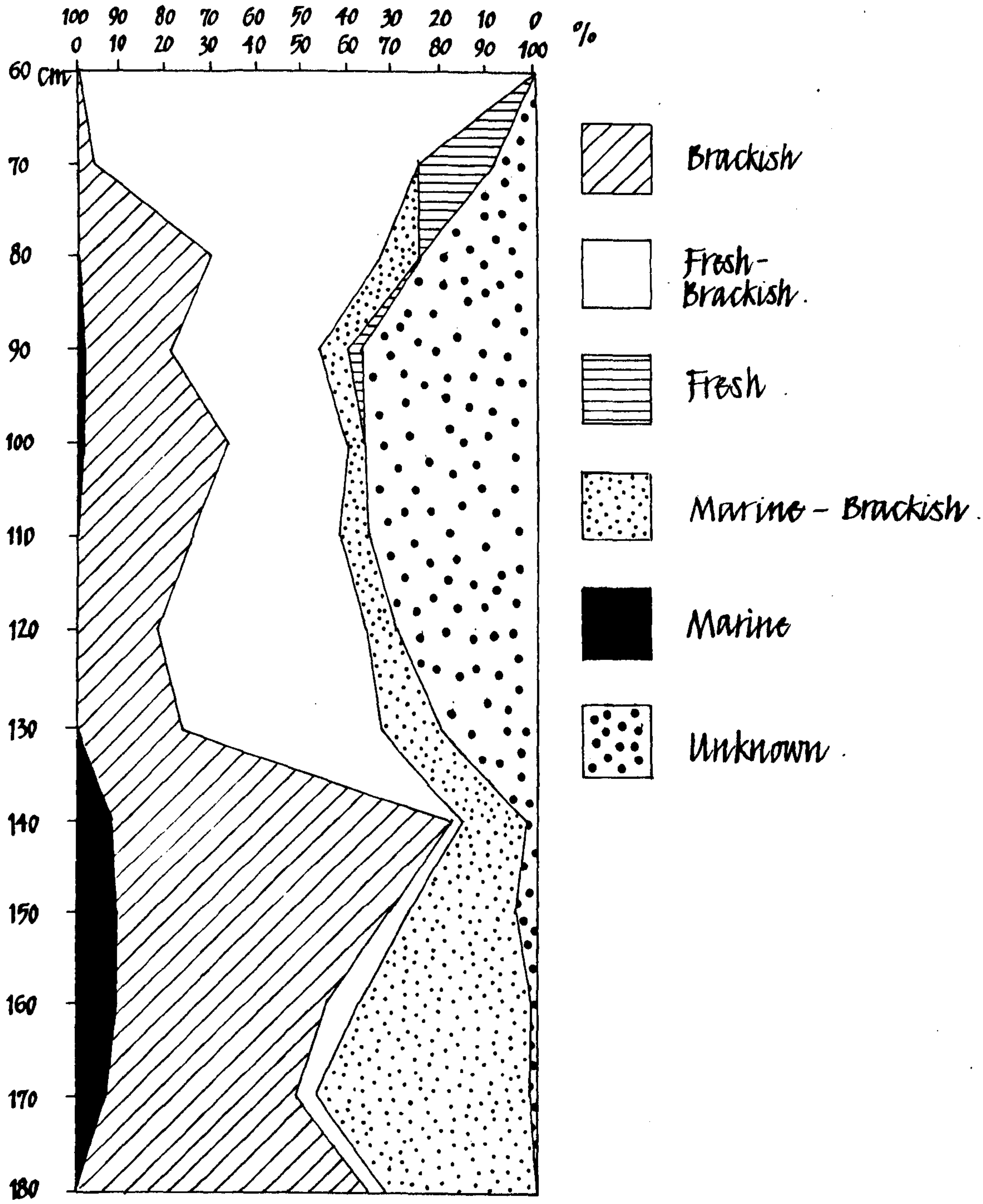
*Description:* From 180-130 cm there is a preponderance of brackish water species and a sizeable percentage of marine-brackish species. There are smaller, but significant percentages of marine and fresh-brackish species.

From 130-80 cm there is a marked rise in the percentage of species belonging to the fresh-brackish group and a corresponding drop in the percentage due to brackish water species. Marine-brackish species also become noticeably less prominent and marine species disappear completely for a time until they reappear in very low percentages from 110-80 cm.

Freshwater species appear for the first time with a small representation at 110cm and increase their representation noticeably at 70 cm. The relative importance of the various changes is not completely clear, however, due to the relatively large proportion of species between 130-80 cm whose chloride grouping is unknown.

Above 80 cm until the diatom-rich samples end there is a marked rise in the proportion of fresh-brackish and fresh water species with a corresponding decline in species belonging to higher salinity classes.

Fig 6.4.
Diatom analysis. M-B-F.
Sedge Marsh Three. Catfield Fen, Norfolk.




below 180 cm diatoms badly degraded and only present in low numbers.

*Interpretation:* The diagram appears to show the dominance of brackish water forms in the lower part of the core up to 130 cm after which species indicative of greater freshwater influence become more prominent although the indications are that the conditions remained predominantly brackish overall. The latter stages of the diagram indicate the further consolidation of the trend towards a less saline environment with the appearance of true freshwater forms.

**Halobian Diagram.**

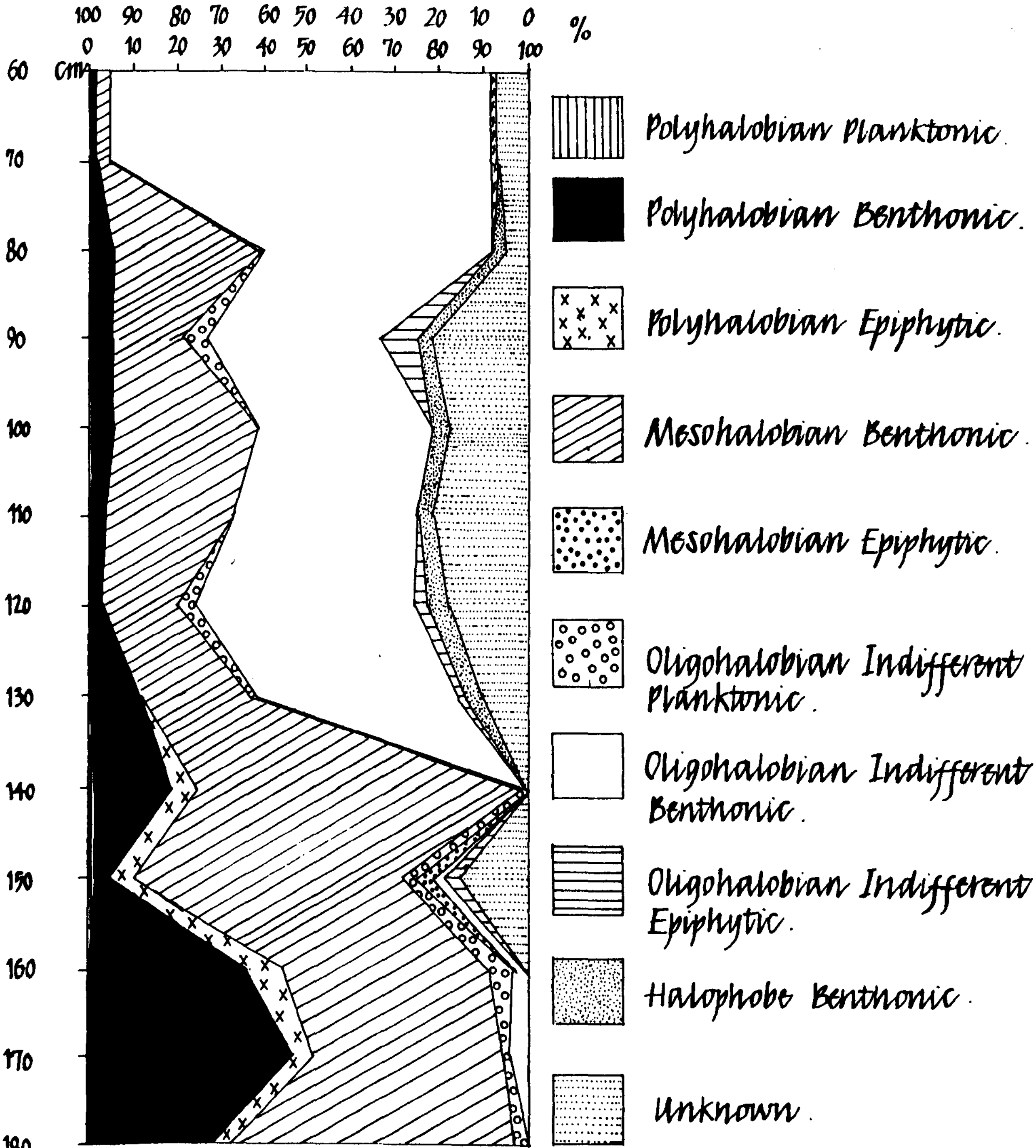
*Description:* From 180-160cm the assemblage is dominated by mesohalobian and polyhalobian forms with a small percentage represented by oligohalobes.

From 160-140 cm mesohalobes become the dominant forms at the expense of polyhalobian types,whose percentage representation declines slightly.

The levels from 130-80 cm witness the rise in oligohalobian types while mesohalobes and polyhalobes become less prominent than formerly. Halophobes also appear for the first time and remain at a low level of representation. 80-70 cm sees the increased representation and dominance of oligohalobian types and the reduction of meso-and polyhalobes to low levels of representation.

The species represented are overwhelmingly benthonic with a low level of representation of planktonic and epiphytic forms.

Fig. 6.5.
Diatom analysis: HALOBIAN DIAGRAM.
Sedge Marsh Three. Catfield Fen Norfolk.




Below 180 cm diatoms are badly degraded and present in numbers too low to count.

*Interpretation:* The levels from 180–130 cm appear to indicate the existence of highly brackish conditions which are followed after 130 cm by an amelioration suggesting a lower level of salinity but still of a brackish nature. These conditions appear to continue up to 80 cm after which there are indications that freshwater conditions achieve predominance.

**pH groupings:** Unfortunately there are a relatively large number of taxa recorded whose pH preferences are unknown but from those that have been classified the assemblage indicates the predominance of alkaline conditions throughout the profile with perhaps a slight lessening in the pH in the upper 60–80cm indicated by the appearance of some acidophilous taxa.

**Summary:** The M-B-F and Halobian Diagrams both exhibit very close similarities supporting the interpretation of a gradual change from highly brackish water conditions in the lower part of the core through more moderately brackish nature in the middle sections to predominantly freshwater conditions above 80cm. The diatom analysis suggests the predominance of alkaline conditions throughout the profile with perhaps a minor lessening in pH in the upper 60–80 cm.

Fig. 6.6.
Diatom Diagram: Sedge Marsh Three. Catfield Fen, Norfolk.

**6.3 Discussion.**

From the incomplete sequences produced it would seem that the diatom evidence complements that of the stratigraphical and plant macrofossil analyses by indicating a brackish estuarine episode reaching a peak of influence at around 160-180 cm below the surface and gradually being replaced by greater freshwater influence with the predominance of mildly brackish conditions in the upper parts of the profile. Alkaliphilous species seem to have dominated the diatom flora throughout the period of deposition.

There is no obvious explanation to account for the poor frustule preservation encountered in several sections of the profiles although there are a number of suggestions current which help to explain dissolution in certain cases. It has been shown that the silicon of diatom cell-walls can become more soluble in water with increasing pH (Kolbe, 1932; Evans, 1969). Such observations seem to be contradicted by evidence from sites where diatom-rich deposits are found in highly calcareous sediments, such chalk-muds in Sweden (Berg and Hessland, 1950) and from the calcareous Malham Tarn (Evans, 1969). The suggestion that alkalinity may play a part in frustule degradation does not appear to aid explanation in the case of Catfield as there seems to be no evidence to suggest that the site has not always experienced a similar pH range and yet the boundaries between sections of good and bad preservation are abrupt.

A more recent suggestion (Juggins, 1988) is that poor preservation may be associated with deposits which stand above the water table for part of the year. In such deposits the interstitial waters would not attain silica saturation and biogenic silica would be leached rapidly. In such cases, the dissolution of the frustules is likely to occur before the deposits became permanently waterlogged. It may be possible that such conditions obtained for a time at Catfield as the plant macrofossil evidence points to episodes where the surface appears to have been relatively dry with the development of carr communities in places. The correlation of such biostratigraphical episodes with levels of poor diatom preservation, however, is far from perfect.

In SM1 poor preservation is encountered between 30 and 110 cm. This most closely relates to macrofossil zones SM1D (30-80cm) and SM1C(80-90cm).

SM1D is a zone marked by a macrofossil assemblage indicative of a shift to very wet conditions while that of SM1C is suggestive of much drier conditions. Poor preservation also occurs in this core below 170cm and the macrofossil evidence places this in the upper stages of zone SM1A;-an episode of perhaps relatively dry conditions indicated by the presence of wood fragments and seeds from arboreal species.

In SM3 the sections of poor preservation occur between 0-70 cm and below 180 cm. The fist section coincides with the plant macrofossil zones of SM3E(0-30cm) and SM3D(30-

70cm) which are interpreted as representing a fen vegetation similar to that obtaining at the present day and to a very wet episode, respectively. An episode suggesting much drier conditions, SM3C, occurs below this but was marked by good diatom preservation, thereby appearing to contradict Juggins' suggestion in this case. Below 180cm, however, the section of poor preservation appears to correspond approximately to a drier episode marked by brushwood deposits.

Overall the evidence cannot be said to be conclusive enough one way or the other to be able to suggest definite reasons for poor diatom preservation. The combination of factors producing such a phenomenon are still too poorly understood to be of much assistance in interpreting these episodes.

# CHAPTER 7. AN INTERPRETATION AND DISCUSSION OF THE MACROFOSSIL EVIDENCE.

## 7.1 An interpretation of the plant macrofossil zones.

Correlation of the plant macrofossil zones with environmental and land use history of the area can now be considered.

### *7.1.1 Zone A.*

The widespread development of carr woodland is indicated by the occurrence of brushwood peat deposits beneath upper clay and nekron mud virtually throughout the alluvial deposits of the Broads region (Jennings, 1952; Lambert et al, 1960; Giller, 1982). This zone therefore represents the already well-established phase of carr development which seems to have predominated in much of the present alluvial area for perhaps a millenium or so until the large scale "Romano-British" Marine Transgressive Overlap swamped the valley system (Jennings and Green, 1965).

### *7.1.2 Zone B.*

The radiocarbon dates available for this zone are in good general agreement with those recorded by Coles and Funnell (1981) for a marine transgressive overlap episode in the Yare valley around Romano-British times (c. 0-400 A.D.). It seems certain that the biostratigraphical zone identified from the present study represents vegetational responses to the effects of the same episode further operating to the north.

Giller and Wheeler (1986) have speculated that the Catfield and Irstead fens were then situated at the head of the northern limb of an estuary formed by this transgression. This interpretation is supported by both provisional results from foraminifera analysis and the plant macrofossil investigations. Initial analysis of small samples of foraminifera from the clay deposits at the Catfield and Reedham sites (see Appendix B) suggests that a mosaic of high intertidal mud-flats and high salt marsh environment existed during this period at the Reedham sites while the foraminiferal assemblage from Sedge Marsh, situated further to the north, indicated high salt marsh. The assemblages appear to be controlled more by a positive position relative to tidal levels than by remoteness either from the sea or an estuarine channel (B.M. Funnell- *pers.com.*).

This trend is supported by the contemporary plant macrofossil indicators which suggest the development of upper salt marsh communities such as the presence of large numbers of macrofossils of species such as *Triglochin maritima*, *Scirpus maritimus*, *Glaux maritima* and *Juncus gerardii* from deposits corresponding to this zone. The assemblages suggest a similarity to the "General Salt-Marsh Community" of the eastern U.K. coastline at the present day

(Chapman, 1976). *Triglochin* is a notable co-dominant in many of the locations where this community occurs today. *Juncus gerardii*, whose seeds are abundant in most of the Zone B deposits, is often to be found in the uppermost levels of the marshes.

*7.1.3 Zone C.*

Chapman (1976) suggests that the normal successor to salt marsh communities in the East Anglian fen country is a *Phragmitetum* while in the south west of England, Gilham (1957) has asserted that salt marsh communities, particularly those characterized by *Scirpus maritimus*, are replaced in successional sequence by *Phragmites australis* and associated species.

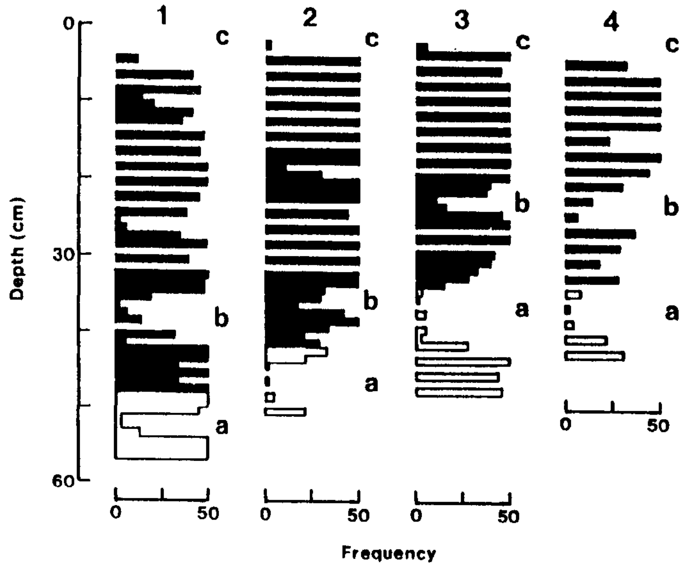
In the Ant Valley , however, it is clear that such a successive community failed to materialise during the time of the deposition of the Zone C deposits and the salt marsh vegetation was superseded instead by tussock-fen/carr communities. This zone appears to encompass a period of much drier conditions than previously or subsequently recorded in the macrofossil record. The lack of a *Phragmitetum* stage suggests a very rapid improvement in the drainage of the Ant Valley.

The radiocarbon dates point to an early Medieval or pre-Medieval date for much of the episode (980-1105 and 1015-1085 Cal.A.D. 68% probability/885-1225 and 995-1165 Cal.A.D. 95% probability). This is in good agreement with the known history of this part of England and with recent palaeoclimatic and palaeoecological studies of this period.

Palaeoclimatic studies over the last two and a half decades, particularly by Lamb (1963, 1965, 1977, 1981, 1982, 1985, 1987a,b) have led to the general acceptance of the concept of the Medieval Warm Epoch (MWE), a post-glacial climatic warming period affecting most of the world but with its climax occurring at slightly different times depending on geographical location. In NW Europe, the main phase of amelioration appears to have lasted from around 900 to 1300 A.D. (with maximum effect from 1150-1300 A.D.) when there are indications that mean annual summer temperatures may have been more than $1^{\circ}$C higher than at present and that annual rainfall amounts were reduced when compared to the present day (Lamb, 1977). It was during this time that the Norfolk broads themselves are thought to have been excavated, the fen surface then apparently being sufficiently dry to allow large scale industrial exploitation of the peat resources without the aid of large scale drainage schemes (efficient mechanical drainage machines such as the scoopwheel and windmill did not come into common use in the Broads until the first half of the eighteenth century [Jennings, 1952]).

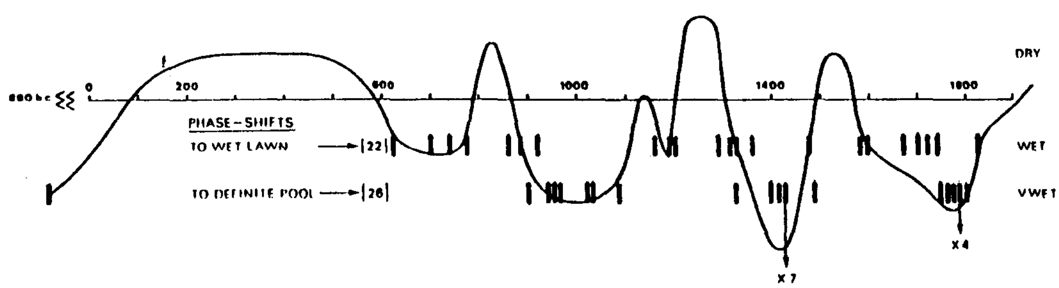
The records of the great ecclesiastical houses of the region, such as Norwich Cathedral, show that upwards of 400, 000 turves a year were being consumed in domestic furnaces from that establishment alone at the peak of exploitation

A.




Frequency (*ex* 50) of *Sphagnum* leaves in peat formed during the last millennium at four sites on Featherbed Moss. Histogram bars below horizon E (*c.*1000 AD) are unshaded; a, b and c designate periods of lowered *Sphagnum* abundance

B.




Surface wetness curve of Bolton Fell Moss since 90 A.D.
N.B. Curve is generalized and includes data other than wet phase-shifts shown and vegetation/humification of hummocks.

Relative height of 'dry' peaks reflects area

**Fig. 7.1** Bio-stratigraphical features interpreted as palaeo climatic "signatures" recorded from two ombrotrophic mires in the north of England.

A. Reductions in *Sphagnum* leaves preserved in Featherbed Moss, southern Pennines by Tallis (1985). Reductions marked as "b" are thought to relate to the effects of the M.W.E.

B. "Surface Wetness Curve" constructed by Barber (1981) from a variety of palaeoecological evidence from Bolton Fell Moss, Cumbria.

giving some indication of the scale of the operation (Smith, 1960).

In Britain, the effects of the MWE on ombrotrophic mires has recently received detailed attention by several workers. Barber (1981), in a study of the biostratigraphy of a raised bog at Bolton Fell Moss in northern Cumbria, has shown that between c.1100 and 1300 A.D. the bog surface was relatively dry (fig. 7.1). He attributes this directly to the early Medieval climatic amelioration.

Tallis (1985) has also recognised a "dry" phase of this antiquity in the plant macrofossil record from Featherbed Moss in the southern Pennines (Fig.7.1). He interprets a reduction in the frequency of preserved *Sphagnum* leaves from peat cores taken there as a response to drier conditions induced by the Medieval Warm Epoch.

The easternmost example of this phenomenon and the one closest to the present study sites is found in the work of Smith (1985), again from an ombrotrophic mire. His study of the vegetational history of the Humberhead Levels recognises a drier episode from levels thought to be of early Medieval age in one of his study sites, Rawcliffe Moss. Peat occurring at this level was found to be relatively well-humified and dominated by *Calluna vulgaris* and *Sphagnum acutifolium* remains, together with some *Eriophorum vaginatum.* Together with palynological evidence showing increasing *Calluna* pollen values and decreasing numbers of *Sphagnum* spores during this phase, he interpreted the episode as showing the establishment of a *Callunetum* with *Sphagnum acutifolium* hummocks and indicative of a drier mire surface than the preceding phase.

In the Broads region, the effect of such a climatic amelioration on mire surfaces may have been enhanced by a possible lower relative sea level on the adjacent coast. Stratigraphical studies of deposits in sections made during construction work at Great Yarmouth led Green and Hutchinson (1960) to conclude that relative sea level on this part of the Norfolk coast may have been lower than that of the present by as much as 13 feet between about 700-1200 A.D. and this has been used by many authors to explain how Medieval turbaries managed to be worked without flooding (Smith, 1960; Rackham, 1986). The interpretation of biological aspects of the Great Yarmouth evidence by Green and Hutchinson, however, has been shown to be flawed due to misinterpretation of the ecology of the particular species of barnacles and molluscs from which remains they had inferred former tidal ranges (Funnell, 1979). Funnell concluded that, "No other evidence [offered by them] requires sea-level at Great Yarmouth to have been sensibly different to the present at 700 B.P." He pointed out, however, that the tidal range of the river side of the Great Yarmouth spit at its proximal end may have been less because of its longer southward extension towards its former sea opening near Lowestoft at that point in time.

Despite the reservations and doubt expressed with regard to the evidence for the state of the relative sea level in early Medieval times, Funnell accepts the logic in connecting the period of Medieval peat exploitation with a lower relative sea level than today's. However the magnitude of the difference seems likely to be much less than previously proposed.

It seems reasonable, therefore, to interpret the "dry" indicators of Zone C as marking a response of the vegetation to the drier, warmer conditions of the Medieval Warm Epoch (of which a possible lower relative sea level was an integral part) which were of sufficient magnitude in this part of the country as to encourage carr encroachment over a wide area of fen.

### *7.1.4 Zone D.*

This zone sees an abrupt switch to a species assemblage indicative of very wet conditions with radiocarbon dates (1255-1350 and 1250-1370 Cal.A.D. 68% probability/1220-1400 and 1225-1340 Cal.A.D. 95% probability) suggesting a late medieval age for the beginning of the episode. Lamb has demonstrated a late Medieval climatic deterioration in NW Europe beginning around 1300 A.D. and continuing with varying degrees of intensity until around the late eighteenth century. This whole period has become known as "The Little Ice Age" although the description is often reserved for the coldest period of the episode during the sixteenth and seventeenth centuries when average annual temperatures fell to their lowest levels since the end of the last glaciation (Lamb, 1977).

The effects of this climatic episode on the plant communities of ombrotrophic mires has been recognised for some time. A recurrence surface dated to this period is found in many bogs throughout north and central Europe and was noted by Grandlund as early as 1932 when he classified it as the youngest of his *recurensytor* (recurrence surfaces), dated to around 1200 A.D. (RY1) (Granlund, 1932).

The palaeoecological studies referred to earlier have helped to define this episode more precisely from some British bogs.

Barber (1981) claims a high degree of sensitivity to be displayed by the macrofossil and pollen record at Bolton Fell and his generalised "wetness curve" shows peaks in wetness indicators corresponding remarkably precisely to Lamb's putative highest rainfall episodes of 900-1100 A.D., 1320-1485 A.D. and 1745-1800 A.D. (fig.7.1).

Tallis' (1985) macrofossil diagrams show a recovery in the frequency of preserved *Sphagnum* leaves in the cores from Featherbed Moss in deposits of this (late Medieval) age following the depressed values recorded immediately previous to it.

In his study, Smith (1985) found a sudden change from relatively dry conditions of the preceding phase to one indicating much wetter conditions. Numbers of *Sphagnum* spores increased dramatically (to a maximum of 100%) whilst pollen of Calluna dropped to as little as 15%. The macrofossil assemblage was found to be dominated by *Sphagnum magellanicum* and *Sphagnum cuspidatum* for most of the phase. A radiocarbon date for the inception of the wetter conditions gave a range of between 1275-1395 A.D. which Smith interpreted as meaning the episode was a recurrence surface analogous to Granlund's RY1.

All these studies are from ombrotrophic mires and so increases in wetness suggested by the macrofossil record can be attributed to increased rainfall with considerable confidence, particularly when backed up with chemical data showing higher iodine content of the peat at the appropriate levels, as in Barber's study. In a minerotrophic system such as the Catfield and Reedham Marshes such a conclusion is not automatically obvious, particularly as the sites are situated relatively close to the sea. The question of whether the increased wetness indicated by the macrofossils is due to increased rainfall and runoff from the adjacent upland, or to incursions of the sea, or to a combination of the two, is a difficult one to answer.

*Historical Evidence.*

It seems undoubtedly true that East Anglia shared in increased rainfall of the climatic deterioration and may even have suffered to a relatively higher degree than some areas. Historical studies of Medieval village abandonment in Norfolk by Allison (1955), have been developed by Lamb (1982, 1987), who points out that many of the deserted Medieval villages of Eastern England which had formerly had their desertion erroneously attributed to population decline due to plague, were in fact abandoned because of climatic deterioration causing a retreat of settlement in marginal environments for farming. He also suggests that the effects of such a deterioration may have been more keenly felt in East Anglia:

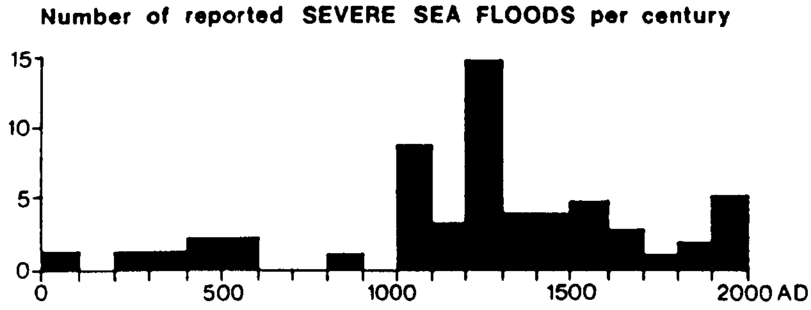
> **"The fact that there was a notably high percentage of deserted villages in the east of England e.g. in Norfolk, and particularly in marshy places and places on high ground with northeast aspects in the east,though none on the extremely well drained chalk soils of the Chiltern Hills, suggests that an important factor was a marked increase ,in and around the fifteenth century, of rainfall on the east side of the country. This points to a substantial increase in the frequency of east winds."** *Climate, History and the Modern World. p.52*

This latter point, the apparent change in wind direction from the usual westerly flow to one dominated by easterly, northerly and north-westerly directions in the fourteenth and fifteenth centuries has another important implication in that it would have promoted the development of storm surges of the sea leading to potentially disastrous flooding episodes inland. The combination of the effects of lowered atmospheric pressure and NW-N storm winds blowing water into the North Sea produce surges of water which can raise sea levels several metres above the predicted tide (Lamb, 1981). This is likely to have been the cause of the great flood of 1287 in east Norfolk which is commonly thought to mark the start of a series of flooding episodes which rapidly led to the abandonment of the Broadland turbaries during the fourteenth century (Smith, 1960; Fig.7.2). Documentary evidence reveals that the Norfolk coast suffered repeated inundation during the fourteenth century and the fact that this was leading to drainage problems in the broadland turbaries is reflected by the need to introduce new peat extracting technology in the form of the "dydle", a dredging implement used to scoop up peat from waterlogged workings (Smith, 1960). By the end of the fourteenth century the account rolls of the ecclesiastical houses were recording that very little turf was now being used signifying the rapidity with which an enormous industry had collapsed.

*Sea Breaches.*

In addition to the group of storm surge records which appear to cluster around the fourteenth and fifteenth centuries there is another series which occurs around the seventeenth and eighteenth (Fig. 7.2). Lamb (1988), for instance, states that at least four, and possibly five or more, storms in the British Isles-North Sea region between 1694 and 1720 rank among the twenty to thirty severest of all the records he has compiled and at least seven more occurred between 1570 and 1694. He suggests that this noticeable concentration of the severest storms in the

A.




20th century total estimated as 4/3 (1900-75) total

Numbers of severe sea floods causing much loss of life or land in the North Sea and Channel coasts per century.

B.

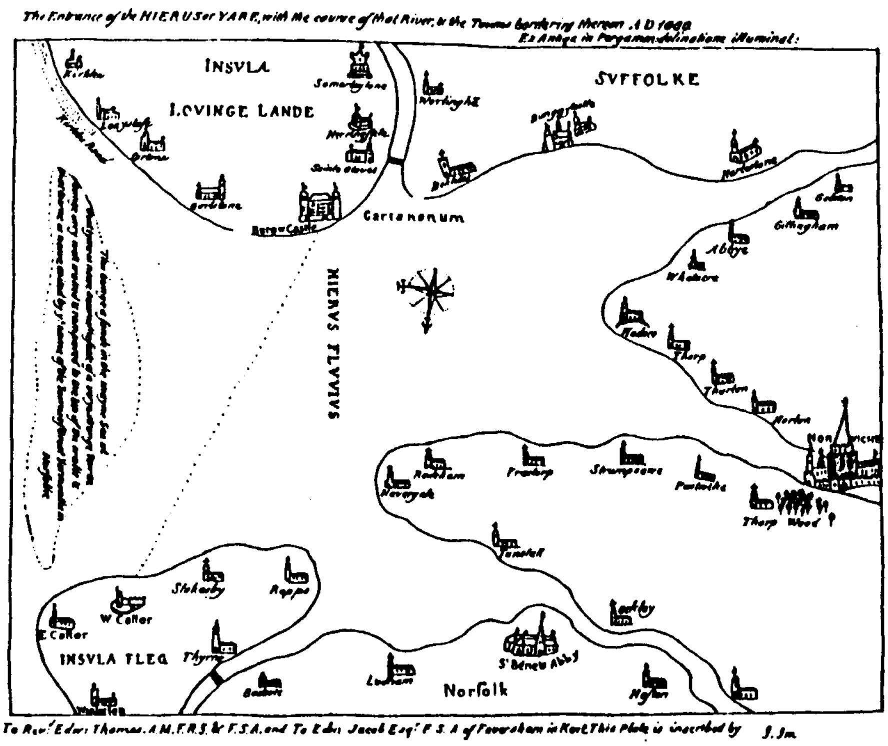



**Fig. 7.2** Evidence relating to sea floods.

A. Rough estimates of severe sea floods affecting the North Sea coasts in the past (*from* Lamb, 1982).

B. Medieval map of the East Anglian coast showing a fjord near Norwich. The map is thought to be derived from a 16th century source showing what was known about the course of the coastline in early Medieval times. It makes the sea floods reported from these times understandable and may even be showing the effects of such an incursion (*from* Lamb, 1977).

climax period of the "Little Ice Age" was no coincidence but was related to a strengthened thermal gradient between latitudes 45 $^{0}$or 50 $^{0}$N and the Iceland region where the Arctic sea ice was prominent. As in the earlier events, the phenomenon was not restricted to East Anglia alone but also affected the countries around the North Sea basin and also the north-west of England and Ireland (Tooley, 1985).

In Norfolk itself, however, the events of this time were so severe that they eventually led to the formation of special commissions to look to repair of sea defences after disastrous sea breaches (Cornford, 1979). Prior to the formation of these "Sea Breach Commissions" there is good documentary evidence to indicate the steadily worsening conditions along the Norfolk coast as the sixteenth century drew to a close. Cornford (1979) has collated evidence revealing a sequence of events indicating steadily worsening conditions from about the mid-sixteenth century onwards. In 1564 there were reports of flooding in the river valleys behind Yarmouth[1] and in 1585 an Act of Parliament authorized magistrates to use statute labour for the repair of the sea defences[2] which was definitely applied in the Hundreds of Flegg and Happing, the latter hundred being the area in which the study sites lie.[3] There are reports of extensive flooding in 1601 and 1605[4]. In 1608 came the worst

1. Calendar of Patent Rolls, 11 July, 1564
2. Statutes of the Realm, 27 Eliz cap 24
3. Norfolk Record Office, Gawdy Letter Book, WLS xvii/1 part 2 fos.77, 78.
4. N.R.O. E.A.W.1/4

flooding yet and this led to an Act of Parliament to be passed, "for the speedye recoverye of many thousand Acres of marsh grounds and other grounds within the Counties of Norfolk and Suffolk" [5]. The preamble describes how the sea had washed away, "the cliffs and higher grounds such as they were", and made them, "all level with the inland". The sea had invaded these breaches at every high tide coupled with a strong wind for many months and had flooded the low lying ground of the Ant valley as far as Stalham as well as far up the Yare,Bure and Waveney Salt water had contaminated the grazing land of the lowlands and had destroyed the fishing in these areas. The Act appointed a body known as the Sea Breach Commission which was composed of local Justices of the Peace with the Bishop of Norwich as chairman. They were empowered by Parliament to levy a rate on all landowners whose properties lay within those "townes" (parishes) which were affected by flooding caused by incursions of the sea. The money thus raised went to the repair and improvement of sea defences on the coast. The Commission was intended as a temporary emergency institution only being activated after a major sea breach and sitting only as long as was necessary to correct damage and carry out repairs.

There are, therefore, strong indications of the severity of storm surges in Norfolk in the seventeenth and eighteenth centuries by the fact that the Sea Breach Commission was obliged to sit in 1617, 1622, 1683, 1702,

5 7 Jacob.1 cap xx.

1715 and 1742. There are also reports of lesser flooding episodes in 1625, 1651, 1717, 1718 and 1720.

The accounts of lands to be taxed on account of flooding contained in the Commissioner's minutes (sometimes with maps attached) always show the parishes which contain Catfield Fen and Reedham Marshes (Catfield, Irstead, Neatishead and Ludham) to be badly affected . The accounts indicate that virtually all the lowland alluvial areas suffered in these flooding episodes, probably returning the valley system temporarily to its former estuarine appearance with flooded arms stretching inland as far as Buxton and Carrow (fig.7.3).

There are indications, at least for the first four decades of their existence, that the commissioners were fighting a losing battle because, As Cornford (1979) points out, "seventeenth century documents reveal a fear that the sea will encroach and swallow up the marshland" (Cornford 1979 p.144). She found documents of 1601, 1608 and particularly 1621 to state this fear;

> **"This coast hath for many years been eaten and worne away be the sea, it hath lost great quantities of uplands and high grounds which in times past did lye between the fenns and the sea,and it doth yearly lose so much that in diverse parts of the cliff it hath eaten through and swallowed up almost all the highlands and is ready to take the fenns into the sea".** [6]

Cornford suggests such evidence shows that, "the early seventeenth century was a critical period when storms and

6 N.R.O.Clayton MS 3423/24

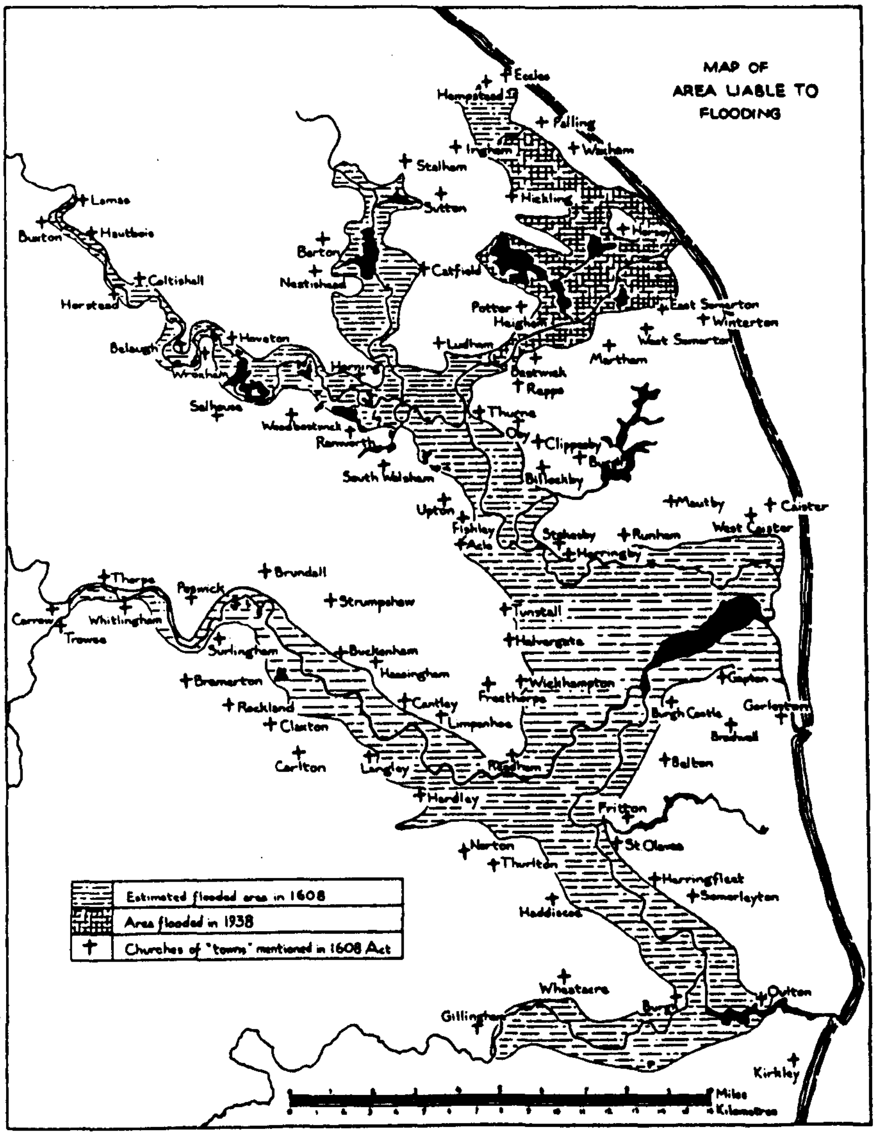



Fig. 7.3. Areas recorded in Norfolk Sea Breach Commission documents as liable to flooding. (from Cornford, 1979).

high tides would easily cause the sea to overtop the sinking defences of the land". Also consistent with the notion that climatic conditions were causing sea floods far beyond the control of such bodies is the fact that the commissioners had the greatest trouble in enforcing the rate on affected "townes" - an indication, perhaps, that the Commission's efforts were failing to prevent damage satisfactorily leading to a refusal to be taxed. The resistance to the Commissioner's attempts to raise moneys eventually led to the abandonment of the institution in 1743 [7]. Sea breaches continued unabated meanwhile and there are reports of further serious flooding in 1774, 1784 (when the curate of Horsey narrowly escaped drowning whilst riding his horse) and 1791. The need for action appears to have become greater than ever, however, as can be gauged by the preamble to an appeal to the Lord Chancellor in 1793 [8] to allow the formation of a replacement commission to tackle the problem;

> **"That for several years past there have been many sea breaches on the eastern coast of Norfolk between Happisburgh and Winterton to the extent of 7 miles at least.....That from the inundation of sea many thousand acres of the marsh ground and other ground in the following towns...are now under water, viz; Eccles, Horstead, Lofingham, Ingham, Hickling, Palling, Waxham, Horsey, Winterton, Potter Heigham, Bastwick, Repps, Ludham, Barton, Catfield, East and West Somerton, Martham, Horning, Thirne and Oby.......That the sea hath got such a draft and current into the Inland parts of the county and into the broad waters and rivers that all the towns in the counties of Norfolk and Suffolk mentioned in the said act are greatly annoyed and generally endangered or like to be**

7 N.R.O. Sea Breach Commission Minute Book 1742-43 EAW/1/2.
8. N.R.O. E.A.W. 2/1.

> **endangered.....That there are many acres of land in the said towns mentioned have become totally uncultivated and unprofitable as well Marsh land feeding land mowing land as corn land - that the seed and tillage have become totally spoiled for three successive seasons last past...That before the overflowings of the sea water there was a great plenty of fresh water for cattle in the marshes but now this water is become entirely salt."**

In 1802 a Commission of Sewers for the Eastern Hundreds of Norfolk was instituted and this body carried out repairs to the sea defences throughout the nineteenth century. A combination of a more professional approach to repair and maintenance and the reduction in storm surge events during this period meant there were to be no further serious breaches until well into the twentieth century.

It is not entirely clear how significant a role a relatively higher sea level may have played in the production of such sea surges. There is some evidence to suggest that sea level in the North Sea may possibly have been higher than at present during the earlier thirteenth and fourteenth century surge events as a result of a general sea level rise due to the preceding Medieval Warm Epoch (Lamb, 1981). By the same token, it has been suggested that during the fifteenth, sixteenth and seventeenth centuries, sea levels could not have been anything other than depressed due to the colder climate of the "Little Ice Age" period (Lamb 1977). The situation is further complicated in the North Sea basin due to the region being a zone of tectonic subsidence. Estimates for average subsidence in south-east

England have been made suggesting a rate of around 10cm per century since 5000 B.P. (Churchill, 1965; Dunham and Gray, 1972). It has been accepted that this is unlikely to be a constant rate and that it is likely to vary from place to place (Dunham and Gray, 1972). There has recently been a suggestion that the Broadland region, in particular, "has been subject to less downward movement than the Fenland and Thames estuary, although it lies between the two." (Alderton, 1983; p.324.).

It seems fair to say that the complex interactions between relative movements of land and sea have yet to be worked out to a satisfactory degree of accuracy. In any case it is probably unnecessary to invoke high sea level as an explanation for flooding events as the evidence available appears to support the notion that the storm conditions were of such severity and high incidence during the "Little Ice Age" period as to have promoted sea surges irrespective of minor fluctuations in relative sea level (Lamb, 1977).

It remains uncertain, therefore, whether flooding episodes may have owed more to increased rainfall or sea incursion. However, the evidence suggests that they were both part of the same climatic deterioration process and are therefore likely to have acted in unison to produce the effects on the vegetation.

*7.1.5 Zone E.*

The final zone marks a change to drier conditions and the beginning of management of the fen vegetation which continues up to the present. The increase in macroremains of *Cladium* and *Phragmites* along with poor representation of remains of species such as *Carex paniculata* and *Carex acutiformis* (Giller, 1982) indicate the utilization of the fens for sedge and reed cutting with the consequent deflection of the sere to a community dominated by the former species. The zone tends to begin around 30cm below the surface which might perhaps indicate the beginnings of management of this kind is only a few centuries old. However, because of the nature of the management regime particular to sedge and reed cutting involving the cropping of vegetative material there will inevitably be some removal of potential peat forming material (Lambert, 1951). Giller (1982), for example, used such an explanation to account for the relatively lower height of the peat surface in Sedge Marshes compared to that in an alder carr community which had obviously escaped human interference. Alternatively, it is likely that the upper levels of the peat appear to display a greater amount of accumulation relative to those beneath because of the more recent, relatively unhumified nature of this material and the fact that it has yet to receive significant compaction by virtue of its upper position. Such factors make precise estimate of the date of the perceived commencement of management practises impossible. However, the notion that large scale development of the fens might be only a few centuries old would agree with the evidence that problems of drainage were beginning to ease towards the end of the eighteenth century allowing the economic exploitation of the marshes to resume in earnest.

