ASPECTS OF THE FLANDRIAN VEGETATIONAL HISTORY OF SOUTH-WEST SCOTLAND, WITH SPECIAL REFERENCE TO POSSIBLE MESOLITHIC IMPACT

by

P.J. NEWELL

A thesis submitted to the
Faculty of Science
of the
University of Birmingham
for the degree of
DOCTOR OF PHILOSOPHY

School of Geography
University of Birmingham
P O Box 363
Birmingham
B15 2TT
England

August 1990

UNIVERSITY OF BIRMINGHAM

University of Birmingham Research Archive

e-theses repository

This unpublished thesis/dissertation is copyright of the author and/or third parties. The intellectual property rights of the author or third parties in respect of this work are as defined by The Copyright Designs and Patents Act 1988 or as modified by any successor legislation.

Any use made of information contained in this thesis/dissertation must be in accordance with that legislation and must be properly acknowledged. Further distribution or reproduction in any format is prohibited without the permission of the copyright holder.

1st of 2 files

Main body of text

Photos and Pullouts are in an additional file

SYNOPSIS

The potential factor of Mesolithic impact on the vegetation of south-west Scotland from c.10 000 - 5000 b.p. was investigated by pollen and charcoal analysis of small peat-filled basins and blanket peat near to the sites of lithics and in the context of subsequent vegetational history (from c.5000 b.p.). Attention focused on upland sites by Loch Doon and Loch Dee. Upland areas by Clatteringshaws Loch and a site at Palnure near the coast provided a late and relatively incomplete record respectively.

Two cores were collected at each of Loch Doon and Loch Dee to enable comparison of microfossil stratigraphies. At Loch Doon several cores were analysed across the rise in Alnus. Preliminary counts were made from a core from Loch Doon itself. Radiocarbon dating gave additional confidence to the chronological framework.

The availability of comparable pollen data enabled some distinction between local and more regional vegetational events. The charcoal profiles were more problematical to interpret, but the contrast between a very low level of charcoal prior to a rise in the early postglacial (Fl I) at both Loch Doon and Loch Dee may prove to be of regional significance. The strongest evidence for local Mesolithic disturbance came from Loch Dee. The results from the small-basin sites were contrasted with those previously recorded from larger mires and loch sediments.

ACKNOWLEDGEMENTS

The basis of the work is that of a project funded by the Science and Engineering Research Council. I would like to thank Dr. K.J. Edwards for offering the opportunity to express the results in the form of a thesis, and Profs. D. Thomas and G. Cherry for granting provision for this within the School of Geography.

The fieldwork was done in collaboration with Drs. Edwards and K.R. Hirons, and the late Mr. T.L. Affleck (University of Glasgow) introduced us to several sites of discoveries of lithics. Dr. W.G. Jardine (University of Glasgow) provided details by which to locate the Palnure borehole.

Dr. Edwards has carried out the charcoal analysis of most of the cores, with the remainder having been analysed by Dr. Hirons, who also analysed the core from Loch Doon and peat from near the loch (LDi and LDiv, Chapter 6). Mr. A.G. Moss prepared many of the samples for pollen analysis.

Prof. A.G. Smith and Miss L.A. Morgan (University College, Cardiff) kindly demonstrated the operation of their computer programs for pollen data handling and plotting, and gave assistance in transferring these to Birmingham and in iniital operation here. Later, Mr. G. Bryan (Centre for Computing and Computer Science) was especially helpful in advising of necessary changes for plotting using the Birmingham facilities.

I am grateful to Miss E. Sanford and Mrs. J. Bradshaw for typing the original drafts of Chapters 1 - 5, and Chapters 6 - 8 respectively; also to Dr. Edwards for his comments as writing proceeded. Mrs. J. Dowling and Mr. K. Burkhill drafted the final versions of many of the Figures and the former labelled Diagrams 6.3.1 - 8.5.2. Mr. G. Dowling took and processed the photograph of Fig. 6.7.

CONTENTS

		Page
Chapter 1	Introduction to the study	1
Section 1.1	Introduction	1
1.2	Thesis plan	4
1.3	Mesolithic preamble - environment and archaeology	4
Chapter 2	Archaeological and methodological framework	10
Section 2.1	Aspects of the British Mesolithic	10
2.2	Aspects of vegetational history and Mesolithic occupation in Britain	12
2.3	The detection of Mesolithic woodland clearance	16
2.3.1	Introduction	16
2.3.2	Site selection	17
2.3.3	Factors to consider for sampling in the field - spatial dimension	18
2.3.4	Factors to consider for laboratory sub-sampling - temporal dimension; and choice of pollen counting sum	21
2.3.5	The interpretation of pollen and charcoal studies in the context of possible Mesolithic disturbance	24
2.4	Specific objectives of the research	29
Chapter 3	Environmental history and archaeology of south-west Scotland	31
Section 3.1	Introduction	31
3.2	The study areas	31
3.3	Geology and landscape evolution	32
3.4	Climate	34
3.5	Soils and peat	35
3.6	Vegetation	37
3.7	The development of Flandrian vegetation in south-west Scotland	39
3.8	Anthropogenic impact on the Flandrian vegetation of south-west Scotland	46
3.9	Postglacial settlement of south-west Scotland with particular reference to the Mesolithic	55
Chapter 4	Methods	63
Section 4.1	Field methods	63
4.2	Laboratory methods	65
4.2.1	Sediment description	65
4.2.2	Loss-on-ignition determination	65

4.2.3 Pollen preparation 66

4.3 Pollen analysis 68
4.3.1 Pollen counting and identification 68
4.3.2 The pollen diagrams 68
4.3.3 Errors associated with the preparation technique and counting statistics 71

4.4 Charcoal analysis 73

4.5 Radiocarbon dating 76

4.6 The presentation of concentration values 77

Chapter 5 Preliminary investigations 79

Section 5.1 Introduction 79

5.2 Moss Raploch 79
5.2.1 Introduction 79
5.2.2 Site and sediment stratigraphy 80
5.2.3 Pollen zonation 81
5.2.4 Dating of the deposit 82
5.2.5 The history of Pinus 83

5.3 Loch Doon 85
5.3.1 Introduction 85
5.3.2 Site and sediment stratigraphy 85

5.3.3 Starr 1 Trench 1 87
5.3.3.1 Sediment stratigraphy 87
5.3.3.2 Pollen zonation 88

5.3.4 Starr 1 Trench 3 88
5.3.4.1 Sediment stratigraphy 88
5.3.4.2 Pollen zonation 89

5.3.5 Starr 1 Trench 4 89

5.3.6 Discussion 90

5.4 Loch Dee Road I 90
5.4.1 Introduction 90
5.4.2 Site and sediment stratigraphy 91
5.4.3 Pollen zonation 92
5.4.4 Loss on ignition 93
5.4.5 Charcoal 94
5.4.6 Pollen concentration 94
5.4.7 Radiocarbon dating 94
5.4.8 Discussion 94

5.5 Loch Dee Peninsula Flint Site 98
5.5.1 Site and sediment stratigraphy 98
5.5.2 Pollen zonation 99
5.5.3 Discussion 99

Chapter 6 Loch Doon - detailed investigations and synthesis 102

Section 6.1 Introduction 102

6.2 The study area 103

6.3 Loch Doon IV 105
6.3.1 Sites and sediment stratigraphy 105

6.3.2 Radiocarbon dating 107
6.3.3 Pollen zonation 109

6.4 Loch Doon III 114
6.4.1 Site and sediment stratigraphy 114
6.4.2 Pollen zonation 115

6.5 Investigation of the Alnus rise at Loch Doon 117
6.5.1 Sites and sediment stratigraphies 117
6.5.2 Pollen zonation 119

6.6 Excavation of the lithics site to the west of Loch Doon 121
6.6.1 Excavation 121
6.6.2 Discussion 123

6.7 Inferred vegetational history by the southwestern shore of Loch Doon 125
6.7.1 Introduction 125
6.7.2 Vegetational history 125
6.7.3 The composition of the mid-Flandrian woodland around Loch Doon in a regional setting 154

Chapter 7 Loch Dee - detailed investigations and synthesis 157

Section 7.1 Introduction 157

7.2 The area of study 157

7.3 Loch Dee Peninsula Bog II 158
7.3.1 Sites and sediment stratigraphies 158
7.3.2 Radiocarbon dating 158
7.3.3 Pollen zonation 161
7.3.4 Sites LDPBIII and LDPBIV 161

7.4 Loch Dee Peninsula Bog I 165
7.4.1 Site and sediment stratigraphy 166
7.4.2 Pollen zonation 166

7.5 Inferred vegetational history 167
7.5.1 Summary of the possible impact on the Flandrian vegetation by Loch Dee 184
7.5.2 Early to mid-Flandrian vegetational history by Loch Dee in a regional setting 186

Chapter 8 Investigations at Palnure 189

Section 8.1 Introduction 189

8.2 Area of study 190

8.3 Palnure 192
8.3.1 Site and sediment stratigraphy 192
8.3.2 Radiocarbon dating 194
8.3.3 Pollen zonation 194

8.4 Inferred vegetational history 195

8.5 The dry-land woodland and the possibility of Mesolithic impact 201

8.6 Comparison with previous work 203

TABLES

Table:		(Following) Page
3.7	Radiocarbon dates (b.p.) associated with events in the Flandrian forest history of south-west Scotland	40
		Page
6.3	Radiocarbon dates from Loch Doon IV	107
6.5	Radiocarbon dates from Loch Doon (loch core)	118
7.3	Radiocarbon dates from Loch Dee Peninsula Bog II	161
8.3	Radiocarbon dates from Palnure	194

CHAPTER 1

INTRODUCTION TO THE STUDY

1.1 Introduction

The idea that Mesolithic man may have had an effect on the vegetation of upland England of a magnitude that can be detected in pollen diagrams has been advanced particularly from investigations on Dartmoor (most recently Simmons et al. 1983, Caseldine and Maguire 1986, Simmons et al. 1987), the Pennines (e.g. Central: Tinsley 1975, 1976; Williams 1985, and Southern: Walker 1956, Pigott and Pigott 1959, Jacobi et al. 1976) and the North York Moors (e.g. Jones et al. 1979, Innes 1981, Simmons and Innes 1981 and Simmons and Innes 1988a,b,c); but also the Lake District (Pennington 1975), Northumbria (e.g. Turner and Hodgson 1983) and Wales (e.g. Chambers 1983a,b; Chambers et al. 1988; and Smith and Cloutman 1988). In lowland England no region has been investigated as intensively as those in the first three regions but analyses of mineral soils in southern England (e.g. by Dimbleby: Rankine et al. 1960, Keef et al. 1965, Palmer and Dimbleby 1979; see also Dimbleby 1985; Macphail and Scaife 1987); mires (e.g. Williamson's Moss, Lake District, Pennington 1975; Winnall Moors, Winchester, Waton 1982; Simonswood Moss C, Merseyside, Simmons and Innes 1987; Willow Garth, Yorkshire Wolds, Bush 1988); and lake sediments (e.g. Barfield Tarn, Lake District, Pennington 1975; Hockham Mere, East Anglia, Sims 1973, 1978) have been considered open to the same interpretation.

In some cases the relationship between the past vegetation and Mesolithic occupancy has been explicitly looked for, when associated with archaeological finds (e.g. at Star Carr, Walker and Godwin 1954; Walker 1956; Dimbleby's investigations cited above); in others, especially since it has become more accepted that the activities of Mesolithic man may be

detected, the factor of Mesolithic disturbance may be invoked to explain changes in the vegetational history inferred from a more general study (e.g. Rowell and Turner 1985). In addition to the evidence of pollen spectra, sedimentological data (e.g. Clark 1955, Smith's [1970] comments on the possible soil erosion represented at Flixton II [Walker and Godwin 1954], Simmons et al. 1975, Innes 1981) and the presence of charcoal or burnt plant remains have been explained in terms of anthropogenic impact (e.g. Tallis 1975, Jacobi et al. 1976, Caseldine and Maguire 1986). For Britain as a whole, Innes (1981) had been able to list over 180 sites where Mesolithic disturbance could be inferred, a recent synthesis by Simmons and Innes (1987) of such evidence for the late Mesolithic of northern England contains a distribution map of the sites for this region.

The possible evidence for Mesolithic impact on Scottish vegetation is reviewed by Edwards and Ralston (1984). At the time of writing only the sites of Kingsteps Quarry, Aberdeenshire (Knox 1954) and those on Jura (e.g. Durno in Mercer 1972) had been examined with the purpose of confirming or otherwise the Mesolithic age of occupation attested archaeologically and therefore to an extent their vegetational context; at other sites circumstantial signs of Mesolithic interference were noted (e.g. Nichols 1967), but in conclusion to the review it was considered that no unequivocal interpretation of anthropogenic change in the Mesolithic could be made from the Scottish literature. Most recently, Birks (1987) has shown the same to be the case for results from work on Colonsay and Oronsay. In this study the pollen analysis was explicitly part of the research design for assessing the environmental conditions of the Mesolithic occupancy.

Hulme and Shiriffs (1985) report macroscopic charcoal in peat 16cm (representing perhaps 400 years) below early cereal-type pollen (5680±70 b.p.), from a core collected from North Mains, Strathallan, Perthshire. This

may indicate Mesolithic presence, but pollen analysis was not carried out at this, or adjacent levels. Boncke (1988) deduced that birchwood may have been burnt by Mesolithic people (c.7900 b.p.) on the west coast of Lewis, Outer Hebrides. The persistence of charcoal and erratic behaviour of the birch pollen curve probably meant that Mesolithic activity continued around the site until the earliest Neolithic disturbance following the regional Elm Decline.

The present research was to provide a coherent approach to the problem of possible impact by Mesolithic man on a part of south-west Scotland. The area was chosen because of the likelihood of finding deposits of suitable age in proximity to known finds attributed to the Mesolithic period. Previously, signs suggestive of a causal connection between this occupation and the vegetational history had been noted (Nichols 1967, Birks 1975), but the inland (and upland) distribution of Mesolithic archaeological sites was not well known and the possible connection was not made. The role of fire as an agent of change was indicated by the occurrence of carbonised plant remains in contemporaneous peats (Birks 1975). It will be seen that the work to be described here has been concentrated in the uplands; though one coastal location is included.

From the outset it was intended to use recent methodology to best advantage in an ever time-consuming exercise and not to be confined to one particular type of sediment. Most effort has been directed towards investigating pollen stratigraphical changes debated elsewhere, e.g. the possible anthropogenic effects at the main Flandrian rises of Corylus and of Alnus (e.g. Smith 1970, R.T. Smith 1982) and around the decline of Ulmus (e.g. Smith 1981a), with its very approximate contemporaneity with the cultural transition from a Mesolithic to a Neolithic economy, however adopted in any given region (e.g. Coles 1976; Welinder 1983a; Edwards and

Hirons 1984; Barker 1985, 197-203; Edwards 1988). For internal comparison at a site, complete Flandrian profiles were analysed in two cases so that any vegetational changes that could have been caused by human occupation in the Mesolithic could be seen in the context of later changes, perhaps attributable to either prehistoric or historic activity (cf. Núnèz and Vuorela 1979, 28; Vorren, 1986, 6).

1.2 Thesis plan

It is the purpose of the remainder of this chapter to briefly review how the landscape history of Britain during the Mesolithic has been understood since the application of pollen analysis to sediments of the post glacial (as this forms the conceptual background to this enquiry), before discussing the relationship between the environmental and archaeological evidence. Answers to the questions raised concerning specific methodological problems to be encountered in the study areas of south-west Scotland will be attempted in the next chapter; the areas themselves and what was known previously of the 'natural history' and archaeology of the region are the basis of the subsequent chapter. An account of the methods used in the field and the laboratory precedes the chapters describing the actual investigations undertaken. The latter divide into an initial chapter containing the results from sites whose history proved to be too young for any adequate inferences concerning the Mesolithic; two detailed studies at upland locations (Chapters 6 and 7) and one from a coastal site (Chapter 8). The final chapter comprises a discussion of the research as a whole and the main conclusions.

1.3 Mesolithic preamble - environment and archaeology

It is significant that Zvelebil (1986a, 1) chose an environmentally determined perspective for a recent collection of essays, concerned with the transition to Neolithic economy, reflected in the term 'temperate

Mesolithic'. Underlying this are his two propositions that the temperate zone of Eurasia (where broadleaved forests and temperate grasslands predominate or predominated during the Holocene) firstly shares a range of possibilities for postglacial adaptations, distinguishable from the nuclear areas of the Near East and secondly, that these adaptations were parallel to those towards socio-economic intensification or domestication in the Near East. Thus the earlier emphasis on the Near East being the origin of any intensification of resources or population perhaps leading eventually to domestication is laid aside and the changes of economy reflected by archaeology and palaeoecology are to be seen regionally in their own right, set within the environmental context.

That this perspective owes a great deal to Grahame Clark is made clear in his next chapter (Zvelebil 1986b, 6ff.), part of which traces how the understanding of Mesolithic subsistence developed so that, with exceptions, self determination has come to characterise this understanding. At the time of Clark's The Mesolithic Age in Britain (1932) pollen analysis of British sites had scarcely begun (e.g. early work by Erdtman) and only two references are made to it (pp. 63, 115). In the first it is used for dating rather than environmental reconstruction, in the second work is in progress on the 'moorlog' hoped to correspond to that adhering to the Maglemosian harpoon dredged from the Dogger Bank in the North Sea (Godwin 1933). The relationship of soil type to the distribution of Mesolithic artefacts is demonstrated for southeastern England, although the equation of 'open or lightly wooded' forest with soils on the sands, chalk and gravel or loam might be questioned (cf. Rackham 1986, 286; Rackham 1988a, 5); the distribution of these likely areas of eventual 'dry' oakwood as apposed to 'damp' (Tansley 1949) is upheld by Mellars and Reinhardt (1978) for the discussion of possible Mesolithic interference and its effects on the forest.

Later (1936), in treating the more extensive region of Northern Europe, apart from the obvious necessity of describing the sea-level changes, Clark gives a far greater weight and space to the 'Natural history of the area of settlement', the title of the first chapter. This includes considerations of the climate, the implications of its change for the tree-line altitude and the spread of forest trees; as well as accounts of the method and findings of pollen analysis. The importance of fauna is stressed. At the back of the book is a graphic illustration of the continuity of the early Boreal forested landscape stretching across the southern part of the present North Sea to unite Britain and the continent.

The integral place of man in the ecosystem is a theme taken up early in Prehistoric Europe - the economic basis (Clark 1952), but the passivity of Mesolithic culture with respect to the the Boreal and Atlantic forests is assumed: 'If one could have flown over northern Europe during Mesolithic times it is doubtful whether more than an occasional wisp of smoke from some camp fire, or maybe a small cluster of huts or shelters by a river bank or an old lake bed, would have advertised the presence of man: in all essentials the forest would have stretched unbroken save only by mountains, swamp and water, to the margins of the sea (pp. 91f.). Darby (1956, 189) offers a similar picture allowing small openings in the forest of western Europe by Mesolithic hunters and gatherers based on the picture presented by Childe (1931).

For Scotland, Lacaille (1954) had very few pollen diagrams (of arboreal types and hazel calculated on the sum of tree pollen only) on which to base any reconstruction of the forest history of the Mesolithic. His interest in pollen-analysis centered on the chronological framework it would help to provide in the absence of radiocarbon dating, with climate considered the principal agent of forest change.

Considering Britain as a whole, whilst the importance of

understanding man as part of the ecosystem for the inference of economic prehistory was well established, the dominance of the forest over Mesolithic populations was still held by Godwin in 1965, and maintained in the second edition of the History of the British Flora (1975, 465). That 'small local clearances' were made by axe and fire is admitted, but these allowed only brief opportunities for certain species. It had been seen at Star Carr that birches had been felled, but no trace of this was detected in the pollen diagram at the occupation site. The response floristically seemed to be the appearance of nitrophilous plants represented by Urtica and the Chenopodiaceae (Walker and Godwin 1954). The results from Hockham Mere (Sims 1973), pointed to a brief opening of the forest canopy in the Mesolithic. Both Godwin and Iversen (1941, 1949, 1960, 1973) and later Behre(1986, vii) were taking a broad view of the woodland landscape in respect of its domination and contrasting any impact on it with developments associated with the Neolithic and later times. It was from this starting point that Simmons (1969a) chose to introduce his contention that Mesolithic man had not been so passive to the woodland environment and present evidence for a greater degree of clearance than had generally been allowed for hitherto. He draws attention to the variety of sites where Mesolithic finds had been found, categorising them as 'upland' and 'lowland' and distinguishing 'dry' and 'wet'. The possible role of fire in opening the forest canopy at the upland sites that belong to areas of Mesolithic occupation, takes up the observations of Dimbleby (1962), firstly, after Stewart (1956,) that fire may have an effect on vegetation far beyond that which might otherwise be suspected for a small number of prehistoric people; and that today it may prevent a deciduous forest climax (Alway and McMiller 1933). Simmons allows the possibility of lightning fire, though is dismissive of it as the cause of the opening witnessed at Blacklane, Dartmoor; however, 'it is not implied that the use of fire was

deliberate' (p. 112). The idea of deliberate burning as advanced by Dimbleby (1962) had impetus in the essays by both Narr and Stewart in Man's role in changing the face of the earth (1956); Simmons (1975a,b) and Mellars (1975; cf. Radley et al. 1974) applied this in their assessments of its effect on both vegetation, and man and animal subsistence in this period.

In the preliminary synthesis of the postglacial history of Scottish vegetation by Birks (1977), signs of man's involvement in the process of deforestation from 5,000 b.p. were noted, but it was not his purpose to relate this specifically to any particular archaeological culture. Walker's (1984) review adopted the same position, though alluded to the hints of possible Mesolithic disturbance before the Elm Decline (e.g. Durno and McKean 1959).

Other important strands to arguments relating to the socio-economic basis of Mesolithic culture are the concepts of the movement of hunter-gatherers to exploit resources (possibly seasonally Clark [1972], although other opinion is against this [see Barker 1985, 195; Schadla-Hall 1987]), site catchment analysis to evaluate resource potential (Vita-Finzi and Higgs 1970, Clark 1972) and the use of ethnographic analogy (e.g. Simmons 1979). Models of resource exploitation and the nature of occupations and activities are given by Simmons (1975a) and Welinder (1978, 1983a). Taken together with the possible use of fire comes the recognition of the potential of Mesolithic peoples to modify or even control their environment in a way that would be detected, if not clarified in detail, by methods of sediment analysis. This is shown by the attention given to such an outlook in the explanations of such palaeoecological findings in England and Wales as instanced above (Sect. 1.1; cf. Dimbleby 1981, 93-110).

Returning to the thesis of Zvelebil (1986a) outlined at the beginning of this section, that later Mesolithic economy may be studied in

a temperate Eurasian context without the earlier assumptions of the primacy of the Near East for eventual innovation at the end of the period it has been shown how this may be justified, by reference to important contributions to the ways of understanding the relationships between the archaeological and environmental evidence in Britain. Simmons's (1983) similar historiographic survey draws out the implications of such a view of the Mesolithic economy so as to raise the possibility that it may lend itself to interpretation in terms of Cohen's (1977) model. In this it is argued that population increase leads to intensification of resource exploitation and control, culminating in domestication (cf. Higgs and Jarman 1969, Mellars 1976a, Williams 1985, 128-134). In order to see how aspects of possible Mesolithic environmental impact may be detected on the much smaller scale of the selected study area within south-west Scotland, the inferences made elsewhere are elaborated and the methodological framework for the study established (Chapter 2). The particular case of the transition to agriculture as inferred palynologically will be dealt with in summary there.

CHAPTER 2

ARCHAEOLOGICAL AND METHODOLOGICAL FRAMEWORK

2.1 Aspects of the British Mesolithic

A number of definitions for the meaning of 'Mesolithic' have been proposed involving cultural, economic, environmental and chronological criteria (e.g. Clark 1980, 1-7; Zvelebil 1986b). It is beyond the scope of this study to discuss these in detail other than to stress the chronological limits of the beginning of the Flandrian c.10 000 b.p. (cf. Mellars 1974) and c.5000 b.p. as broadly encompassing the period of potential Mesolithic presence in Scotland.

The early Mesolithic industries of Britain have affinites with the continental Maglemosian and belong to the 'broad blade' category. This commonality may be explained by the land bridge that allowed the exploitation of the forested and other environments of the much exposed North Sea bed before it was inundated at c.8500 b.p. Thereafter a 'narrow blade' geometric tradition is identified, distinguishable from the technologies on the continent, and from this time the Mesolithic vertebrate fauna is little changed (Grigson 1981a, 116) with further terrestrial migration of the flora also prevented (Barker 1985, 194-197; Simmons and Innes 1987, 386f.).

In a note prompted by the question of the earliest evidence for postglacial occupation of Scotland, Jacobi (1982) sees the element of backed pieces in the assemblages from Lussa I, Isle of Jura (earliest dates: 8194±150 b.p. and 7963±200 b.p.; Mercer 1974, 1981) as belonging to the narrow blade tradition in the south of England; but at Glenbatrick Waterhole, Jura (Mercer 1975) he finds closer parallels with broad blade industries discovered there. In conclusion, he speculates that the barbed bone spearhead from Glenavon (Lacaille 1954, 184f.) may be of late-glacial

age by analogy with other examples. The dates from sites at Morton Farm, Fife range from 8050±110 to 6115±110 b.p. (Coles 1971). Most recently excavations on Rhum have revealed hollows, pits and possible postholes within a scatter of microliths in the sheltered location of Kinloch (Wickham-Jones and Pollock 1987). The charred hazel nuts from a small pit produced dates of 8590±95 b.p. and 8515±150 b.p., as yet the oldest dates associated with a Scottish Mesolithic assemblage. Lawson and Bonsall (1986) equate this assemblage with the narrow blade tradition and thus it is as early as the first such assemblages in northern England. It is inferred that the introduction of the broad blade tradition would likewise be early and so perhaps date from 9500 - 9000 b.p. Like Jacobi (1982), they consider a late-glacial occupation possible (in the Loch Lomond Stadial, based on a date of 10 080±70 b.p.), suggested by the apparent selection of reindeer antler found in an eponymous cave in the Assynt area of Sutherland. The absence of securely dated contexts for broad blade assemblages in Scotland is stressed by Myers (1988).

It has been proposed that microliths of Mesolithic industries may have been the cutting edges of composite implements for food gathering (Clarke 1976) and the possibility of managing hazel so as to promote good yields of nuts (cf. Smith 1970) has been taken up by archaeologists (e.g. Jacobi 1978), but should not be overstated (Williams 1985, 21).

The first domesticates of sheep, goats, perhaps pigs (Grigson 1981b, 194f.) and cereal would clearly have had to be brought across the channel (Case 1969), but whether this necessarily implies the immigration of a new human population appears doubtful to Barker (1985, 203), who like Williams (1985,130), follows Dennell (1983, 180-189) in finding sufficient evidence of the maritime capabilities of Mesolithic people to propose that they could have fetched these for themselves; he points out (p.197) that the invasion hypothesis for the explanation of cultural change within British

prehistory at other times is no longer favoured (Clark 1966).

If Barker's (1985) supposition that outgoing 'British' Mesolithic groups returned with the means for the beginnings of a new dimension to their subsistence is correct , then these elements were probably introduced to a land where there was already a knowledge of plant management. This would obviate the need for a 'seeker of new land' as documented for recent northern Russia, nor would there have inevitably have been competition with indigenous hunters and gatherers (Coles 1976). It is acknowledged by Barker (1985) that the archaeological record does not allow a conclusion as to the origin of the first farmers, but a period of pioneer farming as suggested by Whittle (1978) may be appropriate. Whittle wrote of colonisation, but with the possibility of clearance already achieved by the indigenous population, a view shared by E. Williams (1989). Cultural adoption rather than immigration is envisaged by Bradley (1984). The large monuments (causewayed enclosures and long barrows) and their distribution have been used to argue for organised, sedentary groups with territorial boundaries; they belong to the periods c.3500 - 2500 b.c. (cf. Smith 1974). Whittle (1978) suggests that the extent of the distribution of long barrows to southern Scotland by the end of the 4th millennium may have resulted from the rapid expansion of Neolithic communities, unless there were widespread landings by the pioneers.

2.2 Aspects of vegetational history and Mesolithic occupation in Britain

The distinction between ecological and landscape change was made by Simmons (1975b) whilst introducing his paper on the ecological setting of Mesolithic man in the Highland zone. It is implied there that this is primarily one of scale. The further distinction may perhaps be made that in the usual understanding of the term, 'ecology' describes and interprets (cf. Tansley 1968, 41; Odum 1971, 3; Rackham 1980, vii,ix) the factors of a

system (Odum 1971,8 and cf. Cousens 1974, 1-17). 'Landscape' is concerned particularly with the visual impact of the systems from our vantage point, or from an aeroplane or satellite. In this respect the former contains the assumptions of time, especially over the year (or much longer, e.g. historical ecology), and dynamics; whereas 'landscape' tends to be a static concept (e.g. Jones 1986, 29f.; Faegri 1988, 1). Change in landscape is the difference between the photographs over the seasons or millennia.

These terms are combined in the title Landscape Ecology (Forman and Godron 1986). In this book general principles are tentatively defined after a discussion of themes that includes spatial and temporal change (Forman and Godron 1986, 3-32). Ecological and landscape change as they might be detected palynologically are firstly linked in the association of vegetation and Mesolithic 'impact' by the factor of 'openness'. This relates especially to the extent of herb or ground layer vegetation as opposed to the tree canopy, but also to the performance of shrubs (e.g. Limbrey 1975, 112-114). 'Impact' may be defined as 'all aspects of change concomitant with human societies' (Simmons 1989, 28) and thus the mixture of trees in the woodland and the rates of their establishmant could potentially be included (cf. Smith 1970, R.T. Smith 1982). In concluding his paper, Simmons (1975b) considers that changes in the vegetation would have been by many small temporary, clearances, with perhaps the most pronounced change occurring at the treeline and in association with the development of blanket bog (cf. Simmons and Innes 1985).

Elsewhere (Simmons 1975a), the estimates of former tree lines in parts of upland Britain have been described as 'studied vagueness'; a recent summary is provided by Maguire and Caseldine (1985; cf. Birks 1988a), in which the anthropogenic influence on the earlier treeline on Dartmoor is discussed (cf. Tallis [in Radley et al. 1974; 1975; Tallis and Switsur 1983] for the Pennines, and Jones [1986, 48f.] for the North York

Moors).

The association of woodland clearance with the inception of blanket peat was noted by Simmons (1969a) in interpreting the site at Blacklane Brook (457m, on Dartmoor) and his model for the possible effects of such clearance in the uplands included soil deterioration leading to only partial reforestation. In a series of papers (Moore 1972, 1973, 1975; Merryfield and Moore 1974; Moore et al. 1984; Moore 1988) the implication of woodland removal and the origin of blanket mires has been postulated. The association between the first Neolithic clearance at approximately the time of the Elm Decline, and the change in hydrological regime resulting in peat formation (Moore 1975) seemed to be a particularly prevalent one; but it was later seen that peat initiation occurred at other times and this has been borne out by subsequent studies. The climatic conditions of high precipitation compared to evaporation remains a prerequisite for such formation, but more local factors of soil type and topography are also to be taken into account (e.g. Caseldine 1983; Chambers 1984, 13; Maguire 1987). Blanket peat began in the pre-Elm Decline contexts in Wales where Mesolithic clearance may have been a critical factor (e.g. Chambers 1983b, Cloutman 1983, Smith and Cloutman 1988).

The aspects of possible impact affecting the composition of woodland, the tree-line and the initiation of blanket peat may be considered to occur at the 'macroscale' (Simmons and Innes 1987, 385). The second type of evidence, exemplified by the appearance of Plantago lanceolata in pre-Elm Decline stratigraphy (cf. Simmons 1975a,b; Smith 1970, 85-89) and by other open ground indicators may reflect ecological change at a more local level, and it is in part the multiplication of such evidence that would admit more confident conclusions at the larger scale concerning effects on the postglacial woodland development. At present much of the evidence for Mesolithic disturbance has come from upland and

later (post-Alnus rise) sites (Simmons and Innes 1987). It is not yet possible to conjecture on the number and scale of impacts during the Mesolithic over the landscape of Britain as a whole (Dimbleby 1984, 61).

For a chronological framework for inferences of Mesolithic impact the Elm Decline provides an approximate palynological boundary for the beginning of the period when subsequent Neolithic impact may be thought more likely, as conventionally interpreted (cf. Smith 1970, 90f.; Smith 1981a, 157-160). However, at a more critical level, interpretation is complicated. The cause of the Elm Decline has been much debated, with climate, disease and man variously postulated (e.g. Ten Hove 1968; Rackham 1980, 265f.; Smith 1981a; Sturludottir and Turner 1985; Perry and Moore 1987) and each could have time -transgressive effects. It was shown by Smith and Pilcher (1973) that the Elm Decline dates from the British Isles available to them had their means between c.5300 and 5200b.p. (cf. Smith 1981a, 159). Williams (1985, 119-127) and Scaife (1988, 23) suggest this range could be wider, as does Edwards (1985) for the Irish dates and there may be a difference in those from upland as opposed to lowland sites (Innes and Simmons 1988, 9).

The precise stratigraphical position of the Elm Decline is clearly important. Smith (1981a) observes that the Elm Decline at Ehenside Tarn (Walker 1966) may justifiably be put somewhat lower in the diagram, bringing the clearance phase that was attributed to the Mesolithic (Pennington 1975) within the conventional (post-Elm Decline) sphere of Neolithic culture.

The radiocarbon determinations of pre-Elm Decline Neolithic cultural contexts in Ireland (Ballynagilly and Carrowmore; Edwards and Hirons 1984) mean that the synchroneity of the Elm Decline with the advent of Neolithic culture and clearance may not be assumed. According to Thomas (1988, 61),

however, too great a reliance should not be put on all the radiocarbon determinations for Neolithic contexts suggesting a date towards the middle of the 4th millennium b.c.; he suspects that the Ballynagilly dates are too early on archaeolgical grounds.

For the time around the Elm Decline, cultural assignation on the basis of radiocarbon dating or pollen stratigraphy may not be possible. Pre-Elm Decline cereal-type pollen (e.g. Groenman-van Waateringe 1983; Edwards and Hirons 1984) may represent experiments with cereal growing by indigenous people (Williams 1985), though care is needed in interpretation (e.g. O'Connell 1987); equally, Mesolithic continuity after the Elm Decline should not be discounted (Edwards and Ralston 1984, Edwards 1988), even if the latest date as yet for a 'pure' Mesolithic assemblage (from Dunford Bridge B, 5380±80 b.p.; Radley et al. 1974) does not post-date the majority of Elm Decline determinations (Simmons and Innes 1987). The apparent overlap of Mesolithic and Neolithic dates for Scottish contexts (Edwards and Ralston 1984) is not upheld by Kinnes (1985; cf. E. Williams 1989).

2.3 The detection of Mesolithic woodland clearance

2.3.1 Introduction

It was implied above that it is essentially the factor of more light allowing the ground, herb or shrub flora to respond that characterises the vegetation of a cleared area. It is this response and an initial decline in canopy plants that may be detectable in the pollen record, as they are drawn as percentages (Simmons and Innes 1988a), concentrations (Simmons and Innes 1988b), or as an expression of diversity (Innes and Simmons 1988). If vegetation is fired then 'burnt plant remains' or 'charcoal' (hereafter both are referred to as charcoal unless specifically stated otherwise) may be expected to be registered in a sedimentary sequence. If the field layer alone is burnt or the fire is essentially 'domestic' then

the chances of detecting a vegetational response are diminished, since the canopy remains unaltered and tree and/or shrub pollen production likewise. In the second case no response could result palynologically unless a clearing had been created first. A further line of evidence is the occurrence of mineral sediment resulting from ground disturbance and erosion (e.g. Limbrey 1975, 118-120; Simmons et al. 1975; Simmons and Innes 1985; Simmons and Innes 1988a). The following subsections deal with methodological and interpretative aspects to consider for the possible detection of Mesolithic disturbance.

2.3.2 Site selection

For pollen-analytical studies Jacobson and Bradshaw (1981) succinctly describe factors to be considered in site selection. For the detection of Mesolithic interference in the early Flandrian specifically, R.T.Smith (1982) advocated going to occupation sites in the first instance. He believed that the effects of Mesolithic man could be detected more frequently than they have been and reviewed reasons for the lack of evidence.

In order to find suitable sites for investigation it may be difficult to satisfy both the criteria for palynological detection and the coincidence of datable Mesolithic occupation. In spite of working in an area of an especially high concentration of Mesolithic sites (Central Pennines) and where deposits of peat are frequent, it took Williams (1985, 11) 'six months of futile searching' before finding a site that satisfied her five requirements: a mire deposit, since inwash as is usual in a lake, is avoided; that deposition should have preferably begun from the late-glacial period to encompass the period of the Mesolithic; that rapid peat accumulation would ensure good temporal resolution; that a small mire be found so that local vegetational change would be likely to be registered; that it should be close to areas of Mesolithic occupation.

It has to be decided whether to make an intensive study of a few sites or an extensive study of a greater number of sites in less detail (cf. Dimbleby 1962). On the subject of Mesolithic woodland disturbance, Rackham (1980, 104) opined that 'the evidence is still rather scanty and its interpretation controversial' suggesting perhaps that it is still required to demonstrate disturbance better at particular sites before applying the inference to others where less detail is available. Williams (1985) concentrated her efforts on understanding the vegetational history around one basin; Innes (1981) firstly focused his research on a previously investigated upland site, North Gill (Simmons 1969b, Simmons and Innes 1988a), before looking at others (Simmons and Innes 1988c).

The choice made for the present study has been to look at two upland locations (by Loch Doon and Loch Dee) relatively intensively and the lowland one of Palnure in less detail. Having studies at three locations permits some comparisons over a more extensive area than their individual catchments.