This idea is partly supported by documentary evidence from the period. An account roll from St.Benet's Abbey for 1379, for instance, records that, "nothing was made from the marsh of South Walsham because the marsh was flooded, so that the growing reed could not be cut." (Smith, 1960). Later documentary sources are notable for the lack of attention they give to the subject. An instance of this is the contrasting emphasis placed on the activity in Vancouver's *General View of the Agriculture of the County of Cambridge* (1794), and the equivalent studies for Norfolk. The former volume gives much attention to the sedge and reed cutting industry while the latter hardly mention the activity. The difference appears even more pronounced when it is realised that there are three separate books about the state of Norfolk agriculture dating from the late eighteenth and early nineteenth centuries (Marshall, 1797; Kent, 1794; Young 1771). The first of these mentions reed cutting alone very briefly, the second gives it one sentence (bemoaning the fact that areas of marshy ground near Ludham, "produce little more than sedge and reed", rather than crops) and the last does not mention it at all save to remark that,"reed is used to thatch roofs". It might be inferred from such lack of comment that, unlike the situation in the Cambridgeshire fens (Darby, 1956; Rowell and Harvey, 1988), sedge and reed cutting played a relatively insignificant part in the rural economy up to that time and that the wider application of the industry in Norfolk was a development of the eighteenth and nineteenth centuries.

Certainly, the picture painted of the state of the fens in north-east Norfolk by topographical writers of the eighteenth century suggest that they were in a poor shape for agricultural activities. Thus John Mostyn Armstrong, writing about the topography of Hundred of Happing (the administrative unit covering the eastern side of the Ant Valley) in 1781 stated;

> **"The marshes, commons, broads and warrens which compose a considerable proportion of this hundred are indeed very extensive and very irregular in their forms and uses. Villages are nearly surrounded with unprofitable and uncultivated marshes and heaths; and the eastern part of this hundred is bleak and unsalutary.....the hard-lands are well enclosed and valuable, but the marshes are much in want of proper drainage, which might easily be effected by drain-mills"**

The pessimistic tone of this description belies the fact that it was written on the verge of the beginnings of a massive expansion of the agricultural exploitation of the wetlands and the land they occupied. The following century was to see the drainage of many marshes higher up the valleys by the institution of Enclosure Acts (Clarke, 1965). Standley (1983) has shown that the bulk of Broadland

Inclosure acts took place between 1802 and 1844 and implies that the pace of drainage development quickened during this period. Marshes became intersected by a system of dykes to drain the land and provide channels for navigation. Areas of reedswamp lying between the marshes and the rivers and broads became reduced in extent and the remaining areas represent the least affected relicts of the formerly widespread wetlands, albeit displaying the extensive scars from post-Medieval peat cutting (see chapter 10).

The macrofossil assemblages comprising Zone E, then, probably represent the minimum effects of this activity, coming as they do from a rare uncut fen section. Even so, they have been modified by drainage activity and management for sedge, reed and litter.

## 7.2 General Discussion.

### *7.2.1 Sedge and Reed Management and the history of the Broadland Fens.*

Lambert (1951) postulated that vegetation developed over solid peat and clay was based on direct colonisation by Phragmites which was either succeeded eventually by fen carr, or, as in most cases, open fen communities maintained by anthropogenic interference. Giller (1982) reiterated this notion, suggesting the early economic exploitation of the fens as a reason for the apparently continuous reed and sedge dominated peat he found to occupy the levels above the clay layers. The present study has shown that the biostratigraphy of the "solid" peat areas in the Ant Valley is far from following the relatively simple successional sequence advocated by these earlier workers. It suggests that natural, rather than human, factors are likely to have been the major influence over much of the vegetation in the Broads region until historically recent times. Although economic exploitation of the fens must have been taking place in conjunction with the digging of the Broads basins during the MWE (there are records of "mowing meadow" relating to Medieval Broadland, for instance [Smith, 1960]), its effects seem to have been muted compared to more recent management, judging by the indications of carr and tussock-fen development recorded for this period, for as Lambert (1953) points out, active management of the marshes tends to exclude *Carex paniculata.* The stratigraphical evidence for flooded conditions which follow this, coupled with that cited from documentary sources, suggest a low level of economic activity in later centuries as well. It is only in the upper 30-40cm of the deposits that deflection of the sere towards plant dominants favoured by management occurs.

Such an interpretation of the evidence would have important implications for received perceptions of Broadland agrarian history. It challenges the assumption that extensive exploitation of reed, sedge and litter resources has been carried on in the region for a very long time (Lambert, 1965). Instead, there is the possibility that such activity was constrained by environmental conditions to localised areas on a relatively small scale and that it was only when conditions improved, along with increased drainage activity, from the eighteenth century onwards that such management became intensified and widespread.

*7.2.2 Rates of Deposition.*

Any estimates of deposition rates must assume a fair degree of accuracy in the radiocarbon dates. Every attempt was made to ensure the avoidance of contamination of the samples to be dated by younger material. *Phragmites* is particularly prone to such error, as pointed out by Churchill (1965) and experienced by Coles (1977) and Alderton (1983).

Estimates of the deposition rate of the material from the study sites is further complicated by several factors.

Firstly, the relatively large possible age range of the radiocarbon dates, together with their being unavoidably few in number, precludes precise estimates being attempted. There is added to this the further complication that large sections of cores were necessarily used for the dating meaning that the dated samples were not precisely positioned. There is also the possibility that the upper deposits may have experienced an artificially reduced accumulation rate over the last few hundred years due to harvesting for sedge and reed (Giller, 1982). In addition, the fact that the deposits are composed of several different

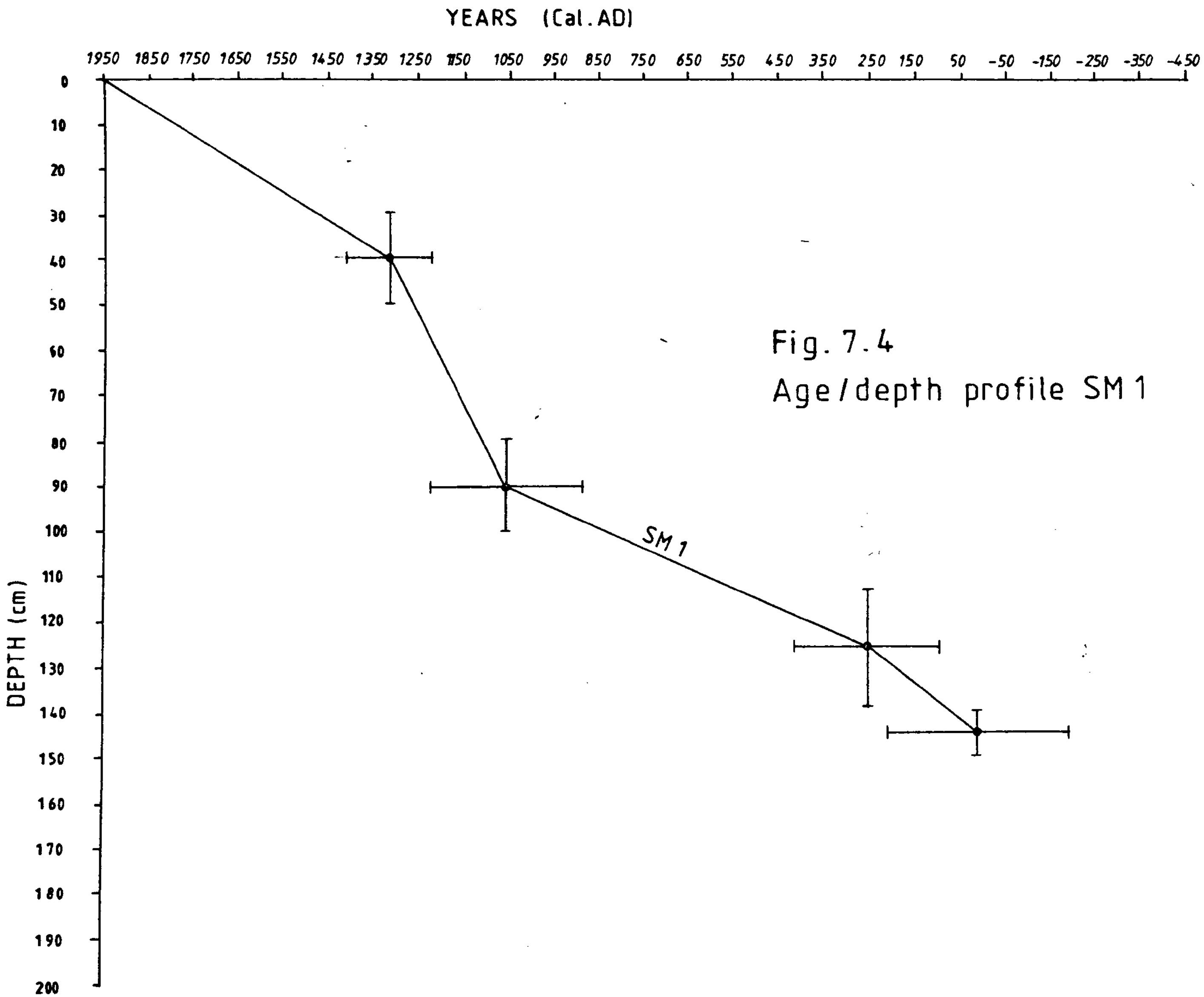



Fig. 7.4
Age/depth profile SM 1

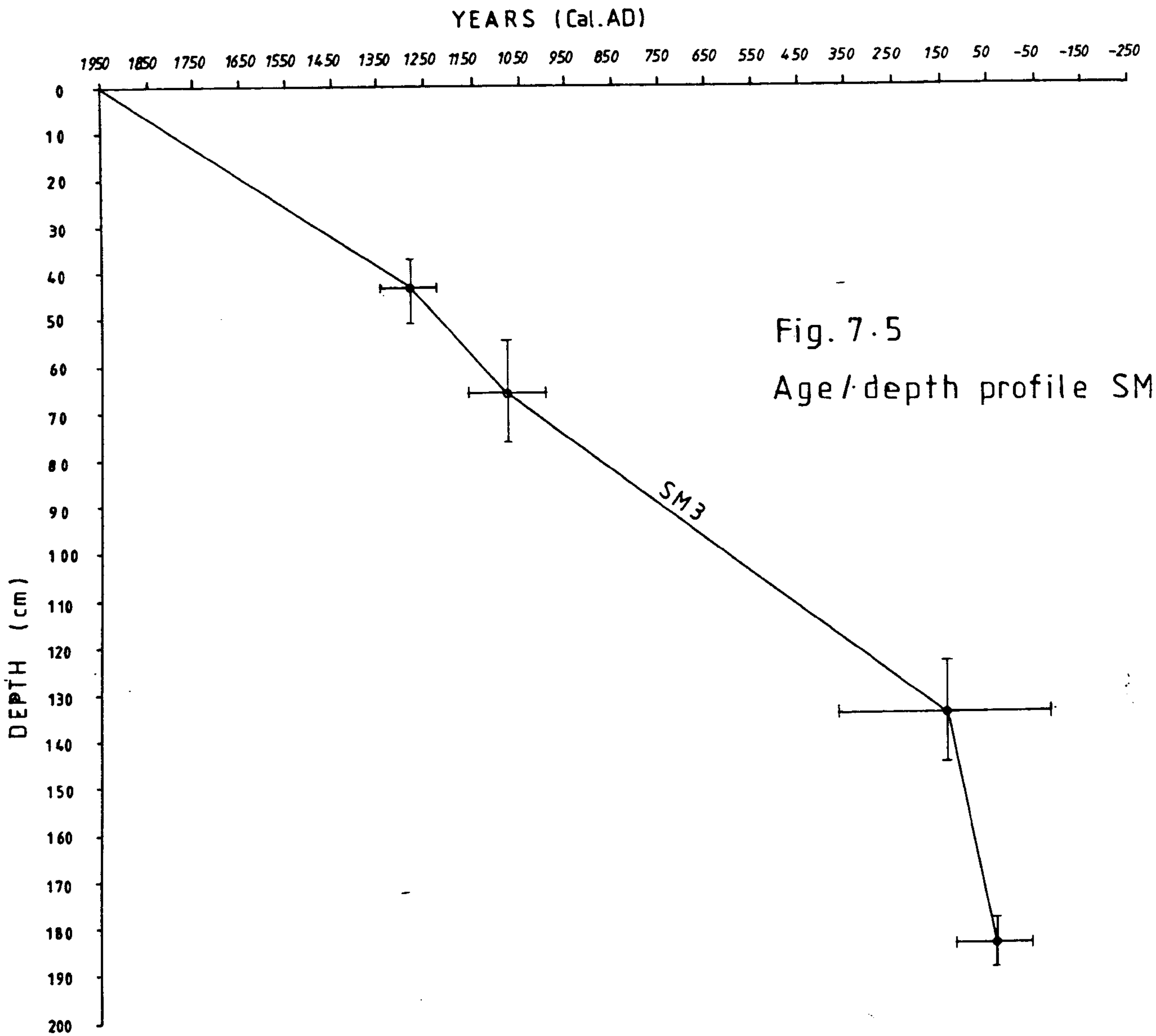



Fig. 7·5
Age/depth profile SM3

kinds of material (clays, silts, peats etc.) which are almost certain to have been deposited at different rates (Walker, 1970) must be taken note of if attempting to estimate any overall "average" rates*.

Deposition rates were calculated from the radiocarbon dates and depth intervals by simple interpolation and extrapolation of the mean points of the age and depth ranges. They are presented as a pair of graphs as Figs. 7.4 and 7.5

Because of the wide potential margin for error inherent in such a calculation the deposition rates are only meant to be regarded as indications of general trends in accumulation rate. As the radiocarbon samples were taken at very approximate boundaries between distinct biostratigraphical boundaries the four estimates from the two sites respectively dated indicate the variability showed by deposition regimes.

Kidson and Heyworth (1979) considered the suitability of salt marsh deposits for reliable radiocarbon dating to be questionable. This is possibly reflected by the way the rates calculated for deposits approximating to the clays and organic muds of the marine transgressive episode vary markedly from the two sites, being 47 cm/100 years at SM 3 and 7.8 cm/100 years at SM 1. However, the margin of error for the latter sample is wider than any other sample due to the need to use a long section of the core for dating because of low organic content. The following rate, which approximates roughly to the period between the end of the transgressive episode and the end of the period indicative of drier conditions is more within the same range from both sites, being 7.2 cm/100 years in SM 3 and 4.2 cm/100 years at SM 1. Because the exceptionally large sample for the organic mud deposit mentioned above is again used in the calculation for SM 1, this rate is likely to be the one with the greater error of the two. The rate covering the approximate period between the later stages of the drier period to well into the late-Medieval "wet phase" of Zone B is again similar from both sites, being 11 and 16.5 cm/100 years from SM 3 and SM 1 respectively.

The final calculation is for the period between the aforesaid "wet phase" and the present day. Both sites again show a similar rate, i.e 6.6 and 7.8 cm/100 years respectively. As indicated earlier, these last rates are possibly an underestimate of potential accumulation rate due to the likelihood of removal of peat forming material during this period by harvesting of sedge and reed. The rates for the non-clay deposits of peat are at the lower end of records for fen peats mentioned by Walker (1970) in his collation of data from various British hydroseres. The eight rates of accumulation he gives lie between 11 and 100 cm per 1000 years. Durno (1961) records rates of 11.2 cm/100 years for Boreal Phragmites/sedge peats at Netherby and a rate of 14.7 cm/100 years at Moss Mound.

Given the wide margin for error which is unavoidably contained within these estimates, the accumulation rates for the non-clay peats seem to be of a similar order of magnitude as those recorded from other studies of deposits of this kind.

*7.2.3 Implications for estimates of the original depth of the broads.*

Irrespective of the problems encountered when attempting to calculate exact rates of deposition, it is clear from the radiocarbon dates available that at least around about half a metre of peat has accumulated in Sedge Marsh since late Medieval times. If such amounts of later peat accumulation are typical of the region, it implies that originally the broads must have been shallower than is currently assumed. This would lessen the problems inherent in interpreting the broad basins as artificial excavations. These problems were outlined by Lambert and Jennings (1960) who were puzzled as to how such deep peat excavations were kept free draining with the limitations of Medieval technology. This led them to speculate on the possibility that the region experienced a lowered water table during the period concerned as a result of a reduction in sea level. At the present time, however, there is no clear evidence one way or the other to support the notion of a lower sea-level but, as mentioned earlier, there is certainly good evidence to show a period of warmer and drier climate during this time which may have had much the same effect, or acted in tandem with such a process. This, when combined with the notion of originally shallower broads, eases acceptance of the ability of Medieval peat diggers to keep the turbaries from flooding.

# CHAPTER 8: THE STRATIGRAPHY OF THE TURF-PONDS.

## 8.1 Introduction.

Today, as one wades through the sedgy tangles and squelchy hollows of the unruly vegetation occupying an old peat cutting like Great Fen (Fig.3.4) at Catfield, it can be difficult to believe that such an untamed place is the result of man's economic activity. Superficially it appears more likely that the seemingly uniform rows of *Phragmites* and *Cladium*, which crowd the adjacent Sedge Marsh compartment like any self-respecting intensively grown crop, must mark the artificially derived section of the fen and that the Great Fen section must be the more natural area. Yet, paradoxically, it is the Sedge Marsh which is the least disturbed of the two compartments with its continuous unbroken accumulations of peat extending to the surface. The upper layers of the Great Fen, on the other hand, are composed of a relatively loose, unhumified peat down to around 80cm underneath which more solid material occurs. The loose material above is the revegetated infill of an old "turf-pond" and it is this regrowth of vegetation which has enabled the establishment of interesting seral plant communities in some cases (Giller and Wheeler, 1986).

The Great Fen of Catfield is not typical of former turf ponds any more than any particular example can be as there is considerable variation in the present day vegetation occupying these areas (Giller, 1982). Some carry carefully managed reed and sedge beds almost indistinguishable from uncut areas, while some have developed shrub communities or even *Sphagnum* cover. Others possess species-rich vegetation with conservationally desirable characteristics It is primarily the latter attribute which has engendered much recent research and conservation interest in them (Giller, 1982; Wheeler and Giller, 1982; Wheeler, 1985; Giller and Wheeler, 1986, 1988).

Lambert (1951) did not consider the presence of former turf cuttings to be of major importance in determining the presence of present day plant communities in the broads, suggesting that the occurrence and distribution of such communities were largely a result of various management regimes to which different areas were subjected. This view has been proved erroneous by Giller (1982) and Giller and Wheeler (1986) who have shown that several plant communities, including the species-rich and conservationally important *Peucedano-Phragmitetum caricetosum*, are restricted to former turf-ponds.

**8.2 Previous research into Turf Pond Bio-Stratigraphy.**

The existence of large areas of former shallow turf cuttings in the Broads region has been recognised for some time. The significance of loose, unconsolidated peat deposits varying from 60-100cm in depth and their connection with the location of historically recent peat cutting was first recognised by Lambert (1951). The wide distribution of the former "turf-ponds" was later confirmed and their known range extended by Giller (1982) and Giller and Wheeler (1986).

Lambert's 1951 investigations, which were concentrated in the Bure Valley broads, produced bio-stratigraphical studies from former peat workings and this led to a generalised description of the general pathways involved in their terrestrialization. This involved frequent initial colonisation by *Typha*, often in the company of *Schoenoplectus* with *Phragmites* becoming the eventual dominant. The *Phragmites* phase could be mixed with *Cladium* or *Juncus* and occasionally the upper strata would be invaded and dominated by developing brushwood peat. Modifications to this successional sequence occurred when *Carex paniculata* invaded the later stages of the *Typha/Phragmites* succession or when *Cladium* was the principal pioneer species which then dominated the sequence throughout.

Giller (1982) and Giller and Wheeler (1986) describe the gross bio-stratigraphy from revegetated turf ponds occupying the Catfield and Irstead Fens. These studies produced a broadly similar view of turf-pond successional development to Lambert's but with some important modifications. Reduced to simple terms, their model of turf pond recolonization was:

(1) In areas over estuarine clay or close to rivers the pioneer plant colonists were Phragmites australis and *Typha angustifolia*. *Schoenoplectus*

*lacustris* occasionally accompanied these species. This eventually led to mostly species-poor vegetation which, they suggested, was due to management for *Phragmites australis.* They found that *Juncus subnodulosus* or *Cladium mariscus* could invade at a later stage and that when such vegetation was managed as litter fen or sedge beds the species-richness would be superior to that of reed-beds.

(2) At places away from rivers and over peat (as opposed to clay), *Cladium mariscus* was the first colonist or arrived very soon after *Phragmites australis.* This vegetation would lead to sedge beds which had the potential to be species-rich.

(3) Some sedge beds were not species-rich because of lack of or mismanagement or a change in the hydrological regime.

These conclusions were generally confirmed and their wider applicability proved by later work from a greater range of Broadland locations by Wheeler (1983).

The present study aimed to take a similar but more rigorous approach to the investigation of the macrofossil content of the turf-pond peats in order to discover whether such a study might yield further information about successional pathways within them.

**8.3 Methods.**

The approach taken was similar to that described for the macrofossil investigations of the undisturbed peats from Catfield and Reedham with modifications made where necessary to allow for the fresh, unhumified nature of the deposits.

*8.3.1 Site selection.*

Giller (1982) identified many plant communities occupying former turf surfaces in the Catfield and Irstead fens and it was felt desirable to include representative profiles from as many as these as possible. Accordingly, the positioning of the sampling sites reflects the distribution of some of the community types identified by Giller and used his vegetation map as a guide to their location. Fig.8.1 shows the sampling positions and Fig.8.2 displays some of the present day plant community occupying the surface using the phytosociological nomenclature of Wheeler (1978, 1980a,c).

*8.3.2 Sampling.*

Few palaeoecological studies have been made of the deposits in old peat cuttings and of those that have been attempted most are from ombrotrophic sites (e.g. Joosten, 1985). The nature of the deposits formed in such revegetated ombrotrophic peat cuttings allowed the use of conventional coring apparatus.

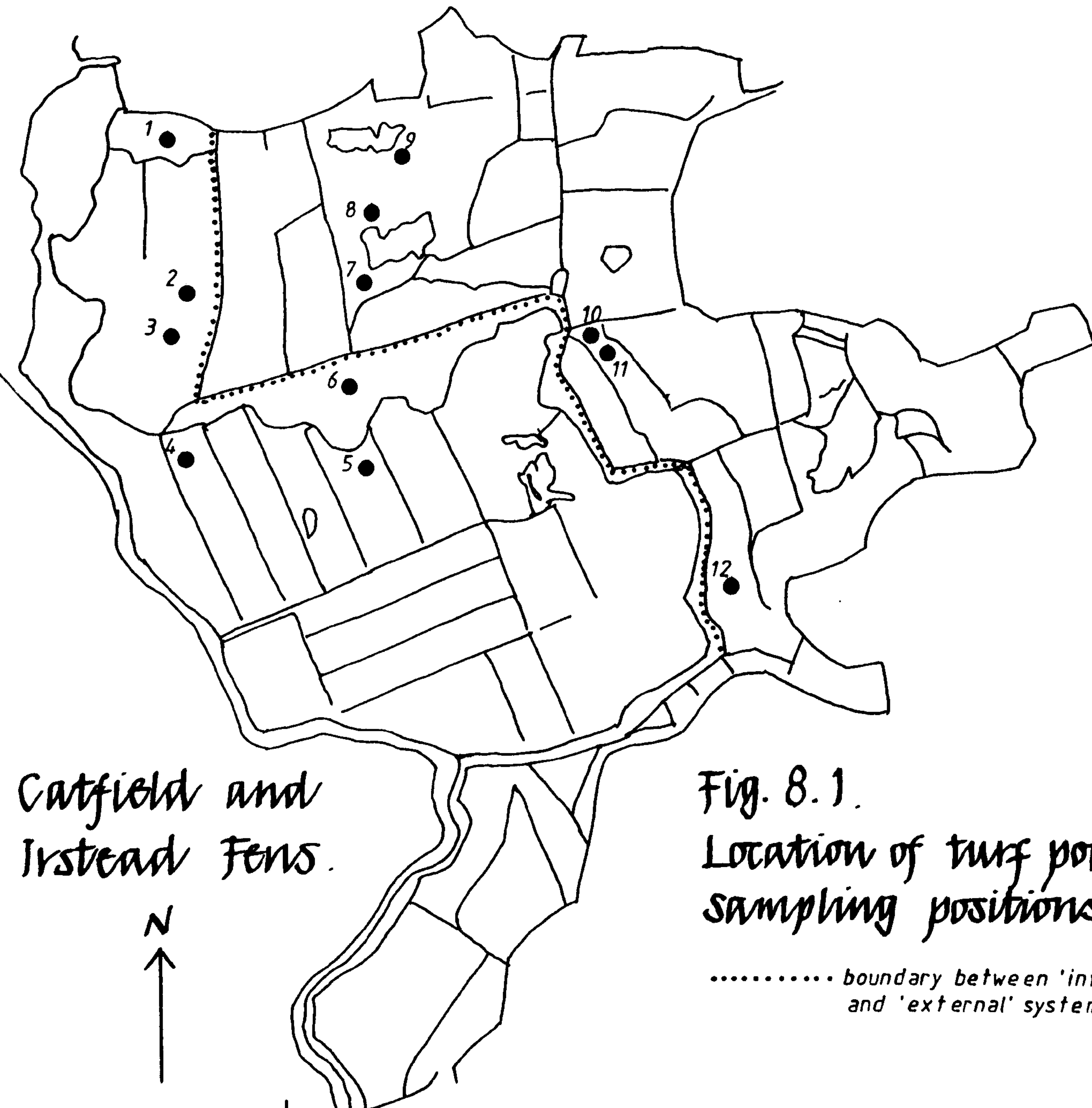



Fig. 8.1. Location of turf pond sampling positions.

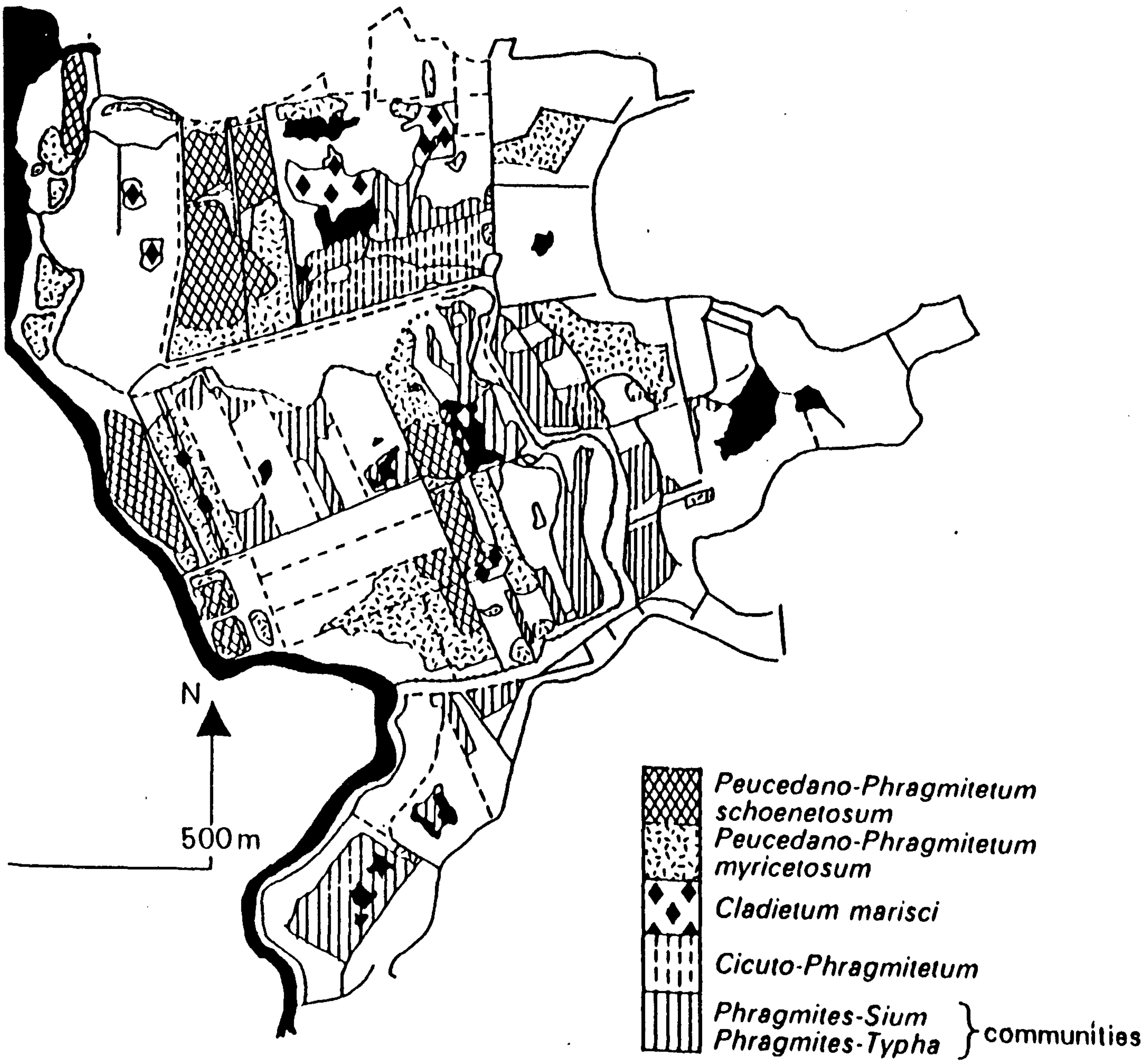



Fig. 8.2. Distribution of some fen communities in the Catfield and Irstead Fens. (After Giller and Wheeler, 1986.)

The relatively unconsolidated nature of the peat infill of the Catfield turf cuttings, however, precluded the use of any mechanical coring implement (other than a sharpened spade for the uppermost layer) and the example of Lambert and Jennings (1951) and Giller and Wheeler (1986) was followed in retrieving much of the material by hand. The latter workers encountered difficulty in reaching material at the base of some cuttings below 60cm but the author was fortunate in acquiring the assistance of a volunteer whose physical dimensions included an 80cm reach when lying face down on the peat surface and stretching to the maximum.

Despite the physical discomfiture this created, the method worked successfully at all the sites visted except number 8, where, due to a flooded surface, retrieval of material below 60cm would have necessitated the submergence of the sampler's head for an extended period and hence the profile is incomplete.

Because of the relatively unsophisticated technique employed it was decided to use a sampling interval of 20cm centimetres as it was felt that the accuracy of smaller intervals would be difficult to achieve. A one metre wooden rule with 20cm intervals notched to enable the depth to be felt by hand was sunk into the peat at the sampling position. Material was then extracted from each 20cm level down to 80cm where possible. The peat was then placed in heavy duty polythene bags,labelled and taken back to

Sheffield where it was put in cold storage until analysis in the laboratory.

*8.3.3 Analysis and Presentation of Results.*

The preparation and analysis of the material was the same as described for the undisturbed peat deposits in 2.2.1-4 with the difference that 200cm $^3$of material was analysed from each sampling level. This was because the fresh, unhumified nature of the material required a greater volume of peat in order to yield significant numbers of seeds.

Owing to the relative freshness of the material and shallowness of the deposits, it was often difficult to determine whether remains of certain plants were genuine macrofossils or more recent intrusive material. This particularly applied to root and rhizome material belonging to *Phragmites australis* and *Cladium mariscus* as it is well known that such organs of these species can penetrate deep into the substratum and thus a certain amount of temerity needs to be applied when interpreting remains left by the larger rhizomatous species (e.g. Giller, 1982).

It was hoped that in the present study, the inclusion of macroremains such as seeds in the total analysis would reduce the level of error engendered by such considerations but the possibilty for confusion still remains.

**8.4 Results.**

The results are presented in figs.8.3–8.14 as a series of twelve histograms presentations in the same manner as **described previously for** the undisturbed peats in 2.2.5 and following the same conventions. In the descriptions below, the present day plant communities are based on Giller (1982).

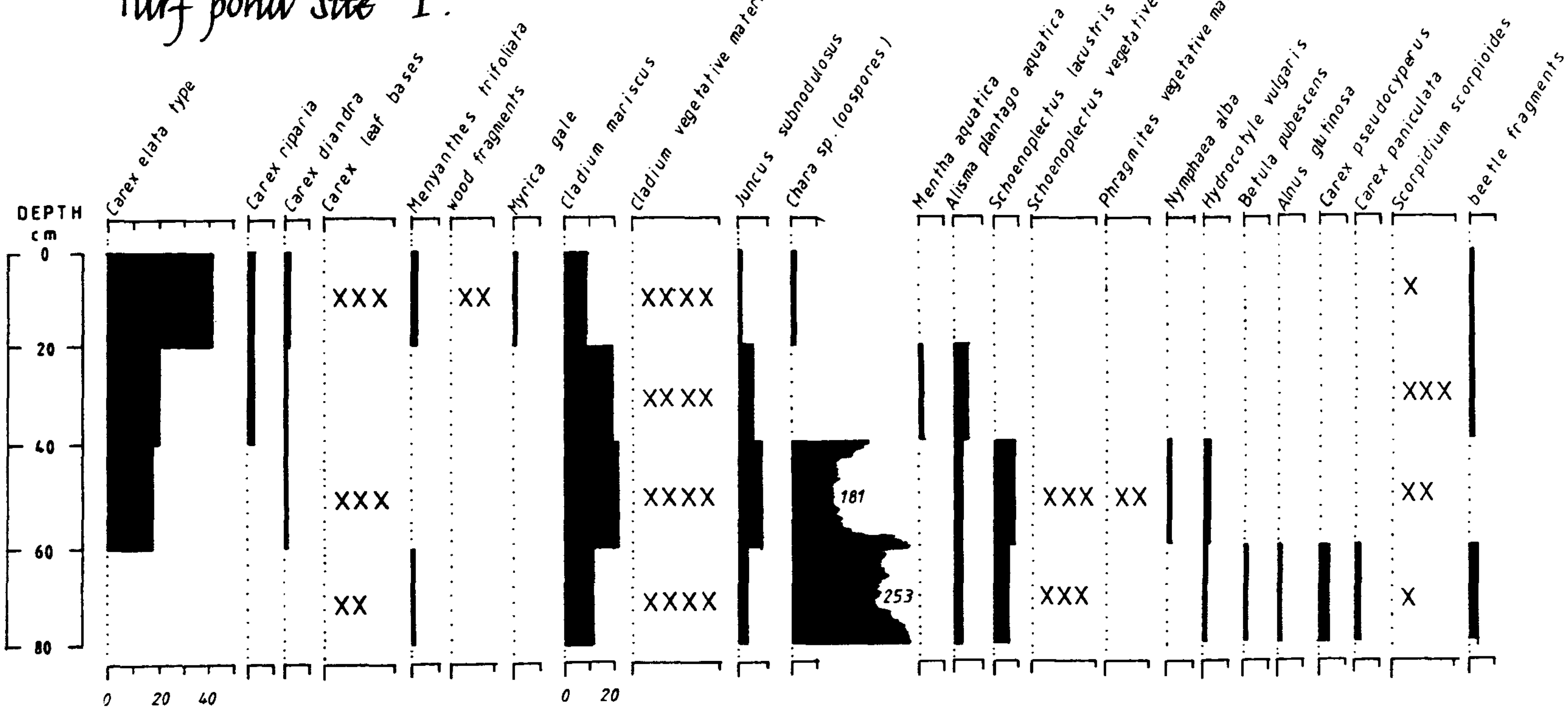
**Site 1. (Fig. 8.3) Grid reference: TG 3657 2135. Present day plant community**: *Peucedano-Phragmitetum Caricetosum* var. *Molinia*.

*Description*: Large numbers of *Chara sp.*oospores are found in the lower half of the diagram with large amounts of *Cladium mariscus* material and slightly lesser amounts of *Schoenoplectus lacustris*. The lower half of the diagram also contains small numbers of seeds belonging to *Menyanthes trifoliata*, *Juncus subnodulosus*, *Nymphaea alba*, *Alisma plantago-aquatica*, *Alnus glutinosa*, *Betula pubescens*, *Hydrocotyle vulgaris*, *Carex paniculata*, *Carex pseudocyperus*, together with remains of *Carex* leaf bases, *Scorpidium scorpioides* and a small amount of *Phragmites australis* material.

*Cladium mariscus* maintains its strong presence throughout the profile while that of *Schoenoplectus lacustris* and *Chara* sp. disappear in the upper portion. Instead,these levels see a rise in the numbers of seeds of *Carex elata*, *Carex riparia* and *Carex diandra*. The uppermost

Fig 8.3.

Turf pond site 1.



level sees the appearance of seeds of *Myrica gale* and wood fragments and the reappearance of seeds of *Menyanthes trifoliata*, *Chara* sp. oospores and *Carex* leaf base fragments.

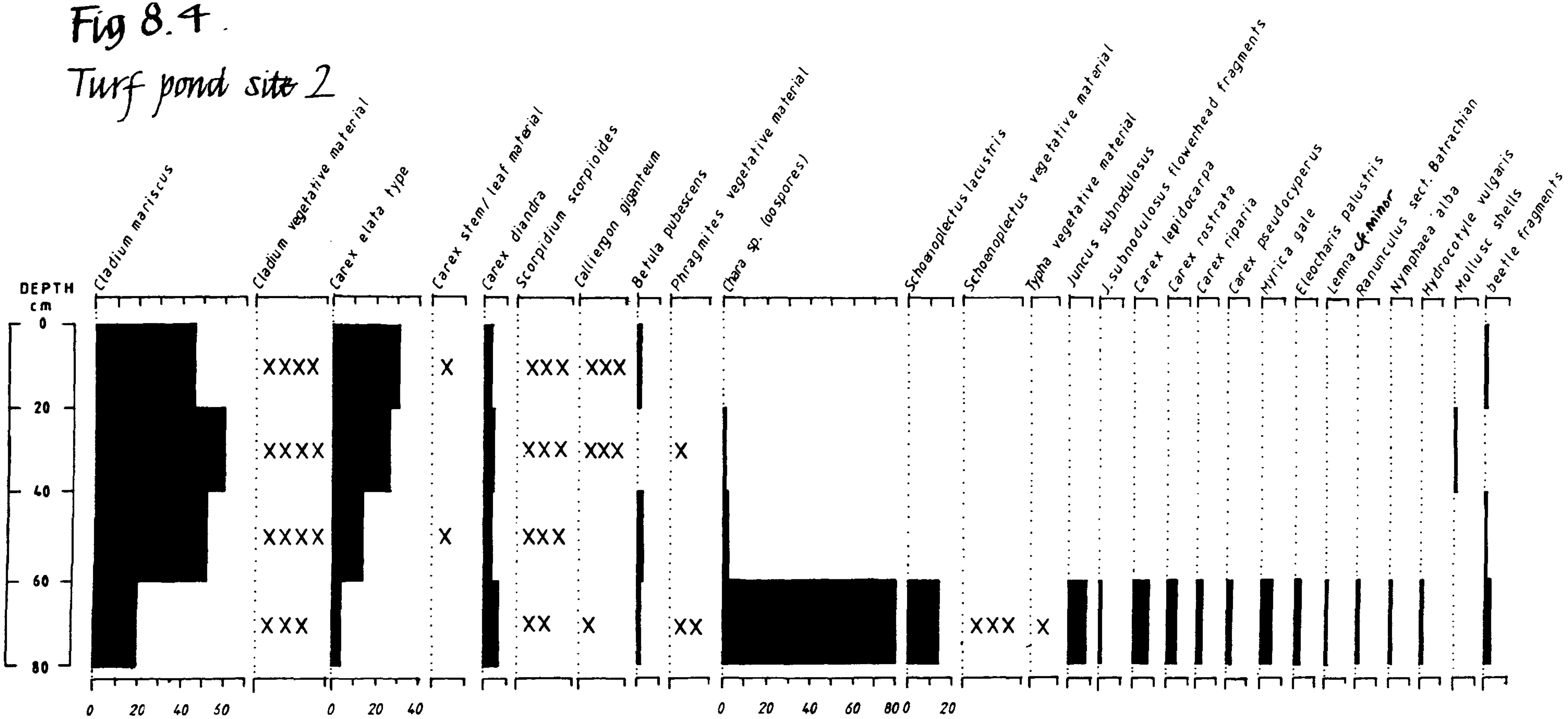
*Interpretation:* There would appear to have been early invasion of flooded conditions by *Cladium mariscus* and *Schoenoplectus lacustris* with the former species maintaining dominance to the present while the latter declined early on. Rapid terrestrialisation seems to be indicated by the strong showing of *Carex elata* in the upper part of the profile which continues to the surface layer along with the appearance of wood fragments and seeds of *Myrica gale*. There is also the interesting and contradictory reappearance of wet indicators ( *Menyanthes trifoliata*, *Chara* sp.) in the topmost layer.

**Site 2. (Fig.8.4) Grid reference: TG 3660 2110. Present day plant community**: *Cladietum marisci.*

*Description: Chara* sp. oospores are abundant at the lowest level along with seeds and vegetative remains of *Cladium mariscus* and *Schoenoplectus lacustris.* Also occurring in the lower levels are seeds of *Juncus subnodulosus*, along with fragments from flowerheads, *Carex lepidocarpa*, *Carex rostrata*, *Carex riparia*, *Carex pseudocyperus*, *Myrica gale*, *Eleocharis palustris*, *Lemna* cf. *minor*, *Ranunculus sp.(sect.Batrachium)*, *Nymphaea alba*, *Hydrocotyle vulgaris*

Fig 8.4.

Turf pond site 2



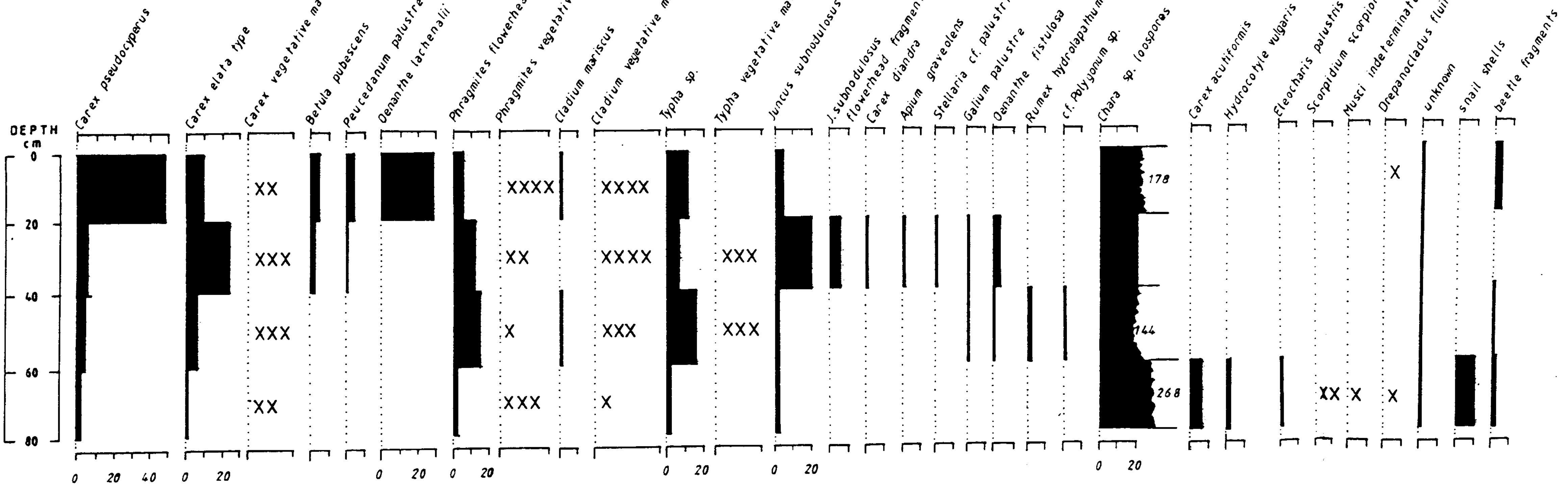
*,Carex elata, Carex diandra, Betula pubescens and Scorpidium scorpioides.* Above the lowest layers there is an increase in the representation of *Cladium mariscus* and *Carex elata* while the uppermost levels see an increase in the prominence of mosses, notably *Calliergon giganteum* and *Scorpidium scorpioides. Phragmites australis* is notable by its absence apart from a small amount of vegetative material between 20-40cm and some mollusc shells also occur at this level.