2.3.3 Factors to consider for sampling in the field - spatial dimension

Crucial to the eventual interpretation of spatial variation is a knowledge of pollen transfer. Important considerations are highlighted by Jacobson and Bradshaw (1981) who found the first model of Tauber (1965) to be inadequate in respect of potential pollen input by water, being particularly significant for lake sites (e.g. Peck 1973; Bonny 1978; cf. Bennett 1986a, 618). For peat sites however, the original model, developed for forested environments, has been used succesfully for the general interpretation of regional clearance and edge effects (Turner 1970). Subsequently, the input from surface water has been taken into account (Tauber 1977). The factor of possible filtering by vegetation is also stressed by Tauber (1965, 1967, 1977). The analysis of surface samples

has been carried out in order to provide analogues for fossil assemblages (e.g. Birks 1973). Others (Edwards [1982] summarises such work) have shown the marked fall of values from the woodland edge within about 100m; i.e. a shorter distance than the diameter of one of Tauber's (1965, 32) hypothetical classes of basin size (diameter 100 - 200m) where it was supposed that 80% of the pollen would be from the trunk space, 10% from each of the canopy and rainout components. It may be necessary to have sites as close as 30m from an edge to register clearance (Edwards 1982). Rowley-Conwy (1982, 204) asks whether upland Mesolithic clearance (by burning) would be more likely registered than lowland, assuming greater transfer at altitude 'and/or a thinner vegetation'. Poor representation of pollen from small clearances in otherwise dense woodland would probably be expected (Coles 1976, 65; Groenman-van Waateringe 1983). There is a potential difficulty in interpreting a forested landscape by comparing spectra derived from modern samples that have been taken from a generally cleared landscape, although Turner (1964a) considered that the exponential decay in pollen percentages was independent of this effect. In a study by Andrews (1986) it was shown how a small clearing (about 150 x 150m) in a woodland area allows more regionally represented types to be recorded. In the particular case of samples from a woodland floor the pollen may be assumed to have originated from within 20 - 30m (Andersen 1970). Other aspects affecting interpretation such as the production of pollen and the use of correction factors (e.g. Andersen 1973), employed by Simmons and Innes (1988c), but not here, are reviewed by Birks and Birks (1981), Andersen (1984), and Andrews (1986).

As with Tauber's (1965) model Prentice (1985) only considers the aerial input to a site and although taking up the terms of Janssen (1966, 1973); 'local, 'extralocal', 'regional'; he adds 'extraregional'. His definition of 'local' concurs with Jacobson and Bradshaw's (1981) in being

the vegetation within 20m of the sampling basin edge, but the ranges of 'extralocal' (20m - 2km), 'regional' (2km - 200km) and 'extraregional' (beyond 200km) are more specific than those of Jacobson and Bradshaw (1981). For convenience the latter's definitions will be adopted in discussion below, the ranges being 0 - 20m; 20m - 'several hundred metres'; and beyond this.

For detecting small-scale clearance by Mesolithic hunter-gatherers it follows that sites potentially beneath a tree canopy or close to the woodland edge are likely to be most useful. Three-dimensional work (cf. Turner 1970, 1975) as recommended by Simmons (1983, cf. Simmons and Innes 1988a) in this regard should help to unravel 'local', 'extralocal' and 'regional' characteristics.

As examples of the application of a three-dimensional approach to the problem of locating possible Mesolithic interference the studies of Jacobi et al. (1976) and Williams (1985) may be cited. The more detailed mapping and stratigraphical recording shown in Smith and Cloutman (1988), combined with pollen analysis at selected sites, gave an opportunity to show variation in the vegetation, with more confidence in delimiting the extent of parts of the mosaic.

Concerning the transfer of charcoal, Patterson et al. (1987) speculated that it might compare with that of pollen. Its sources would then in part be due to the size of the receiving basin. However, in situ burning will perhaps have a greater effect on the recorded abundance of local charcoal (as opposed to other components) than local flowering will to the components of pollen rain received, except in the case of very small basins or hollows, where local pollen predominates. The potential range of particle size is much larger for charcoal than for pollen. Simmons and Innes (1981, 1988c) contrast the 'fallout' of microscopic charcoal (<180 μm) continuously present in a profile commencing in the

Atlantic, with the peaks of such charcoal coincident with the occurrence of much larger fragments in the stratigraphy. A study (Burzynski 1982) cited by Tolonen (1986, 488) showed that particles of >237 µm can readily be distributed at least 800m under conditions of wind speeds of 5m/s - >20m/s at two sites (the first of clearcut conifers, the second of mixed wood). The same study showed that the production and transport of particles is dependent on metereological conditions (Tolonen 1986, 486). Clark (1988) stresses that the main distinction between the transport of charcoal and that of other particles in a forest (e.g. pollen) is the effect of the convection current taking the burnt fragments upward. This effect is attenuated, depending on the wind speed, but strenghtened by the intensity of the burn. There is usually a 'skip distance' between the source and place of deposition of the fragments, which for the smallest pieces (5 - 10 µm) may significantly begin from one km and be well represented at two km. However, for larger fragments (50 - 10 000 µm [1cm] there may be 'little or no skip distance' (p. 72).

2.3.4 Factors to consider in laboratory sub-sampling - temporal dimension; and choice of pollen counting sum

The density of sediment sub-sampling depends on the duration of the events under investigation and the detail required in following their dynamics (e.g. Turner 1964b, 1965, Moore 1980, Garbett 1981, Sturludottir and Turner 1985, Williams 1985, Molloy and O'Connell 1987).

Walker (1966, 19) evaluates the significance of taxa that appear very infrequently as simply a record of presence, and even 'differences of a very few grains between a pair of counts are not generally used for interpretation'. As Smith (1981a, 127) contends, it is the direction of environmental change that can be judged more confidently. For this reason Walker (1966) opted to count a greater number of levels at lower sums than expending the same effort on high sums on fewer samples. By doing

this, important taxa may be missed; but depending on the time represented by each sample, with greater numbers of samples over a period within which ecological change may be detectable, a large overall sum is attained.

It may be possible to count closely-spaced samples to high sums. Williams (1985) was thus able to detect cereal-type pollen at only one level of a contiguous series of counts of about 800 grains; although the periods inferred as having been of more open canopy spanned many centuries. In the latter case these can be interpreted as continuous, with no doubt that unsampled peat may have presented a different story. Simmons et al. (1989) present a diagram in which the sampling resolution is as little as 0.1cm and high counts are employed to discern in more detail the ecological changes involved in the disturbance already adduced from more coarsely-sampled profiles (Simmons and Innes 1988a).

From an a priori assumption that woodland regeneration after disturbance may occur over 100 years (cf. Smith [1981a, 153-6], on Iversen's views of the time taken for the initial regeneration of landnam), the sampling interval can be chosen to be within this as a first objective, if a profile is adequately dated. Ideally, there should be at least a sample on each side of a maximum or minimum value to significantly define a vegetational event (cf. Faegri and Iversen 1975, 187; and Clark 1988, 173, with regard to charcoal studies).

It is impossible to be certain at the outset what the pollen transfer to a site has been in the past and this may clearly eventually influence the choice of pollen sum. For example, where local trees were screening the input of non-arboreal pollen to a small mire (40 x 60m) and it was required to examine the pattern of this input, Tolonen (1987) counted from 2000 to 10 000 tree grains in order to reach a minimum of 100 NAP types. For measuring the diversity of the assemblages there is no absolute criterion by which to choose the sum (Rull 1987). Also dependent

on the size of the pollen sum are the confidence intervals for percentages or concentration values, but no attempt has been made to calculate these in this study, though the latter are considered further below (Sect. 4.2.2). The type saturation point (Rull 1987) of assemblages has not been determined. The routine sum of about 500 grains is such that the asymptotes of the curves of grains counted against width of confidence interval for percentages from 1 to 50% are being approached, and that to significantly improve on the reliability for values of one to a few percent, appreciably higher counts would be needed (Rull 1987).

Charcoal analysis may more usually need contiguous sampling because of the potentially short-lived and episodic nature of the fire record and yet the registration of such an event may be rendered insignificant in a sample of considerable duration (Patterson et al. 1987). Using a typical sedimentation time for lakes (10 years/cm) and a mean fire interval of 1 - 80 years, Clark (1988) shows that to resolve individual fires 'the expected value of the fire interval must be much greater than the sampling intervals, even with close-interval, contiguous samples' (p. 74). A variety of curves are modelled for a burn affecting an entire catchment of a lake (with a sedimentation time as previously) and one for a situation in which five areas burn asynchronously, each with the same periodicity as the first case (c.30 years). The effect of sampling interval on the record of each case is illustrated and also, on the asynchronous record, the effect of bioturbation. General patterns, at the level of presence or absence, will be discernible with wider sampling intervals over long periods, assuming a large catchment, but they remain a partial record, a statement of probability. As an indicator of possible anthropogenic impact (which if low, could perhaps cause infrequent charcoal peaks), the more samples, the stronger the argument.

2.3.5 The interpretation of pollen and charcoal studies in the context of possible Mesolithic disturbance

Discerning critical changes ultimately depends on subjective interpretation of the taxa involved (cf. the comments of Moore and Webb [1978] concerning the Elm Decline), and all interpretation is made within the principle of 'uniformitarianism', which whilst a subject for discussion (e.g. Birks and Birks 1980, Birks and Gordon 1985, West 1988) is at least a practicable approach (Rackham 1988a, 3). For the inference of Mesolithic impact, Preece et al. 1986, 502f.) state that 'the causal link between anthropogenic disturbance and vegetational change is extremely hard to demonstrate and in most cases totally untestable'. Birks (1988b, 124) notes the frequent ambiguity of the evidence. Given the limitations of a (pre)historical science, it is the strength of the circumstantial evidence applied within current ecological and ethnographic knowledge, and the principle of Occam's razor for 'parsimonious' explanation (cf. Birks, in press) that must convince.

The quality of the circumstantial evidence for attributing vegetational change to man is primarily related to the archaeological distributions and stratigraphical control of the data. The felled trees at Star Carr (Clark 1954) are arguably at one end of a scale; although beaver chewing occurred, it is conceded that not all the birch of the platform was brought down in this way (Coles and Orme 1983). Further along such a a scale perhaps are the circumstances of the association between the replacement of heath, as shown by pollen analysis, and the Mesolithic assemblages at Iping Common, for which 'complete proof ' could not be given (Keef el al. 1965, 88). The reinterpretation of the work is more circumspect (Dimbleby 1985, 105-5). Here the archaeological and ecological evidence are at the same site. Often investigations are carried out in areas of Mesolithic finds, where these are undated and the palaeoecological

reconstruction derives from peat deposits within the area (e.g. Simmons and Innes 1988a,b,c). The least convincing circumstances are where there is no supporting archaeological evidence for activity near a site and only small palynological change is reported.

Concerning the pollen evidence, 'occasional single weed pollens can scarcely be considered reliable indicators of the presence of man' (Jones et al. 1979, 18). The grouping of taxa as 'ruderals' in the context of a study on Mesolithic impact (Innes 1981, Simmons and Innes 1988a,b,c) is comparable to the selection of types suggesting activity in later periods (e.g. Turner 1964b, Roberts et al. 1973). Walker's (1966) category of 'heliophilous herbs' is less specific; he arbitrarily chose clearance to be represented by ≥2% of his dry-land sum (cf. Turner's [1965] measures).

The interpretation of such features as Mesolithic impact is probably more warrantable in upland situations where the tendency to retrogressive change is stronger. There is always the possibility that grazing might result in the representation of herbaceous plants (e.g. Buckland and Edwards 1984). For Britain generally, Piggot and Walters (1954) discuss the habitats of light-requiring species when the postglacial forest had an essentially closed canopy, and Rackham (1988a, 5) presumes a 'woodland grassland' in lowland wildwood.

The equivocal nature of the pollen evidence can be illustrated by the interpretation of profiles from Star Carr (Godwin and Walker 1954) and Seamer Carrs (Jones 1976a, 360). Both Bennett (1983) and Preece et al. (1986) cite these as instances where Mesolithic activity is attested archaeologically, but that this is not seen palynologically and both cite Pigott and Walters (1954) as providing the basis on which herbs such as Plantago lanceolata and Rumex acetose might not be unexpected. By contrast, Innes and Simmons (1988) interpret the diagram from Star Carr as

showing possible disturbance, which is compared to that at Flixton II. (Cloutman and Smith [1988] also argue for disturbance at their sites VP85A/2 and VP85/B at Star Carr.) In the full publication of Seamer Carrs (Jones 1976b, 405) the Mesolithic influence was considered minimal, but Innes and Simmons (1988) find the data can be interpreted as showing disturbance in early Flandrian II, together with the diagram from a site nearby (Tooley et al. 1982).

For the inference of vegetational change in response to fire the index of conifer/sprouter may be calculated for each level (e.g. Swain 1973, Tolonen 1985). Again ecological knowledge would be required if selecting 'sprouters' of British trees or shrubs. Tolonen (1985) selected Alnus, Betula, Populus and Corylus as part of her longer list and a similar approach was adopted by Carter (1986). Of these, Corylus is a debatable choice.

Considering the postglacial expansion of Corylus, Bennett (1983) explained the sharp Corylus rise recorded at Hockham Mere as the result of the introduction of the tree into a niche without serious competition and in this took the view of Iversen (1960, 9; 1973, 53), which Birks (1987, 75) sustains. Iversen (1973, 62) also conjectured that although there was a lack of competition, its dispersal may have been connnected with man. The particular case of the Corylus rise following charcoal in the profile at Flixton II was the ground of Smith's (1970) suggestion of a local anthropogenic connection in Britain. He widened this argument (after Rawitscher [1945]) to possibly account for the prevalence of high hazel values during the Boreal. This is disputed by Birks (1987) since the original observation (Rawitscher 1945) was concerned with the behaviour of two American species: C. cornuta and C. americana, of the prairie and savanna. In Iversen's (1956) clearance experiment, Corylus avellana sprouted from stock along with lime and poplar after the area had been

cleared and fired. Rackham (1980, 104) also considers it 'possible that some way may have been found of encouraging the tree', but prefaces this by saying that he has 'no reason to suppose British Corylus avellana to be specially fire resistant'. Forni (1984, 134) has C. avellana as a 'pyrophyte' (p.131), a fire-resistant or fire-promoted plant.

Although from ethnography there is a wealth of instances of fire being a method of opening the canopy of coniferous, deciduous and mixed forests in America (Mellars 1976a), there is still necessarily some reticence about applying this knowledge to the interpretation of Mesolithic impact because of the possibility of lightning fires Innes and Simmons 1988, 18). Nevertheless, the potential improvement in the plant resources available to man and animals from a more diverse vegetation is seen as perhaps the most 'persuasive factor' in advocating deliberate disturbance resulting in burnt woodland (cf. Simmons and Innes 1988a, 264). Jones (1986, 45-49) describes how, by burning and subsequent grazing, woodland could be removed.

According to Rackham (1986, 69-72; 1988), in Britain only pinewoods will burn (a matter raised by Iversen (1941, 25) questioning the occurrence of natural fire in Danish 'foliferous forest'), and that to burn deciduous wood requires it to be dried out after cutting (cf. Coles 1979, 104; Iversen 1956). Previously, Rackham (1980, 104) conjectured that fire might be occurred more readily when pine was important in the Boreal forest and the climate more continental (cf. Taylor 1975), but was later less sure as to whether its decline was likely a result of fire (Rackham 1988a, 4). Tolonen (1985) showed that the replacement of deciduous by coniferous forest was accompanied by an increase in charcoal (from c.1800 b.p.) at a site in south-west Finland.

Mellars and Reinhardt (1978) thought that fire was more likely to combust woodland vegetation on potentially drier, better-drained soils,

such as the sands of southern England and would proceed by igniting the ground and shrub layer whose cover would have been more continuous and better grown as a 'fuel producing' vegetation. Against this 'the combination of perpetually damp soil conditions and limited fuel supplies may well have rendered the woodlands developed on the more fertile soils of southern England virtually fire-proof, except during periods of exceptionally dry climatic conditions' (p.261). Smith (1970, 82-84) certainly considered that birch would be ignited and hazel burnt off.

The long lenses of charcoal at North Gill (Simmons and Innes 1988a) extending for more than 300m x 50m convincingly shows that in situ burning occurred and the fall of tree pollen (oak and alder especially) is seen in terms of pollen concentration as well as relatively. The sandy substratum of the North York Moors sites and their altitude may have rendered them prone to burning if the soils were then freely draining and the trees not always especially well grown (although at Bonfield Gill Head a Quercus stump measured 80cm across and others of Betula range from 15 - 60cm). For disturbance phases on East Bilsdale Moor Simmons and Innes (1988c, 315, 318) infer a 'ground fire of sufficient intensity to remove all plant growth, rather than a lighter burn', the result of this providing an opening suitable for colonisation by Betula from seed. No comment is made concerning the duration of the disturbance phases; their frequency is indicated by radiocarbon dating. The first and second disturbances were separated by c.500 radiocarbon years; the second and fourth by c.300 years, the third has an unaccepted date.

Welinder (1983b) draws attention to possible intended manipulation by fire in his re-interpretation of two sites in Central and Southern Sweden (Welinder 1983c). In the first instance he considers that three clearances took place, associated with minima in the Pinus curve and small maxima in Corylus, accompanied by maxima in Chenopodiacae, Urtica and

charcoal. About 100 years separates the main events. The second site has a single maximum of charcoal as Pinus declines and Corylus expands. Here the expansion of Urtica is prolonged beyond the initial clearance and the later rise of Pteridium is explained as a consequence of the forest having been opened. These observations led to the question as to whether the phenomena are part of a general pattern of fire in coniferous woodland (Welinder 1983b), i.e. whether the sites showing fire clearance will initially be in the south where more open forest would prevail early in the postglacial; but latterly in Central and Northern Sweden. Also, it may be that the fire clearance will have tended to be late as resources became more limited.

In general it seems agreed that deciduous and coniferous woodland have been burnt and that the factor of Mesolithic occupation in this may be important, especially in the uplands. Dimbleby (1981, 103) stresses that not only had Mesolithic man the means to create open areas of forest using fire in particular, but that 'it would be naive to suppose that fires would be started on a haphazard basis'. Miles (1987, 2) endorses this view in supposing that an understanding of succession would have resulted from seeing the vegetational response to fire.

2.4 Specific objectives of the research

The general aim of the research is set out above (Sect. 1.1). Having outlined main themes in the literature concerning the environment of Mesolithic man in Britain during the Flandrian and his possible modification of it, specific aims in extending these ideas to a study in south-west Scotland may be indicated.

A search for sites had to be made in which the choice of site is primarily dictated by the need to demonstrate potential Mesolithic disturbance palynologically (i.e. sequences from under potential tree

canopy or near the presumed woodland edge are preferred) and archaeologically (i.e. the attribution of Mesolithic disturbance is most credible when artefactual evidence is close by).

A priority was to look at the pattern of burning during the entire Flandrian. There is only one published analysis of microscopic charcoal for most of the Flandrian of south-west Scotland, from the Isle of Arran (Robinson and Dickson 1988). The requirement for full postglacial analyses of charcoal is arguably more important than for pollen and spores where models of transfer and regional woodland development can be discussed in a more complete framework than for charcoal where so much is unknown (cf. Patterson _et al_. 1987; Clark 1988). Could the variations be interpreted culturally (cf. Tallis 1975, Simmons and Innes 1981, Simmons and Innes 1988c, for such inference at the Elm Decline); or climatically? Was it possible to see if fire had encouraged the establishment of Flandrian 'new arrivals' of the tree flora (Smith 1970; and for _Alnus_ in particular, Smith 1984, Chambers and Price 1985, Bush and Hall 1987), accepting that if the occurrence of fire has been widespread and from early in the Flandrian this will have been a constant potential factor?

As well as considering the temporal variation represented by the changes in values of microfossils in the vertical dimension of the profile, spatial variability of change would be investigated by taking further cores within an area. This would likely assist in the interpretation of the components of the vegetation locally, extralocally and regionally and perhaps in understanding the origin of recorded charcoal. Pollen concentration would be assessed as an additional source for inferring depositional history or proximity of taxa.

Finally, the interpretations of the sites were to be compared to see whether generalisations concerning the fire histories and any other signs of disturbance could be made.

CHAPTER 3

ENVIRONMENTAL HISTORY AND ARCHAEOLOGY OF SOUTH-WEST SCOTLAND

3.1 Introduction

This chapter reviews the essential environmental history of south-west Scotland including the development of the Flandrian vegetation, the settlement of the area from the Mesolithic onwards, and the possible effects of man's activity on the vegetation.

3.2 The study areas

The main study area is situated near the western extremity of the Southern Uplands (see Figs. 3.1 and 3.2). It extends from north of Loch Doon at its northern boundary (the approximate limit of the hydrological catchment of the Loch) to Clatteringshaws Loch at its most southerly and easterly point; the western edge again being the extent of the catchment for Loch Doon (see Fig. 3.9). The outlying coastal site of Palnure, near the head of Wigtown Bay, an inlet of the Solway Firth, has also been investigated (see Fig. 3.1).

The two most detailed investigations to be described are at Loch Doon and at Loch Dee which are at the northern and southern ends respectively of the landform region recognised by Bown (1973) as the Loch Doon-Loch Dee basin. To the west, the granite hills rise to 692m (Mullwharchar); the eastern edge known as the Rhinns of Kells is of metamorphosed Ordovician rock rising to 814m (Corserine). From about 330m, the basin to the north is drained by the Gala Lane, which flows into Loch Doon (215m). To the south the Cooran Lane joins the Blackwater of Dee, the outflow from Loch Dee (226m). The river continues into the artificially-created Clatteringshaws Loch, emerging near the south end. The steep-sided flanks of the basin have been subjected to glaciation

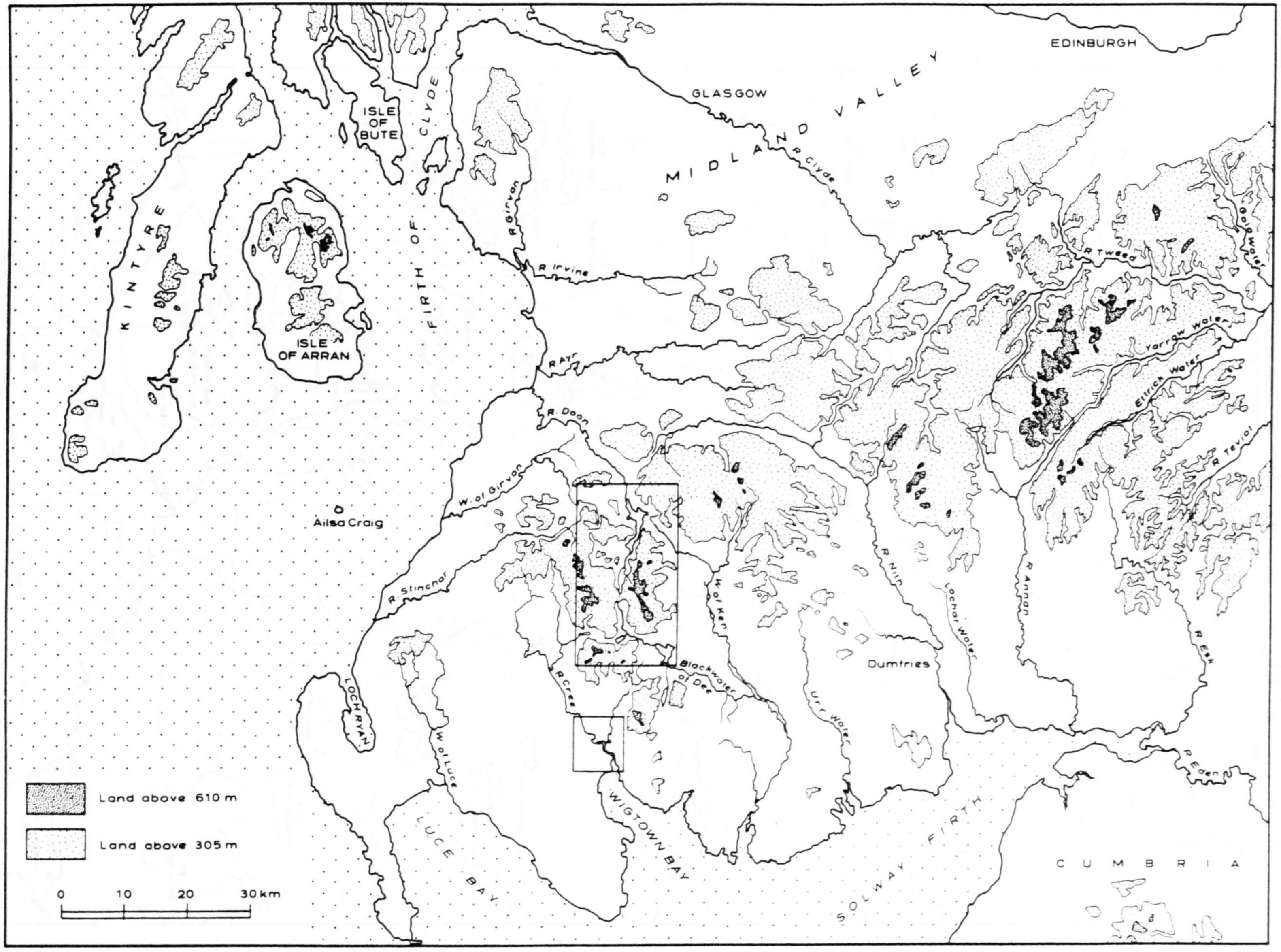


Fig. 3.1. Physiographical map of south-west Scotland showing the positions of the study areas. Loch Doon, Loch Dee and Clatteringshaws Loch lie within the northern area; Palnure is in the southern area.

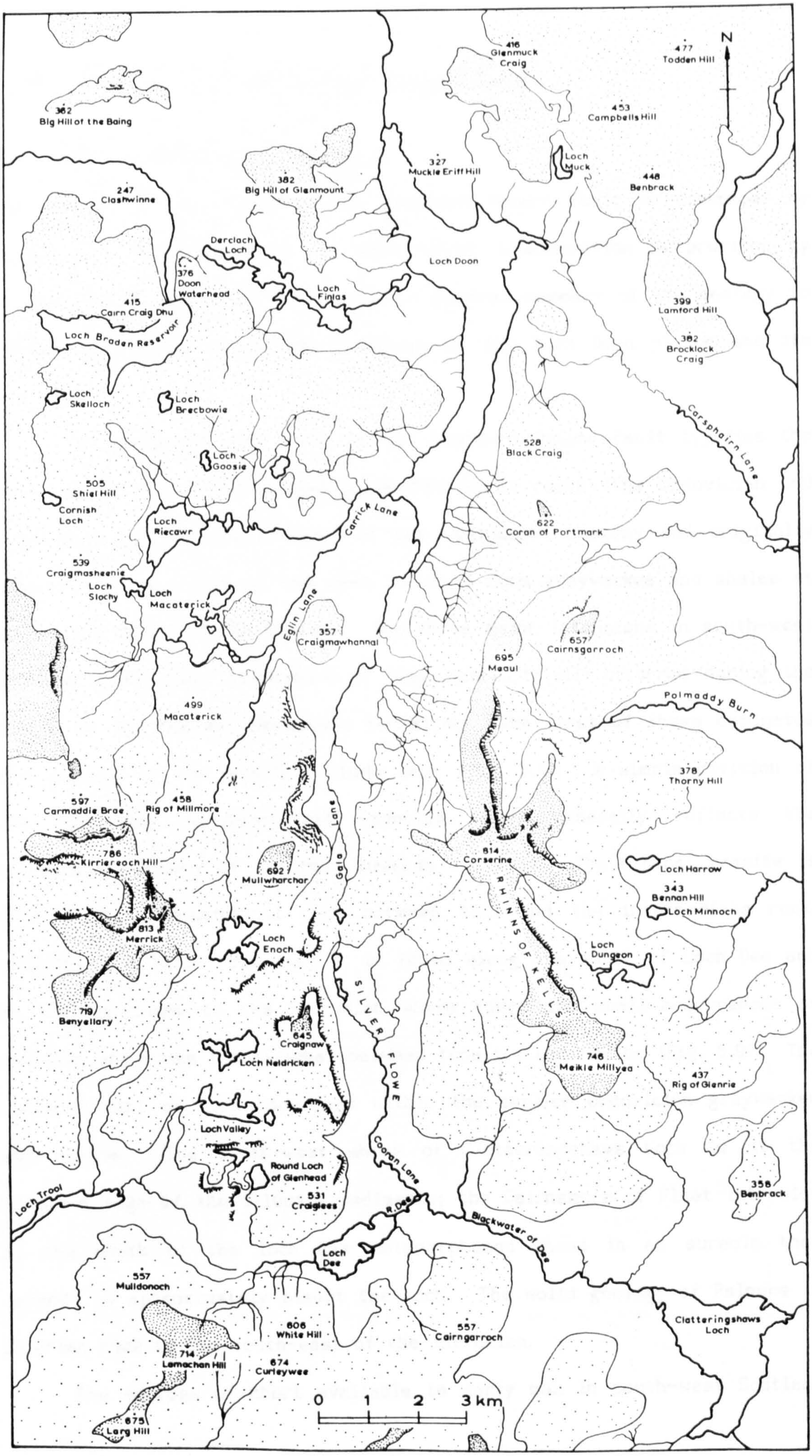


Fig. 3.2. Physiographical map of the principal study area including the Loch Doon-Loch Dee basin.

which has served to accentuate their rugged nature.

3.3 Geology and landscape evolution

The geology to the south of the Southern Upland Fault is described by Greig (1971; see Fig. 3.3). A more recent consideration is provided by Cornish (1979. Whittow (1977) gives a general summary of the geology to explain the structure of the landscape of the Loch Doon pluton and its environs.

The general SW-NE trend of the Southern Upland Fault typifies the axis of the structures of the Lower Palaeozoic rocks (the Ordovician and Silurian), later folded as part of the Caledonian orogeny and originally laid down in a trough of the same trend to form greywackes and shales at an earlier stage of the orogeny. The three major intrusions in south-west Scotland (Loch Doon, Cairnsmore of Fleet and Criffell) occurred during the period of the Old Red Sandstone formation. The first of these dominates the geology of the principal study area (Fig. 3.4). A simple division of the intrusion (Gardiner and Reynolds 1932) generally reflects the increasing basidity of the rock towards its edge. The central granite is acid, with a transitional zone between this and the intermediate rock, tonalite. The basic rock, norite, is found along the south of Loch Dee and in the northwest of the intrusion where there are small occurrences of tonalite and rocks transitional between tonalite and norite (Fig. 5.9). The northern part of Loch Doon lies within the earlier Ordovician greywackes and shales. The north-west shore of Clatteringshaws Loch is at the northern edge of the Silurian sediments; the Cairnsmore of Fleet intrusion at the south of the loch has metamorphosed these in an aureole that extends to approximately bisect the loch. The solid geology of Palnure is Silurian rock to the south-east of the intrusion.

The sources of chert available to early man in south-west Scotland

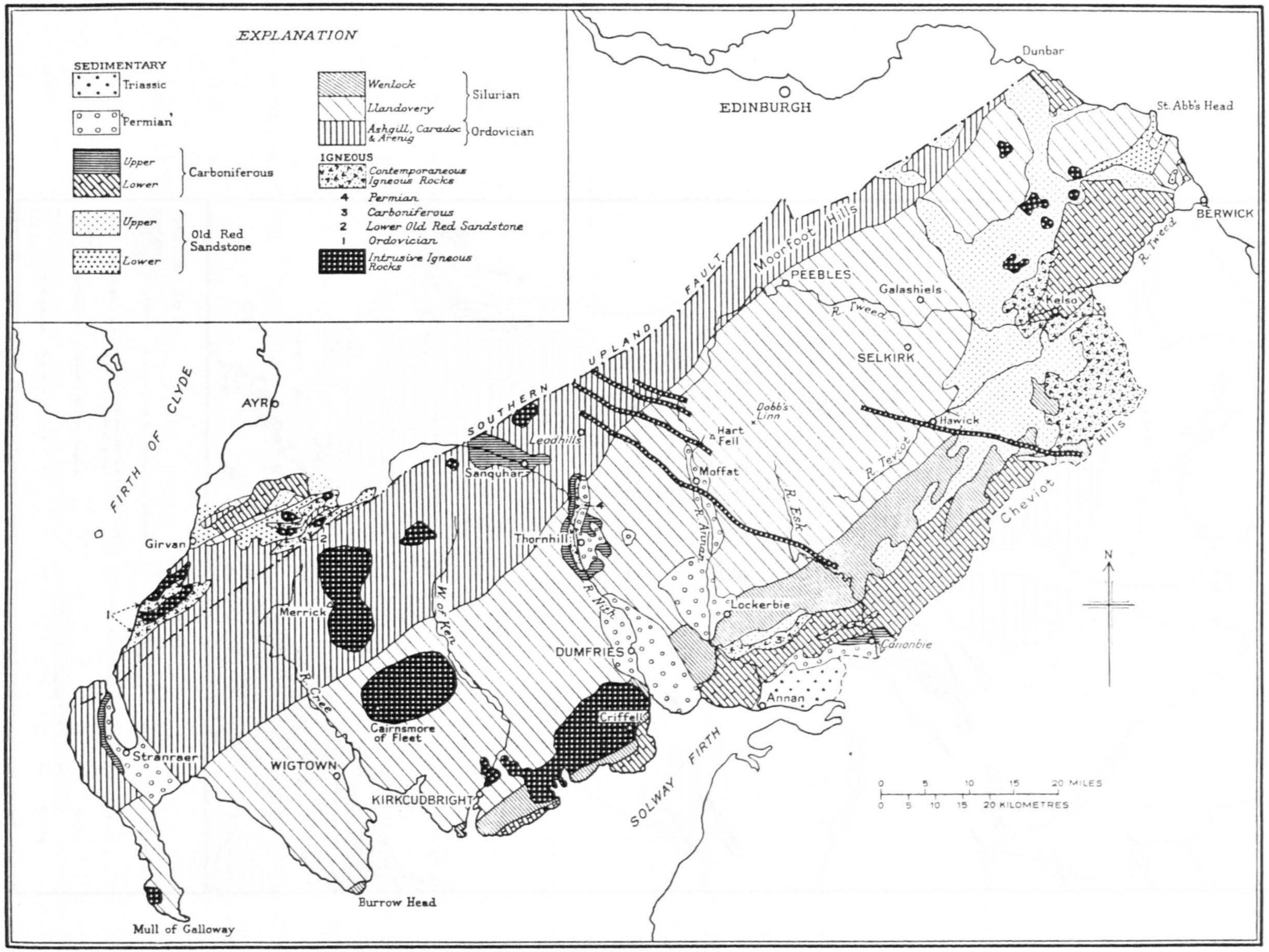


Fig. 3.3. Geological (solid) sketch map of the south of Scotland (from Greig 1971).

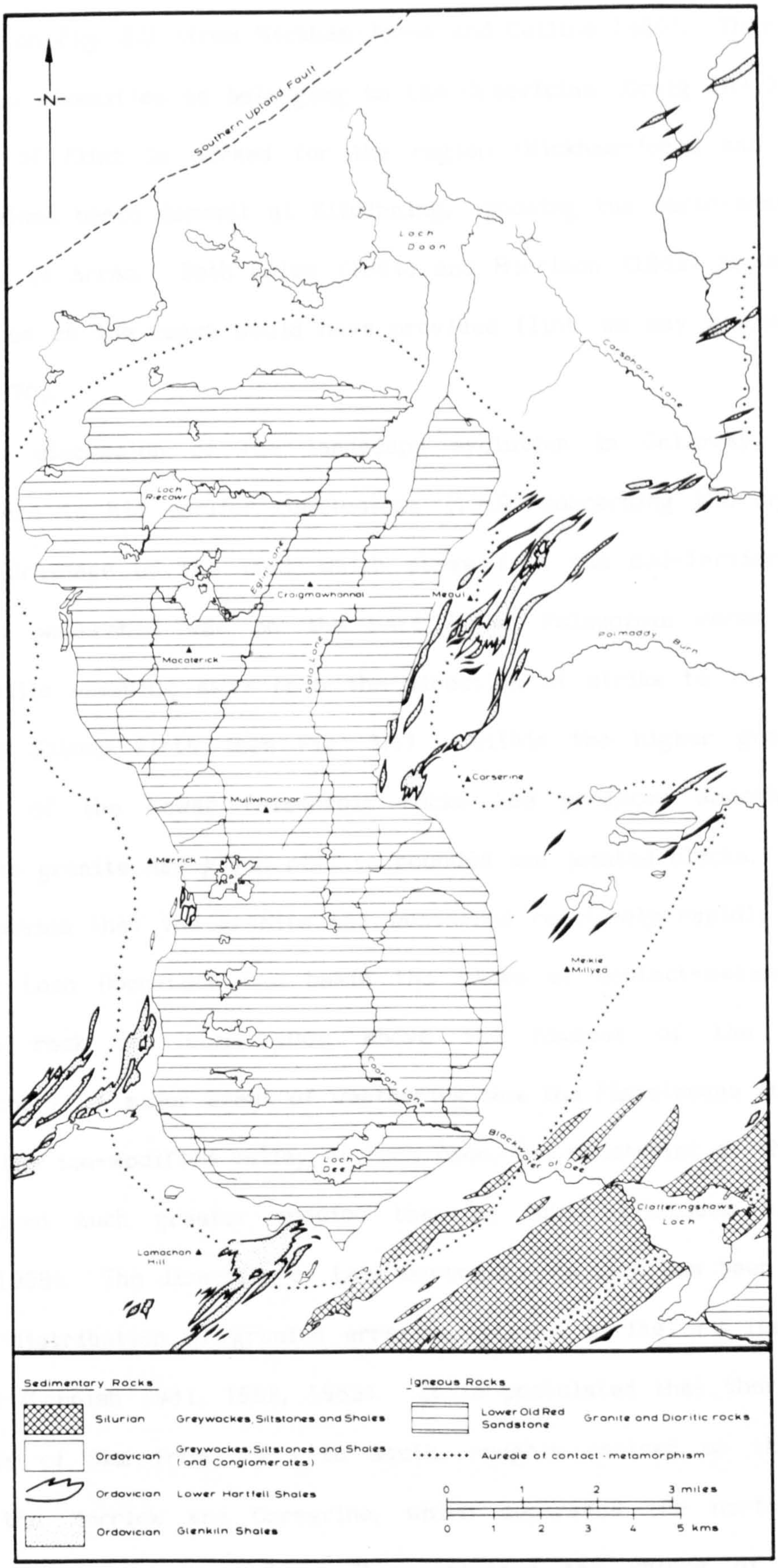


Fig. 3.4. Geological (solid) map of the principal study area.

are plotted on Fig. 3.5 (from Wickham-Jones and Collins 1980). They belong to rocks now classified as belonging to the Ordovician (Greig 1971). Only one source of flint is marked for the region (Wickham-Jones and Collins 1980), a raised beach deposit at Kilwinning, opposing the north-east coast of the Isle of Arran. Both Coles (1964) and Morrison (1982) assume that beach pebbles on the coast would have provided flint, as may glacial drift (Cormack 1970).