*Interpretation:* A sequence of succession similar to that described for Site 1 seems to be indicated with *Cladium mariscus* and *Schoenoplectus lacustris* invasion of flooded conditions with the former species becoming the dominant species throughout the profile. Again there is a noticeable rise in *Carex* remains as one progresses upwards and perhaps a hint of slightly wetter conditions as the surface is neared with the increase in prominence of moss remains.

**Site 3. (Fig.8.5) Grid reference: TG 3658 2105. Present day plant community:** *Peucedano-Phragmitetum caricetosum.*

*Description:* The bottom levels show an assemblage with many *Chara* sp. oospores and *Phragmites australis* remains together with some remains of *Typha. sp, Juncus subnodulosus, Carex elata, Carex pseudocyperus, Carex acutiformis, Hydrocotyle vulgaris, Eleocharis palustris, Scorpidium scorpioides, Drepanocladus fluitans,* a small amount of *Cladium mariscus* material and some snail shells. All these species remain

Fig 8.5.
Turf pond site 3.



prominent through the profile with *Cladium mariscus* becoming a dominant remain higher up whilst *Typha* appears to become important in the the middle stages when it is joined by minor occurrences of seeds from *Carex diandra, Apium sp., Stellaria palustris, Galium palustre, Oenanthe fistulosa, Rumex hydrolapathum* and *Polygonum sp.*

The uppermost layers witness the appearance of seeds of *Betula pubescens, Peucedanum palustre, Oenanthe lachenalii* and a marked increase in the numbers of seeds of *Carex pseudocyperus* and, interestingly, oospores of *Chara sp.*

*Interpretation:* A *Phragmites australis* swamp vegetation is indicated by the assemblage present in the lowest levels. The high number of *Chara* oospores are notable, indicating very wet conditions initially and also appearing to persist for some time. This vegetation is later invaded by *Cladium mariscus, Typha.* sp. and sedge and herb species. The uppermost level is marked by a rise in numbers of seeds of sedge and herb species together with the vegetative remains of *Phragmites* and also in numbers of *Chara* sp. oospores suggesting an increase in wetness as the surface layers are reached.

**Site 4. (Fig.8.6) Grid reference: TG 3665 2073. Present day plant community:** *Peucedano-Phragmitetum typicum.*

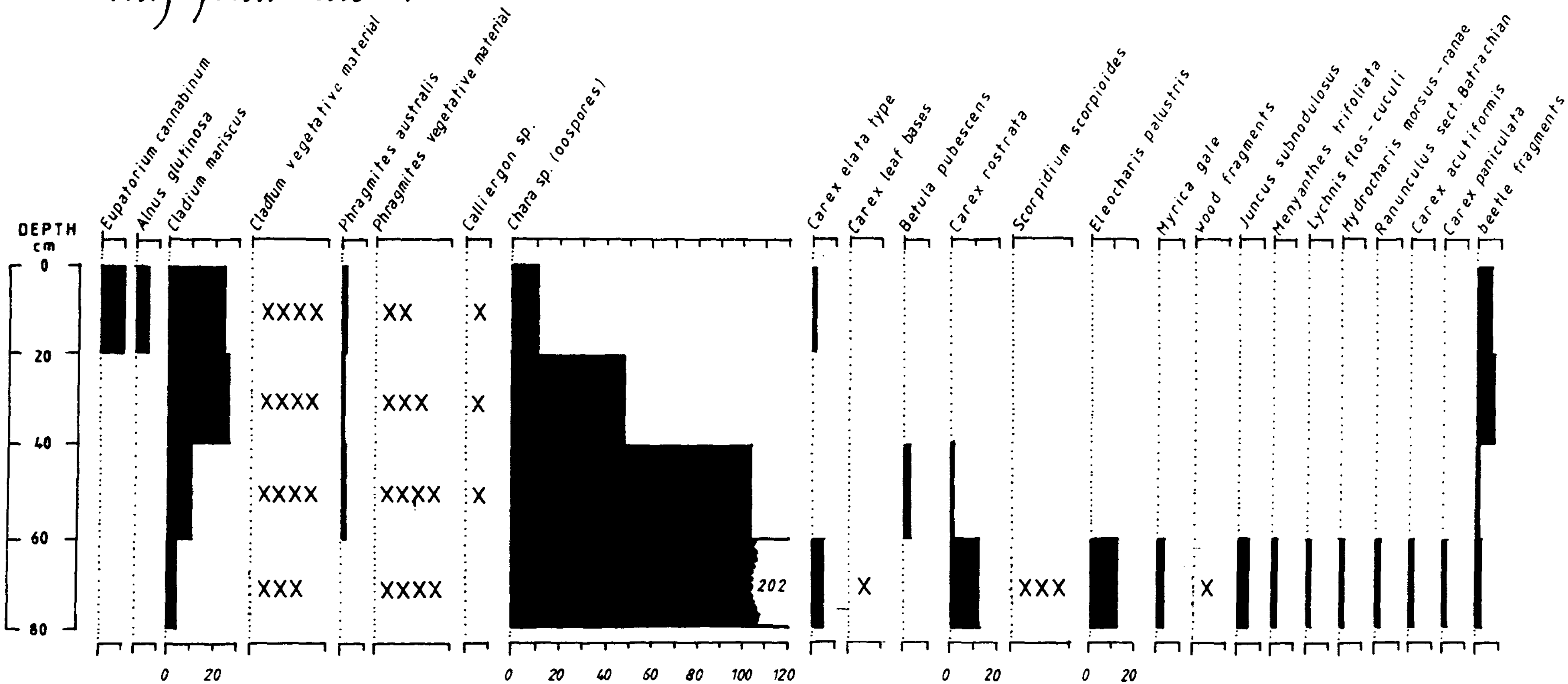
*Description:* The lowest section of the diagram shows the presence of large numbers of *Chara* sp. oospores together *with seeds of Carex elata, Carex rostrata, Eleocharis palustris, Myrica gale, Juncus subnodulosus, Lychnis flos-cuculi, Hydrocharis morsus-ranae, Ranunculus(Batrachium) sp., Carex acutiformis, Carex paniculata, Cladium mariscus* and vegetative remains of the latter species together with those from *Phragmites australis, Scorpidium scorpioides* and wood fragments.

*Chara* sp. oospores remain present through most of the profile but numbers decline as the succession progresses. In the later stages remains of *Cladium mariscus* and *Phragmites australis* become predominant with the uppermost levels seeing the appearance of seeds from *Alnus glutinosa* and *Eupatorium cannabinum.*

*Interpretation:* A *Phragmites australis*-swamp with early invasion by *Cladium mariscus* seems to be indicated with the latter species becoming the dominant species and maintaining this dominance to the top of the profile. The persistence of *Chara* sp. oospores is noticeable almost until the topmost levels where seeds of species such as *Eupatorium* and *Alnus glutinosa* suggest a more recent drying of the surface.

Fig 8.6.

Turf pond site 4



**Site 5. (Fig.8.7) Grid reference: TG 3688 2083 Present day plant community:** *Phragmites-Sium latfolium community.*

*Description:* The lowest levels display large numbers of *Chara* sp. oospores, abundant *Phragmites australis* vegetative material and some *Cladium mariscus* vegetative material together with small numbers of seeds referable to *Sparganium erectum, Carex acutiformis, Nymphaea alba, Juncus subnodulosus, Myriophyllum verticillatum and Carex* vegetative material. The upper sections show the gradual decline in *Phragmites australis* remains while those of *Cladium mariscus* increase steadily to become the dominant macrofossil in the upper portion of the profile. The topmost sample sees the appearance of seeds of *Sium latifolium* and *Rumex hydrolapathum.*

*Interpretation:* The succession appears to have been initiated by a *Phragmites australis*-swamp which was rapidly colonised by *Cladium mariscus* leading to a fen vegetation dominated by these species.

**Site 6. (Fig.8.8) Grid reference: TG 3695 2094 Present day plant community:** *Peucedano-Phragmitetum typicum.association*

*Description:* The lowest levels show very high numbers of *Chara* sp. oospores with much *Phragmites australis* material and also significant amounts belonging to *Juncus*

Fig. 8.7.

Turf pond site 5.

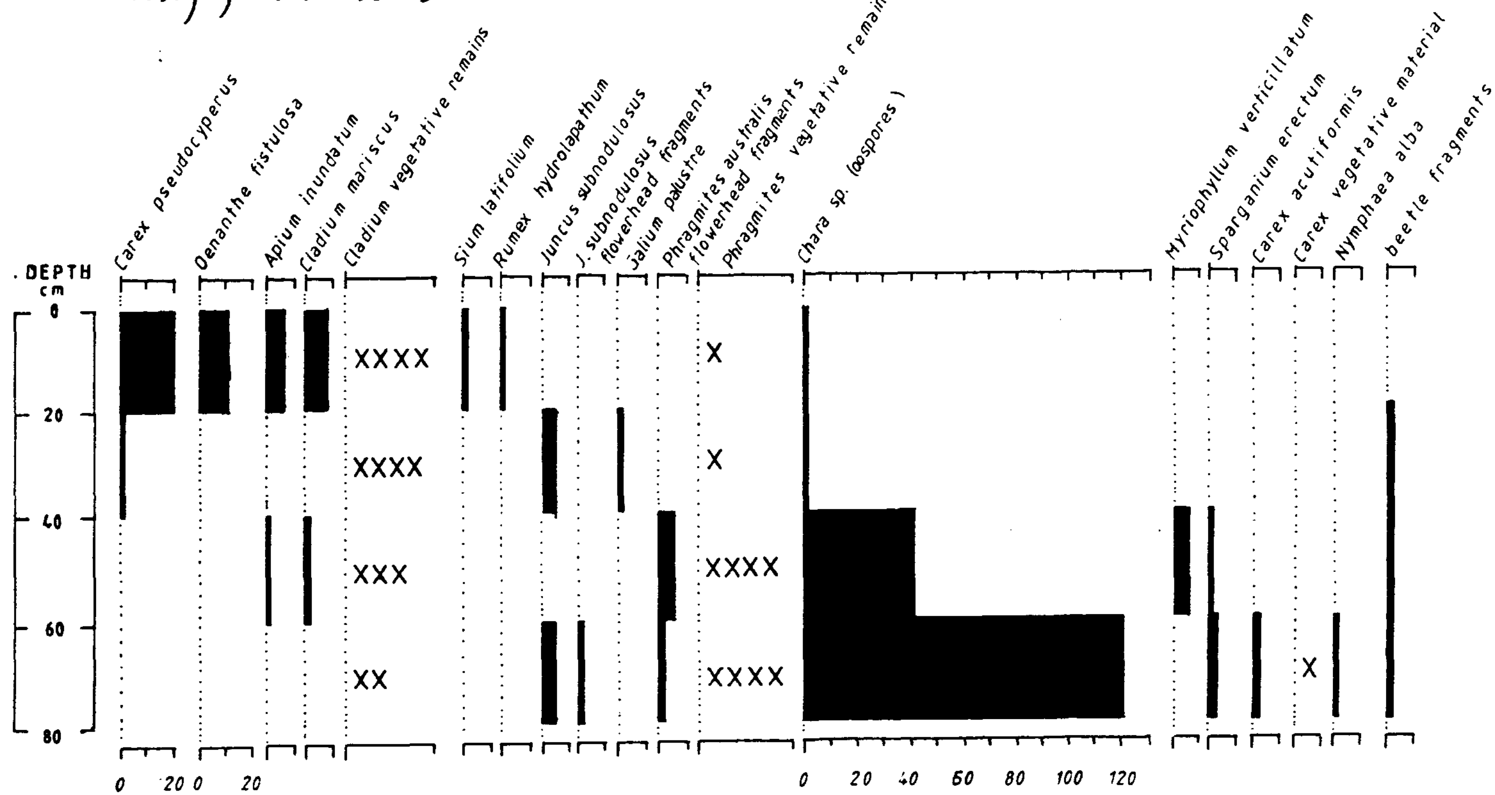
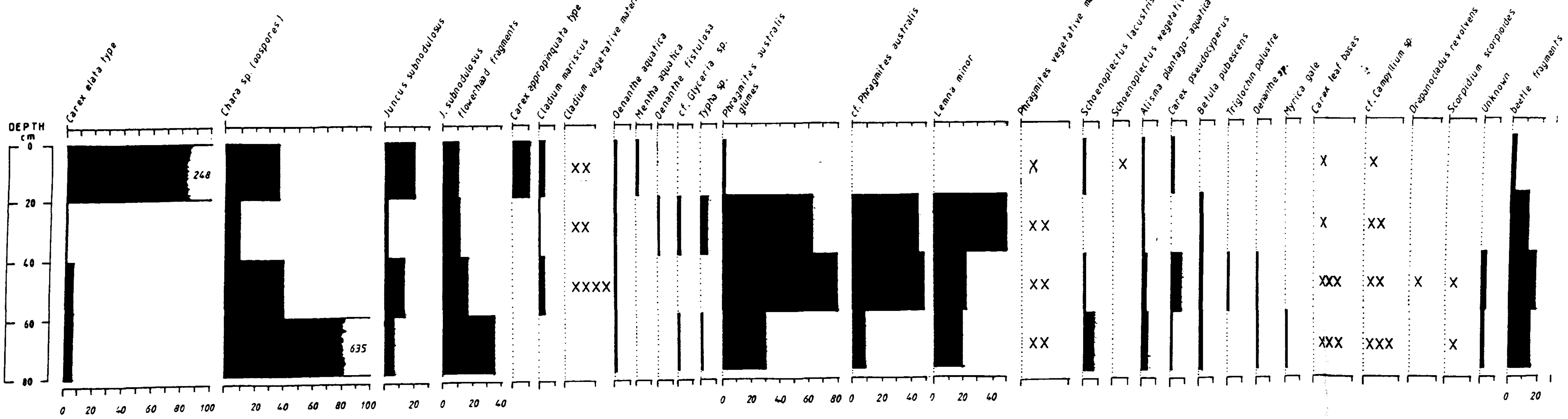


Fig 8.8.
Turf pond site 6



*subnodulosus.* Seeds of *Typha* sp. are also present along with those of *Lemna minor, Glyceria sp., Carex elata, Schoenoplectus lacustris, Alisma plantago-aquatica, Carex pseudocyperus, Betula pubescens, Triglochin palustre, Oenanthe sp.* and *Myrica gale.* Remains of mosses, particularly those referable to *Campylium sp., Drepanocladus revolvens and Scorpidium scorpioides* are most prominent in the lower section of the diagram although they continue to be represented at higher levels in the profile.

*Cladium mariscus* arrives in the middle stages and continues to form a prominent component of the macrofossil assemblage up to the surface, as does *Juncus subnodulosus* while *Phragmites australis* remains continue to be abundant until the uppermost sample. The decline in *Phragmites australis* is matched by the sudden rise in numbers of seeds referable to *Carex elata* and the appearance of *Carex appropinquata* and *Mentha aquatica* seeds while numbers of *Chara* sp. oospores increase very slightly.

*Interpretation:* Again, a *Phragmites australis* swamp vegetation seems to have been the first community to develop over the cutting with the high *Chara* sp. oospore numbers perhaps indicating very wet conditions. *Cladium mariscus* appears to have arrived fairly early on in the succession and to have gradually increased in importance with a large expansion of *Carex elata* occurring more recently.

Site 7. (Fig.8.9) Grid reference: TG 3688 2116 Present day plant community: *Cicuto-Phragmitetum.*

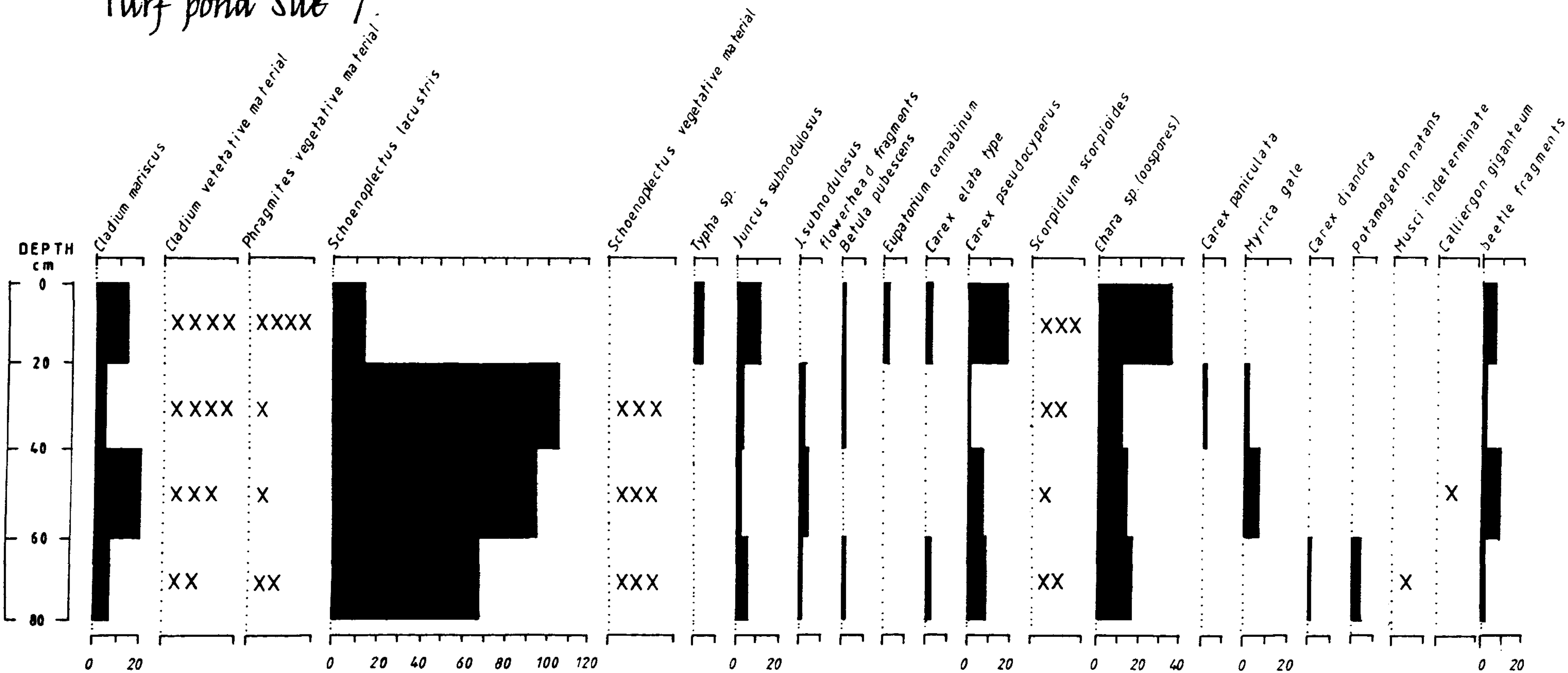
*Description:* Only low numbers of *Chara* sp. oospores are present in the lower layers of this site and they remain at approximately the same level of representation throughout the profile. Instead the bottom sample is dominated by remains of *Schoenoplectus lacustris* with significant amounts of *Cladium mariscus* material and comparatively smaller amounts of *Phragmites australis* material. *Juncus subnodulosus* seeds and flowerhead fragments are also present in low numbers and remain at nearly the same levels up to the surface and also present are small numbers of seeds referable to *Betula pubescens, Carex elata, Carex pseudocyperus, Carex diandra, Potamogeton natans* and remains of *Scorpidium scorpioides.*

Additional species appearing in the middle stages include *Myrica gale, Carex paniculata* and *Calliergon giganteum.*

Remains of *Schoenoplectus lacustris* continue to be the predominant macrofossil until the upper 20cm of the peat when *Cladium mariscus* increases its representation along with remains of *Phragmites australis.* Seeds of *Typha* also appear as do those of *Eupatorium cannabinum.* The upper layer again sees a small rise in the numbers of *Chara* sp. oospores and an evident increase in the frequency of *Scorpidium scorpioides* remains.

Fig 8.9.

Turf pond site 7.



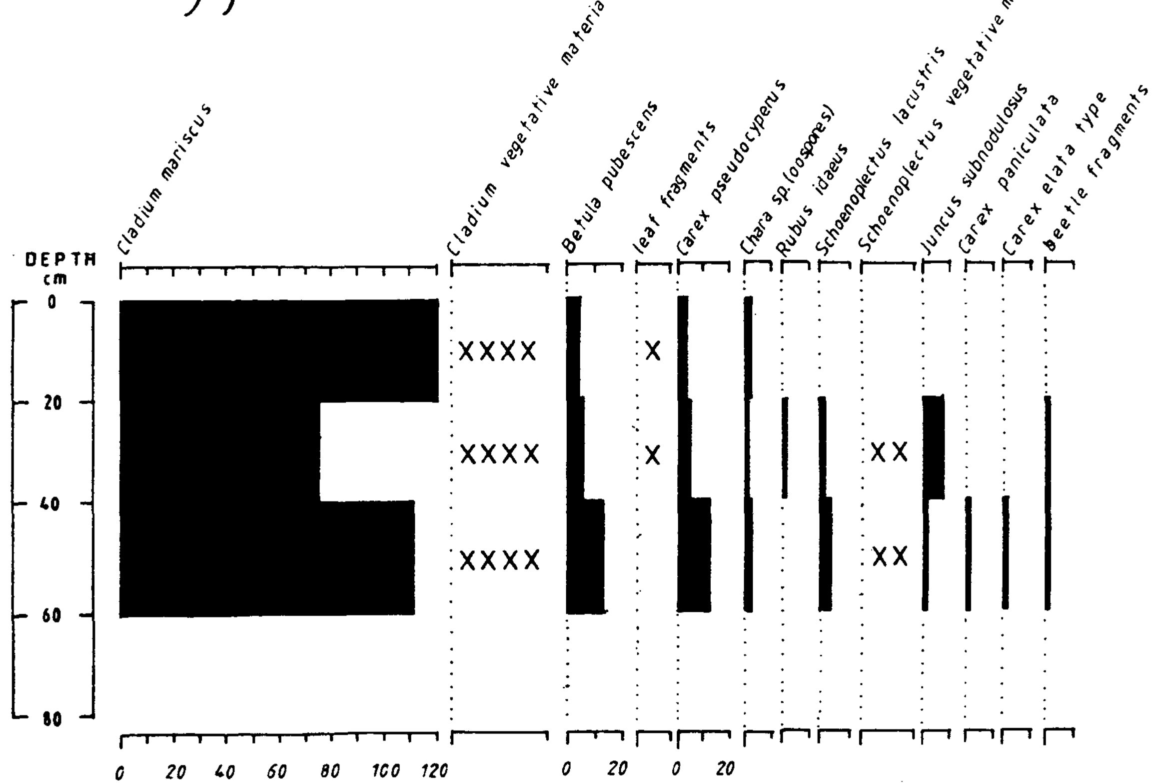
***Interpretation:*** ***Schoenoplectus*** *lacustris* appears to have been the dominant species for most of the successive stages in the turf-pond, which may also have originally had slightly less wet conditions than many others, judging by the relatively low numbers of oospores of *Chara* sp. and other aquatic species. *Cladium mariscus* seems to have gradually become more common as time went on until the final stages where both it and *Phragmites australis* appear to become the dominant species. Once again there is a hint of the development of slightly wetter conditions is indicated in the topmost layers by the small increase in *Chara* sp. oospore numbers and frequency of *Scorpidium scorpioides* remains.

**Site 8. (Fig.8.10) Grid reference: TG 3690 2128 Present day plant community:** *Cladietum marisci.*

*Description:* (The bottom of the profile is truncated due to sampling difficulties (see 10.4) and begins at 60cm below the surface.) Seeds and vegetative remains of *Cladium mariscus* are the predominant macrofossils throughout the samples of the turf-pond. The lowest samples show that initially *Schoenoplectus lacustris* was an important component of the vegetation and also occurring were *Carex paniculata, Juncus subnodulosus, Carex pseudocyperus, Betula pubescens, Rubus idaeus and Carex elata. Schoenoplectus*

Fig. 8.10.

Turf pond site 8.



*lacustris* disappears in the uppermost sample but *Betula pubescens, Carex pseudocyperus* and vey low numbers of *Chara* sp. oospores persist to the top.

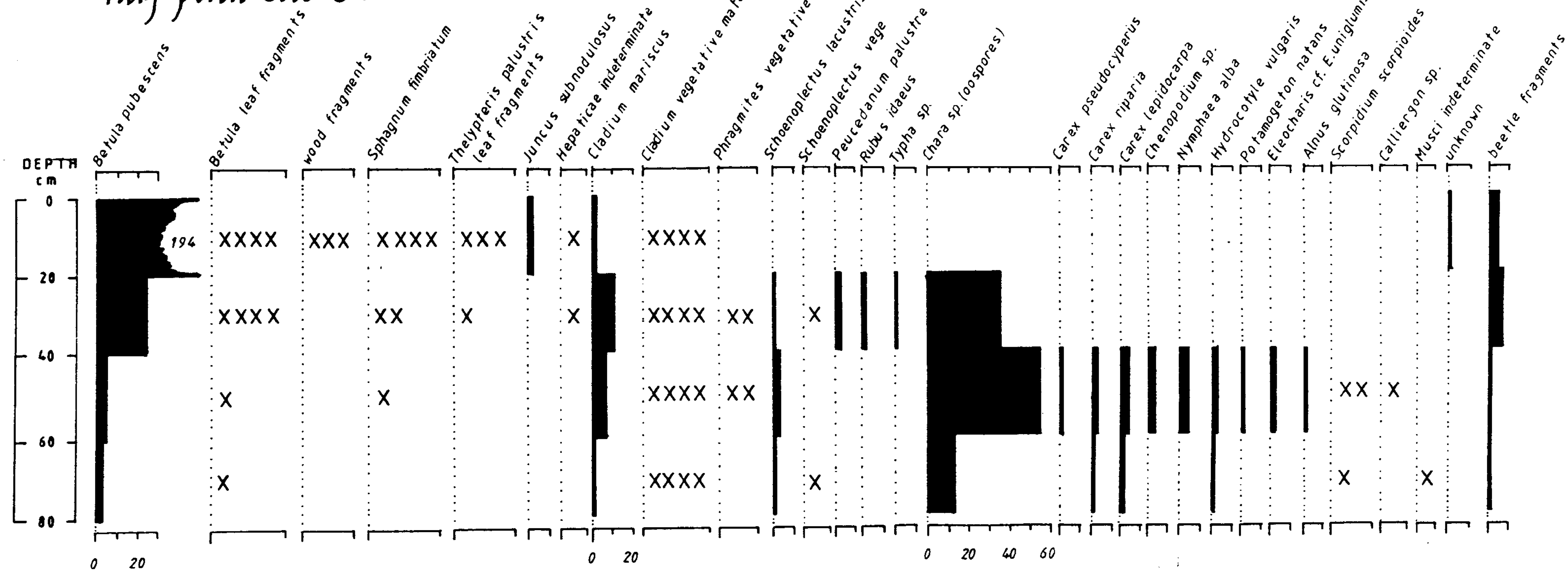
*Interpretation:* As far as is possible to tell, *Cladium mariscus* seems to have dominated the successional sequence in the turf-pond although there was originally a significant contribution from *Schoenoplectus lacustris* which ceases in the final stages.

**Site 9. (Fig.8.11) Grid reference: TG 3697 2134 Present day plant community:** *Betulo- Myricetum peucedanetosum Sphagnum* var.

*Description:* Abundant *Cladium mariscus* material is found in the bottom samples (and continues to be prominent throughout the profile) with a relatively small amount of *Schoenoplectus lacustris* material. Small numbers of *Chara* sp. oospores are present along with low numbers of seeds referable to *Carex riparia, Carex lepidocarpa, Hydrocotyle vulgaris, Betula pubescens* (with some leaf fragments) and remains of *Scorpidium scorpioides.* The penultimate lowest sample (40–60cm) continues to contain small numbers of seeds from these species but in addition seeds of *Chenopodium* sp., *Nymphaea alba, Potamogeton natans, Eleocharis uniglumis* and *Alnus glutinosa* are found along with remains of *Calliergon* sp., *Phragmites australis* and *Sphagnum fimbriatum.* The

Fig. 8.11.

Turf pond site 9.



sample from 20-40cm brings the addition of seeds of *Peucedanum palustre, Rubus idaeus and Typha* sp. The uppermost sample sees the disappearance of most of the aquatic species along with *Schoenoplectus lacustris* and *Phragmites australis* and a large increase of seeds and leaf fragments referable to *Betula pubescens.* Associated with this is the presence of wood fragments, an increase in frequency of remains of *Sphagnum, Thelypteris palustris* remains and the appearance of *Juncus subnodulosus* seeds.

*Interpretation:* Relatively dry conditions seem to be indicated in the deepest sample with low numbers of *Chara* oospores and seeds of aquatics.

*Cladium mariscus* appears to have been the main colonist with *Schoenoplectus lacustris* of lesser importance. The presence of *Betula pubescens* remains, although at a relatively low level of representation, suggest the proximity of source material for subsequent invasion. The sample above the deepest (40-60cm) curiously displays indications of slightly wetter conditions with the appearance of seeds from aquatic species such as *Nymphaea alba, Potamogeton natans* and *Chara.* This phase is short lived, however, and the rapid drying of surface conditions is indicated in higher samples by the rapid rise of *Betula pubescens* remains and seeds. This is paralleled by the increase in frequency of *Sphagnum* remains.

**Site 10. (Fig.8.12) Grid reference: TG 3728 2100 Present day community:** *Phragmites-Typha angustifolia community.*

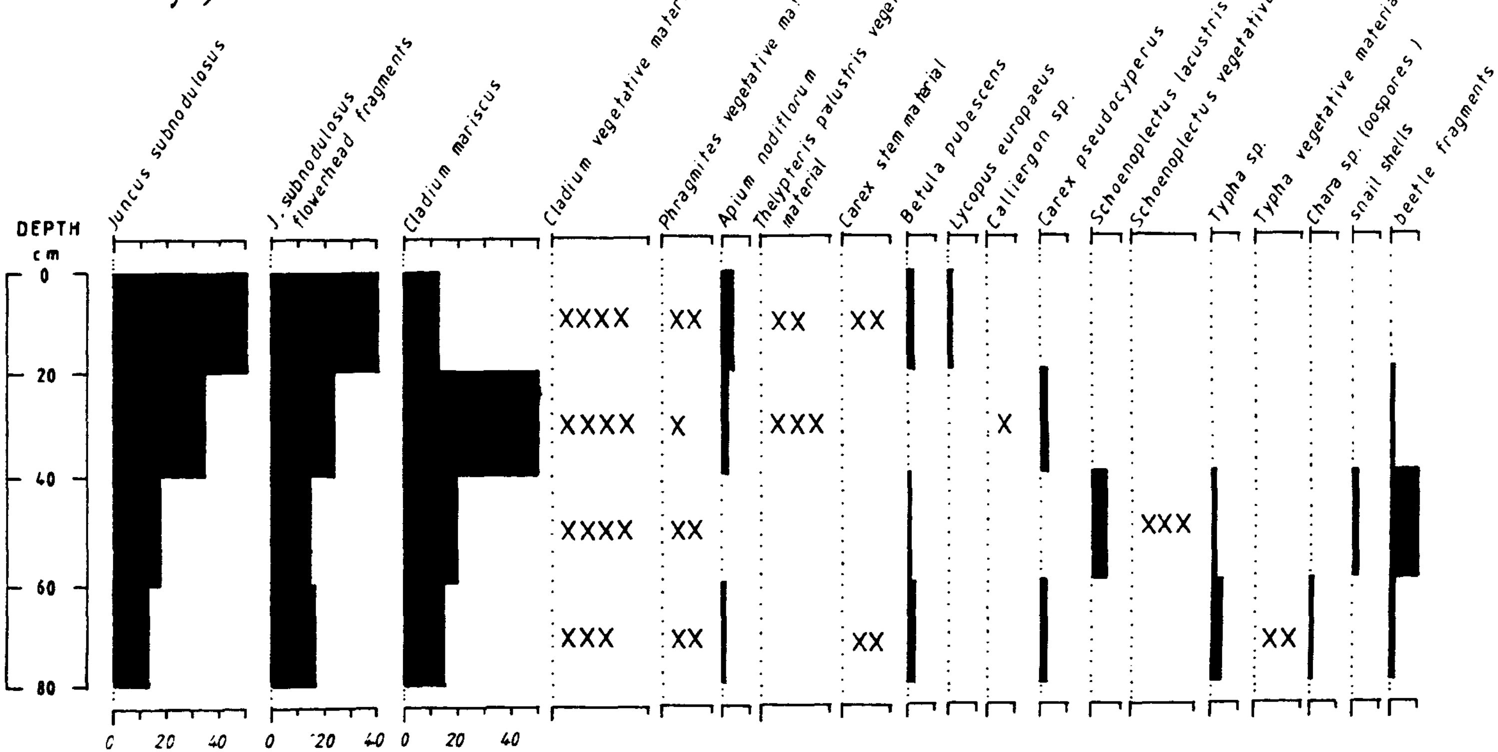
*Description:* *Cladium mariscus*, with slightly smaller amounts of *Juncus subnodulosus*, *Phragmites australis* and *Typha* sp. material form the bulk of the macrofossil assemblage from the lowest samples. Also present are seeds of *Apium nodiflorum, Betula pubescens, Carex pseudocyperus, Chara* oospores and *Carex* stem material.

The following succession sees the maintenance of dominance of *Cladium mariscus, Phragmites australis* and *Juncus subnodulosus* remains while those of *Typha* soon disappear. Frequent remains of *Schoenoplectus lacustris* occur briefly in the 40-60cm sample before disappearing again. The upper samples witness the the arrival of macrofossils from *Thelypteris palustris, Lycopus europaeus, Calliergon* sp., as well as the re-appearance of those belonging to *Apium nodiflorum, Betula pubescens,* and *Carex* sp.

*Interpretation:* A relatively dry surface seems to be indicated in the initial stages judging by the paucity of macrofossils of aquatics. This was rapidly colonised by a *Cladium mariscus/Phragmites australis/Typha* vegetation, evidently with a significant *Juncus subnodulosus* component. *Schoenoplectus lacustris* seems to have made an important, if short-lived, contribution to the vegetation early on in the

Fig. 8.12.

Turf pond site 10.



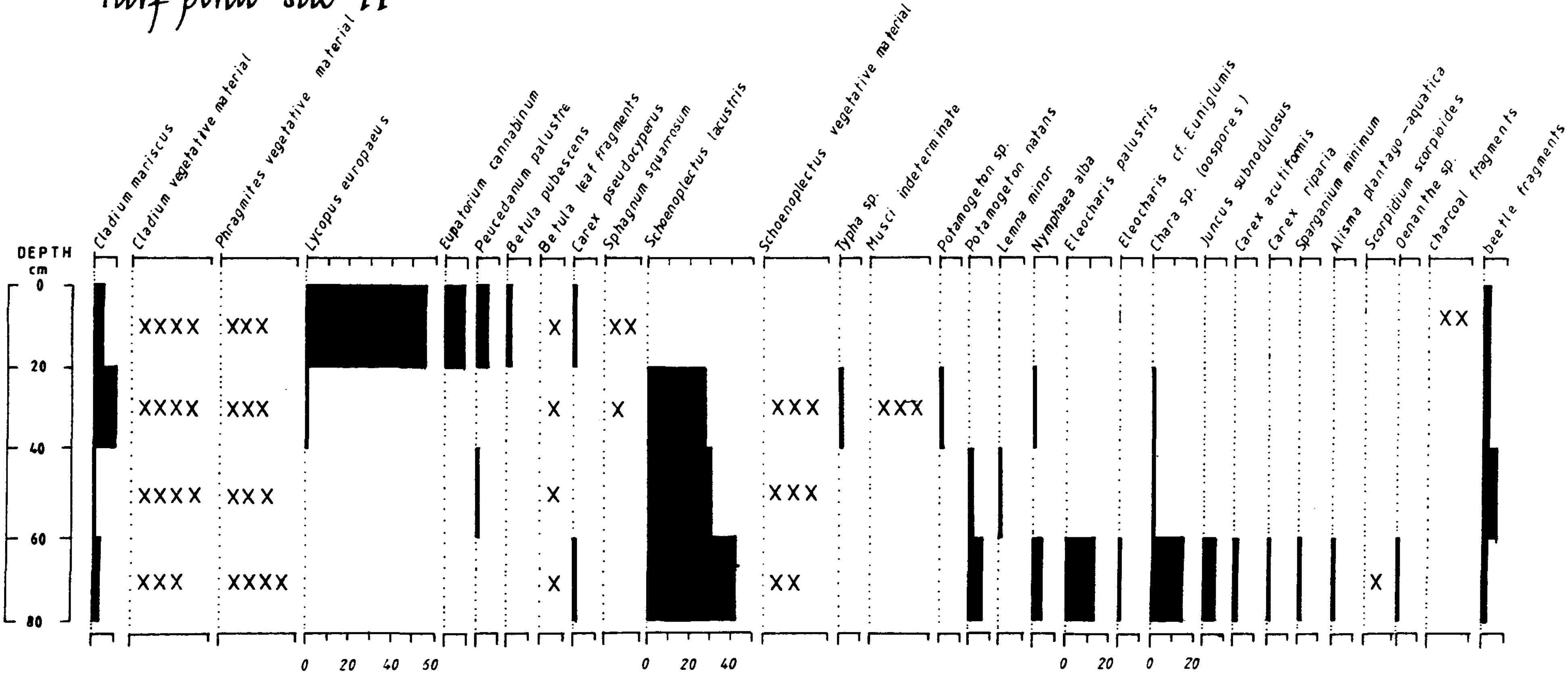
succession but *Cladium mariscus, Juncus subnodulosus* and *Phragmites australis* continue to dominate the assemblage to the surface.

**Site 11. (Fig.8.13) Grid reference: TG 3730 2098 Present day plant community:** *Betulo-Dryopteridetum cristatae* community.

*Description:* Initially, the assemblage is dominated by macrofossils of *Schoenoplectus lacustris, Phragmites australis* and *Cladium mariscus,* with smaller but significant contributions from many other species such as *Juncus subnodulosus, Carex acutiformis, Carex riparia, Betula pubescens, Carex pseudocyperus, Oenanthe* sp. and including several predominantly aquatic types such as *Potamogeton natans, Nymphaea alba, Eleocharis palustris,Eleocharis uniglumis, Chara sp., Sparganium minimum, Alisma plantago-aquatica and Scorpidium scorpioides.*

Remains of predominantly aquatic species soon disappear in the following succession while *Schoenoplectus lacustris* continues to be prominent until the uppermost sample. *Cladium mariscus* and *Phragmites australis* remain important macrofossils allthe way through the profile. The sample from 20-40cm witnesses the appearance of *Sphagnum* remains and the brief reappearance of seds of *Potamogeton* sp., *Nymphaea alba,* together with a marked increase in moss

Fig. 8.13.
Turf pond site 11



remains. *Typha* seeds also make their only appearance at this level.

The topmost sample is still dominated by *Cladium mariscus* and *Phragmites australis* macroremains but there is a large increase in numbers of seeds of *Lycopus europaeus, Eupatorium cannabinum, Peucedanum palustre, Betula pubescens* and a increase in frequency of *Sphagnum* remains. There are also some charcoal fragments.

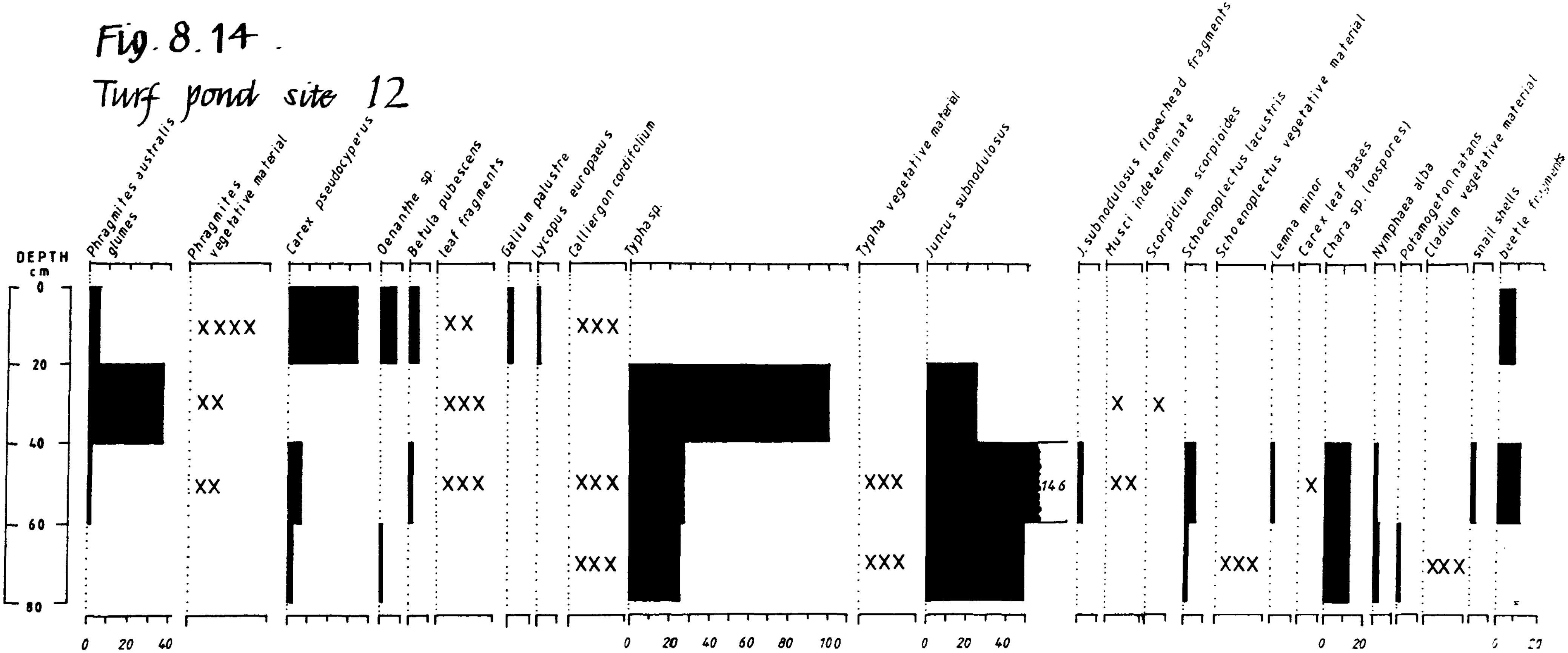
*Interpretation:* The presence of many seeds from aquatic species indicates the existence of relatively wet conditions initially which were invaded by *Schoenoplectus lacustris, Cladium mariscus*, and probably *Phragmites.* A *Schoenoplectus lacustris/Cladium mariscus/Phragmites australis* vegetation seems to have developed and dominated over the middle stages of the succession until the abrupt disappearance of *Schoenoplectus lacustris* remains in the final sample. The sample below this from 20–40cm contains the first *Sphagnum* remains and there is possibly a hint of a slight increase in wetness at this point with the presence of seeds of *Potamogeton* sp., *Nymphaea alba,* and a marked increase in other (i.e. non-*Sphagnum)* moss remains for a temporary period.

The final sample shows the dominance of *Cladium mariscus* and *Phragmites australis* with associated fen species such as *Eupatorium cannabinum, Lycopus europaeus, Peucedanum palustre* and *Carex pseudocyperus.* Increasing acidification of the surface is indicated by the rise in frequency of *Sphagnum* remains and this is possibly associated with the appearance of charcoal fragments indicating some kind of burning episode.

**Site 12. (Fig.8.14) Grid reference: TG 3750 2070 Present day plant community:** *Phragmites-Typha angustifolium community.*

*Description:* The lower section of the diagram is dominated by remains from *Typha* with relatively large numbers of *Juncus subnodulosus* seeds. *Schoenoplectus lacustris* and *Cladium mariscus* are important in the deepest sample and seeds of *Nymphaea alba, Potamogeton natans, Lemna minor, Carex pseudocyperus, Oenanthe sp., Chara oospores,* together with the remains of *Calliergon cordifolium* and other mosses are all present in the lower samples. The upper section of the diagram shows a rise in prominance of *Phragmites australis* macroremains which parallels a decline in those of *Typha, Schoenoplectus lacustris, Juncus subnodulosus* and *Cladium mariscus* (the latter disappearing after the initial sample). The uppermost sample also shows a marked rise in numbers of seeds of *Carex pseudocyperus, Oenanthe* sp. and *Betula pubescens* (and leaf fragments of that species). Seeds of *Galium palustre* and *Lycopus europaeus* as well as remains of *Calliergon cordifolium* are also present at this level.

Fig. 8.14.
Turf pond site 12



*Interpretation:* A moderately wet surface appears to have been invaded by a *Typha/Schoenoplectus lacustris/Cladium mariscus* vegetation of which *Typha* may have become the most prominent species in the middle stages. This assemblage seems to have been succeeded by a *Phragmites australis*-dominated vegetation in the later stages of the terrestrialisation of the turf-pond.