In a discussion of the landscape evolution in Galloway, Jardine (1966) refers to his earlier conclusions (1959) concerning the origin of the major drainage of the land, which stems from the mid-Tertiary. The antecendent watershed was on the hard Lower Palaeozoic rocks of the northern hills draining away from the direction of strike to the Midland Valley and Solway Firth (see Fig. 3.1). Within the higher ground the weathering of the Lower Palaeozoic rocks has produced smooth forms, whereas the granite has given rise to rounded and jointed blocks. Boatman (1983) explains that the granite has weathered relatively rapidly so that above the Loch Doon-Loch Dee basin the peaks of contact-metamorphosed Ordovician rock are some 100m above the highest of the granitic (Mullwharchar). A major agent of weathering was the Pleistocene ice.

In the ice-modified valley of Loch Doon, the constraint of the valley sides caused much greater erosion than at lower altitudes elsewhere, (Jardine 1959). The direction of Late Devensian ice flow has been inferred from the distribution of granite erratics, glacial striae and ice-moulded landforms (Cornish 1981, 1982, 1983). It is postulated that there was an ice divide of 9km from north to south, roughly centred on the ground between the Merrick and Corserine, which separated the northerly and southerly flows (cf. Fig. 3.6). These crossed the Rhinns of Kells in places, but did not merge with other ice to the east at the centre of the range. Only small glaciers formed during the Loch Lomond (Windermere)

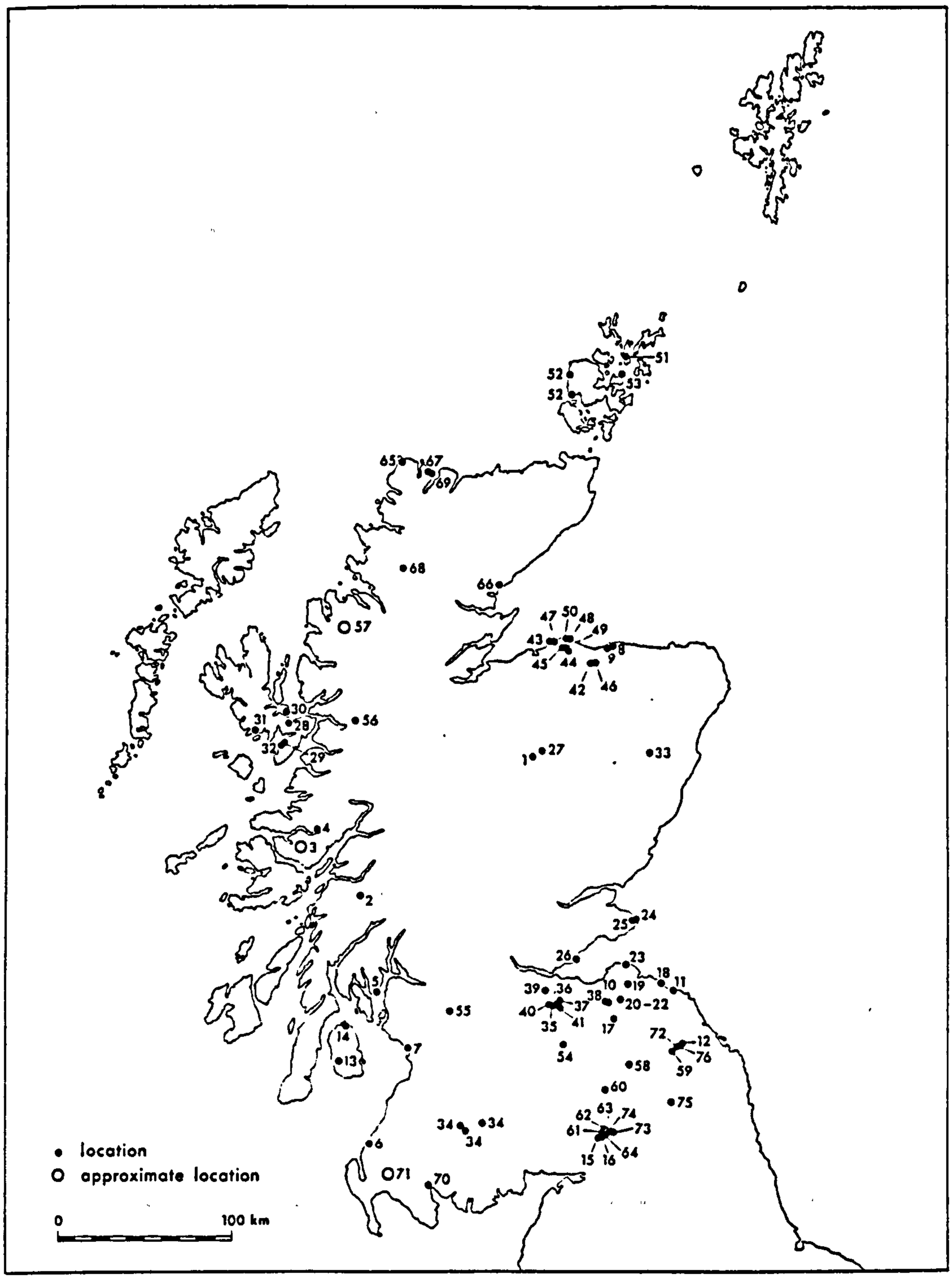


Fig. 3.5. The sources of chert in Scotland (from Wickham-Jones and Collins 1980).

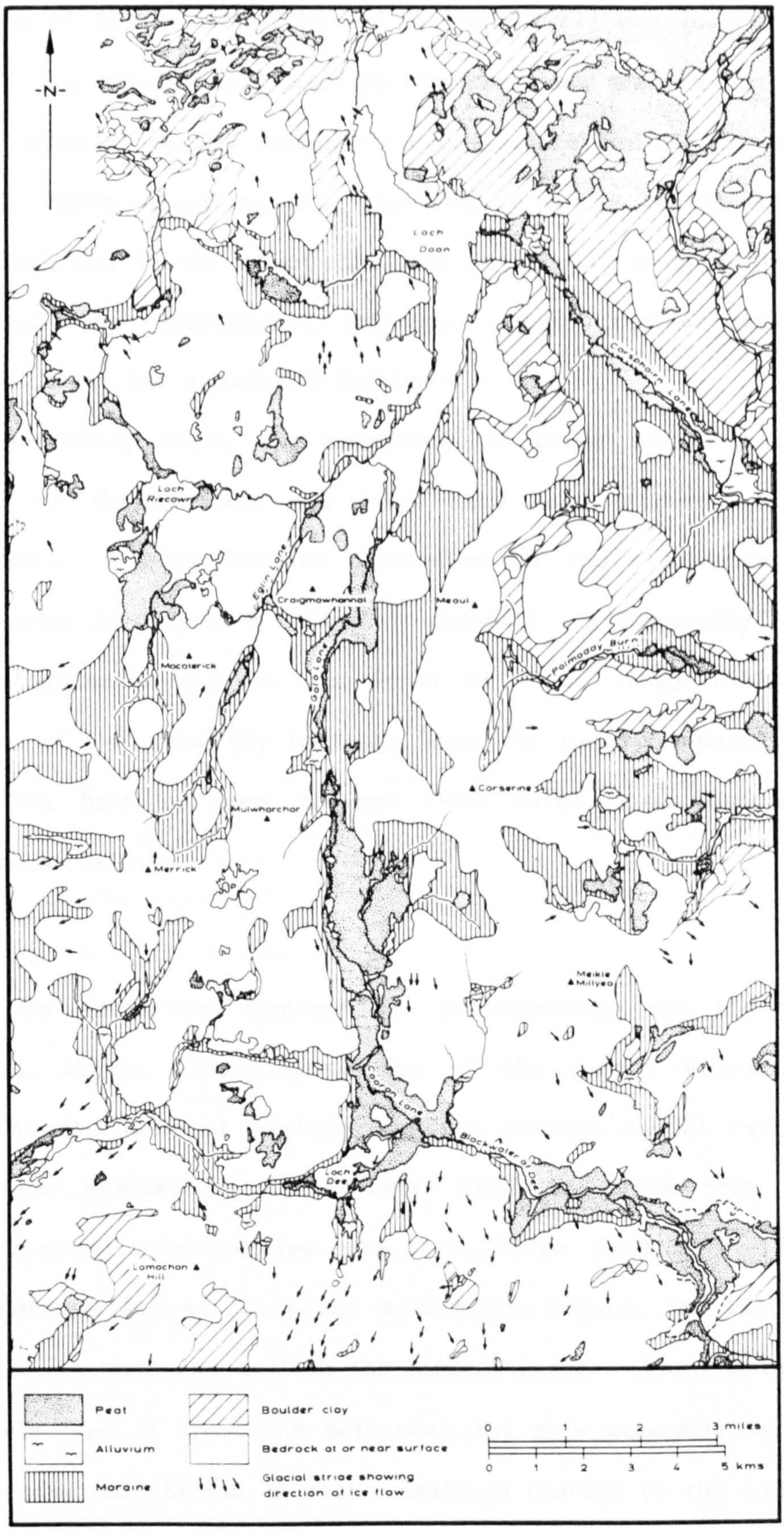


Fig. 3.6. Geological (drift) map of the principal study area. The extent of peat in the area of Clatteringshaws Loch (outlined by the dotted line) is as published by the Geological Survey (1893).

Stadial. One of the 11 identified by Cornish (1981) was located in the study area. The results of glaciation elsewhere are seen in the removal of soil (or material readily suitable for soil formation) e.g. on Craignaw (Bown 1973); valley deepening, e.g. the hanging valley behind Dow Spout (Boatman 1983); and in the material dumped as moraine or drumlins. Both the erosional and depositional processes have created sedimentary environments during the subsequent Holocene.

On the Solway coast, the deposition of carse sediments and the fluctuations of the Holocene sea level have been studied by Jardine (1975a,b; 1980). A more detailed discussion for the study area around Palnure is given in Chapter 8. Biogenic deposits are frequently found in the Solway sediments and on the Firth of Clyde (Boyd 1982). The configuration of the carse may form the locus for the development of deep peat (e.g. the Moss of Cree, Erdtman 1928; Racks Moss, Nichols 1967; Palnure, Jardine 1975a).

3.4 Climate

The winds over south-west Scotland are predominantly from the Atlantic (Bown et al. 1982). The physiography of the region determines the rainfall. At the head of Wigtown Bay the average annual rainfall is around 1200mm, whereas in the Galloway Hills it ranges from 1800 - 2000mm. The summits may receive more than 2500mm (Bown 1973, 17). The coast is characterised as 'warm and moderately dry'; in the Hills it is 'cool and wet' to 'cold and wet' on the highest ranges. The coastal areas are relatively free of frost and both here and more generally inland the influence of the Gulf Stream is felt. Stations nearest to the Loch Doon-Loch Dee basin recorded an average of 2229mm of rain annually (1964-79) at Loch Dee (238m); 1883mm for the same period at Clatteringshaws Loch (178m). The temperature records at the second station show that February

had the lowest mean daily temperature (1966-79) of 2°C. July and August have the highest of 13.3 and 13.4°C respectively (Boatman 1983, 169-171). At Palnure (15m), January was the coldest month (1964-71) with a mean of 3.3°C; July was the warmest at 14.5°C; and the mean annual rainfall (1916-50) was 1359.9mm (Bown and Heslop 1979). It is suggested that snow cover may be continuous for up to two months in glens, valleys and on high ground above 400m (Bown 1973). Below 60m the incidence of snow is likely to be less than 10 days annually (Bown and Heslop 1979).

3.5 Soils and peat

It is mainly the varied topography that has produced a diversity of soil types which for most of the area have had to be grouped in 'complexes' (i.e. they contain variations of soil type within an area of less than 5 acres [about 2ha]) and are thus aggregates of soils that are repeatedly present within the complex (Bown 1973). The morainic materials of rock detritus within the Dalbeattie (granitic) and Ettrick (Ordovician and Silurian greywackes and shales) Associations may promote very freely-drained soils, but the high rainfall has generally meant that leaching and gleying have proceeded to cause 'blanket' and 'basin' peat formation. The clay content and induration of the parent materials and local topography are important factors determining drainage. On the highest ground there are sub-alpine and skeletal soils. Elsewhere brown forest soils are uncommon, but a variety of peaty podsols and gleys are the forms intermediate between the brown forest soils and peat deposits. For the major soil sub-groups, the pH of peaty podsols is around 5.0; of peaty gleys it is 5.5 - 6.5 (Bown 1973, 224f.).

Boatman (1983) has assembled much of the information concerned with the nature of the patterned mires of the Silver Flowe. This lies in the valley of the Cooran Lane and is part of an extensive area of peat in the

study area. (Fig. 3.6). Ratcliffe and Walker (1958) originally identified 8 mires describing the transition from the resemblance to typical raised bog at the southerly end (Craigeazle) to the three at the north (ending by Round Loch), which are classed as typical blanket bog. All have the characteristic hummock and hollow complex whose reflecting pools have led to the name 'Silver Flowe'. In summary, the types were seen as differentiations within the overall classification of blanket bog, rather than raised bog. The mires were considered not to have originated as lake or fen communities and their surface convexity to be dependent on the configuration of the drift, as opposed to more rapid growth at their centres. Bown (1973, 137) reports a maximum peat depth of 7.5m. The classification has been retained by Ratcliffe (1977a, 233), although Bown (1973, 140) considers fen (sedge and reed) peat to be present at the base of the Silver Flowe and suggests a reclassification as 'raised bogs'.

Birks (1972, 200) reports fen peat from the base of Snibe Bog, but she considers it of intermediate type in a developmental sense (after Ratcliffe 1964). This mire type occurs where there is little superficial water (Ratcliffe and Walker 1958, 430f.; Boatman 1983, 192f.). The hill peat is ombrogenous blanket peat (Ratcliffe and Walker 1958) and although there may be topogenous basin peat in hollows (e.g. Bown 1973, 129f.) this grades into the surrounding blanket peat and peaty podsols (cf. Ratcliffe 1977b, 258).

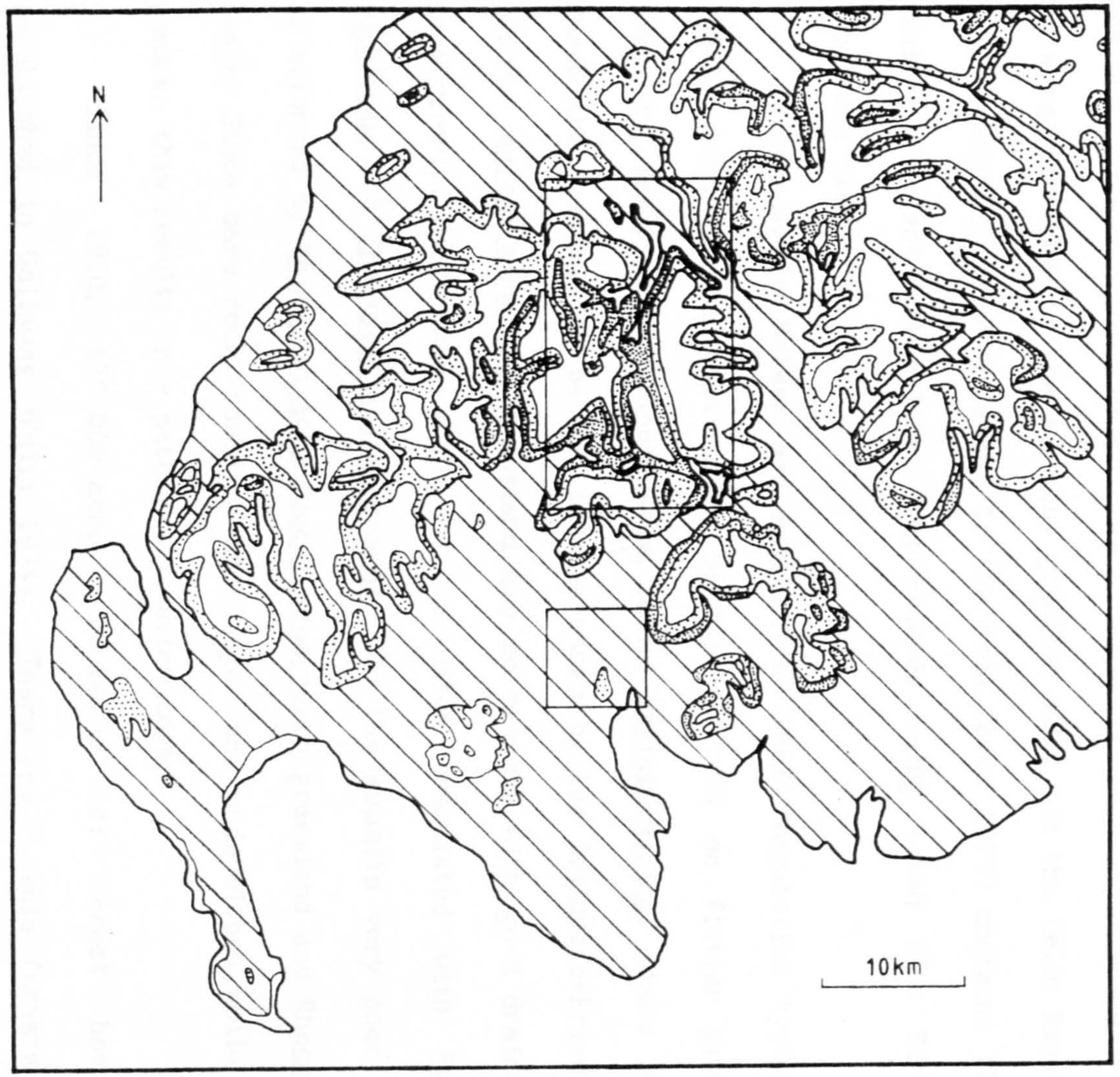
In addition to the Silver Flowe, the peat deposits to the south as far as Loch Dee have been surveyed by the Soil Survey (Bown 1973, 137). The peat to the south east of Ellergower Knowe (which is 400m north of Loch Dee, Fig. 5.8) is currently being investigated by Prof. R.S. Clymo. To the north of the watershed at Round Loch, towards the Gala Lane, most of the peat has not been surveyed (Bown 1973, 137). Continuing southeast from the Loch Doon-Loch Dee basin the distribution of peat is almost

unbroken to beyond Clatteringshaws Loch, which has flooded a large area of bog with subsequent loch-side erosion (Fig. 3.6).

3.6 Vegetation

As an indication of the possible climax vegetation of the Galloway Hills at lower altitudes, Birks (1972, 186) describes the oakwoods in ravines in Glen Trool, and the lowland woods at Glenlee and the Wood of Cree (9km to the south of Loch Trool). On the more acid soils of the first two the canopy dominants are Quercus petraea and Betula pubescens ssp. odorata commonly associated with Sorbus aucuparia and Ilex aquifolium; typical understorey dominants are Vaccinium myrtillus, Deschampsia flexuosa, Luzula sylvatica and Pteridium aquilinum; also Lathyrus montanus and Melampyrum pratense and acidophilous bryophytes. At the Wood of Cree the more basic soils there are reflected in the occurrence of Corylus avellana, Fraxinus excelsior, Ulmus glabra and the herbs Anemone nemorosa, Endymion non-scriptus, Oxalis acetosella and Primula vulgaris. Alder and willows are common. The Galloway Hills, and indeed all of south-west Scotland lie in the 'oak forest with birch' region of McVean and Ratcliffe (1962, Map 3). At a wider scale, south-west Scotland is included in Rackham's (1986, 69; 1988a, 5) Oak-Hazel Province which it shares with the highland zone of England and with Wales.

The tree-line of the oak-dominated woodland is estimated as approximately 300m (McVean 1964, cf. Map B, McVean and Ratcliffe 1962, see Fig. 3.7). Above this, a possible altitudinal zonation of pine then birchwood is drawn, with scrub of perhaps birch, hazel, rowan, and juniper at the highest level. Birks (1988a) includes poplar among birch and rowan as a likely component of uppermost woodland in western and southern Scotland. The altitude and nature of the tree-line would have varied, the presence of a zone of pinewood may have been restricted, depending on soil



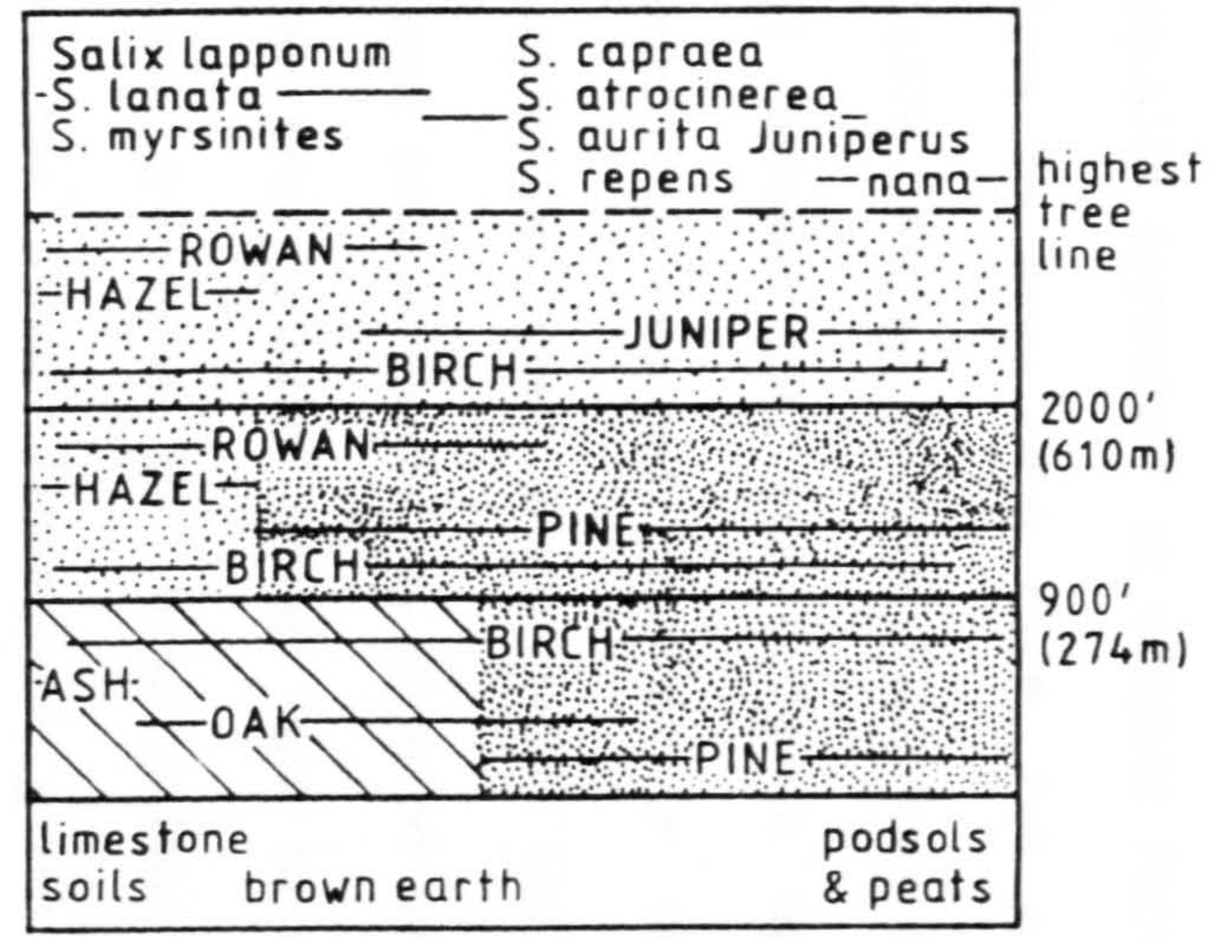


Fig. 3.7. Reconstruction of the climax forest of south-west Scotland (after McVean and Ratcliffe 1962, the key applies to the whole of Scotland).

type or encroachment of wet peat and the composition of higher scrub equally dependent on edaphic factors. Birks (1980) states the upper tree-line to have been 610m, but a later estimate is, more conservatively, >457m, (Birks 1988a). The map (B) of McVean and Ratcliffe (1962) depicts it between 300 and 600m in the Galloway Hills (Fig. 3.7), but even if unknown, exposed, rocky, or boggy areas would probably never have supported trees (Birks 1972, 186). It has been shown above, however, that much of the region is covered by peat and even where suitable soils exist for tree growth, sheep (and to a lesser extent deer) grazing and burning have prevented it. Descriptions of the vegetation of the patterned mires of the Silver Flowe are given by Ratcliffe and Walker (1958) and by Boatman (1983). The former also describe the vegetation of the 'intermediate' bog, of the adjacent granitic hills and the Kells Range. The Soil Survey Monograph relevant to the area (Bown 1973) contains floristic tables of plant communities, the relevés being taken from Birse and Robertson (1976).

Referring to McVean and Ratcliffe's (1962) vegetation types, Birks (1972) outlines the communities of blanket peat on flatter ground as commonly Tricophoreto-Eriophoretum, with Molinia-Myrica, where flushed. Where the drainage is better, this is shown by the Calluneto-Eriophoretum nodum. Agrostis-Festuca grassland may be present with good drainage and particularly on richer soils; it is often associated with Pteridium aquilinum and Thelypteris limbosperma. On the summits very poor grazing is afforded by Nardus stricta-Juncus squarrosus grassland and Rhacomitrium heath. Since bare rock, boulders and ledges and undeveloped soils may be common, this results in a patchy vegetation cover.

Since 1920, 220 000 acres (89 000ha) of forest have been established in Galloway (Edlin 1974). There are 7 main forests in the Galloway Forest Park, which total 165 000 acres (67 000ha, McCormick

1974). Most of the trees are coniferous. The main study area is covered by at least a part of 5 of these forests.

3.7 The development of Flandrian vegetation in south-west Scotland (Fl I and Fl II)

Although more recent pollen diagrams are subdivided on the basis of their pollen stratigraphy into pollen assemblage zones, it is convenient to discuss the stratigraphic records with reference to the Godwinian scheme since a number of diagrams are originally so zoned (see Bennett 1988a for a review of its use). The Flandrian vegetational history is also divided into stages whereby Flandrian I (Fl I) corresponds to Godwin's zones IV, V, and VI; Fl II to VIIa and Fl III to VIIb and VIII (see West 1970). The sites of previous palynological investigations in south-west Scotland are shown on Figs. 3.8. and 3.9.

The diversity of sediments sampled for pollen analysis, the sizes of their catchment and how the percentages are expressed makes direct quantitative comparison between sites impossible, but the relative abundances at each site give an indication of the relative significance of the woodland taxa and timings of expansion. For historical reasons Corylus has been excluded from the AP sum (Faegri and Iversen 1975, 193), but should be regarded as a principal member of the Flandrian woodland, especially early on (cf. Rackham 1980, 204; 1986, 68). The differences in the parent materials for soil formation are factors of central importance to the development of the woodland (e.g. McVean 1964, cf. Pennington 1986), as are altitude, aspect and climate. A recent study by Bennett (1986a) exemplifies how the possible differences in pollen representation can be understood in terms of the dynamics of developing woodlands on two sites of different substrate in close proximity. Some finer detail of relative expansions and the presence of taxa poorly represented before their main increases can only be achieved by having large pollen sums (cf. Bennett

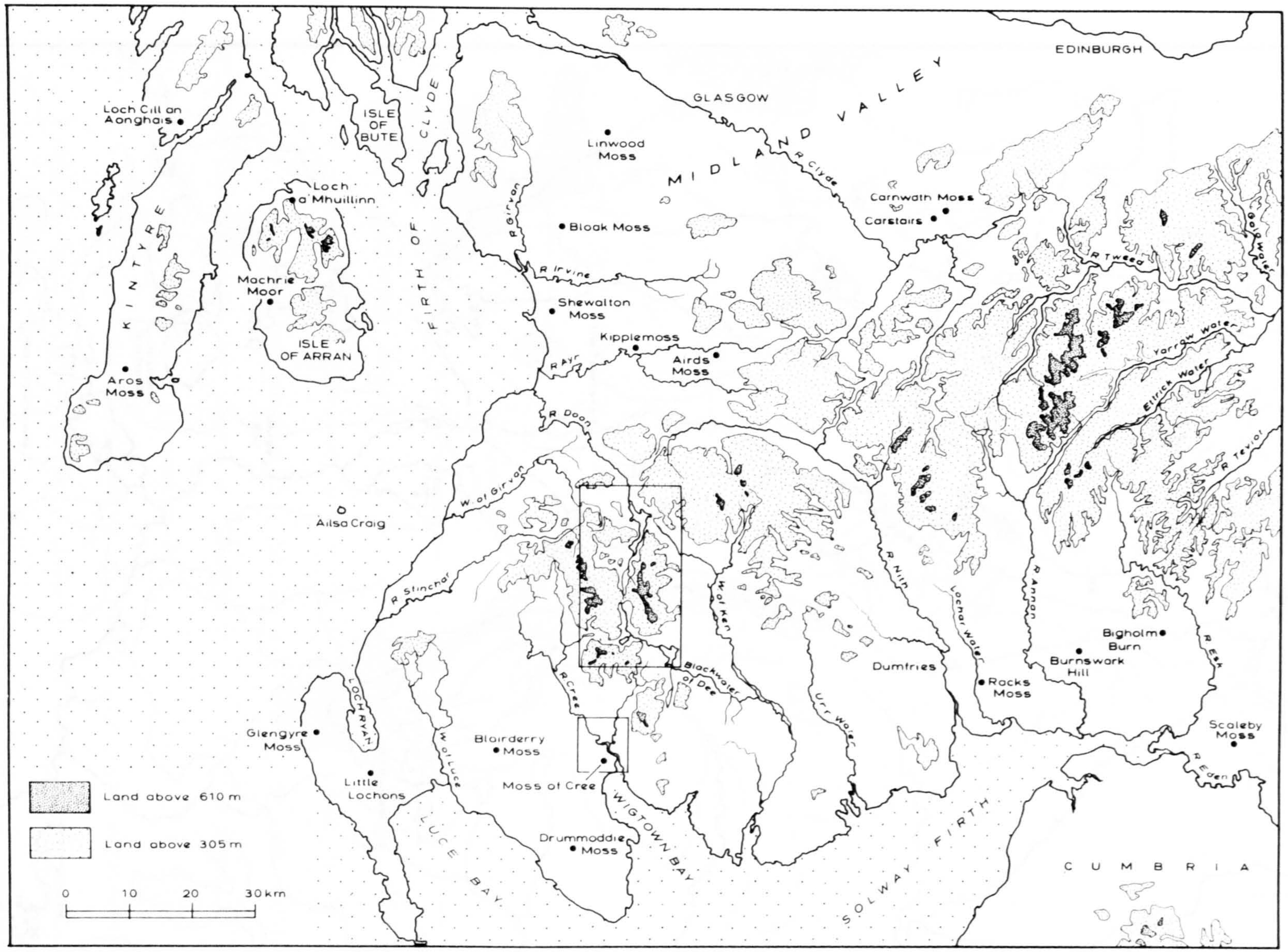


Fig. 3.8. Map of sites of previous pollen-analytical studies in south-west Scotland, outside of the principal study area, and part of north-west England.

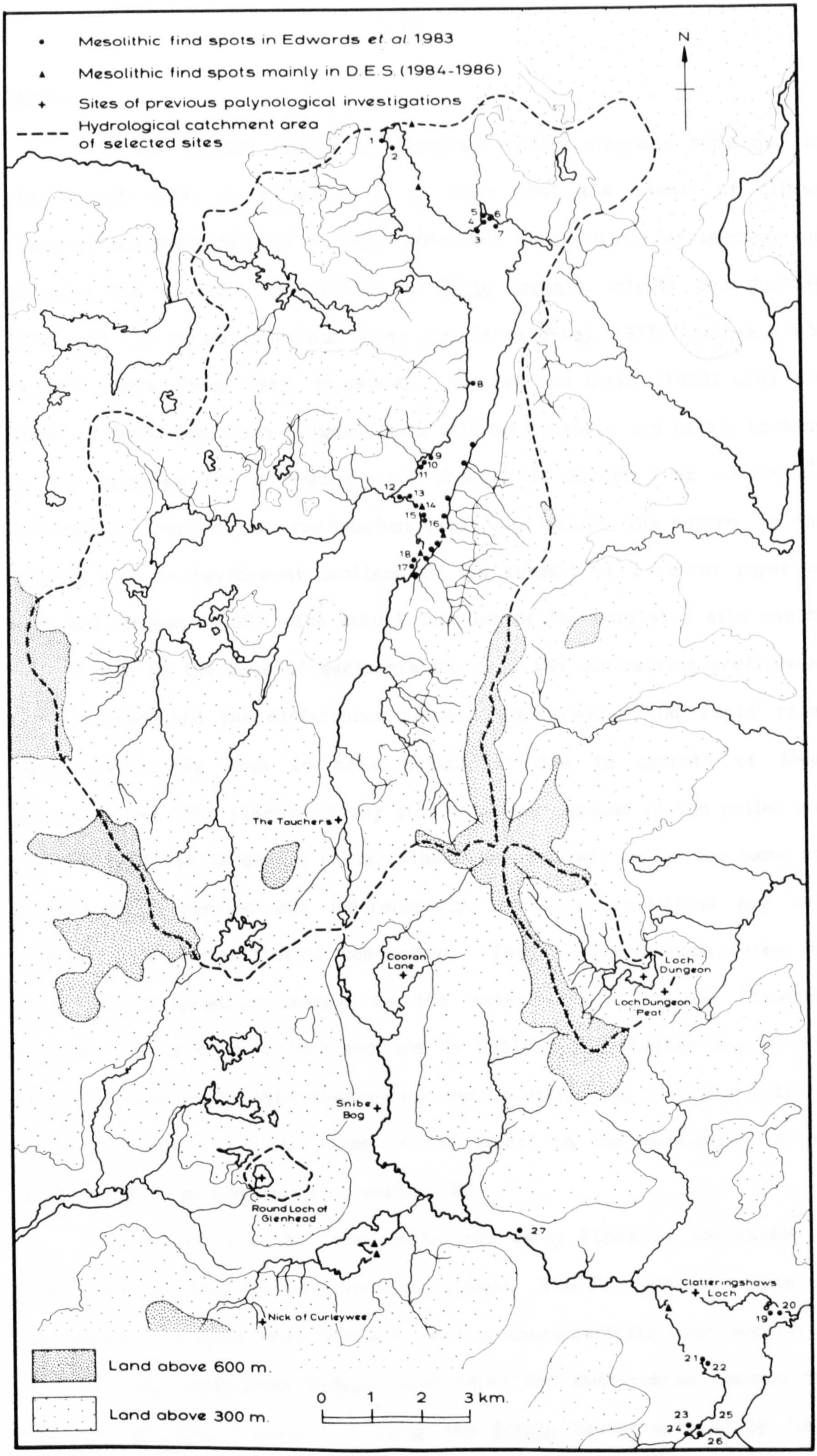


Fig. 3.9. Map of the distribution of Mesolithic finds, hydrological catchments of lochs cored for palaeoecological investigations, and sites of previous pollen-analytical studies within the principal study area.

1986b).

With the greater number of Flandrian pollen diagrams published in the British Isles as a whole it is clear that the mosaic of climax Flandrian woodland depends on major potential distributions of species, for instance the northern restriction on Tilia cordata (Pigott and Huntley 1978) and the variation within these (cf. Birks et al. 1975; Rackham 1986; Bennett 1988a; Birks 1989; in press). Huntley and Birks (1983) used the sites of Snibe Bog, Loch Dungeon, Loch Cill an Aonghais and Little Lochans in the database for phytogeographic changes in Europe from 13 000b.p., although the number of radiocarbon datings is small. The nature of the Corylus rise in south-west Scotland is the subject of a recent paper of Boyd and Dickson (1986). The actual duration of the rise at a site may be in part due to the rate of sedimentation (e.g. the contrasting profiles at Loch Dungeon) and the differences between the 'gradual' and 'rapid' rises (Moar 1969) may also to some extent be due to aspects of local sedimentation. The placing of any zone boundary depends on the pollen sum employed and the threshold value. These are unlikely to be the same for investigations carried out independently and local conditions may well prohibit direct quantitative comparison. The few radiocarbon dates for major phytogeographic change in the establishment of the Flandrian woodland of south-west Scotland are in Table 3.7. Whether any of the features observed in this development can be attributed to human activity or whether there are any signs of his impact on the vegetation at any scale is left for discussion in section 3.8.