**8.5 Discussion.**

The results broadly confirm the Giller and Wheeler (1988) model of turf-pond recolonisation with the first major colonists usually being either *Cladium mariscus* and/or *Phragmites australis*, with less frequent, but important contributions coming from *Schoenoplectus lacustris* and *Typha*.

Some of the findings, however, seem to differ from those of previous research. Giller (1982) states that, "*Juncus subnodulosus* appears to have become an important peat forming species at quite a late time and is only found over *Phragmites* peats". The results of the present study show that *Juncus subnodulosus* remains are often found frequently at early stages in the succession and in some cases apparently before the appearance of *Phragmites australis* remains in what appears to be a *Cladium mariscus* dominated peat (sites 1 and 2). The macroremains found in such positions are, admittedly relatively insubstantial, usually consisting of some seeds and occasionally flowerhead fragments and it could be argued that such material is comparatively unimportant. However, it does indicate the presence of the species from an early stage in the succession in some sites and its persistence through most of the sequence at many.

Extremely wet conditions are indicated initially at many of the turf-ponds. Sites 1, 2, 3, 4, 5 and 6 all display relatively high counts of *Chara* sp. oospores from the bottom samples. In contrast it is possible that sites 7, 8, 9, 10, 11 and 12 all appear to have developed from less wet conditions originally, although conditions were still far from "dry" as shown by the wide range of aquatic species' seeds recorded from site 11 for example. However, some of the sites, such as 10, exhibit macrofossil assemblages in the lowest samples which are indicative of markedly drier conditions in the initial stages of colonisation when compared to other examples. At this site there is an almost complete absence of *Chara* or remains of other aquatic species. All the other samples in this series seem to show a reduction in the representation of aquatics in the lower samples when compared to the remainder of the sites looked at.

This difference is interesting in that the distribution of the sampling positions of the possibly less wet examples are all situated within the compartments of the fen enclosed by the "internal system." This is part of the fen lying within Catfield Parish which is divided into a complex area of small units by many dykes and which is thought to have been drained by a windpump, possibly to allow grazing in some of the marginal marshes (Giller, 1982) (Figs.8.1; 8.15). It is possible, therefore, that the macrofossil analyses may be exhibiting the effects of a lowered water table at the time of the initial colonisation of the turf cuttings. The assemblage recorded for site 9 (Fig. 8.11)appears to indicate an interesting trend in the lower deposits. The sample indicative of the wettest conditions seems to occur above the lowest. Such a feature might suggest the initial drainage of the cutting followed by a wetter surface. However, this appears to be the only example investigated where such a feature can be discerned and documentary evidence for such specific drainage practices remains ambiguous (*see 9.12.3*).

Site 3 (Fig.8.5) displays an interesting feature in the way that *Chara* oospores increase rapidly in numbers in the uppermost sample. This coincides with a marked increase in representation of remains of *Phragmites* and the numbers of seeds of *Carex pseudocyperus*. An increase in the wetness of the fen surface in recent times might be inferred from this *Chara* increase. A possible cause might be due to "turfing out";- the removal of surface peat to encourage the growth of reed in deeper water. Anecdotal evidence suggests that this practice was carried out in several parts of the Catfield and Irstead fens in relatively recent times (Giller, 1982). If the macrofossil record is reflecting the effects of such activity, it might have important implications for future management for conservation purposes as the sampling position is situated in a stand of the floristically-rich *Peucedano-Phragmitetum-caricetosum.*

The two sites sampled which contain *Sphagnum* in the present day community (9, 11) both showed the establishment of the moss to be a recent development with remains confined to the upper samples. This is in agreement with the study of Giller and Wheeler (1988) who investigated the stratigraphical history of *Sphagnum* communities within rich-fen systems in various parts of the Broads. They suggested that invading *Sphagnum* may avoid being flooded with surrounding base-rich waters due to colonisation of areas of vertically mobile peat, such as may occur in parts of historically recent turf cuttings.

The examples investigated in the present study may be slightly unusual in that both display abundant remains of *Cladium* through the profile. Giller and Wheeler (1986) found that *Sphagnum* stands developed only rarely over *Cladium* swamp or fen.

# CHAPTER 9. POST-MEDIEVAL TURF-DIGGING AND THE ROLE OF TURF IN THE NINETEENTH CENTURY RURAL ECONOMY OF NORFOLK.

## 9.1 Introduction.

Historical studies can often aid the ecologist in the interpretation of biological systems, particularly in long settled lands such as Europe where there is often much documentary archive material which can be used to interpret past land uses (Sheail, 1980). The past management of a site may be an important or even overriding factor lying behind its nature and appearance at the present day. The importance of the historical approach as an interpretative tool has been shown in many studies concerning specific habitats such as those of Rackham (1980) and Peterken (1981) in ancient woodland; Pollard, Hooper and Moore (1974) of hedges; and by Rowell (1983) and Rowell and Harvey (1988) in fens, where historical evidence proved to be crucial to the understanding of the present-day ecology of Wicken Fen.

The amount of success achieved, however, is dependent on the quality and quantity of the source material, as Rackham (1986) acknowledges when he states, "Historical ecology sometimes involves the set-piece methods of scientific research: problems defined in advance and information collected wherewith to solve them. But in many areas this will not work because the facts are too thinly scattered to justify a deliberate search."

In keeping with the "set-piece" approach, the original aim of the present study was an attempt to discover more about the historically recent turf-cutting industry which has affected so much of the Broadland fen areas. In particular, the resolution of specific problems such as the accurate dating of the original cuttings and the actual mechanics of the cutting (e.g. how the peat was dug, whether the turbary was drained, whether the cutting was abandoned afterwards etc.) was felt to be most desirable if a better understanding of the processes operating during the revegetation of the turf-pits was ever to be achieved.

Unfortunately, in keeping with the rest of Rackham's warning, only a limited amount of success was eventually achieved in the pursuit of these objectives. Documentary evidence relating to turf cutting in Norfolk proved to be extremely scarce despite extensive searches through the collections of archive material in the Norfolk Record Office and the British Library. In part, it seems probable that this is because turf was chiefly the fuel of the poorer members of society in historically recent times. This would have meant that those people with most direct contact with and experience of turf-cutting were also likely to have been the least educated and literate and therefore unlikely to have recorded their activities to any great degree. It is also because of this that most information which has been gleaned has come from documentary sources relating to the welfare of the poor in Norfolk in the eighteenth and nineteenth centuries.

A very real problem is the fact that many records are as yet unavailable due to the time taken in cataloguing and preserving material, which, in many cases , is in a poor state due to years of languishing in damp parish chests. Many records which were known to be housed at the Norfolk Record Office and which seemed likely to be of interest with regard to the present study could not be consulted for these reasons.

Another surprising discovery was the extent to which recollection of the relatively recent industry had apparently disappeared completely from the collective folk-memory of the region. Despite the former importance of the activity and unlike some other former peat cutting regions (e.g. Martin Lane, 1961), there was a complete lack of anecdotal evidence forthcoming, even after a considerable amount of publicity about the subject generated through appeals for information through local broadcast and newsprint media. It seemed that just a little too much time had elapsed since the turf-cutting heyday for there to have survived an oral tradition pertaining to the skills and methods used in extracting Norfolk turf. There are indications of this sad state of affairs having been the case since at least the last war, for as Carrodus (1949) relates,

> **"It is rather remarkable that during the acute coal shortage in the last year of the second world war there was no movement to go back to turf as a fuel. Probably the main factor would have been the shortage of labour, beside which the giants of the industry were themselves beneath the turf itself. For another thing then turf cutting implements had become museum pieces miles from their native marsh."**

Despite such difficulties, a limited amount of progress has been made in answering some of the questions and knowledge about the extent and importance of peat cutting in Norfolk in the last two hundred years or so has been expanded.

The evidence presented in this chapter then, contains information relevant to the biological problems posed by the effects of former turf-cutting, but is also intended to illustrate the relevance and importance of turf in the wider context of Norfolk's rural history. Such assessments help to put the historical evidence used in the ecological arguments in context but the area of study is also considered to be interesting in its own right. So very little attention has been hitherto afforded to post-Medieval turf-cutting and fuel gathering in Norfolk that it has been felt worthwhile to expand the information presented in this chapter to include aspects important to the rural social history of the region.

The full findings of the historical research are therefore presented, even where such information may not be directly relevant to the ecological aspects of the study. In any case, it is probably unwise to attempt to disentangle "history" from "ecology" when one is dealing primarily with historical documents. The author subscribes to the view of Darby (1953) that; "Such treatments lie in an intellectual borderland. To set tariff frontiers around different academic subjects, and so hinder the flow of ideas, is as unnecessary as it is unprofitable."

## 9.2 The nature of the evidence.

### *9.2.1 Main sources for the present study.*

Previous investigators have suggested that historically recent turf-cutting in Norfolk was a predominantly nineteenth century phenomenon (e.g. Giller and Wheeler, 1986; Wheeler, 1985). This may be due in part to the greater availability and accessibility of archive sources dating from that century.

The major sources consulted in the present study are also predominantly nineteenth century in origin. These include the Inclosure Awards and maps for Catfield (1807) and Neatishead; the Tithe Apportionment (1840) and map (1841); the early editions of Ordnance Survey plans (1840, 1885, 1886); the *Report of the Charity Commissioners for Norfolk* (1815-37) and various agricultural reviews of the period.

Much of the evidence gleaned from the accounts of the Overseers of the Poor of various parishes which have been consulted dates to the period although much has been found which also has relevance to pre-nineteenth century cutting. These records usually take the form of accounts books which detail the amounts of money expended during the years by parish officers in connection with their duties relating to the welfare of the poor. The provision of fuel for paupers is often a prominent item in these accounts and can be used to make inferences such as about the main type of fuel utilised at a particular period, its cost and the amounts used.

Occasionally information may also be gleaned about other costs such as those relating to gathering of the fuel, such as turf or flags, and the transporting of the latter.

An attempt was made to analyse pre-nineteenth century manorial records and court rolls relevant to the parishes of Catfield and adjacent areas but this survey was limited due to lack of time available and difficulties deciphering the sixteenth and seventeenth century latin which encoded many of the records.

The present study, then, suffered from similar problems of bias to previous studies in terms of the temporal distribution of documents studied but it is hoped that the historical material and interpretations offered below will show, amongst other things, that there is reasonable evidence for definite conclusions to be drawn with regard to the antiquity and causality of post-Medieval turf-cutting.

**9.3 The importance of peat cutting in British rural history.**

Today, the only parts of the British Isles where peat is still an important domestic fuel are in the north and west of Scotland and in western Ireland. Here, the widespread availability of the material combined with a relatively remote geographical location continue to allow peat to enjoy a competitive advantage over more modern fuels. The persistence of tightly knit rural communities in these areas also means that the communal pooling of labour which is necessary for the efficient extraction of peat continues (Fraser-Darling, 1955; Geddes, 1955).

Nearly everywhere else, and in England in particular, the practice has long since died out due to many factors including the development of the coal industry, improved communications allowing the cheap alternative fuels to replace peat and the break-up of rural communities together with their long-established practices during the agricultural and industrial revolutions.

Although deposits were never as widespread in England as in Scotland or Ireland, the cutting of peat was carried on virtually anywhere that exploitable deposits were to be found, most notably in the north-western counties of Cumbria (Marshall, 1971; Rollinson, 1981, Winchester, 1987), Lancashire (Crompton, 1966), Cheshire, parts of Wales (Godwin, 1981), Derbyshire (Anderson and Shimwell, 1981) the Somerset Levels (Coles and Coles,1986), Cornwall and the South-West (Hopkins, 1983), the Fenland (Darby, 1956, 1983)) as well as Norfolk and Suffolk. It was the large-scale exploitation of fen peat, as opposed to ombrotrophic material that marked out most of the East Anglian turbaries from most of the other regions mentioned

**9.4 Turf-cutting and the provision of fuel for the poor in Norfolk.**

In Norfolk, in common with East Anglia as a whole, peat was known as *turf* and the combustible dried blocks derived from it as *turves.* These were associated with deeper, more humified sub-surface material in contrast to looser and more rooty superficial deposits which were usually referred to as *flag.* Fuel blocks were also made from this material and these were called *flags* [1](Rye, 1895) or sometimes *hover* (see below). The former items made for a superior fuel compared to the latter which was probably very poor material in terms of calorific content.

Although the two types could often be exploited at the same site, specific references to flags are commoner from sites where peat deposits were very thin, such as heathland and in some places specific reference is made to "upland flags" (e.g. Bird, 1909), presumably in reference to material derived from drier locations where organic composition of the fuel was comparatively low.

1 The East Anglian word for combustible blocks made from the fibrous top layer of peat, *flags* seems to be similar to the word sometimes used for the same material in Cumberland, namely *flaughts* (Rollinson, 1981).

Before the advent of cheap coal in the latter half of the nineteenth century it seems likely that in a relatively treeless county such as Norfolk, turf would have been a major fuel of all sections of society. In the Medieval period this was certainly the case in Norfolk as evidenced, for example, from records of large scale use by Norwich Cathedral (Smith, 1960).

In more recent times it seems that its use became largely confined to the lower echelons of the social order as the most frequent references to the commodity are to be found in the individual parish account books of the Overseers of the Poor and in the Reports of the Charity Commissioners.

Agricultural writers of the period also indicate that peat was the fuel of the less well-off. Quoting a Dr.Hinton talking about the suitability of peat ashes as a fertiliser, Kent (1794) states,

> **"The ashes of this fuel are daily deposited on proper places distant from the habitations of the poor and carefully quenched with water."**

W.G. Clarke (1903) also mentions that;

> **"In former days...turf was then the most common article of fuel among the poor, even in towns far distant from the Fens-Norwich for instance-where the peat was retailed from hawker's carts."**

Prior to the widespread parliamentary enclosures of the late eighteenth and early nineteenth century and the consequent curtailing or extinguishing of common-rights, it carried out by the people who required the fuel themselves, or their proxies, and that the relative amounts to be individually dug were probably decided amongst the people entitled to cut at a particular site in a self-regulatory manner. There may be a hint of such a system surviving in the account given by Dutt (1906) of the reminiscences of an old man who had lived all his life in the Waveney valley.

The account, although somewhat colourful and picturesque, nevertheless gives a glimpse into long-forgotten self-regulatory practises and is one of the few examples of a popular documentary source directly referring to peat cutting in this part of Britain.

> **"When a young man, he had often cut peat there, which was the only fuel used in his father's cottage, and, indeed, in all the cottages on the marsh-border, where the fires were kept burning day and night all through the year, In those days there was an annual "peat-running", at which the men of the village decided where their turves were to be cut during the ensuing 12 months. This peat running took place every tenth of May, on which day all the men who wished to cut turves met in front of an inn in the village street, and the rest of the villagers turned out to see the fun. 'For th'way on it wor like this,' said old Ben. 'A line wor marked acrost th'road, and as in a boy's race at a skule treat, ony each on 'em carried a spade in his hand. Th'parish constable wor th'starter, and as sune as he gin th'wud, they all started a runnin' down th'driftway to th'fen as hard as they could put fut ter th'ground. When they got there, every man had ter stick his spade inter th'middle o' th'place where he wanted to cut his turves, and a-course him as got there fust got fust choice. Widders, owd maids, and owd men wor 'lowed to hev young chaps run for 'em. I can mind as how I used ter run for owd Betty Woodrow, what lived agin th'pound. It wor a rare sight ter see us a-running wi' half th'village at owr haals-sich a sight as can't be seen nowadays nowhere."**

Unfortunately, Dutt does not mention the exact location or date of the episodes recalled by "old Ben" but it seems that he is referring to events in the first half of the nineteenth century. The location of the events could well be the Redgrave and Lopham Fens, as these are the major areas of fen in the Waveney valley where cutting was known to have occurred formerly. The account is interesting by the way that it implies that the quality of the peat varied over the turf-grounds and also because it demonstrates the manner in which rural communities of the day ensured that less able members were looked after - allowing young fit boys to run in their place almost certainly meant they got to the best quality peatland first.

Whether such colourful traditions were widespread in the region is hard to tell. The account quoted is certainly the only one referring to this particular practice known to the present author but the general scarcity of any information directly relating to turf-cutting practices precludes the drawing of definite conclusions on this point.

### *9.4.1 The fuel allotments of the Poor.*

With the advent of Parliamentary Enclosure and the development of the poor-law system, the regulation of turf cutting became more formalised. When parishes were subject to enclosure, it became the practice to allocate certain plots of the land as "fuel allotments", probably in recompense for loss of fuel-gathering rights in other areas.

The management of these fuel allotments became the responsibility of the Trustees for the Poor of the Parish. From the accounts of the Charity Commissioners (detailed below) it seems that the trustees generally consisted of the rector, the churchwardens and overseers but could also include the vicar and occasionally the Lord of the Manor. Frequently the allotment was merely a plot of land which was let to a tenant (usually for grazing) and the rent applied in the purchase of fuel (often coal, but also sometimes turf or faggots) for the use of the poor of the parish. In many parts of Norfolk, and particularly in the Broadland parishes, the ground allotted for the purpose was obviously suitable for exploitation for fuel directly and in these cases the trustees often managed the cutting and distribution of peat.

The volume for the County of Norfolk of the *Reports of the Commissioners to Inquire concerning Charities and Education of the Poor* provides extremely valuable insights into the state of fuel provision for the poor (and hence turf-cutting) across Norfolk during the period 1815-37.

The Commission had been set up by Parliament primarily to investigate the reasons behind an alarming rise in the Poor-Rate which had occurred towards the end of the eighteenth century and into the beginning of the nineteenth (Tate, 1969). Part of the Commissioner's remit was to investigate the management of any plots of ground allotted at the time of enclosure for the provision of fuel to the poor. Many parishes in Norfolk contained such allotments and the thorough descriptions provided in the reports give a unique county-wide review of the subject as it was in the early nineteenth century. Any references to individual parishes detailed in the following sections use the report as a source unless stated otherwise.

*9.4.2 Management of turf-cutting in the fuel allotments.*

There appears to have been no uniform approach to the management of the fuel allotments and parishes seem to have been autonomous in this regard with the consequence that markedly individual or even unique methods were adopted from place to place. The efficiency of the trustees in carrying out their duties also varied considerably as the Charity Commission investigators revealed. At Great Hockham, for instance, the poor of the parish had the best of all worlds. The parish was fortunate enough to have had two fuel allotments, on one of which "the turf is cut by the trustees, which is delivered to the poor at their houses in quantities varying, according to number in the family, from 4000 to 8000 turves", while on the other allotment, "there is very little turf and the poor are allowed to cut it as they please." In other areas it was the practice to allow the poor to cut the turf themselves, subject to certain restrictions, as at Larling where, "All the poor belonging to the Parish are allowed to cut turves in quantities from 2000 to 8000 [yearly] according to the number in the family", and with slightly more restriction at Old Buckenham, where, in addition to allowing the poor to cut 2000-6000 turves depending on family number, "the herbage[2]..is let to two tenants...out of this rent there is paid 2 pounds yearly to a person for looking over the fen and superintending the cutting". In other areas where the quality of the ground was probably inferior and therefore less valuable there were no restrictions employed at all. One example was at Wereham where, "the poor of the parish are allowed to cut turf and flags without restriction".

It is likely that all the allotments were designed to have been superintended and managed by the trustees to some extent when they were set out at enclosure, probably as a conservation measure, as it is clear from the Charity Commissioner's reports that in many areas unrestricted cutting had led to chronic shortage of material. Such was the case at Potter Heigham where, "[the poor] cut turf without restriction; the turf, however is now nearly all exhausted.", and at West Newton where, "The poor have cut fuel on these allotments without any control and there is now very little left".

In a few parishes it is clear that trustees had a hard time trying to implement authority over cutting rights even when they wished to do so. Thus at East Dereham the commissioners reported, "For some years a person was

2. *Herbage* probably refers to material harvested for litter or hay. Rackham (1980) interprets the word in this way when it is applied to ancient woodlands.

employed to superintend the cutting, but it is stated that it was found very troublesome and productive of no good effect and the poor have latterly been allowed to cut turf and turn cattle thereon without restriction". In this case it seems probable that a stubborn refusal to alter a long tradition of common usage triumphed over the attempted imposition of new regulations consequent upon enclosure as the commissioners record that the new fuel allotment was comprised of parts of former commons "which had theretofore been used by the poor inhabitants of East Dereham for cutting fuel". A similar situation seems likely to have existed at Yaxham where, "This land was improperly given up some years ago, to the poor, to cut fuel, without restriction, in consequence of some disturbances which took place in the parish".

At the parish of Marham there appears at first sight to have been a novel method of attempting to control over-exploitation in that there was a surcharge of 1/6 per 1000 turves placed on any poor parishioner who cut more than 8000 turves in a year.

However, closer inspection of parish records by the Charity Commissioners revealed that the Parish Officers were in debt to "Messrs Milliam and Robert Winearls for a charge made in respect of the Wormegay Drainage Commissioners". The officers had changed the rules by which the poor were allowed to use their allotment (as was their right) so that a charge was levied. It seems likely that in this case, rather than being designed as a conservation measure, the charge was effectively a tax on the poor and so was probably set at a level which would ensure rapid return rather than deterring peat usage.

Although most trustees seemed to have had some control over the cutting, it is clear that many were neglecting their duties. The Charity Commissioners' reviews of the fuel allotments for each parish often reflect this markedly. The review is usually set out in two distinct sections, the first describing terms and conditions under which the enclosure commissioners had been directed to lay out the allotment followed by a description of the real situation as they found it in the years 1815-37.

This investigation sometimes showed a total disregard for the directions and occasionally brought corresponding admonishment from the Charity Commission

Such instances reflect the fairly widespread indifference towards statutory duties concerning the poor evidenced by an Act of 1793 which authorised punishment of Overseers of the Poor and constables for neglect of duty (Tate, 1969). The fact that the Commissioners were reporting at all was due to dissatisfaction over the notion that such maladministration was leading to rising poor-rates (Tate, 1969).

*9.4.3 Eligibility for receiving aid with fuel.*

There was no uniform definition of the circumstances under which a person was deemed to be poor enough to receive the right to benefit from a fuel allotment. Thus at East Bilney a person was entitled to use of the fuel allotment if he occupied land or tenements worth "not more than 10 pounds yearly value", whereas at Snettisham fuel "for their necessary firing" could be cut only by those poor inhabitants "not occupying lands or tenements of more than the value of 40 shillings yearly". In view of this measly definition of poverty it is not surprising that the commissioners reported that, "There are now no poor inhabitants in the parish not occupying to the yearly value of 40 shillings." Fortunately, a more typical limit put on the value of a person's possessions after which rights to fuel were stopped was commonly around 5-7 pounds.

*9.4.4 Fuel rights and the law of settlement.*

One criterion which was nearly always applied in relation to fuel rights was that the poor should be "legally settled" in the parish. The development of the poor-law down the years had led to the situation where many poor in England were virtually imprisoned within their respective parishes because of the settlement laws of the late eighteenth and early nineteenth century. Because of the rising poor-rates, parishes were desperate to reduce the cost of maintaining the poor. One reaction was to entitle only those persons who had a legal settlement in a parish to receive poor relief from that parish. To gain a legal settlement a pauper had to have been born in the parish or needed to either rent a tenement of at least 10 pounds in value or serve in a parish office (Tate, 1969). The allocation of fuel rights in a parish was usually worded in the enclosure document along the lines of ,"the turves to be cut by the poor inhabitants legally settled in the parish"(Mileham Enclosure) or occasionally, "legally settled and resident", as at South Lopham. In this latter case, the criterion has been tightened further as it was possible to be on the poor rate of a parish in which one was legally settled whilst living in another whose settlement law the pauper did not infringe. Such a person would still be entitled to rights to fuel from the original parish. It was presumably to close such a loophole that residence was specified in some parishes.

In many parishes, however, it may be that a more relaxed attitude was held with regard to the settlement question as many awards fail to mention the subject and at East Ruston it was specifically stated by the Charity Commissioners that turf was cut for the poor, "whether settled or not".

Such differences are likely to have been related to varying availability of resources and demand for them from the poor in different areas. East Ruston, for example, is one of the few localities in Norfolk for which there is much documentary evidence showing the former existence of large deposits of peat (Bird, 1909).

At Larling there was apparently even provision for remunerative compensation for those poor persons who were obviously living out of the parish. Rent from the letting of an additional allotment to that from which turf was cut, "is applied in payment of the expenses of carting the turf to the houses of the poor, and the residue, if any, is distributed in money equally amongst the same poor persons as are entitled to the turf, or given to persons being too far from the Parish to cut turf for themselves".

However, as Tate (1969) has shown for other aspects of the poor laws, it is possible that such a statement was meaningless because of the probable lack of any residue being left to distribute!

### *9.4.5 Amounts of turf allocated.*

Once again, there was great variability in the amounts of turf allowed to poor persons from the fuel allotments and the method of dividing up the total extracted among the poor populace of a parish. In some places, whether by design or not, the poor had unrestricted access to turf grounds and were allowed to cut as they pleased. As mentioned previously, this appears to have led to severe shortages of fuel in some cases.

In most parishes the turf was allocated to the poor in quantities based on the family as a unit. In some cases the entitlement was further modified so that the amount allocated was proportional to family size. Parishes following such a system included Larling where, "All the poor belonging to the parish are allowed to cut turves in quantities from 2000 to 8000 according to number in the family." Other parishes following this method were Great Hockham, South Lopham, Stanfield and Stoke Ferry. Some parishes, such as Ludham, allocated a fixed amount (500 turves, in Ludham's case) to each poor family, apparently irrespective of size. A similar system operated at Hassingham, where, "There are cut from the allotment 24,000 turves annually, which are divided equally amongst all the poor families belonging to the parish."

Other areas merely allocated amounts on an individual basis, as at Pentney, where "a quantity not exceeding 4000 turves or flags yearly for firing" were allowed to each poor person in the parish. The variation in amounts of turf allowable to the poor in various parishes can be seen in Table 9.1.

### *9.4.6 Carriage of the fuel to the poor.*

The cost of fuel and the labour involved in gathering it were not the only expenses involved in the provision of fuel. The transporting of turf, furze, coal, etc., to the homes of the poor could also be a considerable financial burden on the parish. The carriage seems often to have been paid for either out of the poor rate, as at Billingford, or

**TABLE 9.1.** Variations in amounts of Turf Allowed to the Poor annually in some Norfolk Parishes in the Nineteenth Century. (based on the returns of the Charity Commissioners, 1815-37.)

**Blo' Norton**: 8000 turves/family.

**Geist**: Individual turf allotments.

**Gooderstone**: 4000 turves/flags/occupier of every messuage worth <5 pounds.

**Great Hockham**: 4000-8000 turves depending on number in family.

**Hassingham**: Turf production divided equally amongst all the poor.

**Hingham**: 1-2000 turves per family.

**Larling**: 2000-8000 depending on number in family.

**Ludham**: 500 turves to each family.

**Northwold**: 8000 each occupier of "ancient cottages".

**Pentney**: 4000 per person.

**Wormegay**: Individual turf doles.

*No restrictions:* **Dersingham, Felmingham, Hockwold with Wilton, Mileham, Potter Heigham, Weasanham All Saints, Wereham. West Newton.**

from rents derived from letting out parts of the allotments or rights thereof to a tenant.

In a few parishes there are indications that local farmers seem to have taken on the duty of carting the fuel to the poors' homes, presumably as an act of charity. Such a system seems to have operated Wellingham where coals were, "brought by the farmers without any charge of carriage." and at Wicklewood where, "carriage is provided by the farmers voluntarily", and also at East Harling where,"coals are brought without charge by the farmers and given to widows and such persons as cannot cut turf for themselves". At Shernborn it was the tenant of the fuel allotment who carried furze to the poor, which he had even cut himself. The parish of Great Dunham, however, appears to have experienced some difficulty with its farmers. The Charity Commissioners relate a sad tale, "Up to 1833 about 4 chaldron of coal was, on average, purchased every year, the farmers having brought the coals without charge. In 1833, they declined doing so, and 17 pounds and 10shillings was paid for the carriage and the quantity of coal purchased consequently reduced to 35 chaldron".

### 9.5 The price of turf.

The cost of turf and its winning appears to have varied to some extent, presumably depending on its origin and quality. The only detailed breakdown of costs which is known to exist is that detailed in Marshall's *Rural Economy of Norfolk* (1795) and reproduced in Table 9.1.

Fig. 10.3 shows the variations in the price of turf detailed in the accounts of the Trustees for the Poor of the Parish of Neatishead over the period 1815-1875 (explored in more detail in chapter 10). It shows that although the price paid for a thousand turves could apparently vary widely from as low as 4/3 to 12/-, the bulk of the turf cost around 5/- per thousand. For reasons outlined in detail in *10.2.1* it is likely that in the Neatishead records the price records indicating turf at above 5/- per thousand refer to fuel purchased from other areas whilst those records showing amounts at 5/- or below are likely to indicate "home grown" material from the Poors' Fuel Allotment. The latter would then indicate solely the labour costs (i.e. cutting, stacking and boating the material) as the Charity Trustees were extracting turf from land they owned and it is interesting that the cost is very close to the amount Marshall (1795) indicates as usually being charged by the "turf-man" when the element for renting a turf ground is omitted. At Neatishead, 5/- per thousand turves was the amount paid for most of the turf over a period spanning some 60 years.

Evidence for an even more astonishing example of price stability over a long period is provided by comparison of accounts of the cost of cutting the turf at Hackford in

**TABLE 9.2** "An Account of the Peat Grounds of the Fens" from *Rural Economy of Norfolk*. 2nd edition by Arthur Marshall, 1795. Note 54, p.98.

"The following is an accurate account of the *peat grounds* of the fens.

| | | | |
|---|---|---|---|
| The "turfman" pays for rent | 0 | 4 | 0 |
| For cutting from 1/6 to 2/- | 0 | 1 | 9 |
| For "chimneying" (that is, piling them lattice-wise to dry) | 0 | 0 | 6 |
| For boating to staith 6d to 1/- | 0 | 0 | 9 |
| | 0 | 7 | 0 |
| Profit and hazard (great quantities are sometimes swept away by the floods). | 0 | 1 | 6 |
| The selling price, *per thousand* | 0 | 8 | 6 |

The peats, when cut, are about four inches square (but dry to about three inches and a quarter); and from two to three feet long, or of a length equal to the depth of the moor;- every foot of which, therefore, affords nine peats, each yard 81: each rod 2,540$^{1/4}$: and each acre 392,040: which, at 4/- per thousand. amounts to the sum of 78. 8/2 an acre: besides the additional advantages of having uncovered a stratum of earth, which, in many parts, produces reed, spontaneously; and on which, it is highly probable, that valuable aquatic might, on every part, be propagated."

Norfolk in the early eighteenth century with that around Ely in Cambridgeshire in the twentieth.

The Charity Commissioners reported between 1815 and 1837 that the cost of cutting the turf at Hackford was 2/6 per thousand. Almost exactly a hundred years later precisely the same rate was recorded as having been charged by the last of the turf cutters in the Cambridgeshire fens (Martin Lane, 1961). Marshall gives as the price of cutting as "1/6 to 2/- per thousand" in 1795 so it can be seen that there was negligible movement in price over a remarkably long period of time. Given the effects of inflation over the same period, it can be readily appreciated that turf must have become much less valuable as the eighteenth and nineteenth century progressed. This was no doubt as a result of competition with other major fuel sources, particularly coal, during the same period (see **10.5**).

**9.6 Doles.**

Marshall (1795) gave a definition of the word "dole" as, "A piece of land upon a heath or common, off which only one particular person hath a right to cut fuel." Later, Rye (1895) obfuscated the issue somewhat by adding the definition of "turf dole" as, "A place where turf is being cut, and has nothing to do with dole allotments to the poor." The confusion probably arose from an extension of the word's technical meaning. In pre-enclosure times a "dole" was a portion of the common meadows allocated to the tenants of the related open arable fields. The portions were sometimes allocated by lot or rotation and tenants were entitled to the hay from their portions (Richardson, 1986). It seems likely that in peat producing regions such as East Anglia, the word was extended to cover portions of common ground producing turf which was similarly allocated.

The name for such areas may well have originally been the "turf dole" recorded by Rye but it seems equally likely that common usage inevitably led to the simple "dole" to refer to such areas and that the word continued in use after enclosure in a turf related context after the original meaning had become obsolete. It appears to have been further refined to mean a strip of turf ground used by an individual. The "dole allotments" Rye mentions are probably a reference to ground donated to the poor of the parish as a form of alms, the use of the word in this case derived from another meaning which meant the distribution of money or provisions to the poor (Richardson, 1986), a meaning from which, of course, the current colloquial meaning of the word arises.

Despite this confusion, there were undoubtedly areas where peat was worked in "doles" *sensu* Marshall. At Upton Broad, an area of the surrounding fen known as "The Doles" displays relicts of strip division and documentary evidence has shown that these strips were in private individual ownership and most had originally been used for turf cutting

(Wheeler, 1985). In this example, it appears that it was not only the right to cut turf which was reserved by an individual (as implied by Marshall's definition) but also the ownership of the entire plot. At Blo' Norton Fen, Clarke (1916) mentions that each "rightholder" had a strip 14 yards wide from river to road on which he cut peat.

How widespread a "dole" form of turf cutting management was is difficult to tell. In many areas of the Broads there is certainly evidence of peat working in strips superficially similar to the Upton Doles such as the Irstead Holmes Marshes at Catfield (Figs.3.3, 3.4) . The concept of working peat ground in strips is also common to other areas in Britain where the material was exploited. Rowell (1983) has shown that in 1666 at Wicken Fen, Cambridgeshire, part of the area was divided into "dolls" which took the form of strips which were subsequently worked for peat. In Cumberland private peat strips were known as "dales" (Marshall, 1971) or "dalts" (Winchester, 1987) and in this region bracken is also known to have been harvested from strips on fellside known as "bracken dalts". There are also parallels across the North Sea. Thorpe (1951) showed that in the Danish township of Osterstillinge, seventeenth and eighteenth century peasant-farmers held individual strips of land in a moss for the purposes of peat cutting. These appear to have been "private" strips after the fashion of "doles" as squatters and cottagers (effectively the landless poor of the township) had to rely on being granted the privilege to cut on farmer's plots or had to rely on scavenging kindling or dried dung for their firing. This example is particularly interesting as Norfolk was part of the Danelaw for some not inconsiderable time and it has been suggested that certain aspects of the organisation of the county's land ownership exhibit Danish influence (Stenton, 1951; Hoskins, 1955).

As far as the poor's fuel allotments in Norfolk are concerned the Charity Commissioners record only one parish (Bressingham) where individual plots or strips of peat were laid out for the use of individual paupers. This is not surprising, perhaps, in view of the fact that the poor were usually treated in commonalty when it came to rights and privileges whereas the "dole" was apparently specific to individuals. At Bressingham, however, where there were several allotments they reported that, "The other allotments are divided into small portions, and given up to poor parishioners residing in the parish, each having his own plot, and cutting turf thereon, according to his own convenience." There is another rare reference to individual plots at Geist where the commissioners reported that, "certain plots have been set out to the different cottagers, and a part is reserved and cut at the expense of the parish officers for the widows". There is only one other place where something similar appears to have operated. At Wormegay it is recorded that, "The allotments are all fenced out, and every year in the Spring a portion is set out to each family, to cut turf for fuel." There appears to be a subtle variation on the method of management in this example with plots being allocated to families rather than individuals and the suggestion implied in the description that the plot was a fresh one each year.

How far the "dole" method of managing turf grounds was normal in Norfolk is difficult to ascertain. The Charity Commissioners' descriptions are limited in that they only give an indication of the practice in those areas of ground allocated to the use of paupers, although as has been pointed out, it is this section of society which is likely to have been the major user of the fuel. Records relating to private turf grounds are scarce by comparison and the management of such areas remains uncertain although the aspects of individual rights and ownership, which seem to have been connected with doles, make it likely that such a system was commoner in "the private sector". Even within the poor's allotments, however, in those examples which are dismissed with a peremptory "all the poor cut turf without restriction", the possibility cannot be ruled out that a "dole" system operated, organised informally by the poor of the parish themselves.

**9.7 Multiple use of turf-grounds.**

The majority documentary evidence relating to turf-grounds gives some indication that the land was contemporaneously utilised for other purposes. Many of the reports of the Charity Commissioners record that either parts of, or rights on, fuel allotments were let out to private tenants, thereby indicating activities such as grazing cattle, etc. A common style of entry is along the lines of, "The herbage is let annually to the highest bidder" (Wormegay), or "The feeding is let to..." (Barnham Broom).

The importance of turf-digging in relation to other land uses seems to have varied according to location and circumstances. In some drier areas where the turf or flags were evidently of very poor quality it is obvious that the activity was of relatively minor importance. At the parish of Billockby, for instance, it is recorded by the Charity Commissioners that seven tenants occupied part of the land in the fuel allotments while in addition to cutting turf and reeds in the other parts, the poor also, "keep cows [and] are permitted to feed thereon."

The mention of reeds in the last example is interesting as it has been suggested that in some parts of the Broads, the primary reason for the turf-cutting may have been to provide a good quality supply of reed, rather than fuel (Giller and Wheeler, 1986). There is indeed evidence that in the wetter Broadland turf-cuttings, the promotion of reed growth after cutting was indeed welcomed and taken advantage of. An instance of this is a reference by Marshall (1795). When discussing the economy of peat cutting he talks about, "The additional advantages of having uncovered a stratum of earth, which, in many parts, produces reed, spontaneously; and on which, it is highly probable, that valuable aquatic might, on every part, be propagated." A sale prospectus for an estate at Catfield and Ludham in 1827 refers to Lot 28 as "A PIECE of TURF and REED GROUND", suggesting a multiple use, and there is also a passage in Carrodus (1949), referring to the poors' allotment at Horning which states,

> **"The turf was mainly cut on the water-logged banks of the river, and in its place the graceful reed beds which now fringe the waterside sprang into existence, like a rotational change of crops."**

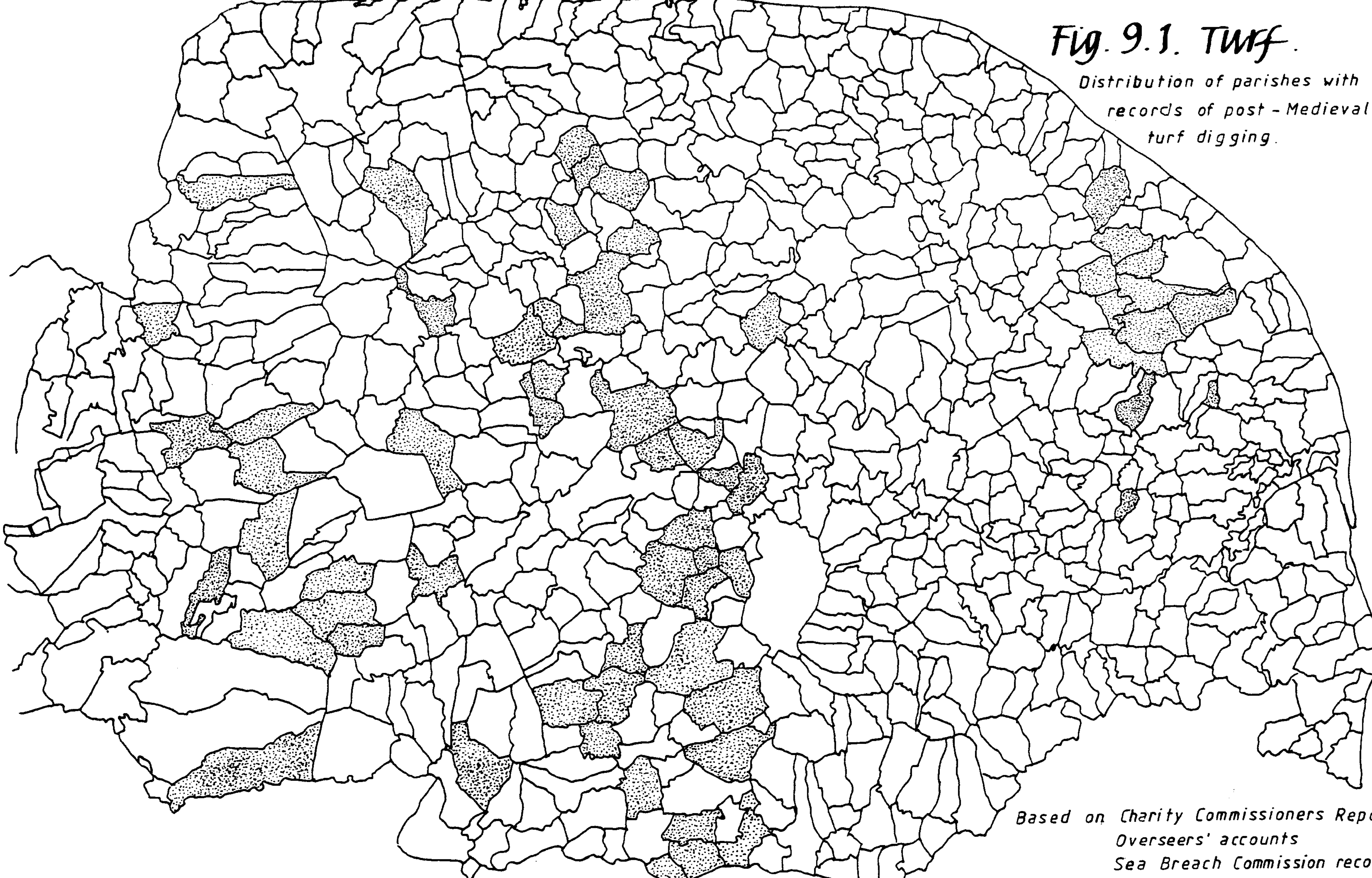
However, the argument for the primacy of the provision of high quality reed over acquisition of turf as the major reason for the instigation of the cuttings used by Giller and Wheeler is based largely on anecdotal evidence from the Catfield and Irstead Fens. The documentary sources quoted above do not conflict with the notion that, although the production of the reed was taken advantage of, the overriding concern in many parts of Norfolk was the production of fuel. The widespread and major importance of turf as a fuel which is shown by the review of evidence from all over the county supports the idea that the turf was usually the primary reason for the excavations. However, this does not rule out the possibility that some cuttings, particularly those in the wetter reed growing areas such as Catfield, were primarily motivated by the desire to improve the growth of reed and certainly any cutting which has taken place since the decline of the use of turf as a fuel seems to have been undertaken with this purpose in mind (Giller and Wheeler, 1986).

## 9.8 Importance of turf in relation to other fuels in Norfolk.

The maps displayed in Figs. 9.1 and 9.2 show the distribution of those Norfolk parishes where turf and flags are mentioned as having been obtained from poor's fuel or other allotments in the early nineteenth century, based chiefly on the Charity Commissioner's reports. It is obvious from the widespread distribution of such parishes that peat of one form or another was an extremely important fuel source for the less-well off members of the Norfolk peasantry at this time. The other main alternatives to turf were furze, whins, coal and wood.