An insight into the late-glacial and early Flandrian vegetation of south-west Scotland is given by Moar (1969). The late-glacial vegetation was thought to have been treeless, with a characteristic open vegetation of Gramineae, Cyperaceae, Rumex, other herbs and dwarf-shrub communities, with the occasional grains of Pinus and Betula having arrived by long-

Table 3.7. Radiocarbon dates (b.p.) associated with significant events in the Flandrian forest history of south-west Scotland and part of north-west England (for the defining criteria of the events the pollen diagrams should be consulted). The locations of the sites are shown on Fig. 3.8.

Site (altitude, m)	*Corylus* r.	*Alnus* r.	*Ulmus* D.	Reference	Laboratory Code No.
Loch Cill an Aonghais (20)	9320+/-130	7490+/-110	5210+/-80	Switsur 1981	Q-1416,1415,1414
Linwood Moss (12)	9290+/-90	---	---	Boyd 1986	SRR-2028
Loch a' Mhuillinn, Arran (25)	8610+/-250	7290+/-120	5360+/-100	Boyd and Dickson 1987	SRR-2580,2579,2578
Machrie Moor, Arran (20)	8665+/-155	6630+/-130	4740+/-80	Robinson and Dickson 1988	GU-1427,1426,1425
Shewalton Moss (13); SM-81-I	9250+/-110	---	---	Boyd 1988	SRR-2025
Rhoin Farm, Aros Moss (11)	---	6910+/-90	---	Unpub., Edwards, pers. comm.	GrN-14667
Loch Doon (loch, 215)	---	>7160+/-240	4950+/-210	Unpub., this thesis	I-15176,15178
Loch Doon IV (220)	9280+/-140	>6500+/-90	4820+/-110	Unpub., this thesis	GrN-14663,13845,13847
Cooran Lane (274)	---	<7541+/-120 >6805+/-200	---	Birks 1975	Q-874,873
Snibe Bog II (250)	---	7290+/-70	4120+/-90	Unpub., Balmer 1987	GrN-14661,14660
Round Loch of Glenhead (300)	9280+3-80	>7250+/-70	---	Jones *et al.* 1986 & 1989	SSR-2828,2821
Loch Dee Peninsula Bog II (230)	8880+/-100	7540+/-70	4920+/-60	Unpub., this thesis	GrN-14131,14666,14665
Bigholm Burn (160)	7735+/-115	5475+/-120	---	Moar 1969	Q-700,702
Scaleby Moss (34)	8905+/-136*	7354+/-146	4925+/-134	Godwin *et al.* 1957	Q-161 & 162,167,171

* calculated according to Olsson (1986)

distance transport. The rise of Betula was gradual at Bigholm Burn (160m) and the Nick of Curleywee (500m), initially occurring alongside the development of shrubby vegetation represented by Juniperus and Salix. As it expanded it may have done so in the possible local presence of Corylus, Ulmus, Quercus, and Alnus at Bigholm Burn. However, the pollen of these trees may have come from a greater distance. At Little Lochans (25m), birch was established more rapidly.

The basal sediments of Loch Dungeon (305m, Birks 1972) show the open grassland of the end of the late-glacial, followed by the post-glacial succession of Juniperus to increased Salix and Betula (cf. the pollen stratigraphy of Round Loch of Glenhead, at 300m, [Jones et al. 1989] and Shewalton Moss, at 15m, [Boyd 1988]). The Cooran Lane (274m) sequence also demonstrates the invasion of open and shrubby habitats by Betula woodland (Birks 1975).

It was considered that there was a relatively rapid amelioration of climate following the late-glacial period, allowing the spread of pioneer trees and shrubs (e.g. Betula, Populus, Salix and Juniperus; Moar 1969, cf. Huntley and Birks 1983). This conclusion is confirmed from the inference from beetle assemblages that a climate at least as warm as the present day prevailed by about 9500 b.p. in south-west Scotland (Bishop and Coope 1977). The rapidity of change, within c.500 years, is also graphically shown in a recent synthesis of results from the British Isles as a whole (Atkinson et al. 1987).

According to Moar (1969), the rise of Corylus was not generally the rapid event seen elsewhere, except at Little Lochans, situated in an area of calcareous soils. The establishment of mixed-oak forest proceeded as Ulmus, Quercus, and Alnus expanded (or immigrated), but Betula continued to be important. Pinewoods were probably not extensive. The vegetation around the site at the Nick of Curleywee apparently remained to some

extent open throughout this time, although Birks (1972, 207) believed there to be insufficient evidence for plants of treeless montane habitats and that there may have been a more or less complete canopy of birch here.

The transition from the late-glacial to the Holocene is not covered in diagrams (based on AP totals) from the two lowland 'basin-peat' sites published by Nichols (1967). At Aros Moss (11m), Kintyre, zone IV assemblages are present, a rapid rise of Corylus to high values is seen, and Pinus is of significance prior to the Elm Decline, especially in zone VI. At Racks Moss (14m), the sequence begins after the Corylus rise, when both Quercus and Ulmus are present, and Pinus achieves very high values in zone VI, whilst Betula is low. The sequence is interrupted by marine clay of the main Flandrian transgression, after which it continues in zone VIIa. The diminution of Betula to negligible values accompanies a rise in the mixed-oak forest.

More recent studies from lowland sites in south-west Scotland (Loch Cill an Aonghais [20m], Peglar in Birks 1980; Machrie Moor [20m] - Robinson 1981, 1983a,b, Robinson and Dickson 1988; Loch a'Mhuillinn [25m] - Boyd and Dickson 1987) are divided into local pollen assemblage zones (cf. West 1970; Holland et al. 1978). They are sites of a small lake, basin bog and of a further small lake having a complex stratigraphy (limnic to terrestrial) respectively. The diagrams are all based on the sum of TLP and include the rise of Corylus. Pinus appears not to have been of sustained importance in the catchments of all the sites, with only brief expansions from low values before the Elm Decline (cf. Birks 1980). There are small rises of Alnus before the B.A.T. (Boreal-Atlantic Transition [zones VI/VIIa]) at each site.

The pollen analysis of three short profiles in the area of Shewalton Moss (15m, Boyd 1988) shows rises of Coryloid, though it is not pronounced in core SM-81-I and at a comparatively low value in the

topmost spectrum. At SM-81-I and Dundonald Burn it is well documented. The significant amounts of Alnus pollen at SM1-81-I (especially) and SM-81-II prompted the suggestion of some disturbance of the peat. However, there is Alnus present at the presumably earlier part of a Corylus rise at SM-81-II, and at SM-81-I, before or within the sample that returned an accepted date (Boyd and Dickson 1986; see Table 3.7). At Dundonald Burn some Alnus occurred before the Corylus rise, but the later peak is from a peat pebble which was not in situ.

An additional lowland site, Linwood Moss Wood (basin peat at 12m, Boyd 1986) records a gradual Corylus rise as Corylus dominates the TLP. Alnus is present for a few levels before the major rise of Corylus. There is a hiatus beginning before the B.A.T. lasting until the 4th millennium b.p., caused by the mid-Flandrian marine transgression.

Investigations in the uplands of south-west Scotland have been concerned with the post-glacial vegetational history of the Galloway Hills, with particular reference to the history of pine in the area (Birks 1972, 1975); and to the problem of lake acidification (e.g. Flower and Battarbee 1983, Jones et al. 1989). As with the lowland sites, different types of deposit have been analysed. Moar (1969) examined peat and inorganic sediments impounded by moraines at the Nick of Curleywee and The Tauchers (270m). Snibe Bog (250m, Birks 1972) may have affinities to a raised bog (see Sect. 3.5); whereas Cooran Lane (274m), Loch Dungeon Peat (396m) and Clatteringshaws Loch (210m) are blanket-peat sites (Birks 1975). Lake sediments have been taken from Loch Dungeon (305m; Birks 1972) and Round Loch of Glenhead (300m; Jones et al. 1986, 1989)

At Snibe Bog the base of the sequence post-dates the Corylus rise, but the pattern of Ulmus and then Quercus expanding close together is as at Loch Dungeon. The Corylus rise is represented differently at the two cores taken there. The Alnus curve at Snibe Bog has a 'tail' of values of

at least 5% AP preceding increased values, whereas at Loch Dungeon the values before the rise are much less. At both sites Betula declines at the increases of Ulmus and Quercus, and then Alnus. Pinus is of major significance during parts of the Boreal and Atlantic. The profile from the Round Loch of Glenhead (based on TLP, Jones et al. 1989) includes a rise of Corylus, then shows Ulmus and Quercus expanding close together, followed soon after by Alnus. Pinus is important as at Birks's sites, but Betula declines more markedly after Quercus and Ulmus are established.

Of the blanket-peat sites (Birks 1975, Sum AP, AP and Corylus), each with Pinus stumps in the stratigraphy, the Cooran Lane diagram shows the start of higher values of Ulmus and Quercus as occurring approximately simultaneously at the end of the gradual rise of Corylus. At Loch Dungeon Peat, the sequence begins after the Corylus rise, the representation of Ulmus is significantly higher than Quercus achieving >30% AP at one level before the latter expands. Before the expansion of Alnus , it may be present at about 5% AP. Finally, at Clatteringshaws Loch, the youngest profile of the three, Alnus starts to rise from the basal sample.

Analyses (based on AP) of 7 sites were used by Durno (1976, 1979) to generally characterise the Flandrian vegetational history of part of south-west Scotland and more widely. Of the four basin mires discussed in Durno (1979), one has a sequence beginning after the Alnus rise (Moss of Cree, 13m: comparison with Moar's [1969] diagram from this bog suggests both profiles begin in the sub-Boreal). The second sequence begins at about the B.A.T. (Blairderry Moss, 100 m), where the percentage of AP of TLP (including Corlyus) is close to 100% for some time. The third site (Drummoddie Moss, 40m) has a history beginning after after the start of the Ulmus and Quercus curves. Before the Alnus rise at there is a significant amount of Alnus pollen and a peak of Pinus just before the B.A.T. At Glengyre (75m) the Corylus rise is demonstrated at the base of

the profile.

Features of the three diagrams published by Durno in 1976 are as follows. Airds Moss (200m, see also Durno 1956) has a pollen stratigraphy starting after the Corylus rise, but the beginning of the Ulmus curve and its continuation at appreciable levels long before the Quercus record begins in the profile may be noted, as may the much lower percentages of the latter. Before the B.A.T. Alnus shows numerous small expansions beginning at the base of the core. Betula and Alnus dominate the assemblages of zone VIIa at Carnwath Moss (220m, see also Fraser and Godwin 1955); the B.A.T. being placed close to the base of the sequence. Pinus is never much more than 10% in Fl II. The Kipplemoss (90m) diagram has widely spaced samples. The Corylus rise is recorded near the bottom after which Pinus is at 30% at two levels. Alnus has a continuous presence of some duration before the B.A.T., when both Ulmus and Quercus are very low. Betula is the most recorded tree until succeeded by Alnus during zone VIIa.

Compared to Moar's (1969) summary of the development of the postglacial forest, the transition from the open late-glacial conditions to communities having a shrub element to be succeeded by birchwood is seen to be similar in later work at Loch Dungeon, Round Loch of Glenhead, Cooran Lane and Shewalton Moss. However, the importance of birch may have eventually become less than he suggested as the mixed-oak forest was established (e.g. at Aros Moss, Round Loch of Glenhead and Snibe Bog). Distinctions in the rate of the expansion of Corylus are especially difficult due to its early position in Holocene sediments. Ulmus and Quercus pollen is indeed present from an early stage in the Flandrian record after the Corylus rise. It varies as to which has the higher representation first, but their earliest expansions are often not widely separated. There is an earlier expansion (and sustained higher values) of

Ulmus at Loch Dungeon Peat and at Airds Moss the record of Ulmus begins well before that of Quercus, which is poorly represented.

The discontinuous presence of pine in the woodland is probably confirmed; Moar (1969) drew attention to the large amount of Pinus in the record at Racks Moss, though he only found Pinus pollen in any quantity at upland sites and at Bigholm Burn. Birks's (1972, 1975) diagrams show the importance of pine at upland sites. Boyd and Dickson (1987) point out that there is a peak of Pinus pollen occurring just before the B.A.T. at many sites in south-west Scotland; Loch a'Mhuillinn, Machrie Moor, Drummoddie Moss, Glengyre Moss and Kipplemoss may be instanced. However, Boyd and Dickson (1987) and Robinson and Dickson (1988) qustion whether Pinus was actually present on Arran (cf. Bennett 1984, 144). A number of sites, both from lowland and upland locations have percentages of Alnus pollen suggesting its presence long before the main rise. The mixed-oak forest, seen as a mosaic of (tree) communities by Moar, evidently had a variety of types of woodland with elm and oak of differing status, the possibility of pinewoods, and perhaps the restricted presence of alder. Hazel and birch were likewise subject to competition and had varying success.

3.8 Anthropogenic impact on the Flandrian vegetation of south-west Scotland.

The tentative suggestion of Nichols (1967, 176f.) that small-scale destruction of woodland by Mesolithic people (perhaps using fire) at the B.A.T. at Aros Moss, Kintyre, was partly based on the two declines of Betula pollen, which are followed by peaks of Corylus.. At the first reduction of Betula there are small peaks of Ericaceae; at the second is a marked rise of Gramineae and lesser increases in Rumex and Pteridium. Of the trees, Alnus expands at the earliest Betula decline, with Corylus. It is maintained that the curves of Quercus and Ulmus are unaffected by the

change, although it could be argued that the initial reduction of Betula may be due to the relative increase in Quercus then subsequent Alnus rise. Pinus approximately reciprocates Betula in its representation; the second Betula decline is similarly accompanied by a rise in Quercus, which is followed by one of Alnus. Charcoal was not recorded. The nature of the evidence for disturbance is in keeping with that at other coastal sites, according to Jones (1988, 98), who also includes Racks Moss as representative. The record from this site was not commented on by the original author in this respect. The late Atlantic peaks of Corylus, Gramineae and presence of Pteridium may be the evidence for this interpretation. Edwards and Ralston (1984, 22) accept only the second of the phases of reduced Betula as indicative of possible clearance evidence, presumably because of the coincidence of the NAP types, although a larger Calluna peak occurs during the first phase. They draw attention to a fall in Corylus rather than the peaks on either side of this, to which Nichols (1967, 177) pointed. Morrison's (1982, 10f.) caution concerning any correlation of the nearby Mesolithic artefacts with such palynological evidence is noted.

Three pre-Elm Decline cereal-type grains where found at Rhoin Farm, Aros Moss (McIntosh 1986, Edwards and McIntosh 1988). The core was taken much nearer the edge of the bog than that of Nichols and contiguous 1cm thick samples were prepared; 2000 - 8250 grains were scanned at each level. The technique (see Edwards et al. 1986) was also applied on an additional profile (Moorlands) from Machrie Moor, Isle of Arran referred to below. Birks (1975, 203) considered that forest clearance began in the Neolithic in the Galloway Hills, but at Cooran Lane discovered evidence for burning of the local vegetation before this time at c.7541±120 b.p.

Microscopic charcoal fragments (>100μm) were encountered and the increase of Gramineae, with Succisa pratensis, Melampyrum, Pteridium, and Potentilla type in the local assemblage could be compared to elements in Swedish spectra, which suggested that fire had occurred. The evidence from Cooran Lane indicated burning of the peat favouring Melampyrum, Pteridium, probably Potentilla erecta and perhaps Molinia. Pinus replaces Betula in this zone, but overall the ratio of AP: NAP is not significantly affected. Mesolithic activity was thought to be a possible explanation, but the inland distribution of artefacts in south-west Scotland was unknown to the author and was not made more widely available until the publication of Edwards et al. (1983).

A summary diagram (based on total pollen) from Carstairs (225m, Dickson 1980) shows a dramatic reduction in the birch and hazel woodland during the pre-Elm Decline times (after the alder rise), the response in the curve of herb types is equally striking; these include maximum values of Melampyrum (670% AP), Papilionaceae (110%, mostly Vicia type), Potentilla (33%), Epilobium (30%) and Rhinanthus type (18%). Charcoal was found in the sieve residues of the pollen preparations at these levels (contiguous samples within 8 cm) and also in pre-alder rise samples, as well as those post-dating the Elm Decline. Burning of the birch woodland allowing the herbs to flourish is offered as an interpretation and it is speculated as to whether this was of anthropogenic origin. Since the core is from a small bog (about 70 x 150m) the pre-Elm Decline woodland reduction is likely to have been close by.

A quantitative measure was made of the area of microscopic charcoal from the early part of the profile from Machrie Moor, Isle of Arran (Robinson 1983b). Examination of its structure showed it to be of

Phragmites australis. The record of charcoal began at the Corlyus rise (8665±155 b.p.) and it was argued that a first episode of fire may have encouraged Corylus and Calluna, when the peat was of Phragmites and Carex. This implies that although the reedswamp vegetation was burned, the effects of fire may also be seen on drier ground around the basin. A second episode is recognised at a time when an expansion in Alnus before the B.A.T. occurs, which is coincident with an early presence of Fraxinus. Pollen of Plantago lanceolata (and Plantago undiff.), with Ranunculus is seen at this stage. The suggestion of Smith (1970) that Alnus may be advantaged by fire is referred to here, but the large expansion in charcoal apparent at the B.A.T. is not commented on. The sampling interval of the diagram is of the order of 100 - 300 years. Boyd and Dickson (1986) discuss the possible factor of man bringing Corylus nuts to the island. A gap of some 400 to 800 years separates the Corylus rise on Arran (there is another date for this, from Loch a'Mhullinn, of 8610±250 b.p.) and the earlier dates obtained from mainland sites of south-west Scotland. However, the placing of the Corylus rise in the pollen sratigraphy is of critical importance and Birks (in press) would have defined the rises as being lower in the profiles, thus negating the apparent gap. The third episode of human interference is identified in the fuller publication of the diagram (Robinson and Dickson 1988, 230). It seemed likely that it occurred in considerably less than 200 years at c.5750 b.p. It was not possible to necessarily attribute this to a Mesolithic population in view of the assignation of Neolithic activity elsewhere for this time; it is an example of the problem reviewed above (Section 2.2). McIntosh (1986) found 7 cereal-type grains before the Elm Decline at Moorlands, Machrie Moor; Robinson and Dickson recorded one grain dated to c.5375 b.p..

In contrast to the Machrie Moor evidence, charcoal (from sieve residues) is recorded from two pre-Corylus rise contexts at Shewalton Moss (Boyd 1988) as well as at the rise. Similar records are from Linwood Moss (Boyd 1986) just after the rise. McIntosh (1986) also found pre-Corylus rise charcoal (<180μm) at Rhoin Farm, Aros Moss; the focus of the work, however, is concerned with the charcoal record across the Elm Decline both here and at the additional site on Machrie Moor (Edwards and McIntosh 1988).

Jones et al. (1989) consider the occurrences of Plantago lanceolata, Plantago major, Bidens type and Fraxinus to be due to 'regional and local anthropogenic disturbance' around Round Loch of Glenhead during the period 6650 - 5450 b.p. and such is seen to continue in the period 5450 - 4200 b.p. The reduction in pine at c.5600 b.p. and rise of peatland indicators suggested that this may have been due to woodland interference by man. It was impossible to accurately identify the Elm Decline.