### *9.8.1 Furze and Whins.*

After turf, the most commonly utilised fuel resource actually occurring in Norfolk was furze and whins. In areas where either no turf or only poor quality peat deposits lay, these plants were used extensively for firing (Fig.9.3). It is known that the plants were utilised for such a purpose in other parts of the country such as Cornwall where Hopkins (1983) found that they were an important domestic fuel both for the peasantry and yeomanry in the Lizard. They were also important in Ireland where Lucas (1960) established that *Ulex europaeus* and *Ulex gallii* were probably the most



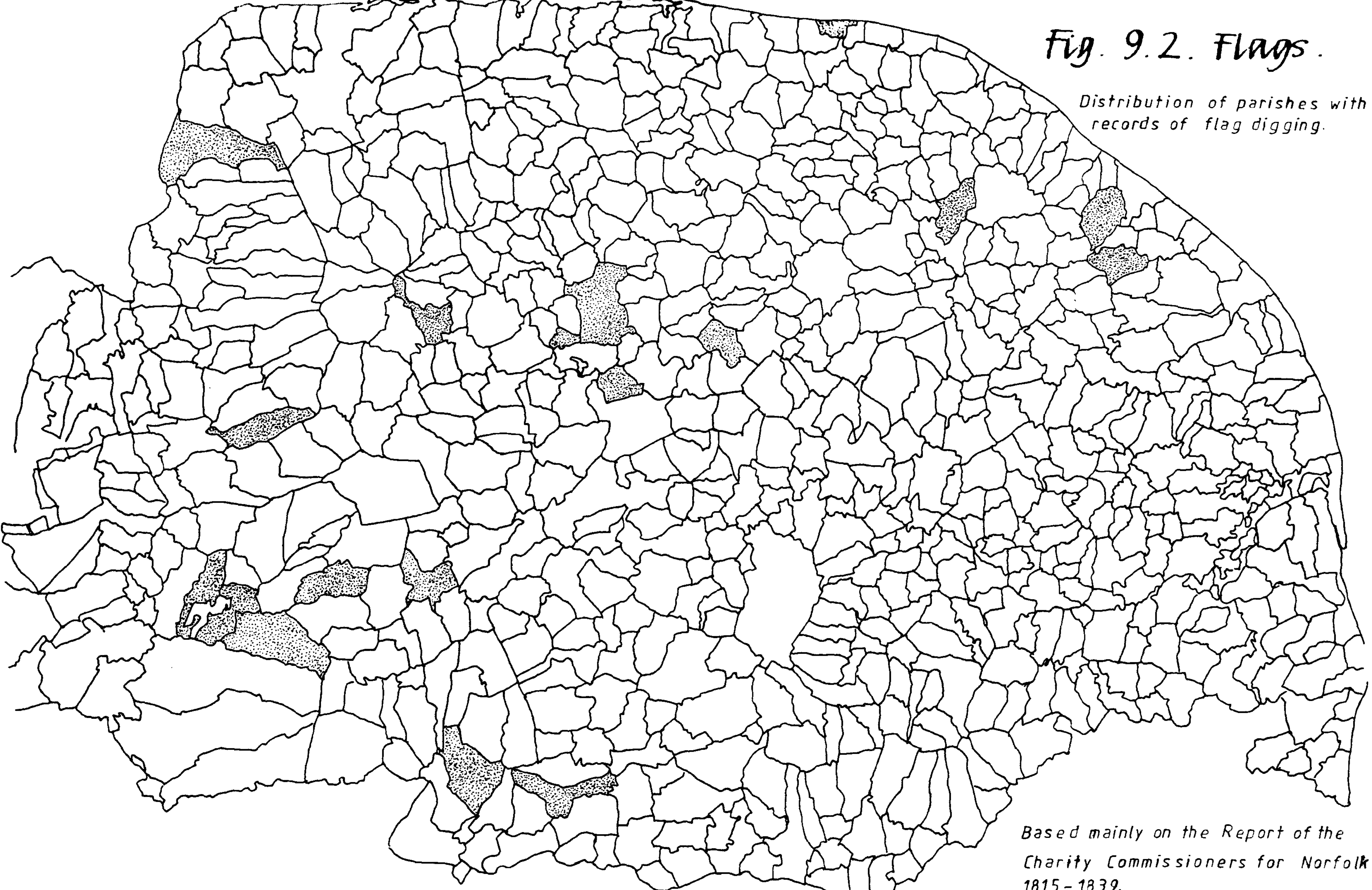
# Fig. 9.1. Turf.

Distribution of parishes with records of post - Medieval turf digging.

Based on Charity Commissioners Reports
Overseers' accounts
Sea Breach Commission records

Fig. 9.2. Flags.

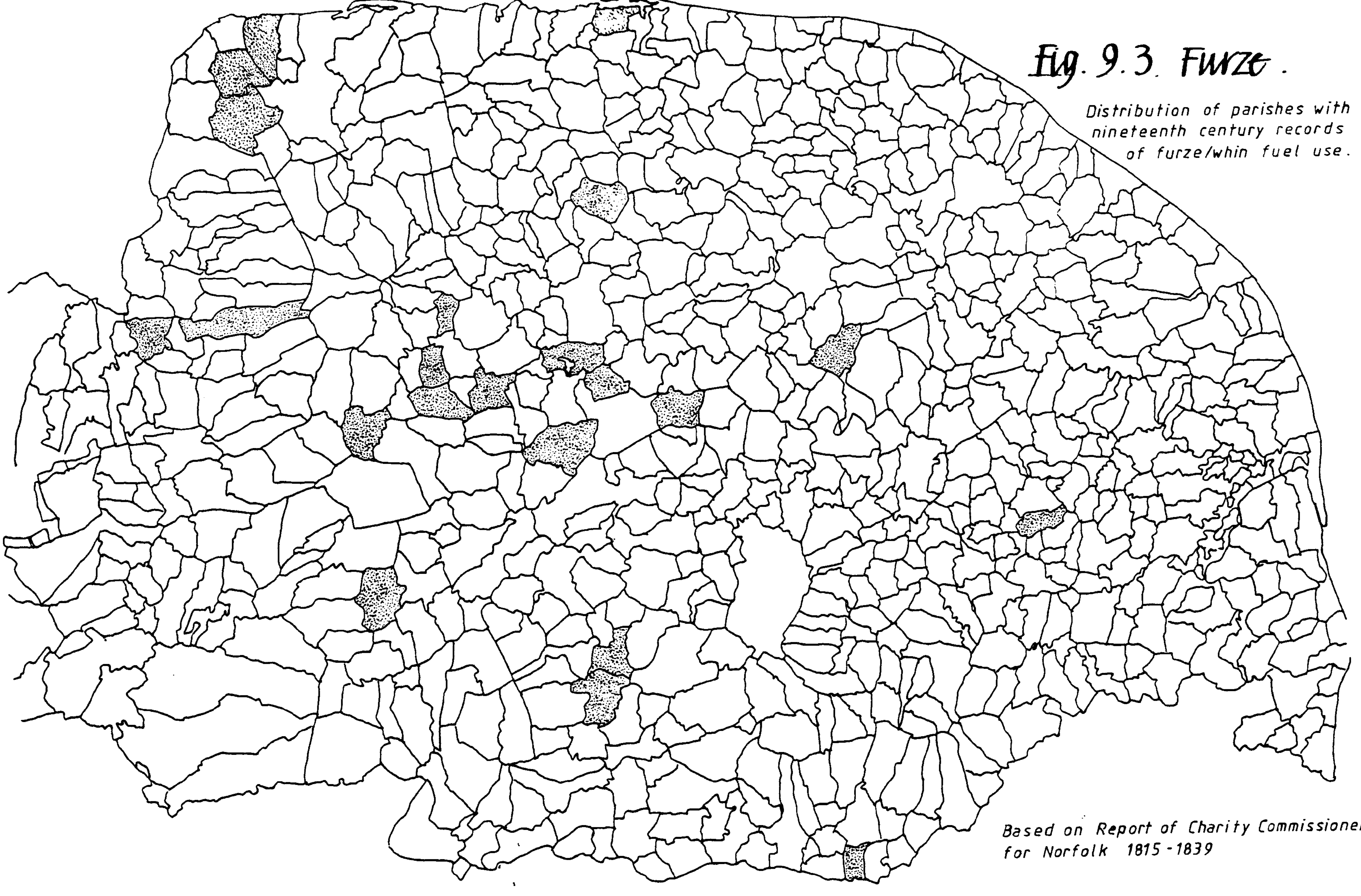
Distribution of parishes with records of flag digging.



Based mainly on the Report of the Charity Commissioners for Norfolk. 1815 – 1839.

Fig. 9.3. Furze.

Distribution of parishes with nineteenth century records of furze/whin fuel use.



Based on Report of Charity Commissioners for Norfolk 1815-1839

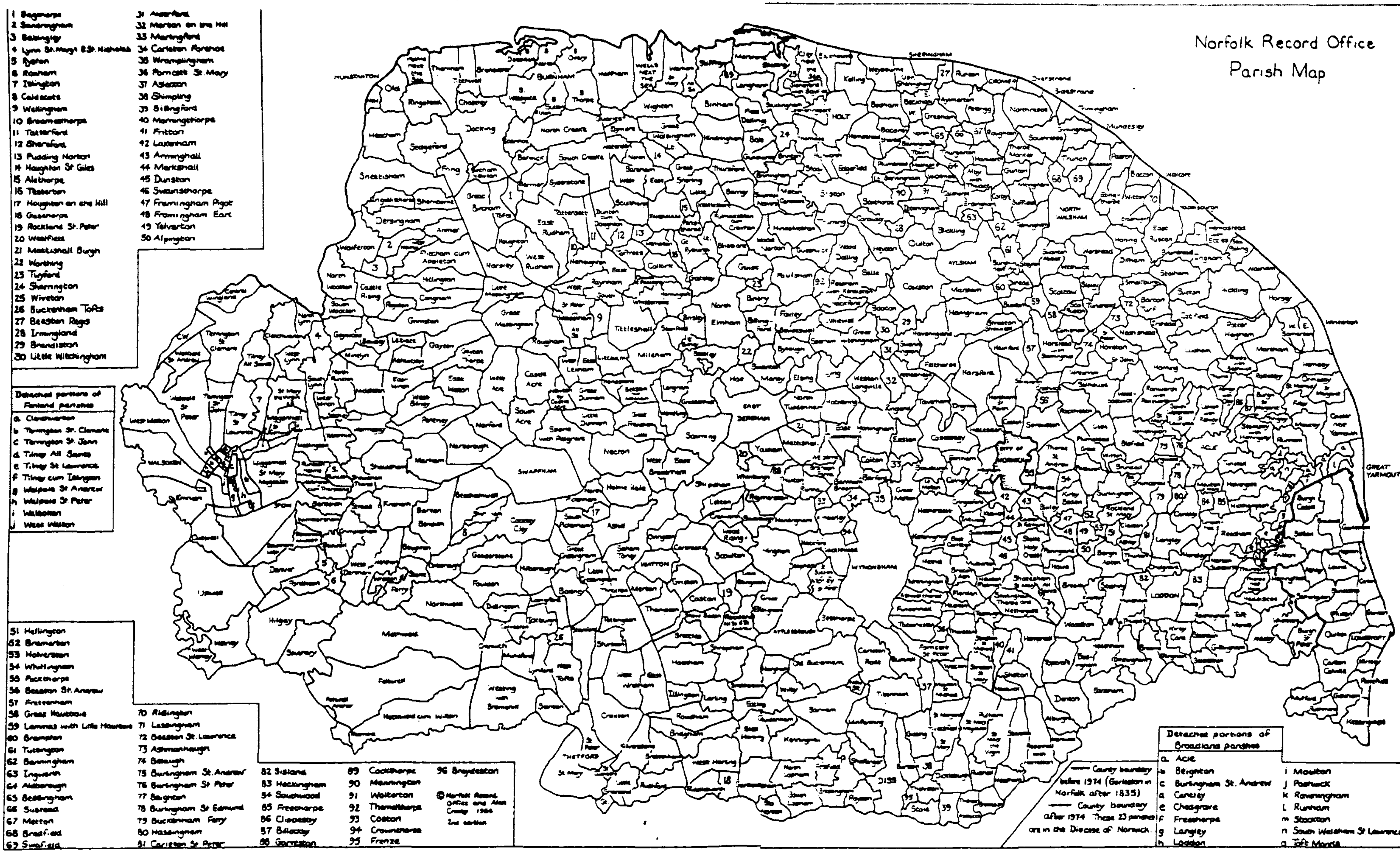



Fig. 9.4. The Parishes of Norfolk.

widely used plants in rural society, for in addition to being put to use as fuel they were pressed into diverse service as thatch, cattle fodder, in dyeing and the making of walking sticks. Their use in Norfolk has a long recorded history. Rackham (1986), for example, found evidence of the sale of "Whynnes" in thirteenth and fourteenth century accounts from Hindolveston. Although virtually every record mentioning furze and whins refer to their use as fuel, there is a possibility that they were put to some of the uses described as occurring in Ireland. Marshall's *Rural Economy* (1795), for instance, contains a section advocating the use of furze as cattle fodder and as hedging material. Whether either of these suggestions was ever acted on in the county, however, is unknown.

In the early nineteenth century the provision of furze and whins was evidently regarded with some importance in certain areas of Norfolk. Several parishes appear to have actually sown fuel allotments with furze and whin seed - a practice also recorded from Ireland and the South-West of England by Lucas (1960). The Charity Commissioners reported that at Great Ringstead, or instance, the trustees were directed to, "cause the [fuel allotment] to be sown with whin seeds, and appoint what manner, at what times in the year, and in what proportions each poor inhabitant should cut and take for their necessary firing." Similarly at Hilborough, "The commissioners [of enclosure] set out 30 acres of land in the Church Field, which were sown with furze for fuel." Records of this practice also come from the parishes of Billingford, Fulmodeston, Beetley and Launditch, and there was also an option to sow ground with furze or whin seeds implicit in the directions of the Enclosure Commissioners at Beeston, Felthorpe and Grimstone. In the latter parishes, however, there is doubt as to whether the action was ever carried out. The complaints of the Charity Commissioners consequent upon inspection of the state of the fuel allotment at Grimstone suggest that this was not always the case;

> **"No person interferes to regulate the mode of cutting or to prevent the poor from exceeding the quantities specified in the award. The consequence is, that the whole is nearly cut up....It seems however clearly to be the duty of the trustees for the fuel allotments to take care that the fuel is not exhausted by improper cutting; and that the supply is kept up by ploughing and sowing whins, whenever it is necessary."**

The problem of conserving furze and whin stocks seems to have led to the evolution of rotational cutting regimes in several places. The allotments or portions thereof containing the furze appear to have been divided up into fractions and the furze of only one fraction cut in any particular year thereby allowing a recovery time to enable regrowth. The degree to which such areas were subject to rotation varied. The Charity Commissioners report fourfold rotations at Billingford, Thornham and Sedgeford while a fivefold one was employed at Beetley. The only mentions of sevenfold rotation are at North Tuddenham and Scarning and both are associated with a failure to maintain the practice.

In the latter case it seems unlikely whether any restrictions at all were eventually placed on fuel gathering while at the former parish the procedure appears to have fallen into disuse, as the Charity Commissioners reported;

> **"Until within 4 or 5 years ago the furze was cut in regular course. It is now cut by the poor without any restriction, and they are not prevented from turning geese and cattle on it. We recommend that it should be again preserved, and cut in proper course."**

In these cases it may be that a sevenfold rotation did not allow sufficient fuel to meet demand leading to the breakdown of the regulations. The rapidly rising numbers of the poor in the late eighteenth and early nineteenth century would undoubtedly have exacerbated such a problem.

*9.8.2 Faggots.*

The generally treeless nature of much of Norfolk might suggest that the use of wood faggots was likely to have been comparatively rare compared to other counties. Nevertheless, the use of wood faggots was common in the region after the abandonment of the Medieval turbaries and continued into the nineteenth century. Smith (1960) demonstrated a marked change from turf to wood faggots as the most popular fuel recorded in the accounts of the Norwich cathedral kitchens at the turn of the fourteenth century. He suggested that after the fourteenth century the cost of faggots was relatively lower than turf due to the flooding of the peat-grounds making extraction more difficult. How long such a putative economic advantage was enjoyed by wood is uncertain. There is some evidence that faggots may have been an important fuel source in many areas right up to the nineteenth century. The overseer's records from East Harling, for instance, show wood faggots as an important and regular component of the firing used to supply the poor of that parish (along with furze, flags and occasionally bracken) up to 1782 when turf and coal become the predominant fuel sources mentioned

The use of wood faggots is recorded from only a few places in the early nineteenth century Charity Commissioner's reports. It is usually recorded as a complementary fuel source to coal, furze, flags or turf and rarely as the main firing material. Exceptions include the parish of West Lexham and Little Cressingham. At the former parish there was a Poor's Wood. All the poor families received between 40 and 50 faggots a year but had to pay for the expense of cutting them at 3/6 per hundred. At Little Cressingham faggots were given to the poor in lieu of rent for occupancy of the fuel allotment by a Lady Goodricke. The relative importance of wood is considered further below.

### *9.8.3 Coal.*

Evidence from overseer's accounts, together with the returns from the Charity Commissioners show that by the early nineteenth century, coal was the most favoured fuel in the absence of turf. As mentioned earlier, many "fuel" allotments were not in fact directly exploited for firing but were let out to a tenant, often for grazing, and the subsequent money raised from rent spent in the purchase of fuel. The most frequent fuel purchased was coal.

In some areas where turf or other fuel was exploited, coal was used to supplement what was evidently an insufficient supply of the former. In many parishes such "coal supplements" seem to have been paid for either partly from rents derived from letting out grazing rights etc. on the allotment or wholly out of the poor rates as at Wereham where, "about 5 pounds is laid out annually in the purchase of coals , and given to the poor."

Some parishes seem to have used coal to supply infirm members of the parish poor as at Great Ryburgh where, "This [the rent from letting the herbage of the fuel allotment] is laid out in the purchase of coals which are distributed amongst such of the poor as are not able to cut turf". At Billingford coals were distributed weekly during the winter amongst all the poor belonging to the parish but, "a larger allowance proportionably being given to widows and women lying in.", and at Barnham Broom the poor cut turf from an allotment while coals were given, "amongst widows and other infirm persons who are unable to cut turf, about eight or nine bushels each." The same process occurred at East Harling. The allocation of the superior and more expensive coal to the underprivileged sections of the poor, or the provision of extra amounts when it was the normal fuel source, suggests a concern for such parish unfortunates echoing the use of proxy turf-runners described in Dutt's account (see 9.4). In both cases it seems that in the parishes concerned, it was ensured that the less well off sections of the poor were allowed the best quality fuel available, or failing that, generous amounts of it.

Not all parishes were as fortunate. In some the price of coal was only subsidised. For example, at the parish of Mileham the poor were allowed to cut turf without restriction but the "herbage" of the allotment was let out to a tenant. The rent from this was used to subsidise the cost of coals which were, "sold out to all the poor belonging to the parish". A similar system seems to have operated at Stanfield where, in addition to the exploitation of turf, it is mentioned that rent from letting out the herbage, "is added to a fund, which is kept up for supplying the poor with coal at a reduced price". Presumably the need to recoup something of the cost of the coal in these cases reflected the greater expense of coal as compared to turf or other fuels at this time.

### 9.9 Minor fuel sources and unusual practices.

There are a few records of the use of ling and bracken as fuel in Norfolk. Their use in the county has a respectable history, Rackham (1986) recording from a 1609 lease that a tenant of a park at Hevingham might not use wood as fuel but was required to, "brewe and bake with furres[3] lyinge and brakes." In the nineteenth century, the use of ling is recorded from Croxton, Congham and Bridgeham. In the latter parish, the poor were allowed a "waggon load of ling" a year as well as up to 4000 flags. There appear to have been separate allotments reserved for the cutting of each fuel source.

*9.9.1 Fuel money.*

In a few rare cases, it seems that the Trustees for the Poor avoided all the complications of attempting to provide fuel to the parish paupers and simplified matters by handing out lump sums of money. This was the case at Haynford where the Overseer "apportioned the sum of 30 pounds per annum amongst the proprietors of new inclosed land in the parish". At the parish of Thurton the fuel allotment was let and the money divided equally among all the poor inhabitants, "provided they belong to some parish in the Hundred." The parish of Topcroft arranged its fuel charity in the same way. This money appears to have been compensation for loss of fuel gathering rights and, with the exception of the latter two examples, was usually distributed amongst the poor according to the number in the family. At Gooderstone, money was evidently used to compensate those sections of the parish poor who, "had not the right of cutting fuel". This

3. Lucas (1960) contains considerable detail on the use of furze as fuel for bakeries in Ireland. In that country the plant was the preferred fuel source for bakers' ovens possibly from Medieval times up to the nineteenth century because it lit quickly, gave intense heat and left little ash.

might imply the existence of differential turf-cutting rights amongst the poor of some parishes.

In the parish of Kettlestone money was given to, "the necessitous and deserving poor, especially such as were unable to cut turf for themselves."

This avoided all the trouble and expense of organising the cutting to be done for the individual concerned as was also the case at Twyford where, "sums are occasionally given in lieu of coals to poor parishioners residing at a distance from the parish." A similar system seems to have occasionally operated at Larling when there was any surplus money available from paying for turf-cutting for those poor actually residing within the parish.

**9.10 Who cut the turf?**

In many parishes where turf was exploited it seems that the poor were left to get on with the cutting, sometimes subject to certain restrictions and, as has been shown, sometimes with none at all. In many parishes, however, it is obvious that the cutting was organised on a more formal basis.

In many cases it is stated that labour is definitely being employed for the purpose, such as at Deopham where rent from letting the "herbage" of the fuel allotment was combined with money from the parish poor rate to pay, "Upwards of 20 pounds a year ...for cutting turves ." At the parish of Hackford it is recorded that , "Out of rent, 6 to 7 pounds a year is paid for cutting turves at 2/6 a thousand." The entry for the parish of Brandon Parva states that, "The Churchwardens were in the practise of setting out a portion of land to be cut for fuel, and employed persons to cut it and distribute it amongst the poor."

In these examples no clue is given as to who the contract labour was. There is, however, some evidence to suggest that at least in some cases it was members of the poor themselves who were employed to cut the turf. This appears to have been the case at Banham where it was recorded that, "Out of rents paid for the herbage and the Holme Hills, there are paid to the poor persons while engaged in cutting the turf, sums varying from 2/6 to 6s according to number in family". At the parish of Attleborough paupers were employed on the fuel allotments, "the expenses of the cutting being paid from the overseer's accounts". Such statements probably indicate the operation of "Outdoor Relief" (a form of welfare wage subsidy) in these instances (Tate, 1969).

In other cases it is probable that outside contractors were employed to cut the turf. There appears to be remarkably little evidence to demonstrate the existence of a body of men who specialised in the turf business. That such "specialists" did once exist is indicated by scattered and infrequent documents such as the detailed breakdown of the financial costs involved in turf digging which Marshall (1795) presented and which is reproduced in table 9.1. He mentions "the turf-man", which suggests the existence of specialists trading in the material. The idea of a group of peat-digging artisans is given some flesh by the account of Carrodus (1949) depicting the turf industry in and around the village of Horning in the first part of the nineteenth century. He describes the former existence of whole families who specialised in the trade and also mentions the fact that a straw and hay merchant also dealt with peat.

Another vague reference is made in a newspaper article by W.G. Clarke in 1903. Writing in the East Anglian Times he mentions the former existence of "turf-cutters and fen drainers" and recalls how they worked on piece work and could earn as much as 15 shillings by mid-day. It is also interesting, although not very edifying, to note the manner in which such riches were put to use:

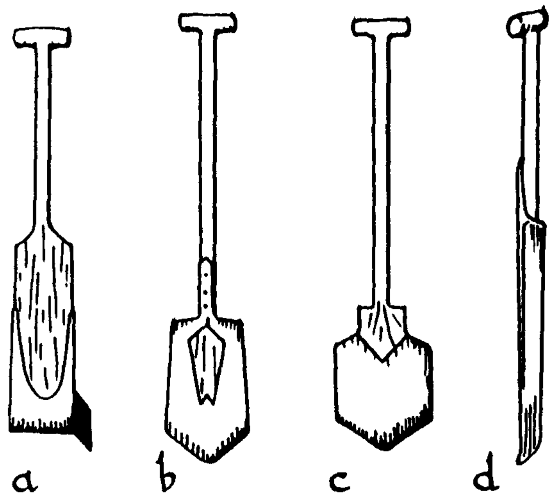
> **"They left off work and disbursed most of their money AT THE NEAREST ALEHOUSE. During the fair many of these men would sit down in an inn and hardly stir for a fortnight, drinking heavily for most of the time."**

## 9.11 Technical aspects and organisation of turf cutting.

### *9.11.1 Peat cutting implements and the digging of turf.*

The implement used to cut turves in East Anglia was a specialised elongated spade known as a *becket* (Rye, 1895) (Fig. 9.4) It corresponds to the Irish *slean* (Estyn Evans, 1957) and the Highland *tosg* (Thompson, 1984) or Orkney/Shetland *tushkar* (Knox, 1985). The becket was a rectangular flat spade made usually from wood and shod at the bottom with iron. It carried a short triangular iron flange placed at right angles to the main blade which allowed two cuts to be made together with one downwards stroke providing rectangular turves to be cut in succession from the peat face (Godwin, 1978). Oblong shaped peats or turves were thus procured. According to Marshall (1795) the turves produced by the implement were, "about four inches square, and from two to three feet long, or of a length equal to the depth of the moor". (This contrasts with the dimensions recorded by Martin Lane (1961) for peats dug in the early twentieth century in Cambridgeshire. They were then said to measure 5.75 x 4 x 18 inches). After cutting, the turves were taken to the staithe (a landing platform for boats) and "tilted at an angle to drain the water off" (Carrodus, 1949). This practice may have been more widespread in the Broadland turbaries than in many other areas because of the relatively wet nature of the peat from the flood-plain mires which formed the majority of the turf grounds in the region (In Cambridgeshire the peats were left

Peat-cutting tools of the Fenland; *a*, becket; *b* and *c*, turf spades; *d*, turf knife. The first three are essentially wooden-bladed tools shod with iron and they existed in some variety: there were also shovels or scoops entirely made of wood. Note particularly the sharp basal flange projecting forward from the base of the blade of the becket.




Modes of turf-cutting with the becket, alternatively with vertical cuts from above (A), or horizontally from the side (B), where the peat is fibrous and strongly layered. In either method the loose upper 'hoddy' peat (*a*) full of roots and often cracked, is roughly cut away with a peat spade and tossed into an existing peat trench: the surface of the good peat (*b*) is smoothed and serves as a working platform. The dotted lines on the uncut platform shew the position of the next cesses to be cut, those in A by the cutter standing on the platform, those in B by him standing on the excavated floor of the trench (*d*). The side wall of the trench commonly shows marks of recent peat cutting (*c*) made by the becket and turf knife.

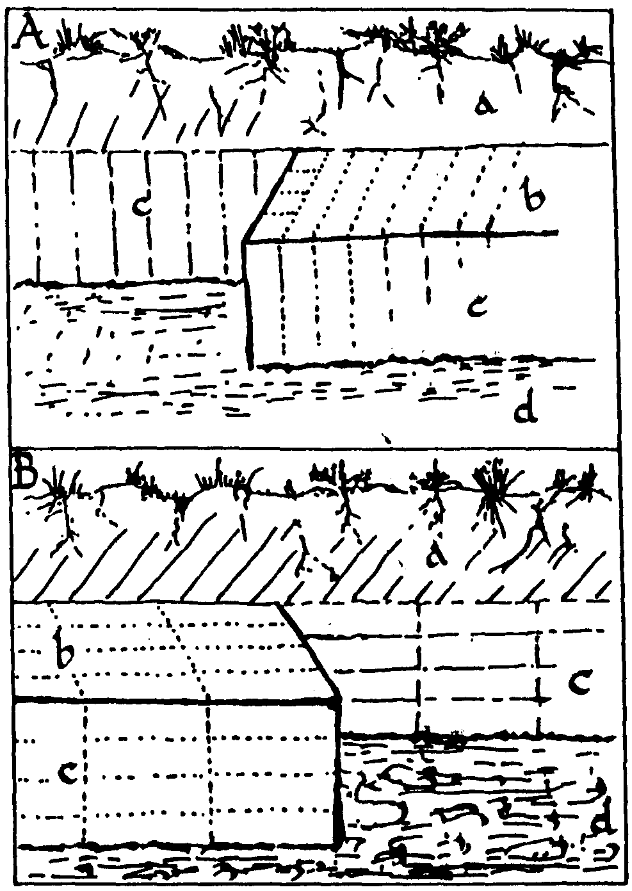



**Fig.9.5** Turf-cutting tools and modes of cutting recorded from the Fens. The Broadland turbaries used very similar tools and probably were probably exploited in the same way. (*From* Godwin, 1978).

to drain and dry where they had been "laid" after cutting; i.e. thrown to the side on a predetermined spot (Martin Lane, 1961). After drying, the turves were "chimneyed" [4] into stacks, or "hales" [5] which were 5 or 6 feet high and contained a certain amount of air space (Carrodus, 1949). It is evident that the peat stacks were laid upon a matting of herbaceous litter during the drying. Entries in the accounts of the Trustees of the Poor of Neatishead [6], for instance, make frequent mention of payments made for, "Stuf used on the bottom of turf hales", or "stuf to set turf on". This probably refers to the material known as "Schoof-Stuff"-summer mown mixed fen vegetation containing a high *Juncus subnodulosus* component (Giller, 1982). There are also references to "shug", used for the same purpose. Anecdotal evidence suggests that "shug" was aquatic vegetation dredged from the dykes. Presumably, the material would be dried before use. Rye (1895), in his East Anglian dialect dictionary gives the definition of the word "shug", and "shuggings" as "to shake" or, "shaking". The application of such a word to loose, floating vegetation certainly sounds plausible.

4. *Chimneying* appears to refer to the action of constructing a peat stack in a particular manner so as to enable the freeflow of air through the structure to assist drying of the peats.
5. The word *hales* in this context may be related to the use of the word "hulls" for similar peat drying structures in Cumberland (Marshall, 1971), possibly referring to their resemblance to upturned boats.
6. PD 251/41 Account of Neatishead Charity Trustees 1815-43.

Before the peat could be extracted efficiently, the superficial layer of fibrous and relatively unhumified peat had to be removed. Other peat cutting regions of the country had special spades to deal with this material but in the Broads it is difficult to find specific references to such a tool. Such a spade undoubtedly was used, however, and it was probably the *Hover-Spade.* This was described by Rye (1895) as, "A tongue- shaped spade for cutting turf." The use of the word "hover" in this context appears a little confused. The only reference directly equating the word "hover" with a block of turf is in an obscure publication by E.R. Suffling (1891). He mentions this in a short section on peat cutting under the title, "Odd Facts and Fancies." Most of the information mentioned by Suffling is a plagiarisation of Marshall's breakdown of turf-cutting costs (see table 9.1) but he appears to add some original information to this by suggesting that this word was the Norfolk name for dried peats.

However, it seems probable that Suffling may have confused the word with "Hovvers" or "Huvvers". According to Rye (1895) this refers to dried flags made from the surface parings from a fen, containing living vegetable matter. The word appears to be the Broadland equivalent of the Fenland, "hoddy" for the same thing (Skertchley, 1877), although there its use appears to have been extended as a synonym for "flag"; the original uncut, rooty, upper peat deposit. It therefore seems probable that the terms "flag" and

"Hover", or "Hoddy" may have become interchangeable to some extent in describing either the fresh, raw top-layers of tough fibrous peat or the dried combustible objects manufactured therefrom whereas the two terms had originally been used specifically to preserve a distinction between the two forms of peat. Further evidence for this assertion is provided by Bird (1909) who writes about, "Peat digging or Hover-cutting" taking place at East Ruston Common in the nineteenth century and continually refers to the peats exploited there as "Hovers." The original Overseer's records for the parish, however, refer to nothing but "flags" during this period. There seems to have been a change in the technical meanings of the two terms in the nineteenth century leading to semantic confusion. This being the case, it would be logical to conclude that the Hover-Spade was in fact the Broadland version of the "Hoddy-Spade" of the Fens, its broad blade designed to deal with the relatively unconsolidated and fibrous nature of the upper layers of peat deposits which needed to be removed before the turf could be got at with the becket. This would fit in with Bird's description of the blade of the implement used to cut the East Ruston "hovers" as, "Either heart - or shield shaped."- it was certainly not a becket.

These spades were probably the East Anglian analogues of the Cornish *biddock* (a small short hafted mattock with a blade 10cm wide designed to cope with the rooty ericaceous peat from the south western heaths [Hopkins, 1983]), the

Ulster *flachter* and western Scottish "breast-plough."(Estyn Evans, 1957). Probably the nearest equivalent is in southern Ireland where a relatively unspecialised broad bladed spade is used to remove the material corresponding to flag or hover - known there as "flow" or "fum" (Estyn Evans, 1957).

*9.11.2 Units of Measurement.*

In the Fens peculiar units of quantity specific to turf were employed in that 100 turf blocks actually referred to 60 and consequently a thousand really meant 600 (Martin Lane, 1961). Judging by the wider East Anglian application of other unique units of quantity in related fen industries, (e.g. the use of the "Fathom" in calculating amounts of reeds (Haslam, 1972), it seems possible that a similar system operated in Norfolk.

*9.12.3 "Shoeing."*

The present study was able to throw no new light on the question of whether the Broadland turf ponds were subject to *shoeing*: the process of returning living turves to the pits possibly to encourage regrowth of vegetation. This practice is certainly known to have occurred in the Cambridgeshire fens in the early nineteenth century (Vancouver, 1794) and similar encouragement of regrowth of vegetation over old cuttings is well known from small scale cuttings in ombrotrophic mires in other parts of the country.

Circumstantial evidence for the activity in Broadland exists in the form of a possible "sub-fossil" turf block which was encountered by Giller (1982) during stratigraphical investigations in the Catfield and Irstead Fens turf ponds. However, the exact significance of this find remains unclear.

The related question as to whether the turf ponds were partly drained or immediately flooded after cutting also remains mostly unanswered. The only fresh evidence which was unearthed in relation to this is a hint that some Broadland turf cuttings may have been prone to almost instantaneous flooding in the articles based on anecdotal evidence procured during interviews with marsh men in the Waveney valley by Dutt (1906). He wrote;

> **"The marshmen say that the time will never come when the fen will be drained as dry as the surrounding marshes. Beneath it, they tell you, there are ever flowing springs, which, in the days when peat was in the fen, used to fill the holes with water as soon as the "turves" were taken away."**

The marshman is obviously referring to turf ponds as the passage also mentions "pools" that were "now entirely grown up" as well as the turves. The statement could well be referring to the Redgrave and Lopham fens as these are spring-fed fen systems. This could explain the rapid inflow of water to the newly created cuttings.

*9.11.4 The seasonal timing of the cutting.*

In all the northern and western ombrotrophic peat-winning areas the cutting is traditionally a Spring or early summer activity. The combination of the driest part of the year, long daylength and the necessity to allow the turves to dry during the remainder of the summer ensured this timing (Estyn Evans, 1957; Fraser Darling, 1955; Geddes, 1955). East Anglian turf-cutting was also subject to these constraints, albeit to a lesser extent, and the few direct references to the subject point to the major period of activity being concentrated in and around the months of May, June and July. Clarke (1916) states that at Brunstead Common, "No turf or hovers may be cut before May 1st or after July 30th." At East Ruston in 1832 digging could only commence on May 8th, at 2 p.m. and had to be completed by July 15th (Bird, 1909).

In some areas, however, there was provision for a more generous timescale allowed for cutting, as at the Parish of Snettisham where the Charity commissioners recorded that up to 3000 flags could be taken of the fuel allotment by any qualifying family between the first of March and the first of November.

In these cases, it seems that the placing of time limits was probably another conservation measure intended to prevent over exploiting of the peat resource. Although limits on the permissible number of turves or flags to be cut by individual poor or their families were widely employed it is obvious that checks would be difficult with the limited supervisory manpower available. It would, however, be much easier to observe people cutting outside the accepted time limits. Bird (1909) noted that at East Ruston Common the time limits placed on cutting became more and more relaxed as the nineteenth century progressed. He ascribed this to the decreasing demand for peat as a fuel.

# CHAPTER 10. Documentary evidence for turf-cutting in the Catfield and Irstead fens and the chronology of post-Medieval turf-cutting.

## 10.1 Introduction.

Stratigraphical study has shown that most of the areal extent of the Catfield and Irstead Fens has been affected by shallow peat cutting (Giller and Wheeler, 1986). Despite this, only a limited amount of documentary evidence pertinent to the subject could be located. Most directly relevant information was to be found in the account books of the Neatishead Charity Trustees. These refer to land which is actually in the parish of Irstead but which was allocated as a fuel allotment for the poor of the adjacent parish of Neatishead. According to the report of the Charity Commissioners this land had been exchanged for a piece a land in Neatishead at the time of enclosure. This was presumably because there was little or no suitable turf-land in the latter parish. The new fuel allotment consisted of two parcels of land; the first measuring 6 acres and one rood, and the second 26 acres, 3 roods and 8 perches. On modern maps (Fig.10.1) these pieces of land correspond to a section of the fen still known today as Neatishead Poor's Fen together with a section of the Irstead Holmes Marshes

Large sections of the remaining fen system were also allotted to the poor of both Irstead and Catfield but

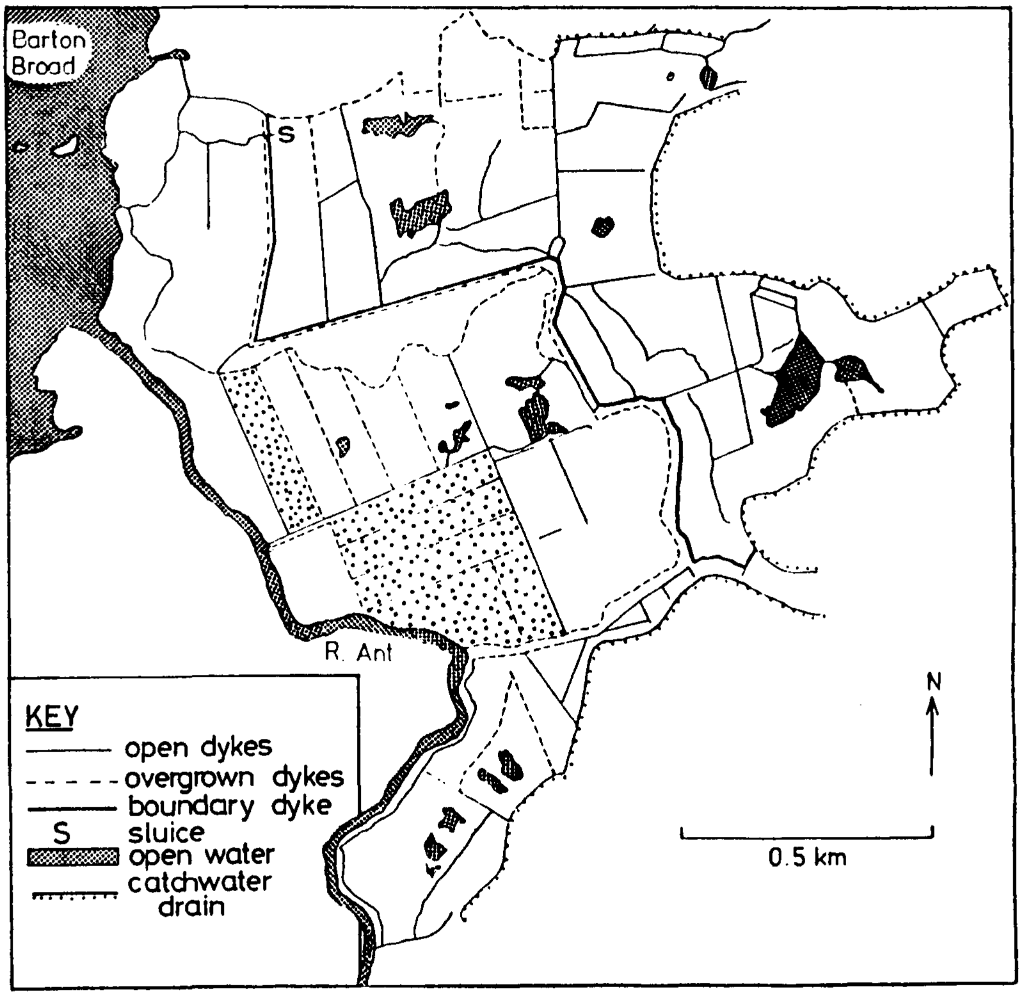



Fig. 10.1 Location of Neatishead Poors' allotments. (indicated by stippling).

unfortunately the relevant Trustees and Overseers records have apparently not survived. Most of the rest of the fen was in private hands with the land being divided up into relatively small plots with a plethora of leaseholders and owners. Very little indication of the management of these private plots could be found beyond the terse and potentially misleading entries of land use appended to such plots in enclosure and tithe documents (see *10.2.2*). The large number of individual landowners combined with the fact that virtually the whole of the fen surface seems to have been exploited for turf cutting might imply that there must have been some form of co-operation with regard to access and transportation of the material after cutting. Any mutual agreements thus reached might reasonably be expected to have been recorded in documentary form but if such evidence ever existed, it has not survived or remains undiscovered. There certainly appears to be no obvious relation between ownership and any pattern of turf exploitation. Similarly, it is not immediately apparent whether the leaving of the Sedge Marsh compartment in an undisturbed state is connected with any management idiosyncrasies of the owner, specified in both the Enclosure and tithe Commutation documents for Catfield as Henry Neville, Lord Abergavenny. He appears to have owned other allotments which were subsequently used for turf-cutting and so the reasons remain mysterious.

The records for the Neatishead allotments, therefore, stand as the main source of evidence for use in attempting to construct a picture of the events behind the creation of the Catfield and Irstead turf-ponds. It is, however, not known how representative these records might be and whether it is possible to apply the findings to the site generally.

**10.2 The Neatishead Records.**

The Neatishead records which are extant cover the accounts of the expenditure by the Trustees of the Poor from the period 1815-1927. For much of the first half of the nineteenth century a prominent feature of these accounts is expenditure on turf and its cutting, stacking and transporting. Figure 10.2 displays the amounts of turf recorded annually as having been paid for by the Trustees between the first available records in 1815 to the last year in which turf was mentioned, 1875. The vertical axis records "thousands" of turves although this possibly refers to multiples of 600 (see *9.11.2*). Two obvious trends are immediately discernible. The first is the gradual and steady overall rise in amounts of turf recorded until 1841, after which there is a marked decline. Secondly, there is superimposed on this trend a curious semi-regular fluctuation.

Figure 10.3 shows the differences recorded in the price paid for these turves recorded by the Trustees during the same period. It can be seen that wide differences in the

FIG. 10.2

Neatishead Charity Trustees: turf cutting 1815-75.

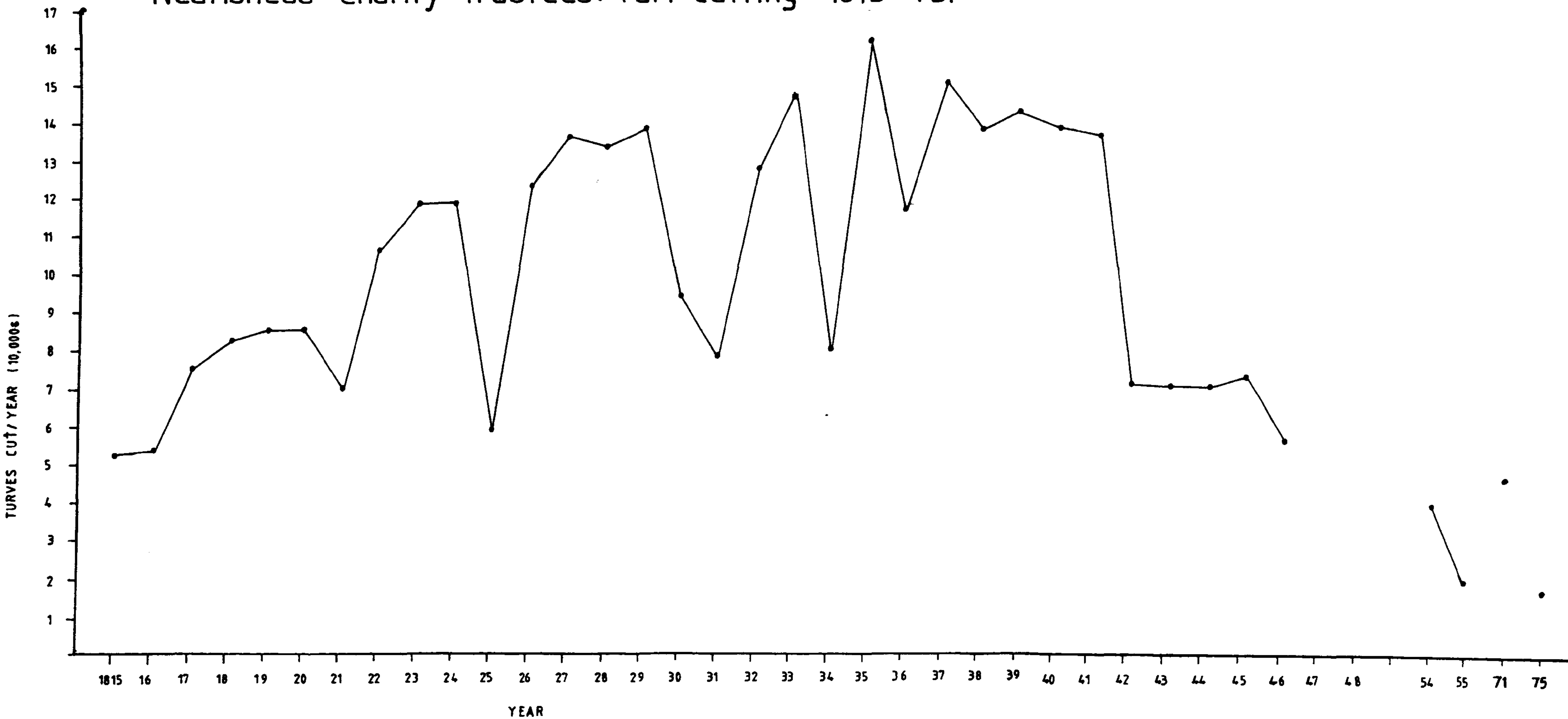
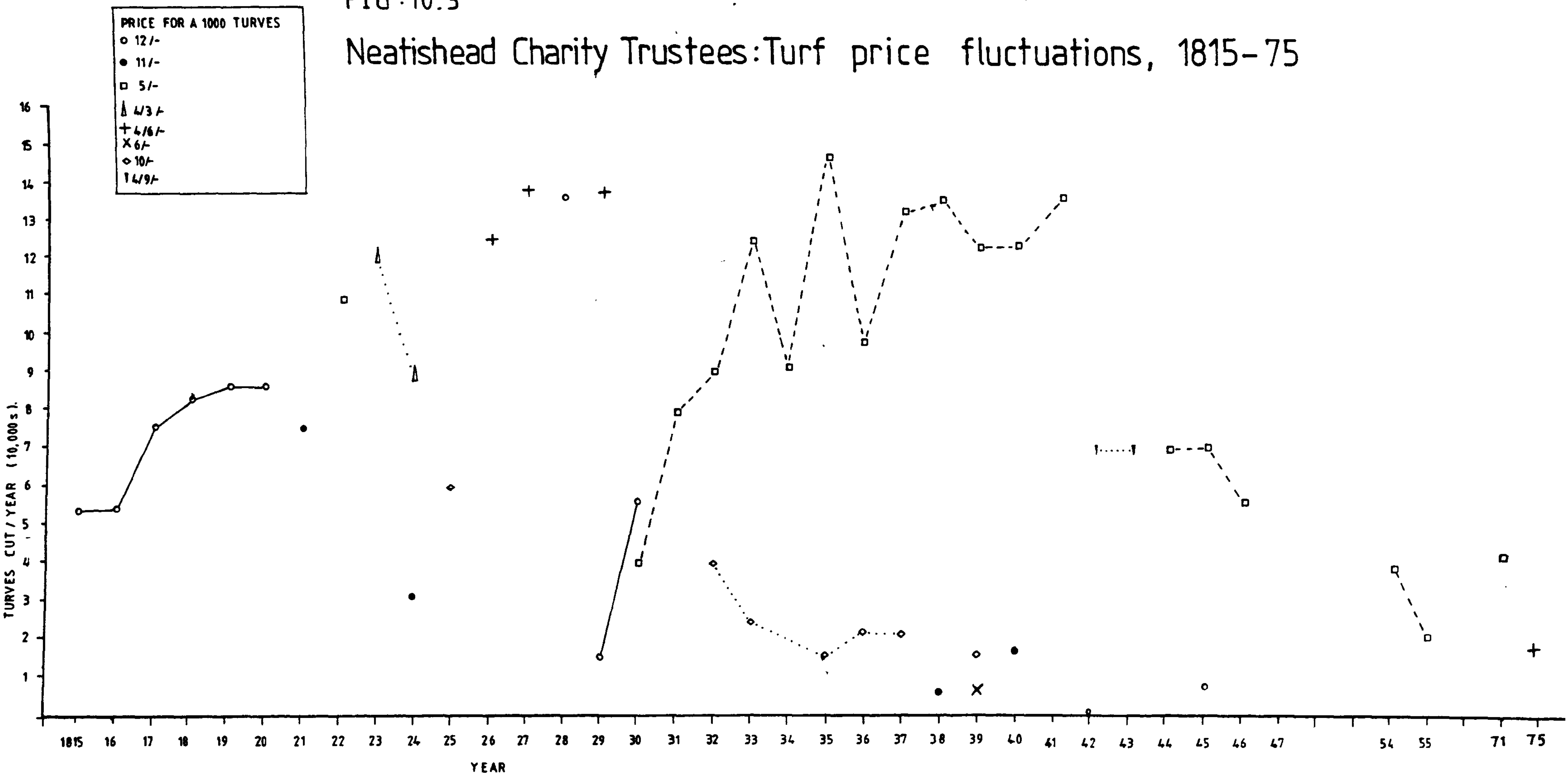


FIG. 10.3

Neatishead Charity Trustees: Turf price fluctuations, 1815–75



cost for some of the peat occurred during this time. The highest prices paid were 12/- for a "thousand" and the lowest that was ever paid was 4/3 for a "thousand". The bulk of the turf appears to have cost in the region of 5/- per" thousand".

*10.2.1 Interpretation.*

A certain amount of caution needs to be exercised in interpreting the records. Although it seems likely that the bulk of the turf mentioned came from the fuel allotments (particularly when activities such as "chimneying" [see 9.9.1] and boating the turf are frequently mentioned ), it is probable that some of the turf recorded in these figures was derived from outside sources. Evidence to this effect is found in the Charity Commissioners' report on the Neatishead fuel allotments which states, "Out of the rents derived from these allotments [the leasing of the remaining allotment in Neatshead itself and the letting of the "herbage" on the Irstead compartments]...the expense of ...cutting and boating the turf are paid and the remainder is applied *in purchasing coals or turf*"(present author's italics).

The extra cost of "outside" turf when coupled with the labour costs already incurred in the provision of "home grown" turf could be a possible explanation for the higher turf prices which are sometimes recorded. There is also the possibility that the higher price was the result of buying higher quality turf.

Bearing such caveats in mind, the evidence suggests that the bulk of the turf extraction was completed by the early 1840's. The exact timing of the initiation of the cuttings cannot be ascertained due to a lack of evidence relating to the pre-1815 period, but the extant records point to peak exploitation of the turf grounds occurring between the early 1820's and early 1840's. As far as the Neatishead Poor's plots are concerned, it would appear that the cuttings had become largely redundant as turbary by the mid-nineteenth century.

*10.2.2. Comparisons with previous studies.*

This places the activity in the cuttings at significantly earlier dates than those tentatively proposed by Giller (1982) and Giller and Wheeler (1986). It was suggested that cuttings in the Catfield and Irstead Fens dated from a period between 1842 and 1885. This chronology was based on cartographic evidence from comparison of early Ordnance Survey maps and plans appended to tithe commutation documents. The latter, dated 1842, show no evidence for large areas of standing water which might signify abandoned turbary and all the plots of land known from stratigraphical investigation to have been the site of former turf cuttings are registered as "pasture" in the accompanying documentation (Wheeler (1985) found an exact parallel at

Upton Fen where linear "dole" peat cuttings were also recorded in the tithe documentation in this way). The 1st edition 1:10 560 and 1:2500 Ordnance Survey plans, published in 1885 and said to be based on a 1881-84 survey, show large areas in flooded state (sections marked as "swamp", Fig.10.4). The conclusion drawn was that this showed the cuttings to have taken place in the intervening period.

The apparent anomaly between the descriptions of land use in the tithe documents and the evidence for turf cutting during the time of their compilation might be explained by the nature of tithe documents. Certain constraints are sometimes applicable to tithe records. The information contained in such documents was collected primarily for assessment of land valuation to help apportion rent-charge consequent on tithe commutation. Because of this the description of the land use was often assigned to broad categories relevant to such valuation, rather than being intended as a literally realistic account of the agricultural practices taking place (Prince, 1959). Descriptions in the documents such as "pasture" therefore, may not have been wholly accurate. Instances of this kind, for instance, are known to have occurred in other parishes where land shown on the map as woodland might be classified as "grass," and marsh or heath might be returned as "arable" (Prince, 1959.). There is also the possibility that the turf grounds were being used simultaneously for different

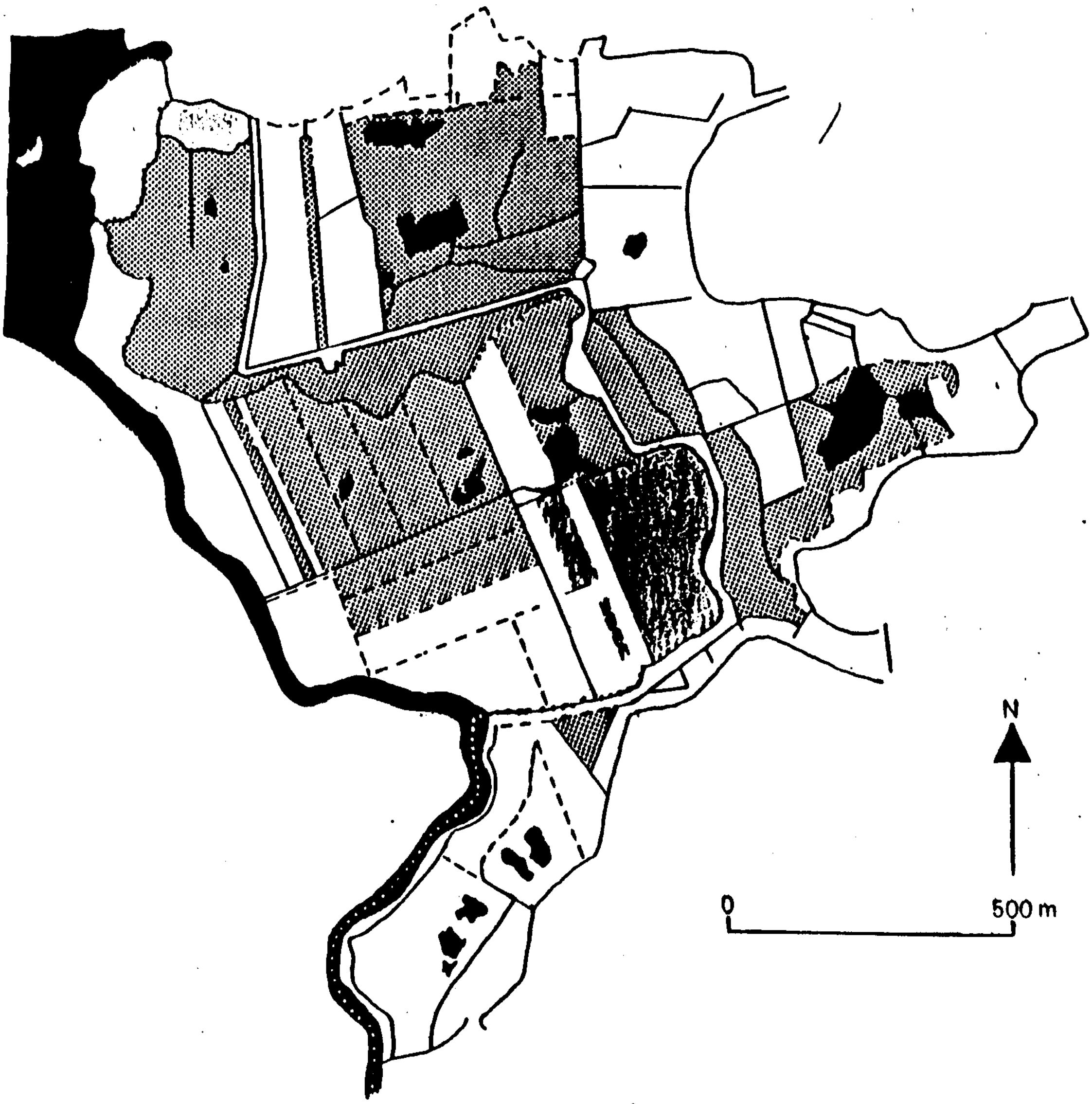



Fig. 10.4 Distribution of shallow turf ponds (shallow post-Medieval peat excavations) in the Catfield and Irstead fens, Norfolk. Stippled araes represent total extent of turf ponds as extrapolated from stratigraphical data; coarse stippling, turf ponds which are also shown (as areas coloured blue) on 1st. Edition (1885) 1:10 560 Ordnance Survey plans (*after* Giller and Wheeler, 1986).

purposes of which only one of them, "pasture", was recorded. As has been shown (see *9.4.7*) the multiple use of turf-grounds was common in many parts of Norfolk.

The absence of references to turf-cutting and lack of obvious cartographic evidence for it in tithe plans, therefore, might not necessarily conflict with the evidence outlined from the Neatishead Charity Trustees accounts suggesting that extensive peat extraction was underway at the time of the Tithe Commutation.

The evidence from the Ordnance Survey maps is more problematic. Although caution must be exercised when using cartographic evidence, [1]the first edition Ordnance Survey maps were famous for their accuracy and attention to detail. The recording of the "state of cultivating", for instance, was the responsibility of a specialist field examiner rather than a surveyor whose primary responsibility lay in other aspects of the survey (Harley, 1979).

The maps show extensive stretches of flooded ground marked as "swamp" and coloured in blue. If it is accepted that the cuttings date from around the middle of the nineteenth century then there is the implication that the cuttings were flooded for 40 years or more. The alternative interpretation is that the Neatishead documents are recording an unusually early exploitation of peat and that

1. An example of how caution must be exercised in using cartographic evidence in historical interpretation is, coincidentally, provided by the Catfield turf-ponds themselves by the fact that the flooded compartments of the first 1885 O.S. edition were still being reproduced on Bartholomew's 1/2 inch maps in 1969!

in fact some, or most of the cutting did indeed take place between 1842 and 1886. Certain features of the maps appear to lend support to this view. The Hundred Stream, for instance, is shown as intact on the tithe commutation map [2] (Fig. 10.5) while the Ordnance plan records it as having been partly removed, apparently by peat cutting (Fig.10.6). This would suggest peat cutting after the tithe commutation since even if the tithe map was recording the distribution of active turf-cuttings under the guise of "pasture", it might be reasonably expected that such a topographical change would have been noted. One possible explanation might be that parts of the tithe map were simply based on the original enclosure map without the addition of major changes which might have been occurring in the intervening period but how likely this might be is unknown.

In the absence of further specific evidence it seems impossible to categorically date the Catfield and Irstead turf-cuttings. There appears to be a conflict between the information in the Neatishead trustees documents and the cartographic evidence. However, the evidence from other parts of Norfolk presented in **10.4**, seems to suggest the demise of the use of turf for fuel in the region by the beginning of the second half of the nineteenth century. This would tend to support the Neatishead Trustees evidence for an earlier date for the Catfield cuttings, but only if the main role of the cutting had been to obtain fuel.

2. N.R.O. P.D.531/37(H). Catfield Tithe Apportionment 1840, and map, 1841.

Alternatively, if, as suggested by Giller and Wheeler (1986), the cuttings had been created primarily to improve the growth of reed, it is possible that they could have been dug later in the nineteenth century without the turf being necessarily recorded, since its importance as a fuel may have become relatively unimportant by this period. If this was the case, the fact that turf was primarily a fuel of the poor (see 9.4) may have meant that possibly only the poors' allotments were exploited for the material during the first part of the nineteenth century, whilst the remaining (privately owned) areas of the fens were subsequently cut over for quite a different purpose at a later date. There is a possibility, therefore, that the present day infilled turf ponds may represent a mosaic of cuttings of varying age.

**10.3 Drainage activity in the Catfield and Irstead fens.**

Knowledge about the origins and development of drainage systems in the Catfield and Irstead Fens is largely non-existent before the Parliamentary Enclosure period. This tends to be the case for most of the Broadland Fens (Standley, 1985). After this period what little information there is has to be inferred mainly from archive cartographic evidence.

Information on maps suggests that improvements in the system of drainage in the Catfield and Irstead Fens took place between the time of the Enclosure of the parishes involved in 1807 and around the time of tithe commutation in 1841 when a further map was drawn. The enclosure map[3] shows the fens divided into the series of compartments along similar lines to those found subsequently in the Tithe plan but there appears to be no indication of drainage pumps or the like. The enclosure document, however, is also an award for embanking and drainage, although whether this means that the award was enacted to promote drainage and embanking, or whether it merely enabled the enclosing of already existing dykes and banks, is not clear.

The tithe map clearly shows a windmill symbol, presumably indicating a wind-pump, marked in the centre of the map (Fig. 10.5). It is shown to be standing on a strip of ground (known as the "rond") with dykes running either side of it. There appear to be no connections between the dykes and the presence of a road is indicated as entering the compartment marked as 161. The marsh delimited by the dyke/rond system was divided by further minor dykes into a complicated system of small compartments, different from the units existing today. It seems probable that the windpump was used to lower the water table in this area of the fen, which is referred to as the "internal system". The rest of the fen outwith the rond is called the "external system" (Giller, 1982). The remains of a windpump are still visible in this part of the fen.

3. Catfield and Sutton Enclosure Award, 1807.

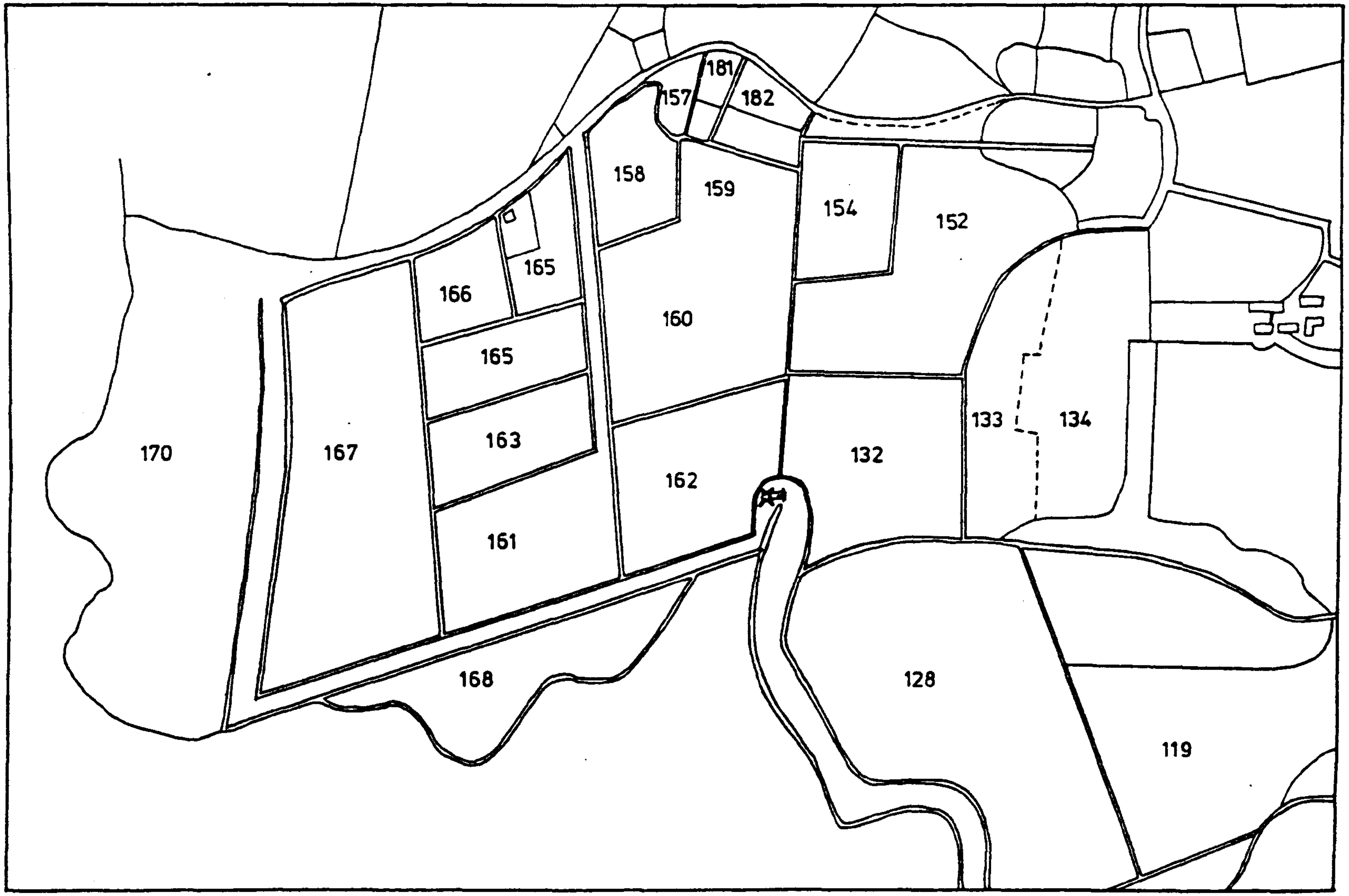



Fig 10.5. A reproduction of part of the map of Catfield Parish produced by the Tithe Redemption Commission in 1840.
Numbers refer to individual owners. Note that the line of the Hundred Stream (south of compartment 168) is shown as intact.

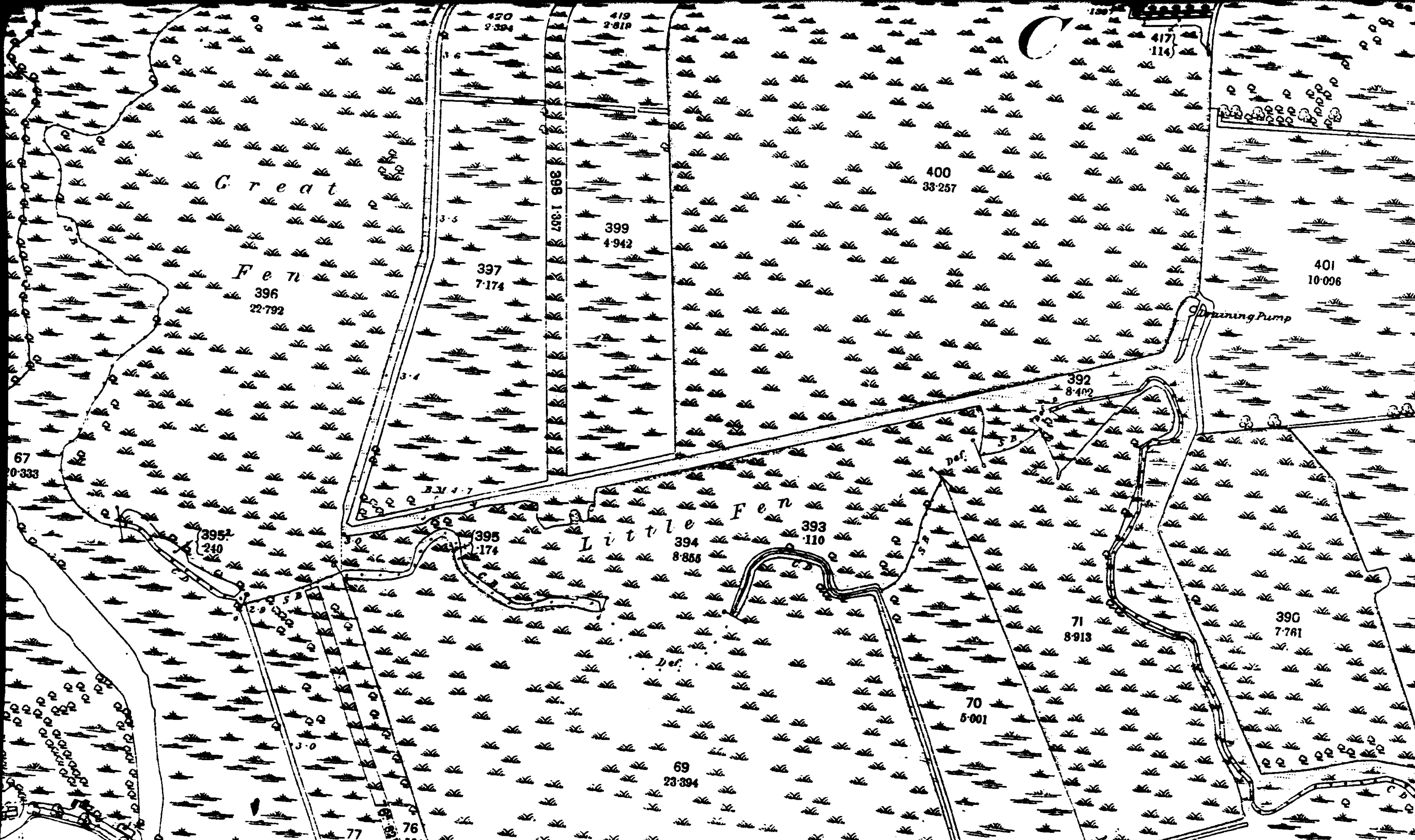



Fig. 10.6. A reproduction of part of the 1st edition (1886) O.S. 1:10560 map of Catfield showing the interrupted line of the Hundred Stream south of Little Fen and the linear cutting running the length of Sedge Marsh.

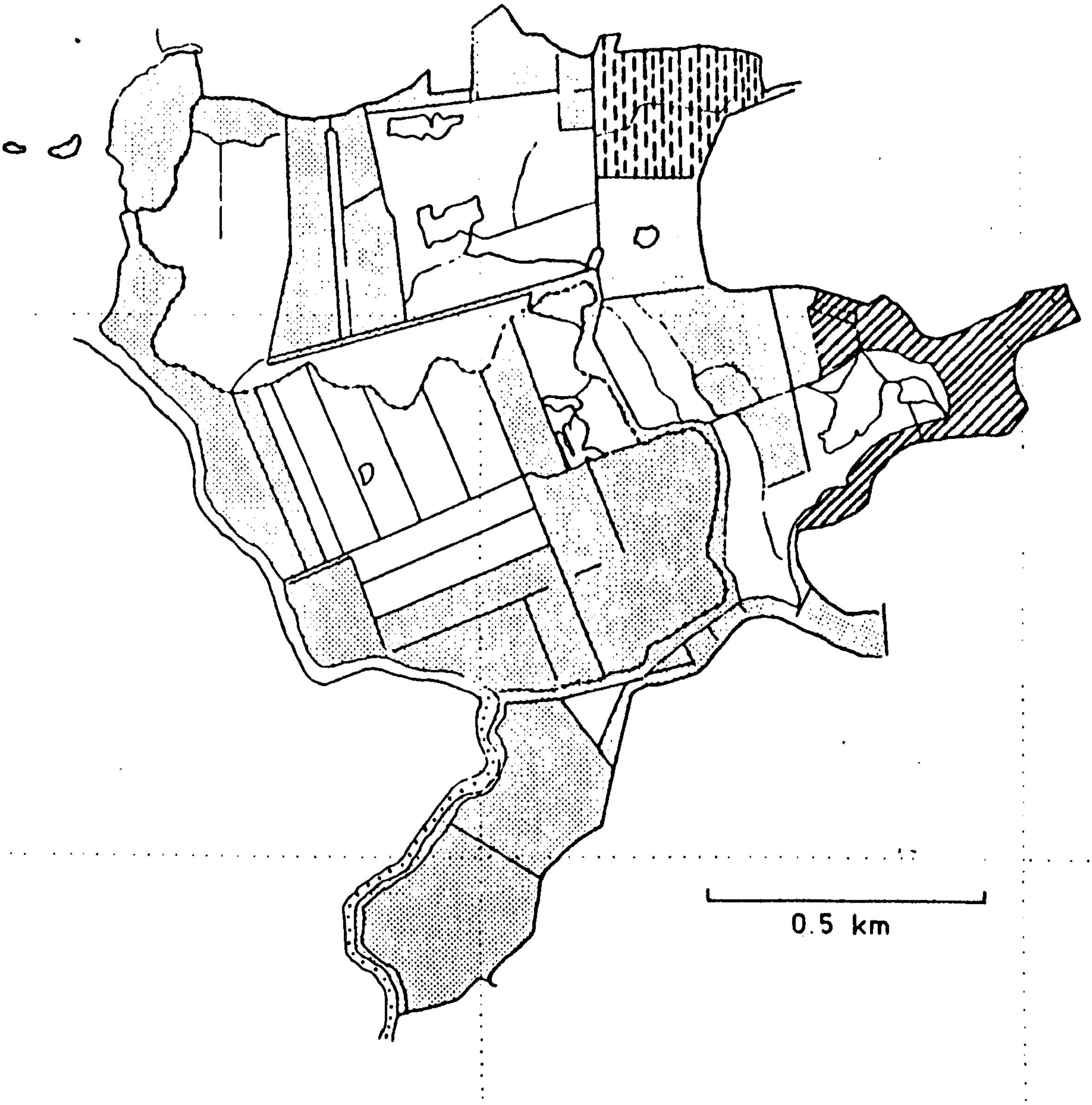
swamp
rough grassland

The tithe documentation refers to the land use of all the present day marsh areas occupied by the compartments simply as "pasture" (but see *10.2.2*).

The first edition 1" Ordnance Survey map of the Catfield and Irstead Fens (1838-40) does not show the marshes in detail but indicates the presence of another windmill further south down the "rond" at the eastern end of the East-West Dyke. Many of the compartments within the "internal system" are shown as "rough pasture" (the mid-nineteenth century O.S. symbol indicating any combination of unimproved ground-level plants; Harley, 1979).

The first edition 25 inch (1886) and 6 inch (1885) O.S. maps of Catfield show the two wind-pumps operating along the "rond" but now many of the former compartments of the "internal system", along with areas in the "external system" have been replaced by large undivided areas marked in blue with symbols denoting the presence of "swamp" or open water, i.e. turf ponds (Fig. 10.4). Many of the dykes marked on the tithe map are missing from these later ones but there are some new ones including one running centrally north-south along the length of Sedge Marshes (see *3.1.1*). Giller,(1982) suggested that the windmill shown on the tithe map was used for pumping water out of the "internal system", possibly to allow grazing in North Marsh and some of the other marginal marsh compartments.

Little further evidence was discovered relevant to the history of the development of drainage in the Catfield and




Swamp (□), Marsh ( ▩ ), rough grassland (▥) and woodland ( ▨ ) as shown on the 1885, 6" Ordnance Survey map.

**Fig. 10.7** Indications of past land-use as recorded by the first edition 6" Ordnance Survey map.

Irstead Fens or the motivation behind such activity. Whether the additional wind-pump was installed to assist the extraction of turf or not remains unknown as does any documentation which might throw light on the probable co-operative nature of the peat exploitation which appears to have taken place between the drawing of the tithe map and later Ordnance plans. It would certainly seem that major developments in the drainage of the fen systems were undertaken between 1807 and the 1880s but their relation to turf extraction in both functional and chronological terms remains not clear.

## 10.4 The overall chronology of the post-Medieval turf cuttings.

### *10.4.1 Introduction.*

Following the discussion on the dating of the post-Medieval turf-cuttings specific to the Catfield and Irstead fens presented above, the present section explores the evidence for dating the period when historically recent Norfolk cuttings were generally in use and suggests causes underlying their instigation and eventual demise.

The first use of peat as a fuel in Norfolk is unknown. There has been speculation that the turbaries which were to lead to the formation of the broads may possibly have been initiated during the period of Danish influence in the 9th and 10th centuries as east Norfolk was the area of the county most thickly populated by Danish settlers (Green and

Hutchinson, 1960). It has been shown in the present study, for instance, that there are linguistic similarities in the terminology of Norfolk turf-cutting to another area subject to Scandinavian influence, namely, Cumbria (see **9.6**; *9.11.1*). All that is known for certain, however, is that by the eleventh century the huge turbaries that were later to become transformed into broads were being energetically excavated (Smith, 1960).

In a county where most of the indigenous woodland had been removed it was inevitable that the sub-fossil fuel deposits would be exploited for fuel. Turf appears to have fulfilled the role of major fuel source to the population of Norfolk (and probably much of East Anglia) all through the early and high Middle Ages. It was only after the disastrous flooding episodes of the late thirteenth and fourteenth centuries and the onset of the wetter conditions induced by the late-Medieval climatic deterioration that the material began to decline in importance. Smith (1960) has shown that from the fourteenth century onwards the incidence of records of turf in documents lessened whilst that of alternative fuel sources, particularly those of wood faggots, increased. By the fifteenth and sixteenth centuries wood appears to have become the main fuel used in the region and few records referring to turf cutting have been found which are datable to this period. Smith (1960) speculated that the changeover to non-turf fuel sources may have been related to turf becoming relatively uneconomic to exploit due to increasing difficulties of extraction.

Warren (1983) has shown how increasing flooding caused the extremely valuable turbary of South Walsham to play an insignificant role in that parish's agrarian economy after the medieval period. There is certainly evidence to show substantial increases in the price of turves in the latter part of the fourteenth century and this, combined with a falling population (because of, amongst other things, the effects of plague) which meant that labour would have been scarcer and demand for fuel was likely to have lessened. This could have le. d to cheaper wood[4].

Whatever the exact reasons for the changes, it seems that turf became relatively unimportant in the economy of Norfolk from around the end of the fourteenth century until the end of the seventeenth. Smith (1960) failed to find extensive references to the fuel after the fourteenth century and the earliest references to turf extraction encountered in the present study which post dated this time were from 1677 (Hockwold with Wilton) and 1702 (South Walsham and Martham). Thus there seems to have been an apparent hiatus in turf exploitation in Norfolk between the fifteenth and seventeenth centuries. The records of the Overseer of the Poor for the parishes of Barnham Broom and Felmingham are interesting in this regard as they are rare

4. Cornford (1979), for instance, records a drop in the price of faggots from 21/- a hundred in 1625 to 7/6 a hundred in 1715.

examples of occasionally uninterrupted series of records relevant to fuel usage covering the period from the late seventeenth and early eighteenth century up to relatively recent times. Equivalent records from East Harling, although not as complete, also shed some interesting light on the changing trends in fuel source usage during this period.

*10.4.2 East Harling.*

The records, which begin in 1699, mention sums of money paid for "loads of flaggs" and wood in the early period or make reference to unspecified "firin". In 1703 there is a mention of "furs" (furze). The latter fuel source becomes very prominent in the years 1709-1710 and after this time they remain one of the most frequently mentioned materials. Flags also remain prominent and there are frequent mentions of "feagots of wood" or "loads of wood", and in 1715, a rare mention of "a load of brakes". Wood, furze and flags appear to become the main fuel sources from about this time until a break in the sequence of records at 1721. When the records recommence at 1784 turf, and, to a much lesser extent, coal have taken over as the predominant fuel sources recorded. Furze and faggots are still occasionally mentioned but they are rare by comparison to turf. By the time the second sequence of records terminates in 1808 turf appears to have been the predominant fuel for about 20 years.

*10.4.3 Barnham Broom.*

The surviving records of the Overseers from this parish begin in 1714. From this year up to 1746 the records refer exclusively to wood in one form or another whether it be "fagots", "blocks" or simply "wood". There is frequent mention of money being paid to individuals for, "carriage of blocks to ye poor", or for, "shubing and ryving of blocks", and in one entry, "for feling and riving trees for ye poor." The years from 1725 to 1734 contain no entries but instead state that, "The layings out of Samuel Hibkin, Overseer of the Poor being too large to insert in this place." A similar hiatus occurs for the years 1741-1745. The records for 1746 mention a considerable amount of wood as having been used by the parish poor but it is not until the following year that turf is mentioned at all.

In 1747 a remarkable change appears to have taken place in the provision of fuel for the poor of the parish. After this year turf suddenly became the major fuel source recorded. Initially, other sources are not mentioned at all but in later years, from about the mid-1750s onwards, relatively small amounts of wood are mentioned as supplementing the turf. This remains the case up to the date of the last surviving records in 1771. It is evident that most, if not all of the turf was derived from local sources as in addition to money paid for the turf there is also recorded costs such as "paid for cutting tending and carrying of turff", and "for stacking turf". "Town Turf" is also often specified, this presumably referring to turf from the parish fuel allotment.

*10.4.4 Felmingham.*

These records differ from the others described up to now in that turf is only mentioned once. However, they indicate the long usage of flags compared to the latter material and the records also show the increasing influence which coal seemed to play in the later stages of the eighteenth century.

The records begin in 1679 when a sum paid for, " 5000 flaggs with carriage." Flags continue to be the predominant fuel source although smaller amounts of wood, or faggots thereof begin to be mentioned sporadically after 1688. Payments for carriage of the flags also included an element required for beer in 1763, 1764, 1768 and 1770 suggesting the transportation of the material may have been a little erratic at times. 1776 sees the first instance of coal being recorded when "4 chaldron and a half" were ordered. From this date onwards, although the provision of flags remains the most widely recorded fuel, coal becomes an almost constant feature of the accounts. The only mention of turf comes in 1781 when a small amount was paid for the carrying of the material for a pauper called Neal. It seems that the person concerned may have actually cut these himself or bought them privately but required financial assistance to transport them.

**10.5 Discussion of the evidence relating to turf-cutting chronology.**

Although the records described above are relatively few in number and therefore cannot be used to generalise too greatly, they do hint at some interesting possibilities. Firstly, the records do not contradict the view that turf was uncommon as a fuel source before the mid-seventeenth century. The East Harling and the Barnham Broom accounts in particular display a remarkable changeover from predominant wood usage to that of turves around this time. The reasons for this must necessarily remain speculative in the absence of further firm evidence. However, it is known that numbers of people reliant on the poor rate began rising as the eighteenth century progressed (Tate, 1969) and this would inevitably have led to greater demand for fuel. The records from Barnham Broom seem to bear this out with the Overseer missing out records in the account books because they were too large to fit in. The cost of material such as wood would inevitably rise with the consequence that it may have become economic to operate turbaries in the region once more, particularly as the conditions of drainage of the turf grounds, which appears to have caused cessation of cutting in medieval times, seems to have been improving (see *7.1.4; 7.1.5*). Such reasoning implies that in the mid-seventeenth century a reversal of environmental conditions and economic factors prevalent at the time of the late medieval abandonment of the Broadland turbaries was occurring. As conceded above, such assertion must remain tentative until additional research unearths further supporting information.

The procurement of coal was taking place in some parishes by the later eighteenth century as can be seen from the Felmingham record. Its use, however, appears to have been as a supplementary fuel source to flags and it is not mentioned in the other early records. In the Neatishead accounts it suddenly becomes prominent in 1858 after which it remains almost the only fuel mentioned. The coal used in Felmingham was evidently of Northumbrian origin as the amounts used are measured in "Chaldrons"[5] or portions thereof and there is an entry for 1779 which includes a payment of 18/- for "Carrage from Cromer and Delivering to the Poor." It seems probable that in those parishes in close proximity to ports where the sea-coal was unloaded such as Felmingham, the use of the fuel was economically viable during this period. Parishes further away from the ports may have found the acquisition of turf to be cheaper. The Napoleonic War also had an effect on the price of coals during this period, as was noted by Dr. Hinton in Nathaniel Kent's *General View of the Agriculture of Norfolk* (1796) when he stated, "Coals are dear, and the war has advanced the price of them." Factors such as these are likely to have ensured that turf was the most cost effective material

5. In documentary sources dating from this period Northumbrian sea-coal is always measured in *chauldrons*, as opposed to coal from the Midlands which is always measured by the ton, hundredweight, or *load*.(Rogers, 1866-1902).

for supplying the poor with fuel until the middle of the nineteenth century. The arrival and expansion of the railway network in Norfolk from this time onwards ensured that this changed to the detriment of turf, probably reversing the economic advantage of the latter over coal in areas distant from the sea ports as well. As an instance of this, it seems more than coincidental that the dramatic drop in amounts of turf recorded in the Neatishead records in the early 1840s (Fig.10.2) and the remarkably rapid switch to coal seems to have occurred at around the same time as the sudden expansion of railway communications within the region such as the opening of several Great Eastern Railway lines eg. Great Yarmouth to Norwich via Reedham (1844), Norwich to Cambridge and London (1845) and Norwich to Ipswich (1849) (Gordon, 1968). Such improvements must necessarily have allowed for easier and cheaper transport of coal from inland coalfields and from sea-ports.

Such an explanation remains the most satisfying explanation for the rapid decline and cessation of turf-cutting activity. The arrival of railways are similarly judged to have been a major reason behind the demise of turf cutting and other traditional fuel sources in others regions, such as the Lizard Peninsula of Cornwall (Hopkins, 1983).

Turf was still being used in parts of East Anglia other than Norfolk into the twentieth century (Martin Lane, 1961; Godwin, 1978). In Norfolk itself the latest records which have been located (apart from the isolated 1871 and 1875 instances from Neatishead) are those at Stalham for 1862 [6] and South Lopham in 1868 [7]. Both instances record isolated events and it seems clear that the days of large scale exploitation of the turf grounds had passed by this stage.

The almost total collapse of the Norfolk industry by the beginning of the second half of the nineteenth century could be the reason why apparently little or no oral history relating to it has survived. In contrast, some still existed in Cambridgeshire until quite recently (e.g. Martin Lane,1961.).

It is possible that the apparently earlier abandonment of turf-cutting in Norfolk, and Broadland in particular, may be related to the wetter nature of the turf grounds. The extra effort and expense that would have necessarily been incurred in exploiting these areas due to drainage, boating of the turf, etc., may have meant that the peat in these areas was relatively more expensive and would thus have succumbed earlier in the battle for economic supremacy with coal.

Estyn Evans (1957), referring to ombrotrophic peat from Ireland, points out that the calorific value of the material is less than half that of coal and its bulk makes its transporting costly. The fen peats from the Broads would

6. N.R.O. P.D.262/63. Documents referring to a dispute over the ownership of some turf grounds.
7. N.R.O. P.D. 311/16. South Lopham Church and Fuel Allotment; a receipt for a thousand turves from the Church and Fuel allotment.

have suffered in these respects to an even greater degree. This, when coupled with the extra difficulties and expense mentioned above, might account for an apparently early demise of the Broadland industry  Turf from better drained parts of Cambridgeshire, acquired with much less trouble, may have maintained its competitive edge longer until it too was eventually edged out of the market.

# CHAPTER 11: Synthesis and Significance of main points and Suggestions for Further Research.

Tooley (1985), writing about the effects of climatic change upon plant communities, stated that, "To have an effect on vegetation succession, a repetitive pattern of extreme events, (either river or sea floods, or frost or extreme dryness) is necessary; an isolated event will have little or no effect either on the vegetation structure and composition, or on the sedimentary regime."

It is felt that the evidence for distinct plant macrofossil assemblage zones in undisturbed Broadland peat deposits presented in this thesis can be said to fit Tooley's criterion and that they represent responses of vegetation to climatic change over the last 2000 years similar to those recorded from mires elsewhere. As far as is known, this study is the first time major features of probable palaeoclimatic importance have been identified from a soligenous system, for, as Barber (1985) pointed out, "almost all the work in reconstructing past climate from peat stratigraphy has been undertaken on raised or ombrotrophic bogs." This state of affairs has probably arisen because of possible difficulties involved in separating features due to climate from those caused by other factors when dealing with minerotrophic systems. The much greater range of plant remains found in such deposits can also mean analysis is more demanding and time consuming.

It is hoped that these results demonstrate that the neglect of minerotrophic systems in palaeoecological studies is undeserved and that, in certain circumstances and with careful appraisal of additional corroborative sources of evidence, they are capable of producing information relating to environmental history which is just as valuable as that found from ombrotrophic mire investigations. It is important that such systems should be investigated in the future otherwise a geographically skewed data set biased towards the north and west of the country will persist which, in the absence of evidence from other regions, must necessarily remain as an incomplete record of palaeoclimatological and palaeoenvironmental change.

Since Roman times the history of the Broadland environment has been affected by a complex of interlinking natural and anthropogenic factors. The creation of the broads themselves is the most obvious example of the enormous impact which pre-Industrial Revolution human activity could have on the ecology of the region. It is hoped, however, that the evidence which has been presented illustrates the importance of the influence of natural events upon the behaviour of plant communities in fen systems thought to have been long subject to management and therefore largely under the control of anthropogenic factors. The macrofossil assemblages appear to suggest that such human interference may have become the most important controlling factor only in comparatively recent times.

Future archive documentary researches relating to this aspect of the study would be well worth pursuing in order to try to discover if the origins of large scale fen management can be discovered and related to the bio-stratigraphical record.

The last two hundred years, however, has seen the increasing importance of human influence on the fen areas of Broadland. Pre-eminent amongst such activities has been the drainage of the fens and their exploitation for reeds, sedge, litter and turf. It has been shown that the role of turf in the Norfolk rural economy, particularly with regard to the poor, was of major importance during the late eighteenth and nineteenth centuries. It is possible that study of Charity Commissioners' Accounts and Overseers' accounts from other regions of the country where peat was known to have been utilised may produce evidence along similar lines. It would be interesting to pursue such research to enable comparative study with the Norfolk records and allow them to be set in a national context. Such study may also allow the identification of those aspects of the peat cutting industry which are generally widespread and which may possibly be unique to Norfolk. Despite its former importance in economic terms, and its implications for the ecology of the areas affected by it, the study of peat cutting appears to be somewhat neglected. There is likely to be considerable scope for discovering much information relevant to historical ecology.

The reason why turf in Norfolk apparently fell from widespread use between the abandonment of the Medieval turbaries and the later period of recorded turf-cutting is not clear. The available evidence appears to support the idea that natural factors, in the form of climatically induced flooding episodes (as recorded in the macrofossil record from the uncut sites), may have resulted in the neglect of turf exploitation due to difficulties of exploiting the turf grounds of the marshes until historically recent times. In the absence of more substantive evidence, such a hypothesis must remain tentative. Once again, further research of historical documents (if, indeed, such documents exist) will be necessary if such questions are ever to be answered satisfactorily..

The function of many historically recent turf cuttings and their precise chronology also remain unresolved for the most part. What is clear, however, is that many, if not most, of the cuttings were carried out with the intention of obtaining peat for fuel, as in the original Medieval turbaries. Most of the documentary evidence relating to this activity suggests that the bulk of turf cutting for fuel took place between the latter part of the eighteenth century and the middle of the nineteenth and that subsequently coal replaced turf as the most generally used fuel source. In places such as the Catfield and Irstead Fens, however, cartographic evidence appears to conflict with the limited documentary sources available relating to turf cutting activity when it comes to the timing of the cuttings. This raises the possibility that cutting continued after the decline of the use of turf as a fuel, possibly as a means of encouraging the growth of better quality reed. The likelihood of such "turfing out" is highly probable in known reed harvesting areas such as Catfield but other than some anecdotal information, site specific evidence relating to the activity is lacking and so the idea must remain unproven. More research into this area is highly desirable as this aspect of the study is of potentially outstanding importance with regard to the understanding of the processes involved in the revegetation of the turf cuttings.

Further macrofossil analyses of the turf pond areas are also felt to be worthwhile in order to confirm features already recognised and to extend investigations to cover a wider geographical and phytosociological range than was possible in the present study. The factors dictating the successional sequence in the various turf-cuttings are evidently complex and not easily discerned. A larger data set from a wide range of turf-pond sites might aid the identification of general trends or characteristics of succession leading to specific present-day communities.

**Conclusion.**

Overall it is hoped that the present study has given an indication of the potential for the study of palaeoecology and historical ecology in Broadland, and that the reason why Steers was able to imply that the The Norfolk Broads were, "the best known and least investigated" area of lakes in Britain is not due to lack of interest. The origin of the broads themselves, which occupied the minds of so many ecologists three decades ago, can be seen to be but one of the historical factors and processes involved in the formation of the present day mosaic of plant communities and landscape features found in the region. Such factors are as complex and varied as those communities and features themselves and the current study can only claim to make a small contribution to the further unravelling of the complicated and fascinating history behind the development of the semi-natural wilderness that we call, "The Norfolk Broads."

# APPENDIX A. CHEMICAL ANALYSES and LOSS-ON-IGNITION.

## 1.1 Chemical Analyses.

Chemical analysis of peat deposits has been undertaken in many past studies. Most of these have involved the investigation of ombrotrophic peats (e.g. Chapman, 1964, Wimble, 1986). In many of these studies the chemical investigations were aimed at identifying features of palaeoecological significance. Chapman (1964) suggested that in an ombrotrophic system the ratio of various major cations could be used to identify changes in environmental conditions in former bog surfaces. Thus calcium and magnesium values, and their ratios, have been claimed to be an indicator of relative oceanicity of rainfall, due to an input of magnesium from fine sea spray incorporated in the rain (Gorham, 1957; Sparling, 1967.). Calcium, however, is regarded as being of predominantly terrestrial origin, mainly from percolation through calcareous rocks and soil.

Sodium and potassium ratios are similarly thought to be related to oceanicity with the sodium having its origin in sea water and potassium from terrestrial sources (Sparling, 1967).

Because such postulation is only valid for truly ombrotrophic systems, interpretation of chemical analysis of fen peats is more complicated. By its very definition, such peat is subject to minerotrophic influence and thus any cation input from rainfall is likely to be swamped by more direct sources.

Bearing this in mind, it was decided to limit the chemical aspects of the study to the investigation of the Sodium content of the peat as this cation was the most likely to indicate past marine influence in the deposits.

An attempt to detect the presence of sodium was approached in two ways:

(1) By recording conductivity from the deposits.

(2) By extraction and measurement of total sodium cation content of the materials.

**1.2 Loss-on-ignition.**

This value is widely interpreted as a rough estimate of organic carbon in soil and peat deposits (Allen *et al.*, 1986). The loss-on-ignition values were determined for each 10cm segment of the cores as an additional aid to identify and/or confirm lithological features recognised from the stratigraphy.

**1.3 Methods.**

*1.3.1 Collection of material.*

Using a Hiller-type chamber corer, peat cores down to two metres were taken at the same sampling positions as the original macrofossil samples. Material from the corer chamber was extracted in 10 cm segments down the core and placed in polythene bags, labelled and stored in a cold room until analysis.

*1.3.2 Conductivity measurements.*

From each 10cm segment down the core three replicate samples of 10 $cm^3$ of core material were placed in a glass beaker and mixed with 30 ml of distilled water to enable a sufficient volume of liquid to cover the conductivity probe. The material was thoroughly mixed and the probe left in the solution until the reading stabilised. The readings were recorded and means and standard errors calculated for each 10cm interval.

*1.3.3. Sodium and loss-on-ignition.*

Material used for sodium extraction was taken from the same samples collected for the conductivity measurements. For each 10 cm segment of the core, three replicates of material were prepared and analysed. Samples of material weighing between about 3-4g were placed in glass beakers and dried in an oven at $80^{0}C$ for three days. After this interval the samples were re-weighed and the dry weight thus obtained. The material was then placed in a muffle furnace and heated at $500^{0}$ C for 10 hours. The resulting ash was weighed and the loss-on-ignition calculated for the material.

5 ml of 1M nitric acid was then added to each ash sample. The solution was made up to final volume of 25 mls

with deionised water and analysed for sodium using a *Corning M410* flame photometer. The concentrations of sodium are expressed on a unit dry weight basis.

**1.4 Results.**

The results are shown as a series of graphs with conductivity (Fig.A.1) and sodium values( Fig.A.2) plotted against the depth of the segments from which they were derived.

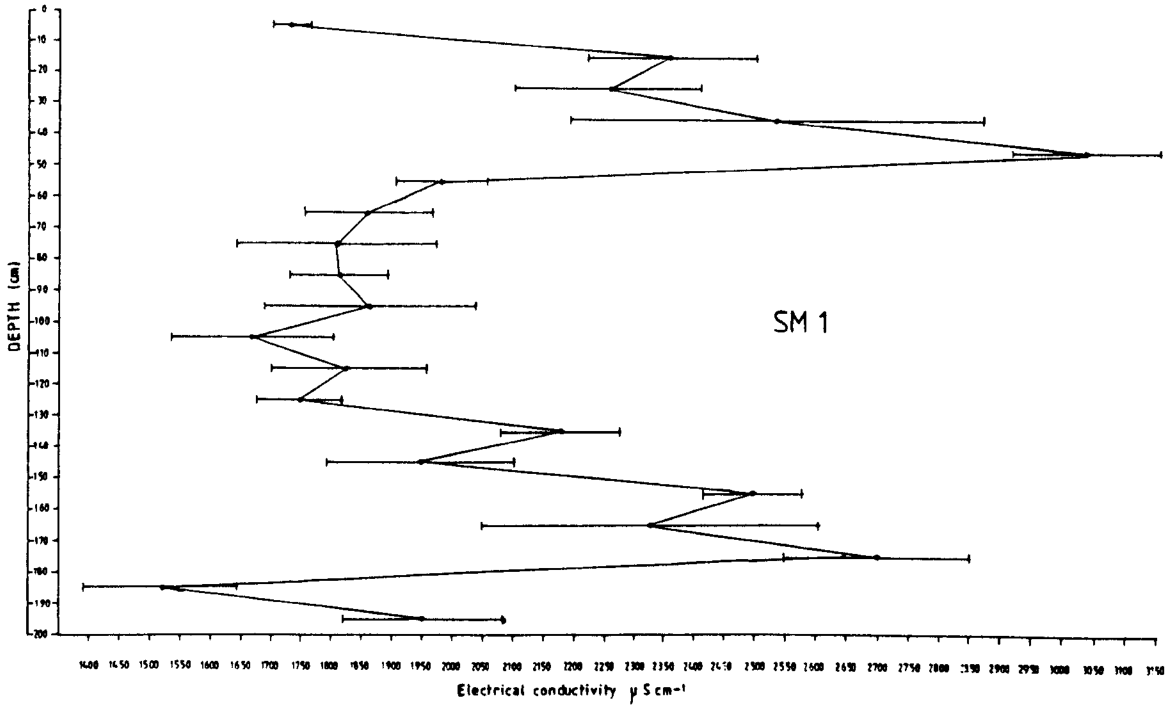
The loss-on-ignition calculations are presented in graphical form in Fig.A.3.

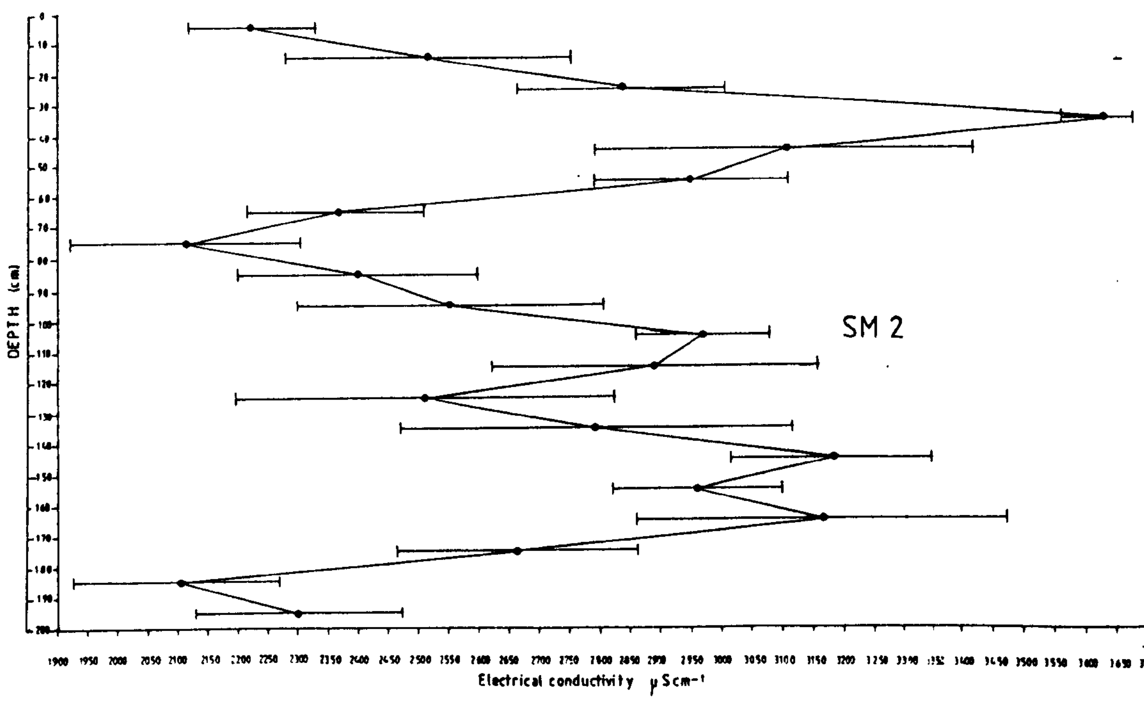
All the chemical analyses are presented with standard error bars (n=3). The standard errors of the means of the loss-on-ignition results were of a negligible magnitude and are omitted from these graphs.

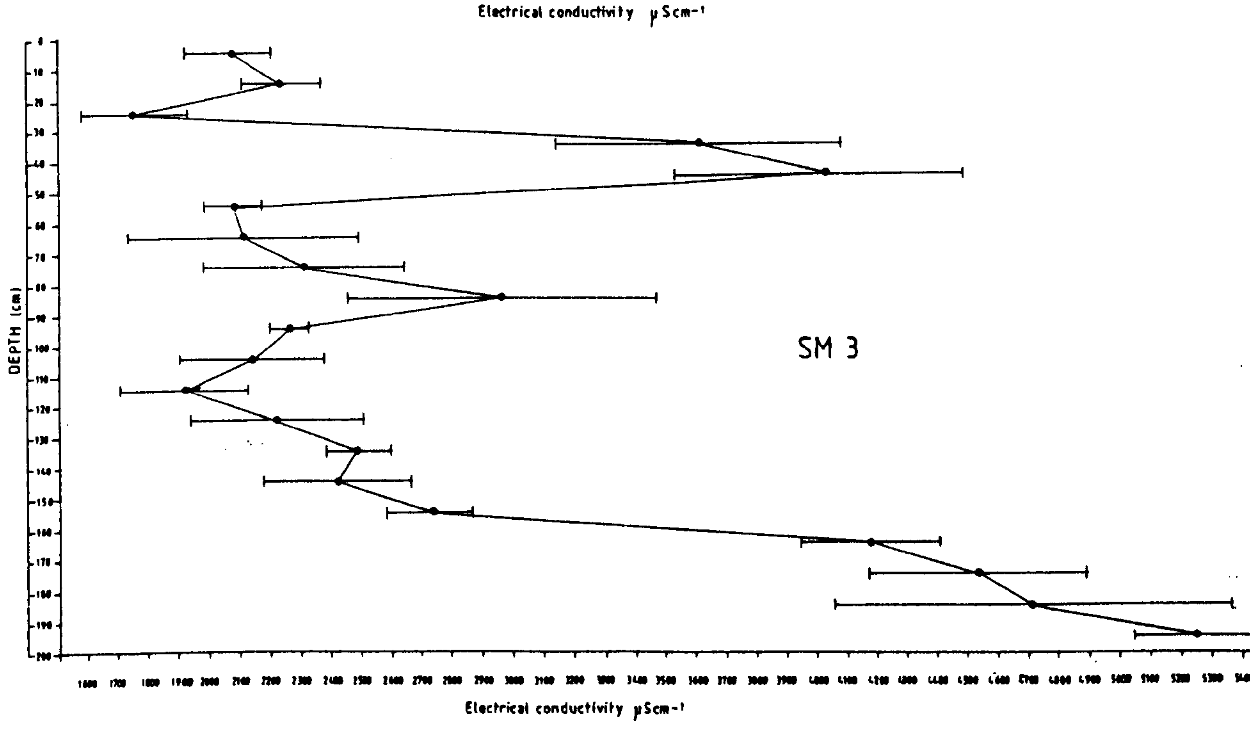
*1.4.1 Conductivity values.*

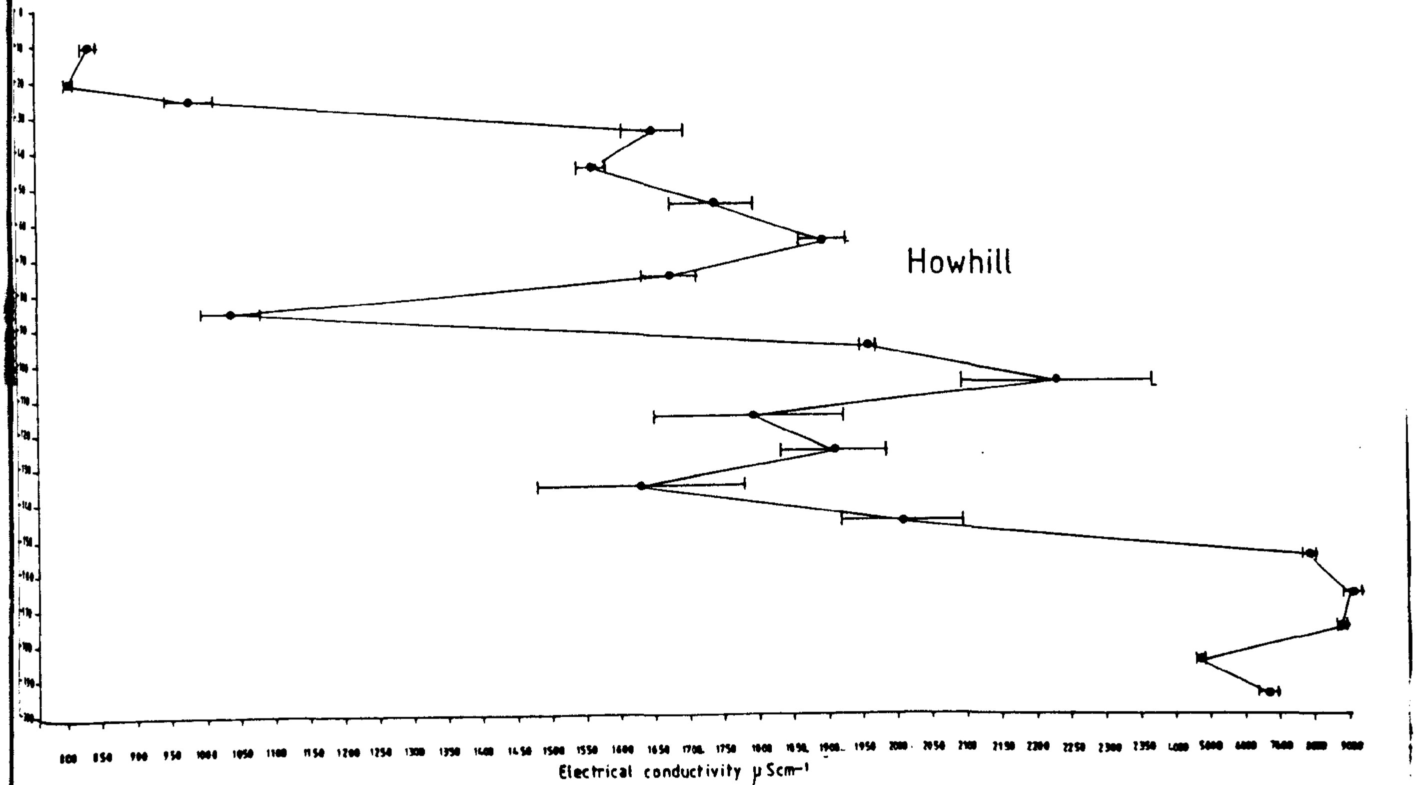
Most of the values for the conductivity measurements exhibit large potential margins of error. This may be due to the unavoidable mixing of material from relatively large (10 cm long) sections of core at each individual "sample points". Despite this, most of the sites display two major peaks in conductivity which are sufficiently large and distinct as to be likely to reflect real differences. The first tends to occur at between c.30 and 60 cm while the second usually appears below c.100cm.

**FIG. A1** Conductivity values.
(bars indicate +/- S.E., n=3)


DEPTH (cm)
SM 1
Electrical conductivity μS cm⁻¹


DEPTH (cm)
SM 2
Electrical conductivity μS cm⁻¹


DEPTH (cm)
SM 3
Electrical conductivity μS cm⁻¹


Howhill
Electrical conductivity µScm⁻¹

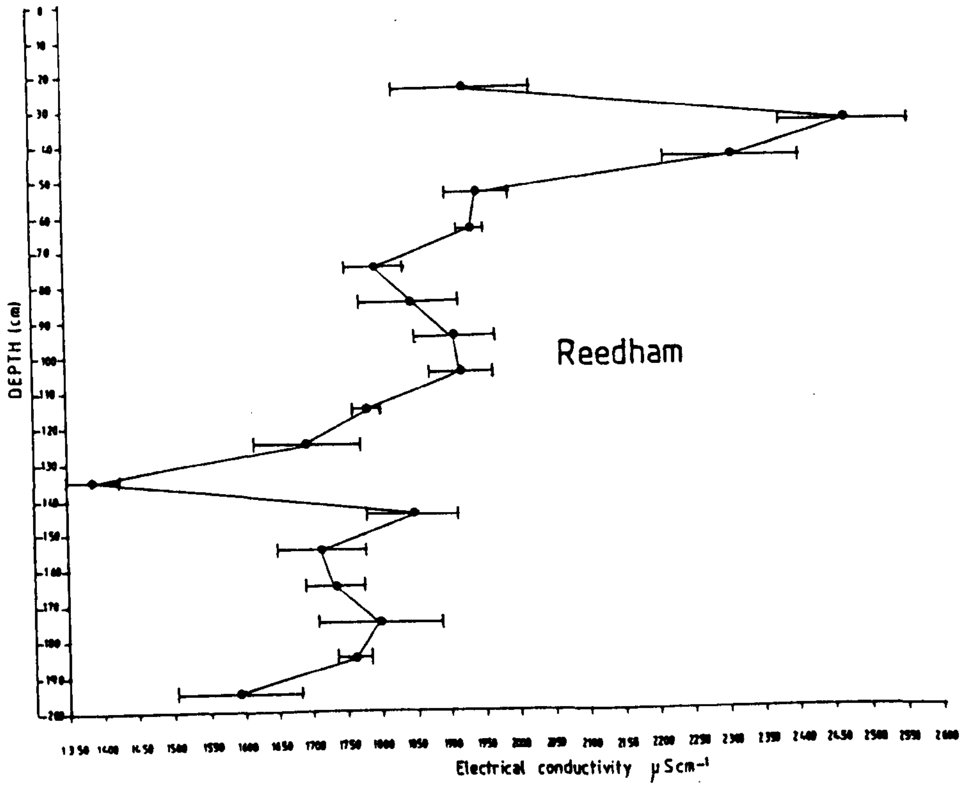
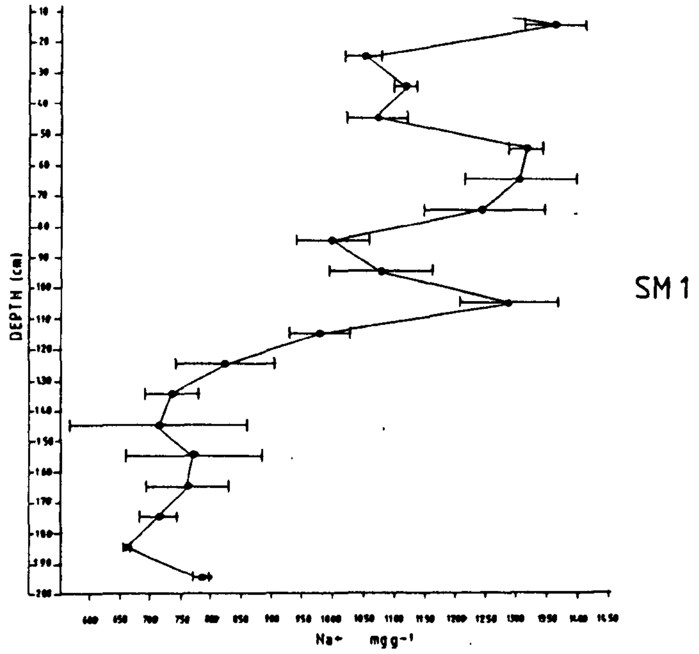
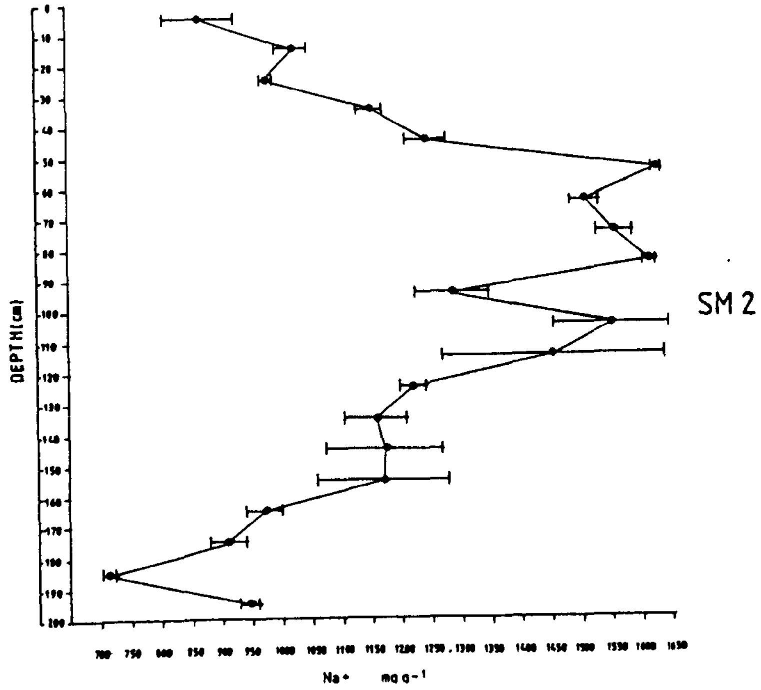
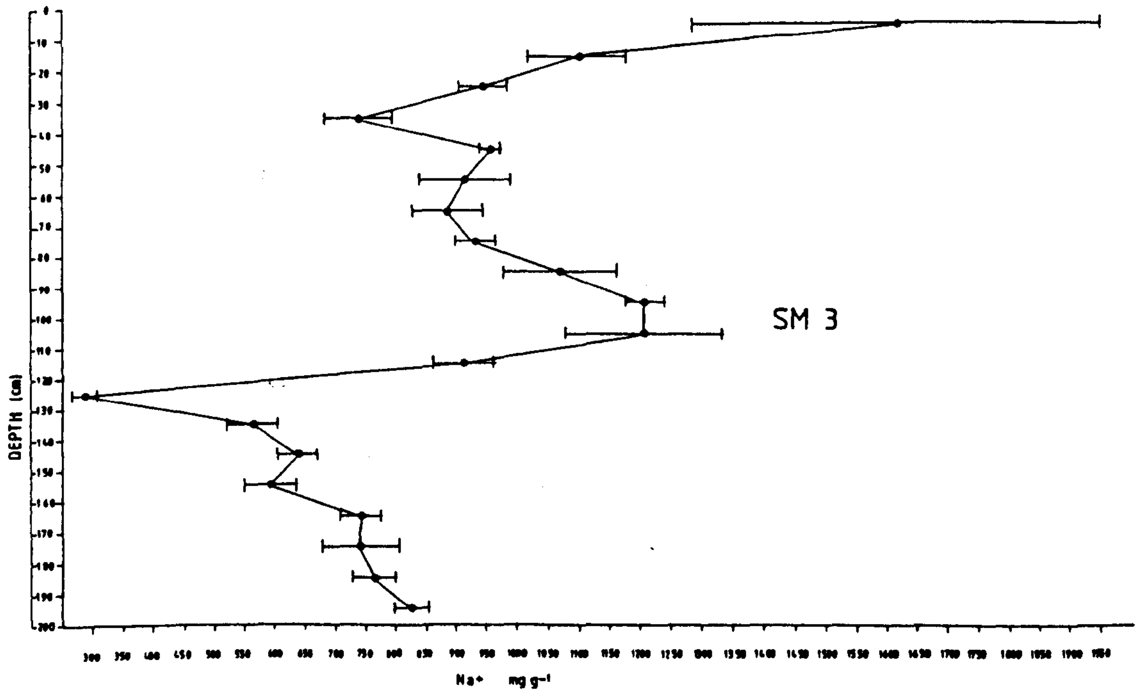
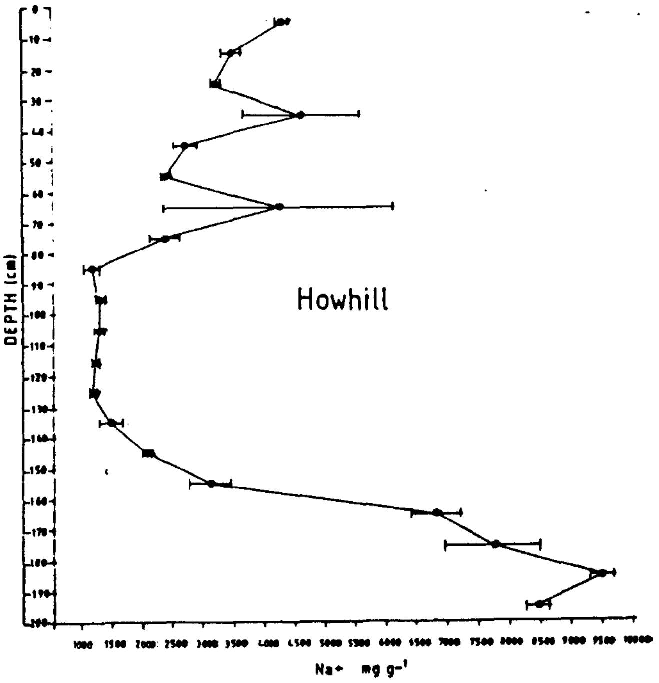

Reedham
DEPTH (cm)
Electrical conductivity µScm⁻¹

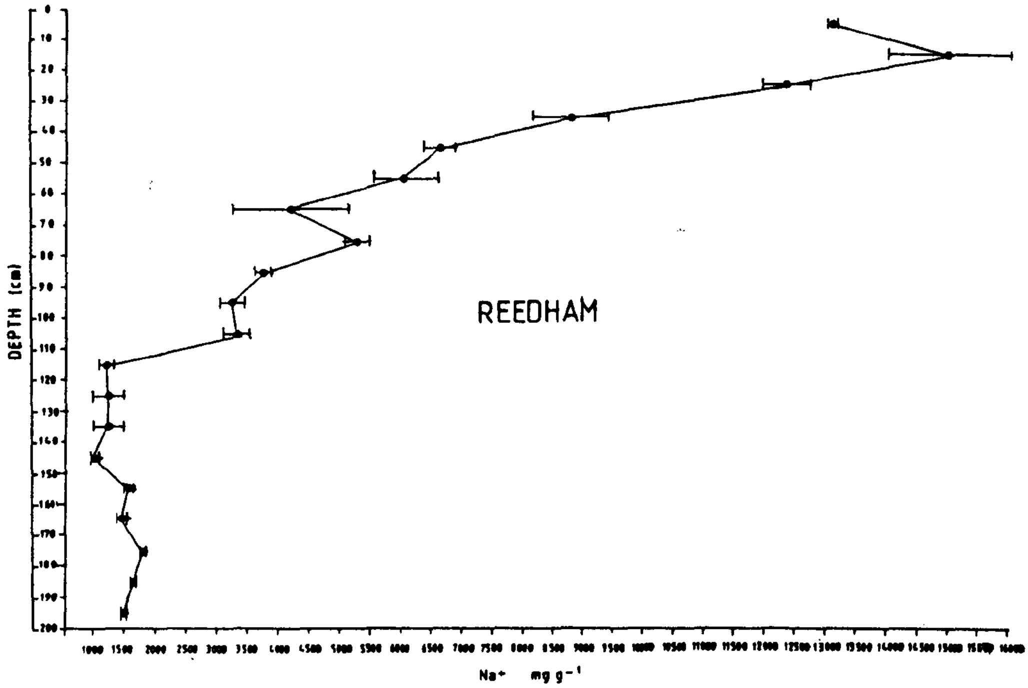
FIG. A2 Sodium analyses.
(bars indicate +/- S.E., n=3)


SM 1
DEPTH (cm)
Na+ mg g-1


SM 2
DEPTH (cm)
Na+ mg g-1


SM 3
DEPTH (cm)
Na+ mg g-1


Howhill
DEPTH (cm)
Na+ mg g-1


REEDHAM
DEPTH (cm)
Na+ mg g-1

### *1.4.2 Na*$^+$

In the Sedge Marsh cores, Sodium displays relatively low values approximately coinciding with the conductivity peaks and similarly higher values roughly where the conductivity values decline. The Reedham and Howhill cores do not appear to show the same degree of negative correlation between the two data sets and there is a more obvious coincidence between relatively high conductivity and sodium values in the lower samples.

## 1.5 An Interpretation of the Sodium and Conductivity Results.

At first sight many details of the graphs appear to contradict each other. In particular, the upper peak of conductivity, which is discernible in most of the cores, seems to coincide with a trough in the sodium levels at the same points whilst a similar effect is seen in the lower conductivity peaks in the Sedge Marsh examples (see Figs. A4-8). The Reedham and Howhill cores do not show a decline, but rather a recovery in Sodium values at these levels. It is difficult to explain these apparently anomalous findings. As the results are presented on a microgramme per gramme dry weight basis, complications caused by differences in bulk densities of the different sediments occurring in the cores could have occurred but if this were to be a significant factor it might be expected that the lower conductivity peak (at the "Romano-British marine clay levels)might have coincided with an overrepresentation of Sodium at the same levels as the clays are likely to have a much higher bulk density than the overlying peats. However, this does not appear to be the case with actual drops in Sodium values corresponding to the conductivity peaks at these levels from the Sedge Marsh sites whilst, although there is a rise rise in Sodium values in the Reedham Marsh cores, it does not reach particularly high values.

Despite this, there is evident. .ly a difference in the Sodium content of the two sites in the sediments from these levels and it is possible that the apparent differences in Sodium content between the two sites may be reflecting the lower marine influence experienced by the the northerly sedge marsh site during the "Romano-British" transgressive overlap episode. This would concur with the evidence from the macrofossil peats showing that a vegetation typical of a lower salt marsh zone than that at Sedge Marsh may have existed at Reedham Marsh (see 7.1).

The divergence between the upper conductivity peak and sodium values is also difficult to interpret. Original stratigraphical inspection of the peat from these levels did not suggest a marked difference in peat type beyond a tendency to slightly greater humification. It may be possible that the conductivity peak is reflecting a subtle change in stratigraphy which is difficult to detect by other methods. In terms of correlation with possible vegetational episodes, the conductivity peak tends to coincide approximately with the later stages of the Zone D "wet phase". However, without further evidence, it seems impossible to tell whether this is merely a co-incidence or whether it is a meaningful correlation.

Bearing such doubts in mind it is clear that further analyses of the Ant Valley peats will be necessary before any firm conclusions can be reached as to the implications of the chemistry of the deposits. Any such further investigation of the cation content would probably be better served by analysis of material on a volume basis, rather than dry weight, thereby avoiding potential confusion caused by different bulk density values.

**1.6 An Interpretation of the Loss-on-Ignition results.**

The loss-on-ignition (L.O.I.) results (Fig.A3) tend to confirm the existence of the major stratigraphical units noted in the sediment descriptions. In the Sedge Marsh cores there is a noticeable drop in the % loss-on-ignition below c.120cm but the reduction is much more marked in the SM3 core. This is undoubtedly related to the transgressive clays which underlie the sampling position occupied by this core. The reduction in L.O.I. in the more northerly cores, albeit less substantial, also suggests that they are likely to contain a significant non-organic component indicating that they are probably clay-related deposits formed at the head of the estuarine system.

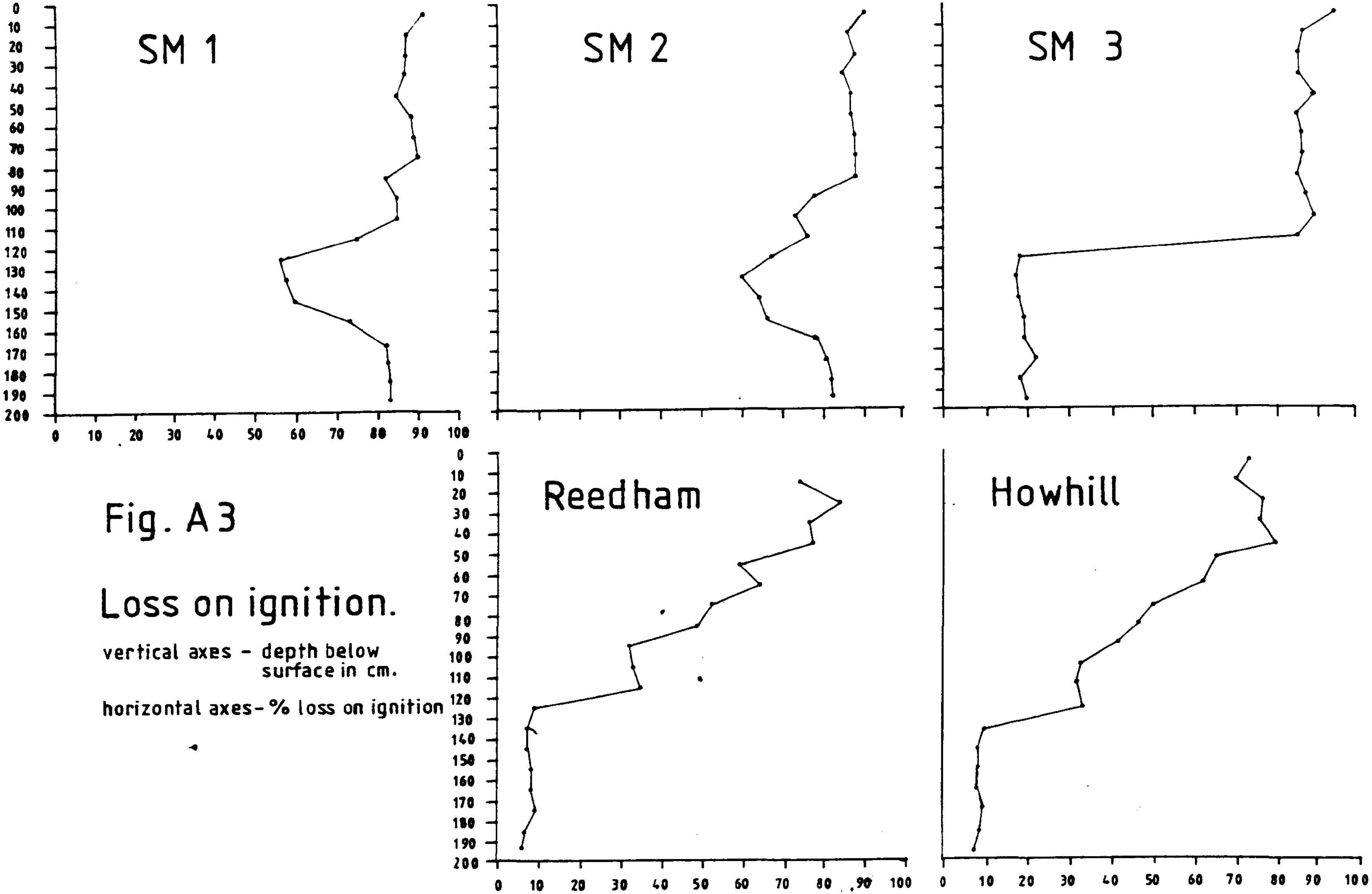



Fig. A3

Loss on ignition.

vertical axes - depth below surface in cm.

horizontal axes - % loss on ignition

# Fig. A4 Summary diagram

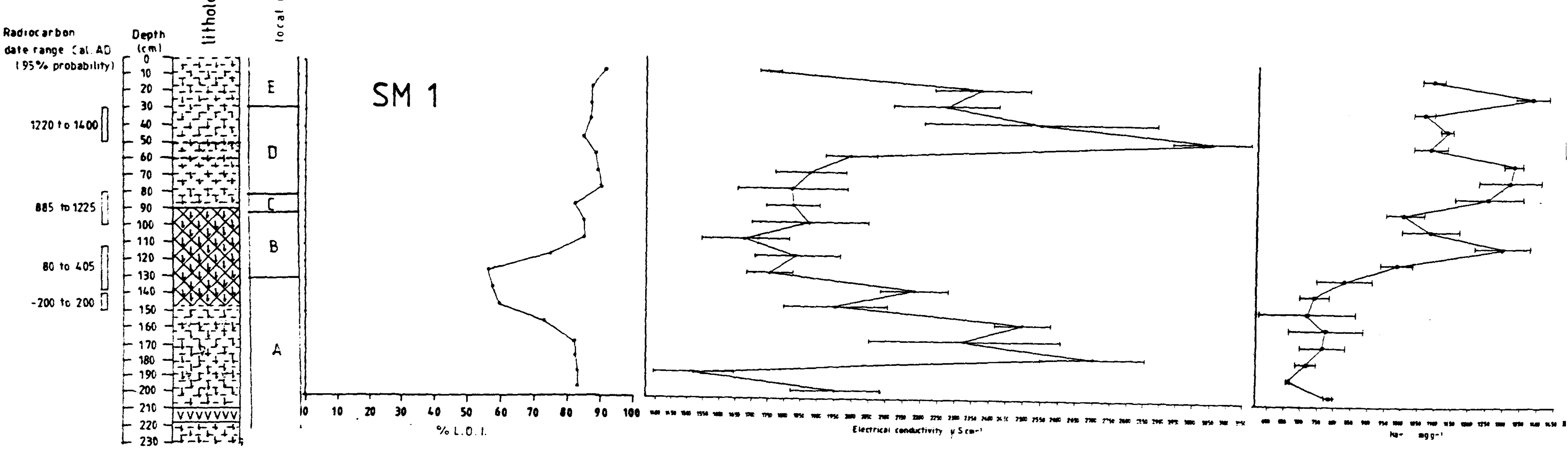


Fig. A5 Summary diagram.

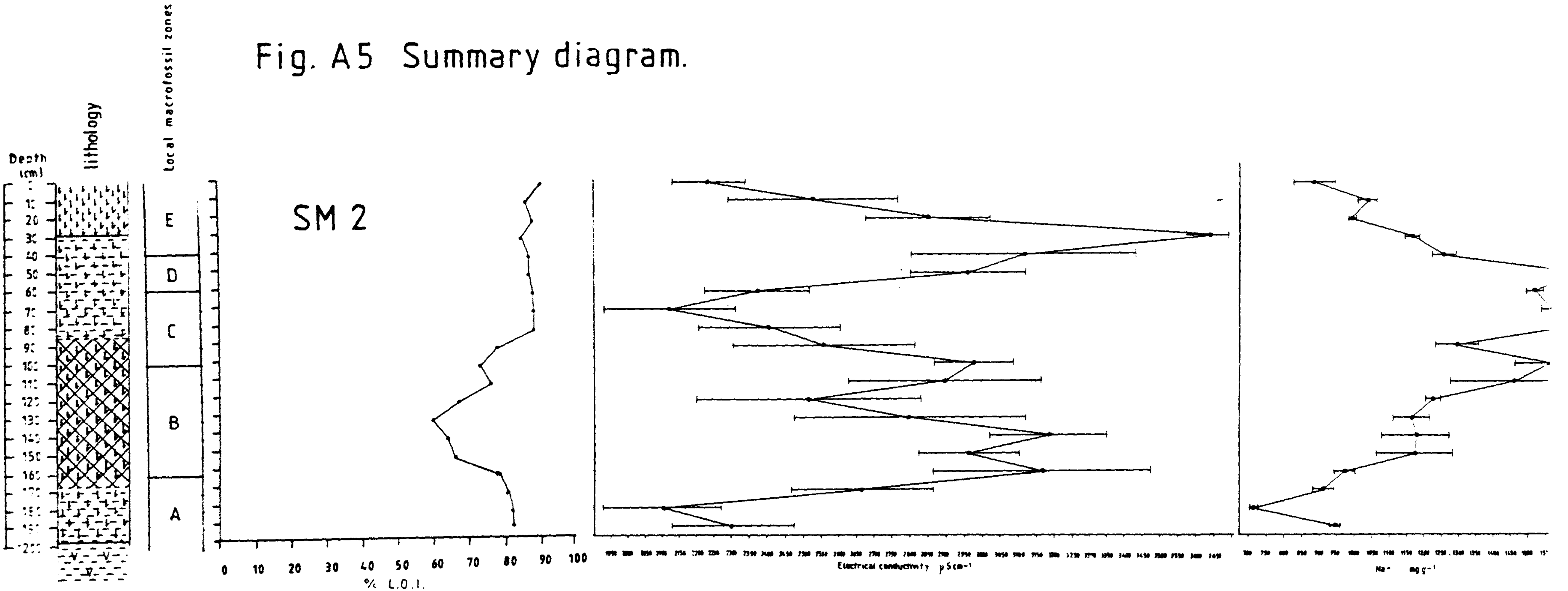


Fig. A6 Summary diagram.

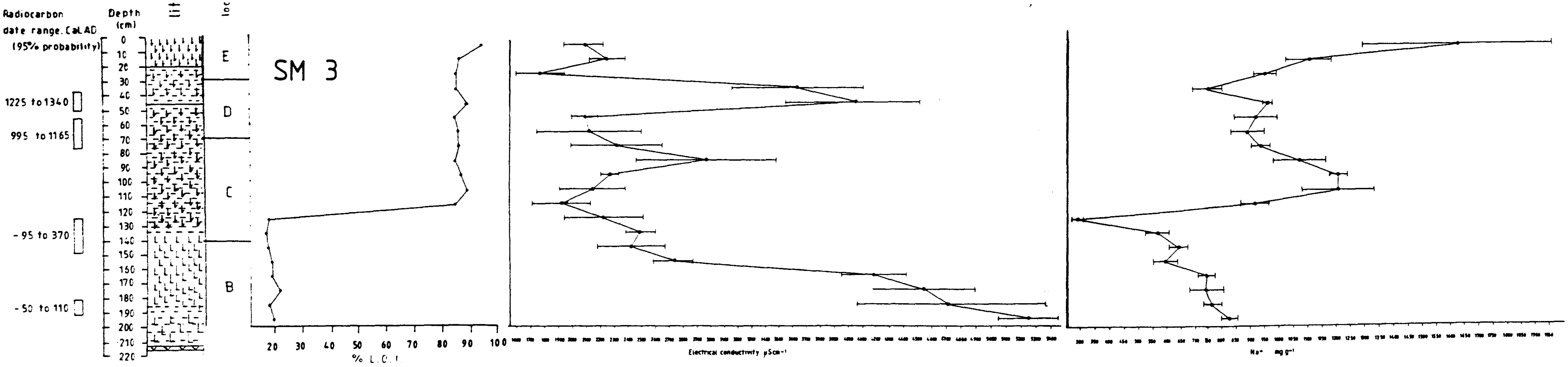


Fig. A 7. Summary diagram.

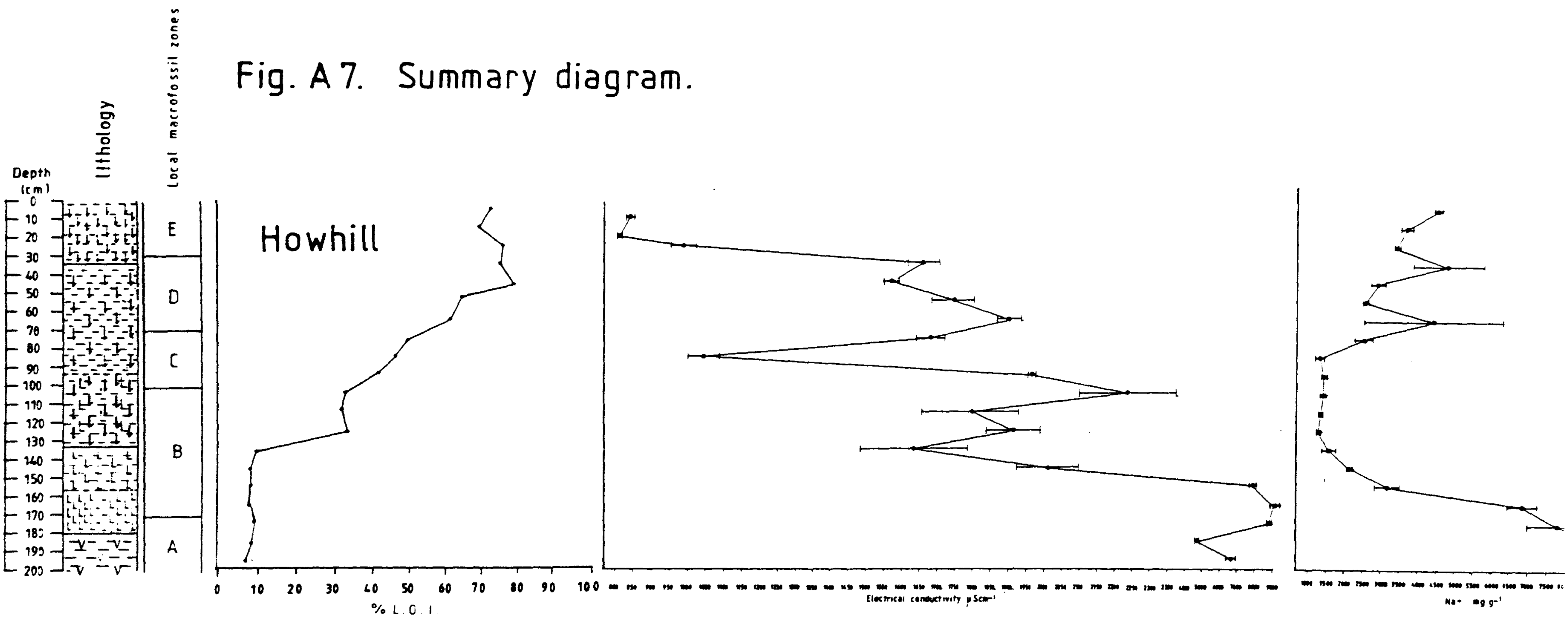
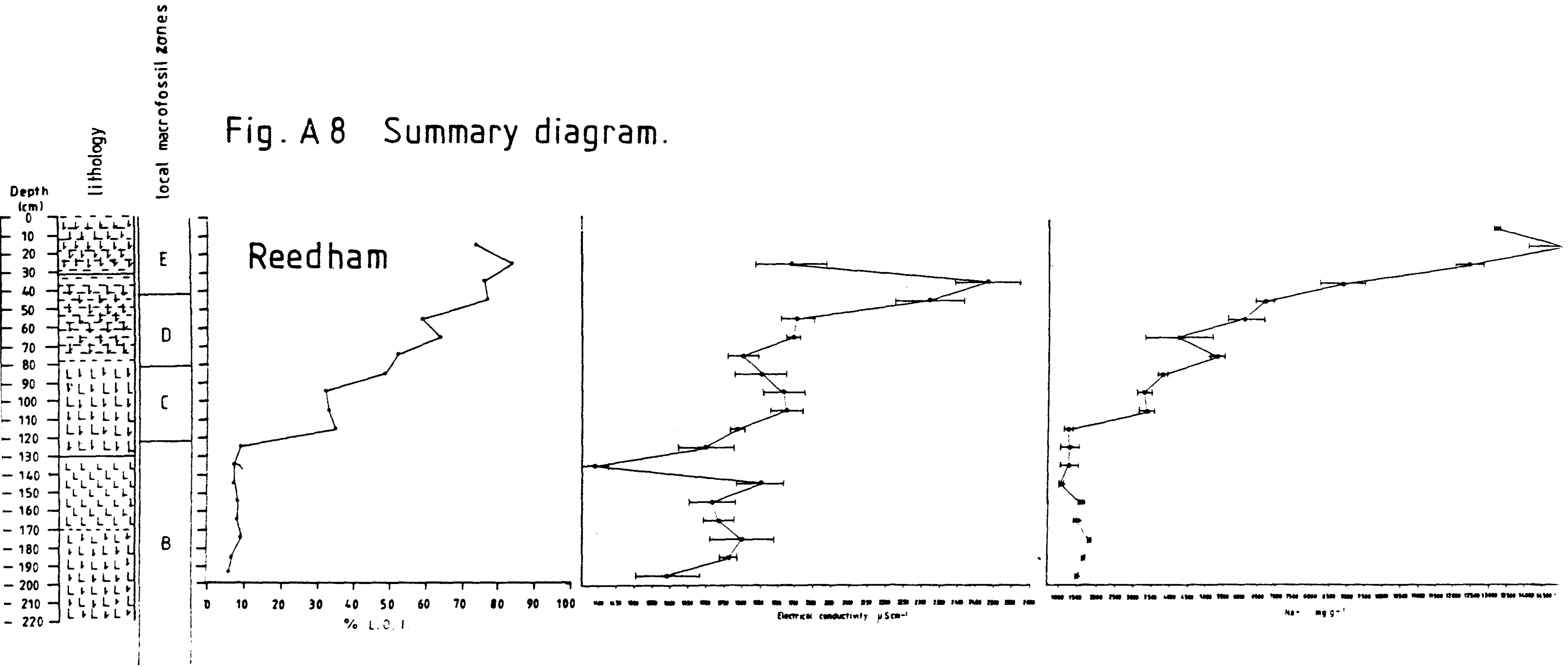


Fig. A 8 Summary diagram.



The results from the two Reedham cores show that the deposits from this site tend to have a generally lower overall organic content than those from Sedge Marsh. This is likely to be related to the more southerly position of Reedham Marsh which resulted in its being more prone to marine influence, and hence mineral deposition, at times of incursion from the sea. This is also probably reflected in the lower L.O.I. values recorded for the levels corresponding to the "Romano-British" transgressive overlap clays when compared to the equivalent stratigraphical units in the Sedge Marsh cores.

**APPENDIX B: Identifications of foraminifera from some provisional samples from "Romano-British" clays in the Ant Valley.**

*Identifications and interpretation by Professor B.M.Funnell of the School of Environmental Sciences, University of East Anglia.*

| | HH80 | 130 | 140 | 150 | SM2 | R90 | SM3 |
|---|---|---|---|---|---|---|---|
| A. Tiphotrocha sp. | | 1 | 64 | 55 | 6 | | 1 |
| B. Trochammina inflata | 3 | 2 | 12 | 36 | | 8 | 27 |
| C. Jadammina macrescens | | 2 | 25 | 39 | | 1 | 9 |
| D. Haplophragmoides sp. | 1 | | 5 | | | | 1 |
| E. Elphidium williamsoni | | $10^{4}$ | | | | 13 | |
| F. Protelphidium germanicum | | $7^{1}$ | | | | 6 | |
| G. Ammonia limnetes | | $3^{1}$ | | | | 3 | |
| H. Thecamoeban | 1 | | | | | | |
| Total | 5 | $25^{6}$ | 106 | 130 | 6 | 31 | 38 |

key: HH: Howhill
R : Reedham
SM2: Sedge Marsh 2
SM3: Sedge Marsh 3
Numbers refer to depth below surface in centimetres. The two Sedge Marsh samples are both from 170cm.

*Interpretation.*
HH130 and R90 show the strongest brackish-marine influence. The calcareous species (E to G in the list) are typical of high intertidal mud-flats and the lower fringes of the salt marshes. Where accompanied, as here, by agglutinating species(A to D in the list) lower salt marsh is indicated. In the present channel of the River Yare such assemblages might be expected from between Buckenham and Cantley to just downstream of Reedham. The calcareous specimens show signs of fragmentation (? corrosion), and the superscripts in the table refer to the fragments only.

HH140, 150 and SM3 consist exclusively of agglutinating species suggesting a high salt marsh environment. These species extend up the Yare channel as far as Postwick as occasional examples, but are uncommon above Brundall. They would usually be expected to be accompanied by significant numbers of Thecamoebans (of which there is only one, in HH80 in the present collection) upstream from Cantley (occasional thecamoebans, which are freshwater protistans, occur downstream as far as Reedham). It is therefore concluded that the assemblages are controlled by a more positive position relative to tidal levels than by remoteness either from the sea or an estuarine channel. The same considerations, only more so, apply to the limited agglutinating assemblages from HH80 and SM2.

## APPENDIX C: Preparation of Fossil Diatoms.

Disperse c. 0.5 $cm^3$ of sediment with a few drops of distilled water. Add a few $cm^3$ of concentrated sulphuric acid and leave until the sediment is dispersed and any of the effervescence has stopped. To remove organic material, add approximately 2 spatula tips full of potassium dichromate, and then c. 20$cm^3$ of 30% W/V 100 vol. hydrogen peroxide.

After effervescence has ceased (2–12 hours) fill to 40 $cm^3$ with distilled water and decant into centrifuge tubes. Centrifuge at 2500 r.p.m.for 4 minutes and decant. Resuspend the pellet with distiled water and centrifuge. Repeat until the sediment is clean and the clay fraction has been removed. Store residue in distilled water.

For sampling, resuspend sediment and remove a fraction with a Pasteur pipette to a 24mm (o) coverslip on a warm hot plate. Allow the distilled water to evaporate. Add a small drop of mountant (*Naphrax*, refractive index 1.74) centrally on a microscope slide. Invert the coverslip over this and pass through a bunsen flame until the *Naphrax* bubbles. It must not be allowed to do so for longer than 3 seconds. The slide is then cooled rapidly, labelled and examined.

**APPENDIX D. DIATOMS: SEDGE MARSH ONE. Ecological Data.** [1]

| taxon | Halobian | V-D-Werff | pH |
|---|---|---|---|
| 1. *Achnanthes brevipes* | ME | BM | |
| 2. *Amphora sp.* | | | |
| 3. *A. ovalis* | OIB | FB | alkf |
| 4. *Anomoeoneis serians v. sculpta* | | | |
| 5. *Caloneis formosa* | MB | B | alkf |
| 6. *C. tousengii* | | | |
| 7. *Cocconeis scutellum* | PE | MB | |
| 8. *C. scutellum v. parva* | ME | | alkf |
| 9. *Coscinodiscus sp.* | | | |
| 10. *Cyclotella sp.* | | | |
| 11. *Cymbella aspera* | OIB | FB | alkf |
| 12. *C. cistula* | OIB | FB | alkf |
| 13. *C. turgida* | OIB | FB | alk/bi |
| 14. *Diploneis crabro* | PB | M | |
| 15. *D. didyma* | MB | MB | |
| 16. *D. elliptica* | OIB | FB | ind |
| 17. *D. interrupta* | MB | B | alkf |
| 18. *D. ovalis* | OIB | FB | alkf |
| 19. *D. smithii* | PB | MB | |
| 20. *Epithemia sp.* | | | |
| 21. *E. argus var. alpestris* | | | |
| 22. *E. penundulata* | | | |
| 23. E. adnata | OIE | FB | alk/b |
| 24. *Eunotia sp.* | | | |
| 25. *E. arcus* | HE | F | ind |
| 26. *E. arcus v. fallax* | HE | | ind |
| 27. *E. attenuata* | | | |
| 28. *E. faba* | HE | F | acidf |
| 29. *E. exigua* | HE | F | acidf |
| 30. *E. curvata* | OIB | FB | ind |
| 31. *E. pectinalis* | OIE | F | acidf |
| 32. *E. pectinalis v. minor* | OIE | F | acidf |
| 33. *E. praerupta* | HE | F | acidf |
| 34. *Fragillaria capucina v. lanceolata* | OIP | | alkf |
| 35. *F. construens v. subsalina* | OHE | FB | alkf |

1 Nomenclature follows Hartley (1986).

| | | | |
|---|---|---|---|
| 36. *Gomphonema acuminatum* | OIE | FB | alkf |
| 37. *G. truncatum* | OIE | FB | alkf |
| 38. *G. quadripunctatum* | | | |
| | | | |
| 39. *Grammatophora oceanica* | PE | M | |
| | | | |
| 40. *Hantzschia marina* | PB | MB | |
| 41. *H. virgata* | M | BM | |
| | | | |
| 42. *Mastogloia smithii v. lacustris* | OIE | BF | alkf |
| | | | |
| 43. *Paralia sulcata* | PP | M | alkf |
| | | | |
| 44. *Navicula elegans* | ME | B | |
| 45. *N. tripunctata* | IB | F | |
| 46. *N. halophila* | OHB | | alkf |
| 47. *N. pseudolanceolata* | OIB | | alkf |
| 48. *N. ludloviane* | | | |
| 49. *N. peregrina* | MB | B | alkf |
| 50. *N. radiosa* | OIB | FB | ind |
| 51. *N. subtilissima* | HB | | acidf |
| 52. *N. viridula* | OIB | FB | alkf |
| | | | |
| 53. *Nitschia sp.* | | | |
| 54. *N. amphibia* | OIB | FB | alkf |
| 55. *N. circumsuta* | MB | B | |
| 56. *N. denticula* | OIB | FB | alkf |
| 57. *N. navicularis* | MB | B | |
| 58. *N. punctata v. coarctica* | MB | BM | |
| 59. *N. scalaris* | MB | B | alkf |
| | | | |
| 60. *Pinnularia gibba* | OIB | F | acidf |
| 61. *P. gibba v. sancta* | OI | | ind |
| 62. *P. gibba v. subundulata* | OI | | ind |
| 63. *P. viridis* | OIB | FB | ind |
| | | | |
| 64. *Rhoicosphenia abbreviata* | OIE | FB | alkf |
| | | | |
| 65. *Rhopalodia gibba* | OIE | FB | alkf |
| 66. *R. gibberula* | ME | B | alk |
| 67. *R. operculata* | ME | B | alkf |
| | | | |
| 68. *Stauroneis agrestis* | OI | | ind |
| 69. *S. pygmaea* | Mesohalobe | | |
| 70. *S. javanica* | | | ind |
| | | | |
| 71. *Stephanodiscus rotula* | OIP | FB | alkf |
| | | | |
| 72. *Surirella striatula* | MB | B | |
| | | | |
| 73. *Synedra ulna* | OIP | FB | alkf |
| | | | |
| 74. *Tabellaria sp.* | | | |

| | | |
|---|---|---|
| 75. *Trachyneis aspera* | PB | M |

**APPENDIX E DIATOMS, SEDGE MARSH THREE: Ecological Data.**

| taxon | halobian. | V-D-Werff. | pH |
|---|---|---|---|
| 1.*Achnanthes sp.* | | | |
| 2.*A.brevipes.* | ME | BM | |
| 3.*Actinoptychus sp.* | | | |
| 4.*Amphora sp.* | | | |
| 5.*A.ovalis.* | OIB | FB | alkf |
| 6.*A.ovalis* v.affinis. | OIB | FB | alkf |
| 7.*Anomoeoneis costata.* | | | |
| 8.*A.sphaerophora v.sculpta* | halophilous | | alkbi |
| 9.*Aulocoseira .granulata.* | OIP | FB | |
| 10.*Caloneis sp.* | | | |
| 11.*C.formosa.* | MB | B | alkf |
| 12.*Cocconeis sublittoralis.* | | | |
| 13.*Coscinodiscus sp.* | | | |
| 14.*C.radiatus.* | PP | M | |
| 15.*Cyclotella comta.* | OIP | FB | alkf |
| 16.*Cymbella sp.* | | | |
| 17.*C.aspera.* | OIB | FB | alkf |
| 18.*C.cistula.* | OIB | FB | alkf |
| 19.*C.frigida.* | | | |
| 20.*C.helvetica.* | OIE | | alkf |
| 21.*Diploneis sp.* | | | |
| 22.*D.bombus.* | PB | M | |
| 23.*D.didyma.* | MB | MB | alkf |
| 24.*D.interrupta.* | MB | B | alkf |
| 25.*D.ovalis.* | OIB | FB | alkf |
| 26.*D.smithii.* | PB | MB | |
| 27.*D.smithii v.maior.* | | | |
| 28.D.smithii v.rhombica. | PB | MB | |
| 29.*Epithemia turgida.* | OIP | FB | alkbi |
| 30.*E.adnata.* | OIE | FB | alkf/bi |
| 31.*Eunotia sp.* | | | |
| 32.*E.pectinalis.* | OIE | F | acidf |
| 33.*E.praerupta.* | HE | F | acidf |
| 34.*Fragilaria sp.* | | | |
| 35.*F.alpestris.* | | | |
| 36.*F.capucina.* | OIE | F | alkf |

| | | | |
|---|---|---|---|
| 37. *Gomphonema sp.* | | | |
| 38. *G. gracile.* | OIE | FB | alkf |
| 39. *G. vibrio var. intricatum.* | OIE | FB | alkf |
| 40. *G. lanceolatum* | I | | alkf |
| 41. *Mastogloia smithii v. lacustris.* | OIB | BF | alkf |
| 42. *Melosira sp.* | | | |
| 43. *Navicula sp.* | | | |
| 44. *N. amphibia.* | OIB | FB | |
| 45. *N. marina.* | PB | MB | |
| 46. *N. peregrina.* | MB | B | alkf |
| 47. *N. marina.* | | | |
| 48. *N. pupula v. rectangularis.* | OIB | | ind |
| 49. *N. radiosa* | OIB | FB | ind |
| 50. *Nitschia sp.* | | | |
| 51. *N. navicularis.* | MB | B | |
| 52. *N. scalaris.* | MB | B | ind |
| 53. *Paralia sulcata.* | PP | M | alkf |
| 54. *Pinnularia sp.* | | | |
| 55. *P. biclavata.* | | | |
| 56. *P. biclavata v. media.* | | | |
| 57. *P. bicostata.* | | | |
| 58. *P. brevicostata.* | OIE | | ind |
| 59. *P. cardinalis.* | HE | | acidf |
| 60. *P. cruciformis.* | PB | | |
| 61. *P. gibba v. linearis.* | OI | | ind |
| 62. *P. globiceps.* | OHB | | |
| 63. *P. biceps.* | OIB | F | acidf |
| 64. *P. mesolepta.* | OIB | | acidf |
| 65. *P. viridis.* | OIB | FB | ind |
| 66. *Psammodiscus. nitidus.* | PP | M | |
| 67. *Rhabdonema arcuatum.* | PE | M | |
| 68. *Rhaphoneis amphiceros.* | PE | MB | |
| 69. *R. gibba.* | OIB | | acidf |
| 70. *Rhopalodia gibberula.* | ME | B | |
| 71. *Stauroneis sp.* | | | |
| 72. *S. anceps.* | OIB | FB | ind |
| 73. *S. phoenicentron v. genuine.* | OIB | FB | ind |
| 74. *Surirella sp.* | | | |
| 75. *Synedra sp.* | | | |
| 76. *S. tabulata var. acuminatum.* | ME | BM | |

| | | | |
|---|---|---|---|
| 77. *S. ulna*. | OIE | FB | alkf |
| 78. *Tabellaria sp*. | | | |
| 79. *Thallasiosira baltica*. | | | |
| 80. *Trachyneis aspera*. | PE | M | |

ABBREVIATIONS.

| | |
|---|---|
| PP | Polyhalobous/Pelagic |
| PB | " " /benthonic |
| PE | " " /Epiphytic |
| MB | Mesohalobous/Benthonic |
| ME | " " /Epiphytic |
| OHP | Oligohalobous-Halophile/Pelagic |
| OHB | " " " " " /Benthonic |
| OHE | " " " " " /Epiphytic |
| OIP | Oligohalobous-Indifferent/Pelagic |
| OIB | " " " " " /Benthonic |
| OIE | " " " " " /Epiphytic |
| HP | Halophobous/Pelagic |
| HB | " " /Benthonic |
| HE | " " /Epiphytic |

# BIBLIOGRAPHY.


**Alderton, A. (1983)** *Flandrian Vegetational History of the Waveney Valley.* Unpublished PhD.Thesis, University of Cambridge.

**Allen, S.E., Grimshaw, H.M. and Rowland, A.P. (1986)** *Chemical Analysis.* In: *Methods in Plant Ecology.* 2nd edition. (P.D.Moore & S.B.Chapman, Eds.). Blackwell Scientific Publications.

**Allison, K.J. (1955)** The Lost Villages of Norfolk. *Norfolk Archaeology,* 31(1), 116-162. Norwich.

**Anderson, P and Shimwell, D. (1981)** *Wild flowers and other plants of the Peak District.* Morland Publishing Co. Ashbourne.

**Armstrong, M.J. (1781)** *The History and Antiquities of the County of Norfolk.* Vol. 7, *An Account of the Hundred of Happing.* Norwich, M.Booth.

**Barber, K.E. (1985)** *Climatic change recorded in peat deposits.* In: *The Climatic Scene.* (Ed. M.J.Tooley and G.M.Sheail). London, Allen and Unwin.

**Barber, K.E. (1981)** *Peat Stratigraphy and Climatic Change.* A.A.Balkema, Rottardam.

**Battarbee, R.W. (1986)** *Diatom Analysis.* In: *Hanbook of Holocene Palaeoecology and Palaeohydrology.* (B.E.Berglund, Ed.)

**Beijerinck, W. (1974)** *Zadenatlas der Nederlandsche Flora.* N.Veenman and Zoren, Wageningen.

**Berg, A. and Hessland, I. (1950)** A quaternary diatom spectrum from Bohuslan. *Ark.Miner.,*1(6),169.

**Berggren, G. (1969)** *Atlas of Seeds. Part 1.* Swedish National Science Research Council, Stockholm.

**Berggren, G. (1981a)** *Atlas of Seeds. Part 2 Cyperaceae.* Swedish National Science Research Council, Stockholm.

**Berggren, G. (1981b)** *Atlas of Seeds. Part 3 Salicaceae Cruciferae.* Swedish Museum of Natural History, Stockholm.

**Berglund, B.E. (1971)** Littorina transgressions in Blekinge, South Sweden: a preliminary survey. *Geol. Foren. Stockh. Forh.* **93**, 3, 625-652.

**Bird, M.C.H. The Rev. (1909)** The Rural economy,sport and natural history of East Ruston Common. *Transactions of the Norfolk and Norwich Naturalists' Society.* **8**, 631.

**Birks, H.J.B. (1976)** Late-Wisconsinan Vegetational History at Wolf Creek, Central Minnesota. *Ecological Monographs.* **46**, 395-429.

**Bloom, A.L. (1964)** Peat Accumulation and Compaction in a Connecticut Coastal Marsh. *Journal of Sedimentary Petrology.* **34**,599-603.

**Brothwell, D and Dimbleby, G. (Eds.) (1981)** *Environmental Aspects of Coasts and Islands.* Symposia of the Association for Environmental Archaeology No.1. B.A.R. International Series **94**.

**Carrodus, C.F. (1949)** *Life in a Norfolk Village.The Story of Old Horning.* Soman-Wherry,Norfolk.

**Chapman, S.B. (1964)** The ecology of Coom Rigg Moss, Northumberland. *Journal of Ecology.* **52**, 315.

**Chapman, V.J. (1976)** *Coastal Vegetation.* Pergamon Press, Oxford.

**Charity Commissioners (1815-37)** *Reports of the Commissioners appointed in persuance of Acts of Parliament to inquire concerning charities and education of the poor in England and Wales.* Vol.XXIII. *County of Norfolk.* House of Commons.

**Chatwin, C. P. (1961)** *British Regional Geology, East Anglia and Adjoining Areas.* 4th Edition. H.M.S.O.

**Churchill, D.M. (1965)** The displacement of deposits formed at sea level,6500 years ago in Southern Britain. *Quaternaria.* 7:239-47.

Clarke, R.C. (1965) Man in Broadland. in: The Broads. Ed. E.A. Ellis.

**Clarke, W.G. (1903)** Greendyke Farm. *East Anglian Times,* 16th May, 1903.

**Clarke, W.G. (1916)** President's Address: The Natural History of Norfolk Commons. *Transactions of the Norfolk and Norwich Naturalists' Society.* **10**, 294-318.

**Clements, F.E. (1916)** *Plant Succession: an analysis of the development of vegetation.* Carnegie Institute. Washington. Publication No. 242.

**Clapham, A.R., Tutin, T.G. and Warburg, E.F. (1981)** *Excursion Flora of the British Isles.* Cambridge University Press.

**Coles, B. and Coles, J. (1986)** *Sweet Track to Glastonbury. The Somerset Levels in Prehistory.* Thames and Hudson.

Coles, B.P.L. (1977) *The Holocene Foraminifera and Palaeogeography of Central Broadland.* Unpublished PhD. Thesis, the University of East Anglia.

**Coles, B.P.L and Funnell, B.M. (1981)** Holocene palaeoenvironments of Broadland, England. *Spec.Publs.int.Ass.Sediment.* **5**, 123-131.

**Collinson, M.E. (1983)** Accumulations of Fruits and Seeds in Three Small Sedimentary Environments in Southern England and their Palaeoecological Implications. *Annals of Botany*, **52**, 583-592.

**Cornford, B. (1979)** The Sea Breach Commission in East Norfolk 1609-1743. *Norfolk Archaeology.* 37,137-145.

**Crompton, E. (1966)** *The Soils of the Preston District of Lancashire.* Memoirs of the Soil Survey of Great Britain. Agricultural Research Council. Harpenden.

**Darby, H.C. (1953)** On the Relations of Geography and History. *Transactions and Papers of the Institute of British Geographers.* **19**, 1-12.

**Darby, H.C. (1956)** *The Medieval Fenland.* Cambridge University Press.

**Darby, H.C. (1983)** *The Changing Fenland.* Cambridge University Press.

**Devoy, R.J.N. (1977)** Flandrian Sea Level Changes in the Thames Estuary and the Implications for Land Subsidence in England and Wales. *Nature.* **270**, 712-715.

**Devoy, R.J.N. (1979)** Flandrian Sea Level Changes and Vegetational History of the Lower Thames Estuary. *Philosophical Transactions of the Royal Society of London.* B **285**, 355-410.

**Dunham, K.C. and Gray,D.A. (eds.), (1972)** A discussion on problems associated with the subsidence of southern England. *Phil.Trans.Royal Soc.Lond.* Series A **272**, 81-86.

**Durno, S.E. (1961)** Evidence regarding the rate of peat growth. *Journal of Ecology* **49**, 347-351.

**DuSaar. A. (1978)** *Diatom Investigation of a Sediment Core. Downholland Moss.* In: Tooley, M.J. *Sea-Level Changes in North-West England.*

**Dutt, W.A. (1906)** *Wildlife in East Anglia.* Methuen.

**Ellis, E.A. (1965)** *The Broads.* Collins, London.

**Erdtman, G. (1928)** Studies in post-arctic history of forests in north-west Europe; 1. The British Isles. *Geologiska Foreningens i Stockholm Forhandlingar* **50**, 150.

**Estyn Evans, E. (1957)** *Irish Folk Ways.* London, Routledge and Kegan Paul.

**Evans, G.H.(1969)** Pollen and Diatom Analyses of Late Quaternary Deposits in the Blelham Basin, North Lancashire. *New Phytologist.* **69**, 821-874.

**Foged, N. (1954)** On the diatom flora of some Funen Lakes. *Folia Lmnol.Scand.*, **6**, 1.

**Fraser Darling, F. (1955)** *West Highland Survey - an essay in human ecology.* Oxford University Press.

**Funnell, B.M. (1979)** History and prognosis of subsidence and sea-level change in the lower Yare valley, Norfolk. *Bulletin of the Geological Society of Norfolk.* **31**, 35 -44.

**Geddes, A.G. (1955)** *The Isle of Harris and Lewis.* Edinburgh University Press.

**Gilham, E. (1957)** Vegetation of the Exe Estuary in relation to water salinity. *Journal of Ecology.* **45**, 735-56.

**Giller, K.E. (1982)** *Aspects of the Plant Ecology of a Flood-Plain Mire in Broadland, Norfolk.* PhD Thesis (unpubl.) University of Sheffield.

**Giller, K.E., and Wheeler, B.D. (1986)** Past peat cutting and present day vegetation patterns in an undrained fen in the Norfolk Broadland. *Journal of Ecology.* **74**(1) 219-249.

**Giller, K.E. and Wheeler, B.D. (1988)** Acidification and Succession in a flood-plain mire in the Norfolk Broads, U.K. *Journal of Ecology.* **76**, 3, 849-865.

**Godwin, H. (1975)** *The history of the British Flora: A factual basis for Phytogeography.* (2nd edition). C.U.P.

**Godwin, H. (1978)** *Fenland-Its Ancient Past and Uncertain Future.* C.U.P.

**Godwin, H. (1981)** *The Archives of Peat Bogs.* C.U.P.

**Gordon, D.I. (1968)** *A Regional History of the Railways of Great Britain.* Vol. 5: *The Eastern Counties.* David & Charles; Newton Abbot.

**Gorham, E. (1957)** The Chemical Composition of rain from Rosscahill in County Galway. *Irish Naturalists' Journal.* **12**, 1-4.

**Granlund, E. (1932)** De Svenska Hogmossarnas geologi. *Sver.geol.Unders.* **C26**: 1-193.

**GreatRex, P.A. (1983)** Interpretation of macrofossil assemblages from surface sampling of macroscopic plant remains in mire communities. *Journal of Ecology.* **71**, 3, 773-792.

**Green, C. and Hutchinson, J.N. (1960)** *Archaeological Evidence.* In: *The Making of the Broads.* R.G.S. Research Series **No.3.** pp.113-145.

**Harley, J.B. (1979)** *The Ordnance Survey and Land-Use Mapping.* Historical Geogrphy Research Series, No. 2.

**Hartley, B. (1986)** A Checklist of the Freshwater, Brackish and Marine Diatoms of the British Isles and Adjoining Coastal Waters. *Journal of the Marine Biological Association.* **66**, 531-610.

**Haslam, S.M. (1972)** *The Reed, Phragmites communis.* In: *The Reed ("Norfolk Reed")* 2nd Edition. Norfolk Reed Growers Association.

**Haworth, E.Y. (1976)** Two Late-Glacial (Late Devensian) Diatom Assemblage Profiles from Northern Scotland. *New Phytologist.* **77**, 227-256.

**Hopkins, J.J. (1983)** *Studies of the Historical Ecology, Vegetation, and Flora of the Lizard District, Cornwall, with particular reference to Heathland.* Unpublished PhD. Thesis, University of Bristol.

**Hoskins, W.G. (1955)** *The Making of the English Landscape.* Hodder and Stoughton.

**Hustedt, F. (1937-39)** Systemstische und okologische Untersuchungen uber den Diatomeen-Flora von Java, Bali und Sumatra. *Arch.Hydrobiol.*(suppl.) **15, 16.**

**Hustedt, F. (1957)** Die Diatomeenflora des Fluss-systems der Weser im Gebeit der Hansestadt Bremen. *Ab. Naturw. Ver. Bremen.* **34**, 181-440.

**Jansma, M.J. (1981)** *Diatom Analysis from coastal Sites in the Netherlands.* In: *Environmental Aspects of Coasts and Islands*, Dimbleby and Brothwell, Eds.

**Jennings, J.N. (1952)** *The Origin of the Broads.* R.G.S. Research Series **No.2**

**Jennings, J.N. and Godwin, H. (1952)** *Chapter 8: Pollen Diagrams.* In: *The Origin of the Broads.* (J.N. Jennings).

**Jennings, J.N. and Green, C. (1965)** *The Physiographical Evolution of the East Norfolk River Valleys since the Ice Age.* In:*The Broads*, E.A.Ellis (Ed.). Collins, London.1965.

**Jennings, J.N. and Lambert, J.M (1951)** Alluvial Stratigraphy and Vegetation Succession in the Region of the Bure Valley Broads.1. Surface Features and General Stratigraphy. *Journal of Ecology.* **39**, 106-119.

**Jessen, K. (1955)** Key to Subfossil Potamogeton. *Botanisk Tidsskrift.* 1-7.

**John, D.M. and Moore, J.A. (1987)** An S.E.M. study of the oospore of some *Nitella* species (*Charales, Chlorophyta*) with descriptions of wall ornamentation and an assessment of its taxonomic importance. *Phycologia*, **26** (3), 334-355.

**Joosten, J.H.J. (1985)** A 130 Year micro-and macrofossil record from regeneration peat in former peasant peat pits in The Peel, The Netherlands: A palaeoecological study with agricultural and climatalogical implications. *Palaegeography, Palaeoclimatology, Palaeoecology.* **49**, 77-312.

**Juggins, S (1988)** Unpublished MSc dissertation. University College of London.

**Katz, N.J., Katz, S.V. and Kipani, M.G. (1965)** *Atlas of Keys of Fruits and Seeds Occurring in the Quaternary Deposits of the U.S.S.R.* Nanka, Moscow.

**Kent, N. (1794)** *General View of the Agriculture of Norfolk.* Board of Agriculture, London.

**Kidson,C and Heyworth.A(1978)** Holocene Eustatic Sea-Level Change. *Nature.* **273**, 748-750.

**Knox, S.A. (1985)** *The Making of the Shetland Landscape.* Edinburgh. John Donald.

**Kolbe, R.W. (1927)** Zur Okologie, Morphologie und Systematik der Brackerwasse-Diatomeen. *Pflanzenforschung.* **7**, 1-146.

**Kolbe, R.W. (1932)** Grundlinien einer allegemeinen Okologie der Diatomeen. *Ergebn. Biol.*, 8, 221-348.

**Lamb, H.H. (1963)** *On the nature of certain epochs which differed from the modern (1900-39) normal.* pp.125-150. In: *Changes of Climate:Proc. UNESCO/WMO Rome 1961 Symposium on Climatic Cange.Paris*(UNESCO Arid Zone Research Series XX).

**Lamb, H.H. (1965)** The Early Medieval Warm Epoch and its Sequel. *Palaegeography, Palaeoclimatology, Palaeoecology* 13-37

**Lamb, H.H. (1977)** *Climate present,past and future.* Volume II *Climatic history and the future.* Methuen,London.

**Lamb, H.H. (1981)** *Climatic fluctuations in historical times and their connexion with transgressions of the sea,storm floods and other coastal changes.* In: *Transgressies en Occupatiegeschiedenis in de Kustgebieden van Nederland an Belgie.* (Eds.Verhulst,A.G. and Gottschalk) 251-284. Rijksuniversiteit. Ghent.

**Lamb, H.H. (1982)** *Climate,History and the Modern World.* Methuen,London.

**Lamb, H.H. (1985)** *The Little Ice Age Period and the great storms within it.* In: *The Climatic Scene.* (Eds. M.J.Tooley and G.M.Sheail) Chapter **6**. 104-131. Allen and Unwin, London.

**Lamb, H.H. (1987a)** What Can Historical Records Tell us about the Breakdown of the Medieval Warm Climate in Europe in the Fourteenth and Fifteenth Centuries-An Experiment. *Beitrage zur Physik der Atmosphere.* **60**,2.

**Lamb, H.H. (1987b)** Some aspects of climate and life in East Anglia down the ages. *Transactions of the Norfolk and Norwich Naturalists' Society.* 27(5), 385-397.

**Lamb, H.H. (1988)** The Storm of 15-16th October 1987: Historical Perspective. *Weather.* **43**, 136-139.

**Lambert, J.M. (1951)** Alluvial Stratigraphy and Vegetational Succession in the Region of the Bure Valley Broads. III. Classifi cation, Status and Distribution of Communities. *Journal of Ecology*, **39**, 149–169.

**Lambert, J.M. (1965)** *Vegetation.* In: *The Broads* (E.A.Ellis, Ed.).Chapter **4**. 69–93. Collins, London.

**Lambert, J.M. and Jennings, J.N. (1951)** Alluvial stratigraphy and vegetational succession in the region of the Bure valley broads. III. Classification,status and distribution of communities. *Journal of Ecology.*,**36**, 149–170.

**Lambert, J.M. and Jennings, J.N. (1960)** *Stratigraphical and Associated Evidence.* In: *The Making of the Broads.* R.G.S. research series **No.3**. Murray, London.

**Lambert, J.M., Jennings, J.N., Smith, C.A. and Hutchinson, J.N. (1960)** *The Making of the Broads.* Royal Geographical Society research Series **No.3**. Murray, London.

**Livingstone, D.A. (1955)** A lightweight piston sampler for lake deposits. *Ecology,* **36**, 137–9.

**Lucas, A.T. (1960)** *Furze: A survey and history of its uses in Ireland.* Dublin: National Museum of Ireland.

**Marshall, A. (1797)** *Rural Economy of Norfolk.* Board of Agriculture, London

**Marshall, J.D. (1971)** *Old Lakeland.* David & Charles; Newton Abbot.

**Martin Lane, W. (1961)** The Last of the Fen Peat Diggers. *The East Anglian Magazine.* **20**, 683–

**Miller, U. (1964)** Diatom Floras in the Quaternary of the Gota River valley (W. Sweden). *Sver. Geol. Unders.*, **44**, 1–67.

**Nicholson, W.A. (1909)** A Preliminary Sketch of the Bionomical Botany of Sutton and the Ant District. *Transactions of the Norfolk and Norwich Naturalists' Society.* **8**, 265–289.

**Nilsson, O and Hjelmqvist, H. (1967).** Studies on the Nutlet Structure of South Scandanavian Species of *Carex*. *Botaniska Notiser.* **120**, 460–485.

**Pallis, M. (1911)** *The River valleys of East Norfolk* In: *Types of British Vegetation* (Ed. A.G.Tansley). Chapter 10, 214–245 C.U.P. London.

**Pearson, G.W. (1987)** How to cope with calibration. *Antiquity* 61, 98-103.

**Peterkin, G. (1981)** *Woodland Conservation and Management.* Chapman and Hall, London.

**Pollard, E., Hooper, M.D. and Moore, N.W. (1974)** *Hedges.* Collins, London.

**Prince, H.C. (1959)** The Tithe Surveys of the Mid-Nineteenth Century. *The Agricultural History Review.* 14-16.

**Rackham, O. (1980)** *Ancient woodland: its history, vegetation and uses in England.* Edward Arnold, London,

**Rackham, O. (1986)** *The History of the Countryside.* Dent, London.

**Ratcliffe, D.A. (1977)** *A Nature Conservation Review, Vol. 2.* Nature Conservancy Council.

**Richardson, J. (1986)** *The Local Historian's Encyclopedia.* Second Edition. Historical Publications.

**Rollinson, W. (1981)** *Life and Tradition in the Lake District.* J.M.Dent & Sons, Clapham.

**Rogers, J.E.T. (1866-1902)** *A History of Agriculture and Prices in England.* 7 vols. Clarendon Press, Oxford.

**Rowell, T.A. (1983)** *History and Management of Wicken Fen.* Unpublished PhD.Thesis. University of Cambridge.

**Rowell, T.A. and Harvey, H.J. (1988)** The Recent History of Wicken Fen, Cambridgeshire, England: A Guide to Ecological Development. *Journal of Ecology,* **76,** 73-90.

**Rye, W. (1895)** *A glossary of words used in East Anglia.* English Dialect Society, Series C; Original Glossaries No. 75.

**Sainty and Ellis, E.A. (1965)** *Geology.* In: *The Broads;* E.A. Ellis, Ed.)

**Sheail, J. (1980)** *Historical Ecology: the documentary evidence.* Institute of Terrestrial Ecology.

**Shennan, I. (1980)** *Flandrian sea-level changes in the Fenland.* Unpublished PhD. Thesis, University of Durham.

**Sims, R.E. (1978)** *Man and Vegetation in Norfolk.* In: *The Effects of Man on the Landscape: The Lowland Zone.*(Ed. by S. Limbrey and J.G.Evans).C.B.A. research Report 21.

**Skertchley, S.B.J. (1877)***The Geology of the Fenland.* Mem. Geol. Survey Eng. Wales.

**Smith, A.J.E. (1978)** *The Moss Flora of Britain and Ireland.* Cambridge University Press.

**Smith, B.M. (1985)** *A Palaeoecological Study of Raised Mires in the Humberhead Levels.* Unpublished PhD. Thesis. University of Wales.

**Smith, C.T. (1960)** *Historical Evidence.*In: *The Making of the Broads.*R.G.S. Research Series No. 3.

**Sparling, J.H. (1967)** The occurrence of *Schoenus nigricans* in Blanket Bogs. 1. Environmental Conditions Affecting the growth of *S.nigricans* in bogs. **55**, 1-15.

**Standley, V. (1983)** The Draining of Norfolk Broadland. *Norfolk Research Committee Bulletin.* **30**, 7-10.

**Steers, J.A. (1941)** The Physiography of East Anglia. *Transactions of the Norfolk and Norwich Naturalists' Society.* 15, 231-258.

**Steers, J.A. (1950)** The Coastline of East Anglia. *New Naturalist,* **6**, 6.

**Stenton, D.M. (1951)** *English Society in the Early Middle Ages.* Penguin Books.

**Suffling, E.R, (1891)** *History and Legends of the Broads District.*

**Swinnerton, H.H. (1931)** The Post-Glacial Deposits of the Lincolnshire Coast. *Quarterly Journal of the Geological Society of London.* **87**, 360-391.

**Switsur, V.R. (1986)** 884 Cal.BC and all that! *Antiquity* 214-216.

**Tallis, J.H. (1985)** *Erosion of blanket peat in the southern Pennines: new light on an old problem.* In: *The Geomorphology of North-West England* (pp.313-332). R.J.Johnson (Ed.). Manchester University Press.

**Tate, W.E. (1969)** *The Parish Chest.* Cambridge University Press.

**Taylor, J.E. (1871-2)** The Norfolk Broads and Meres geologically considered. *Transactions of the Norfolk and Norwich Naturalists' Society.* 1.

**Thompson, F. (1984)** *Crofting Years.* Barr. Luath Press.

**Thorpe, H. (1951)** The Influence of Inclosure on the Form and Pattern of Rural Settlement in Denmark. *Transactions and Papers of the Institute of British Geographers.* 17, 111–130.

**Tooley, M.J. (1978)** *Sea level changes in North-West England during the Flandrian stage.* Oxford, Clarendon Press.

**Tooley, M.J. (1985)** *Climate, sea-level and coastal changes.* In: *The Climatic Scene.* (Ed. M.J.Tooley and G.M.Sheail). London, Allen and Unwin.

**Troels-Smith, J. (1955)** Characterization of unconsolidated deposits. *Danm. Geol. Unders. IV R* 3(10), 1–73.

**Vancouver, C. (1794)** *General View of the Agriculture of the County of Cambridge.* Board of Agriculture, London.

**Walker, D. (1970)** *Direction and rate in some British Post glacial hydroseres.* In: *Studies in the Vegetational History of the British Isles.* (Ed. D.Walker and R.G.West).

**Warren, P. (1983)** South Walsham: The Agrarian Economy in the Late Sixteenth Century. *Norfolk Research Committee Bulletin.* **30**, 11–14.

**Watts, W.A. and Winter, T.C. (1966)** Plant macrofossils from Kirchner Marsh, Minnesota: a palaeoecological study. *Geol. Soc. Amer. Bull.* **77**,1339–1360.

**Werff, A. van der; and Huls,H. (1958–66)** *Diatomeenflora van Nederland.* (Vols 1–8). Published privately by A.van der Werff, Westzijdt, 13a; De Hoef(v), The Netherlands.

**Wheeler, B.D. (1983)** *Turf Ponds in Broadland.*Broads Authority, Norwich.

**Wheeler, B.D. (1978)** The Wetland Plant Communities of the River Ant Valley, Norfolk. *Transactions of the Norfolk and Norwich Naturalists' Society.* **24**(4) 153–187.

**Wheeler, B.D. (1980a)** Plant Communities of rich fen systems in England and Wales.1. Introduction. Tall sedge and reed communities. *Journal of Ecology.* **68**, 365–395.

**Wheeler, B.D. (1980b)** Plant Communities of rich fen systems in England and Wales.2. Communities of calcareous mires. *Journal of Ecology.* **68**, 405–420.

**Wheeler, B.D. (1980c)** Plant Communities of rich fen systems in England and Wales.3. Fen meadow,fen grassland and fen woodland communities and contact communities. *Journal of Ecology.* **68**, 761–788.

**Wheeler, B.D. (1985)** Observations on the Plant Ecology of Upton Fen, Norfolk, with special reference to the Doles. *Transactions of the Norfolk and Norwich Naturalists' Society.* 27(1) 9-32.

**Wheeler, B.D. and Giller, K.E. (1982)** *Factors and Processes in Broadland Fen Vegetation.* Unpublished report to the Nature Conservancy Council

**Wimble, G.T. (1986)** *Palaeoecolgical Studies of Raised Mires in South Cumbria.* Unpublished PhD thesis. University of Wales, Cardiff.

**Winchester, A.J.L. (1987)** *Landscape and Society in Medieval Cumbria.* John Donald, Edinburgh.

**Woodward, S. (1834)** Bound MSS.,Castle Museum, Norwich.

**Young, A. (1771)** *General View of the Agriculture of Norfolk.* Board of Agriculture, London.