There is a clear Elm Decline at Snibe Bog, Loch Dungeon (Birks 1972) and at Bloak Moss (Turner 1965, 1970), but those for Racks Moss and Aros Moss (Nichols 1967) have fluctuating values for Ulmus (sum of dry-land AP and other taxa) with a more obvious decline somewhat later. At each of these sites there is no Plantago lanceolata at the initial decline, it is present in the second zonule of Birks (1972) at Snibe Bog and analogous assemblage zones at Nichols's (1967) sites, his A2. At Bloak Moss (76m, Turner 1970) the records in F1 II are part of the evidence for the clearance episode suggested by Evans (1975, 123). There are no dates for the Elm Decline at the sites. Dates from other locations are set out above (Table 3.7).

On the Isle of Arran at Loch a'Mhuillinn (Boyd and Dickson 1987)

there is Plantago lanceolata pollen just before the Elm Decline; as there is for a period before the event at Machrie Moor, subsequent to the debated third episode of Mesolithic activity (Robinson and Dickson 1988). At Loch Gill an Aonghais it is represented contemporaneously (Birks 1980). The Declines are well defined, which is not the case for Clatteringshaws Loch (Birks 1975), where a pine stump was dated to 5080±100 b.p. and the peat a little below it to 4815±80 b.p. Plantago lanceolata is continuously recorded from this time and twice previously after a date of 6820±180 b.p. Pre-Elm Decline occurrences may also be noted at Snibe Bog and Loch a'Mhuillinn.

It is not possible to generally characterise the land-use history of south-west Scotland from 5000 b.p. even making a distinction between that of the lowlands and uplands, because of the few sites investigated to this end and also because of the small number of dates available for any detailed division of sites or their correlation. Nichols (1967) proposed several zones within the post-Atlantic period of his two sites of Aros Moss and Racks Moss. He treated both sites together in this zonation believing parallel changes had occurred, but only had two fixed points for his timescale: the Elm Decline and the recurrence surface putatively equivalent to the 'Grenzhorizont' (Granlund's RY III), at that time dated to 800 - 400 b.c. The variability in the dating of such horizons is illustrated by Barber (1982) and the need to define them stratigraphically with accuracy is a point made by Turner (1981).

No cereal pollen was found at the Elm Decline by Nichols (1967), though it was considered that man was probably instrumental in its demise. This conclusion may be supported by the discovery of 17 cereal-type grains at Rhoin Farm, Aros Moss at the Elm Decline, and soon after, by McIntosh

(1986, Edwards and McIntosh 1988). After a period of forest regeneration, a greater degree of clearance took place in the Bronze Age; cereals were first discovered at levels corresponding to this inferred activity at both Aros Moss and Racks Moss. No correlations could be made between the zones following the 'Grenzhorizont' and periods of settlement.

Although an insular site, Machrie Moor is low-lying and near to the coast, situated just north of the Shiskine valley which would have been one of the most favourable parts of Arran for agriculture and settlement; the coastal distribution of chambered cairns is well known (e.g. Hunt 1987). In this respect its location compares with Aros Moss (a peninsular site), though Racks Moss is surrounded by less favourable land (Nichols 1967, 181). The Elm Decline date of 4740±85 b.p. for Machrie Moor is c.600 years later than the date at the north of the island at Loch a'Mhiullinn (Boyd and Dickson 1987; see Table 3.7), and some contamination by Phragmites may be the explanation (Robinson and Dickson 1988). The fall in elm values occurred within an estimated period of 120 years and a combination of possible utilisation of elm for fodder (cf. Troels-Smith 1960), causing vulnerability to fungal infection, and ensuing disease (cf. Rackham 1980) is thought to be the mechanism for this. Some restoration of woodland (including elm) follows the Decline, although agriculture is not altogether absent, and this activity is renewed (c.3950 b.p.) in Beaker times. A second sharp fall in elm, (and pine, perhaps a more regional representation) signals the beginning of further activity. This continues through the Bronze Age until tree pollen reaches its nadir, at a time of intensive activity when Plantago lanceolata achieves very large values (maximum 49% TLP) and several cereal-type grains are recorded, having been sporadically represented previously. By analogy with Irish vegetation

history, the deterioration of soils and the beginnings of blanket peat probably characterised the Bronze Age landscape in upland marginal areas. The record of charcoal during the post-Elm Decline period shows a significant reduction from the Decline until a rise in Bronze Age deposits. There was less agricultural impact through the Iron Age in the Machrie Moor catchment. Between c.100 - 750 a.d., a further reduction of agriculture is envisaged and contrasts with the extensive clearance inferred from mainland sites (Turner 1965, cf. Birks 1972), including the Lake District (between c.200 - 600 a.d., Pennington 1970, cf. Birks 1988a). More intensive land use in the Viking and early mediaeval periods is suggested (Robinson and Dickson 1988). Some restoration of woodland presaged a decline to low tree values, when both Pinus and Fagus occur, implying that sediment of the last 300 years may be present.

Following possible leaf gathering by Neolithic people (Turner 1970, 100), the 'landnam'-type clearances demonstrated from Bloak Moss (Turner 1965, 1970, 1975) occurred during the Bronze Age (from c. 1400 and 1000 b.c., Turner 1965); no cereal grains were associated with these. This type of 'small temporary clearance' was thought to persist in lowland Ayrshire during the Iron Age and until 'extensive' clearance was briefly made between c.450 and 580 a.d. The former scale of clearance typified any woodland destruction from this time until about the 18th century A.D., when the extensive clearance led to the present, largely deforested, landscape.

Boyd (1986) also comments on the possible indicators of woodland clearance in the lowlands from late Neolithic or early Bronze Age times in the areas surrounding Linwood Moss. The summary diagram from Carstairs (Dickson 1980) based on the sum of trees, tall shrubs and agricultural

indicators (mainly Gramineae, Plantago lanceolata and Pteridium) indicates that pastoral activity began at about the same time with cereal pollen not encountered until later in the core.

The pollen diagram best showing upland vegetational change is from Snibe Bog (Birks 1972). In a similar way to Nichols (1967), most of the post-Atlantic pollen stratigraphy is subdivided (on the basis of dry-land pollen), into zonules. These could not be imposed on the Loch Dungeon stratigraphy since it was less clearly differentiated due to the more diverse catchment. The pollen would have been transported by the inflow to the loch as well as at its surface, with the possibility of older pollen, soil and peat becoming incorporated into the sediment. Such inwash was not evident at the Elm Decline. In zonule 2, following the Decline, a small reduction of tree pollen and a slight increase of grasses and weeds was attributed to Neolithic activity and at Loch Dungeon it is likely that inwashed material is represented by the rise in indeterminable pollen. As for zonule 3 it is suggested that small temporary clearances (cf. Turner 1965) in various locations, at overlapping times in the Bronze Age were effected. Continued deforestation precedes the 'extensive clearance' (which is compared to Turner's 1965 assemblages) and although some regeneration may have followed, this was against a background of an increasingly open landscape.

The profile from the Round Loch of Glenhead (Jones et al.) 1989) has similarly-spaced samples to those of Snibe Bog, but there are reversals in the dates and no division of their zone 5 (4200 - 1905 b.p.) was attempted. Phases of increased disturbance of the regional woodland compared to previous zones were noted.

The site of a small mire to the northeast of Burnswark Hill (183m,

Squires 1977-1978) may be mentioned as providing evidence of charcoal and mineral inwash at a time when tree pollen is greatly reduced and herb pollen displays a reciprocal peak. This was interpreted as an anthropogenic change and by interpolation of two dates (widely separated in age: 5350±65 and 1489±55 b.p. centred on depths of 52 and 36cm), the decline of trees began at 2400 b.c. (4350 b.p.) with recovery commencing after 461 b.c. The presence of further inorganic material in the profile during the regeneration may mean that older pollen, belonging to a period of afforestation, was inwashed.

The uppermost two spectra from near Burnswark Hill show tree pollen to be less than 5% TLP and spores, which compare with the recent spectra from Bloak Moss (Turner 1965), Snibe Bog (Birks 1972), Clatteringshaws Loch (Birks 1975), and Machrie Moor (Robinson and Dickson 1988). Present-day samples from Carstairs have tree pollen of c.10 - 15 % TLP (Dickson 1980, cf. the recent sediment of Round Loch of Glenhead, Jones et al. 1989). Durno's (1979) sites of Moss of Cree, Drummoddie Moss and Glengyre Moss show comparable low percentages of AP with respect to TLP and the same trend is seen at Aird's Moss (Durno 1976), until some recent afforestation, evident at uppermost sample of the diagram.

3.9 Postglacial settlement of south-west Scotland with particular reference to the Mesolithic

The evidence for Mesolithic occupation in south-west Scotland including the Isles of Arran and Bute is reviewed by Morrison (1982). He draws attention to the few dated and excavated sites in the region and the unclear typological affinities that make comparison with other areas of the British Isles difficult. The earliest dates are of 8000±65 b.p. and

7935±110 b.p. obtained from charcoal derived from a hearth at Redkirk Point (5m, Masters 1981) on beach deposits which predate the main Holocene transgression (Bishop and Coope 1977). Morrison points out that the settlement of the early occupations at Mount Sandel and Newferry in the Bann Valley, Northern Ireland have dates in the 9th millennium b.p. (Woodman 1978), even if specific technological or cultural links cannot be made. No dating is available from the surface finds of the Tweed Valley, whose many microliths might suggest a narrow blade/later Mesolithic (after c.8500 b.p., Mellars 1974, 1976b) age. At the mouth of the river Esk, Cumbria the dates of 7380±370 b.p. and 6752±156 b.p. (this is preferred by the excavator, Bonsall 1981) from Eskmeals are clearly later than those at Redkirk. In spite of the lack of excavated Mesolithic sites in south-west Scotland and only one additional radiocarbon determination (from Barsalloch, 6010±110 b.p., Cormack 1970), Morrison (1982) notes that many sites have been discovered, particularly along the coast, since Lacaille's (1954) map.

Along the Solway Firth many of the sites are on the marine cliff above the main Holocene raised beach, suggesting occupation at the time of the maximum transgression. They are often situated near streams (Jardine and Morrison 1976). The sites of Low Clone (Cormack and Coles 1968) and Barsalloch are taken as typical, although there are only five excavated sites from the region. The occupants used natural and scooped hollows as camp sites, the stake holes perhaps those of a light shelter. The industry comprised a few microliths and burins, scrapers, awls and notched flakes, blades and points, and may have been part of the technology associated with coastal occupance and subsistence. It is possible that movement inland was made on a seasonal basis. Applying Mellars's (1976b) criteria

the excavated assemblages are characteristic coastal of sites. The settlement type at Low Clone (54.5 m^2) belongs to Mellars's Type II having a single well defined and evenly distributed scatter of artefacts, which is larger than the very restricted area of Type I and not part of an extensive grouping of scatters, Type (III).

The Firth of Clyde has an increased number of find spots, but there has been no systematic excavation of these or direct radiocarbon dating of associated material. Relative dating with respect to the main Holocene transgression has been reconsidered in the light of recent work on the raised sediments at Shewalton (Boyd 1982). Any number of early Mesolithic sites may have been submerged at various times by the transgression along the coastlines of south-west Scotland.

The inland distribution of sites along the terraces of the river Annan and Water of Ken are mentioned by Morrison (1982), and also the finds of hearth-like stone settings and the chert cores, flakes, blades, scrapers and few microliths at Loch Doon. More than 50 new inland locations of Mesolithic finds have been published by Edwards et al (1983). Further discoveries have been made since by Affleck (1983 - 1985) and these are shown on Figs. 3.9 and 3.10.

Concerning the possible clearance of scrub or woodland other than by fire, Morrison (1982, 11) finds 'no definite evidence for heavy equipment which might indicate the exploitation of forested areas'; there are a few references to possible axe or adze tips and 'tranchet' flakes.

The problem of survival and possible bias in the distribution of Mesolithic and Neolithic finds is highlighted by Hunt (1987, 5). The least suitable land for intensive use offers a better chance of preserving structural remains, but equally, especially under peat, the detection of

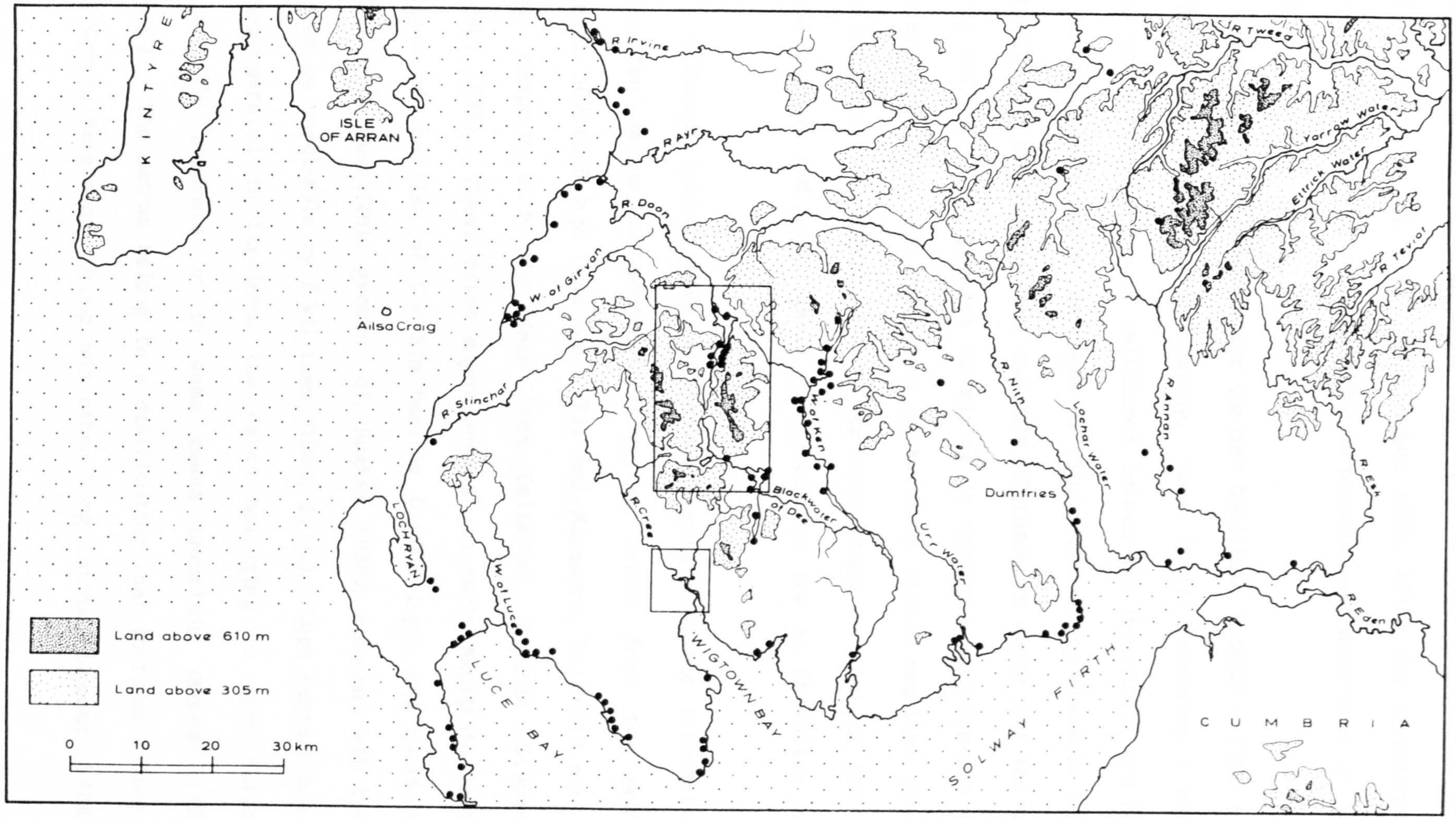


Fig. 3.10. Map of the distribution of Mesolithic sites in south-west Scotland (after Edwards et al. 1983).

artefactual evidence in particular, may be difficult. The uneven efforts of fieldworkers is also an important factor in this regard (cf. Stevenson 1975; Chambers et al. 1988, 392; Hughes 1988, 45). The circumstances of discovery of some inland Mesolithic artefacts are described in the next chapter.

Reviewing the evidence for earlier Neolithic (c.5600 - 4300 b.p./3650 - 2350 b.c.) settlement and economy, Hunt (1987) tabulates a number of sites where a continuity of settlement betwen the Mesolithic and Neolithic may be implied by the assemblages of flints containing elements from both cultures. He admits that the analysis of these is early and the typology poorly defined. The problem of mixing in unstable environments such as coastal sand dunes was emphasised by Morrison (1982) and Luce Sands is a case in point. Neolithic pottery has been found on most of the western raised beaches and particularly rich locations are at Shewalton and Luce Bay.

Although burials have not provided much economic information, the radiocarbon dating of contents from two cairns from the south-west (Lochill, 5070±105 b.p. [Masters 1973] and Monamore, 5110±110 b.p. [MacKie 1964]) compare with the date from Dalladies, Tayside, 5190±105 b.p. (Piggott 1972). These dates might suggest an early Neolithic settlement, at least by the time of the Elm Decline (c.5000 b.p.), and quite possibly contact with Mesolithic groups (cf. Hughes 1988); however, all three are rejected as unreliable by E.Williams (1989, 511f.). Such contact has yet to be demonstrated in Scotland, the dates belonging to each culture are statistically separate or in some cases uncertain (Kinnes 1985, see Sect. 2.2). The cairns belong to a distribution that includes cairns of the Clyde Group, Bargrennan Group and other Long Cairns (Henshall 1974). The

settlement they represent had penetrated the Southern Uplands of south-west Scotland along major route-ways (see Fig. 3.11a for their distribution more locally).

In the later Neolithic (4300 - 2950 b.p./2350 - 1000 b.c.), which overlaps with the conventional Early and Middle Bronze Age (Hunt 1987), the distribution of henges and stone circles into the south-west Southern Uplands follows that of the earlier cairns. Over southern Scotland generally, settlement appears to have occupied upland areas that are now unsuitable and were abandoned at a later stage, perhaps as a result of deteriorating environmental conditions. The conclusions are based on more than 3000 finds including 630 stone axes, 277 items of metalwork, and more than 1700 burials (see Figs. 3.12a and 3.12b for distributions local to the study areas). Precise contemporaneity cannot be assumed and the lack of radiocarbon dating renders any regional chronology impossible (Hunt 1987). Further detail on the Bronze Age round cairns is provided by Yates (1984) who includes an inventory. There is doubt about the antiquity of a cairn near to the study area (his NK 16), but the northerly distribution within the Ken Valley is seen as a real indication of prehistoric activity; there is one cairn (White Cairn, NK 19) situated in the valley of the Blackwater of Dee, less than 1500m from the south-west extremity of Clatteringshaws Loch; Carlin's Cairn (NK 12) at 808m is clearly visible from far around (see Fig. 3.13a).

There is a dearth of archaeological evidence by which to infer the reaction of the indigenous people to the invasion of new settlers and/or culture at the transition of the Bronze to Iron Age (Scott 1966). The distribution of hillforts in the Southern Uplands shows a concentration in the east, in the Borders, where there are a number of 'major' size

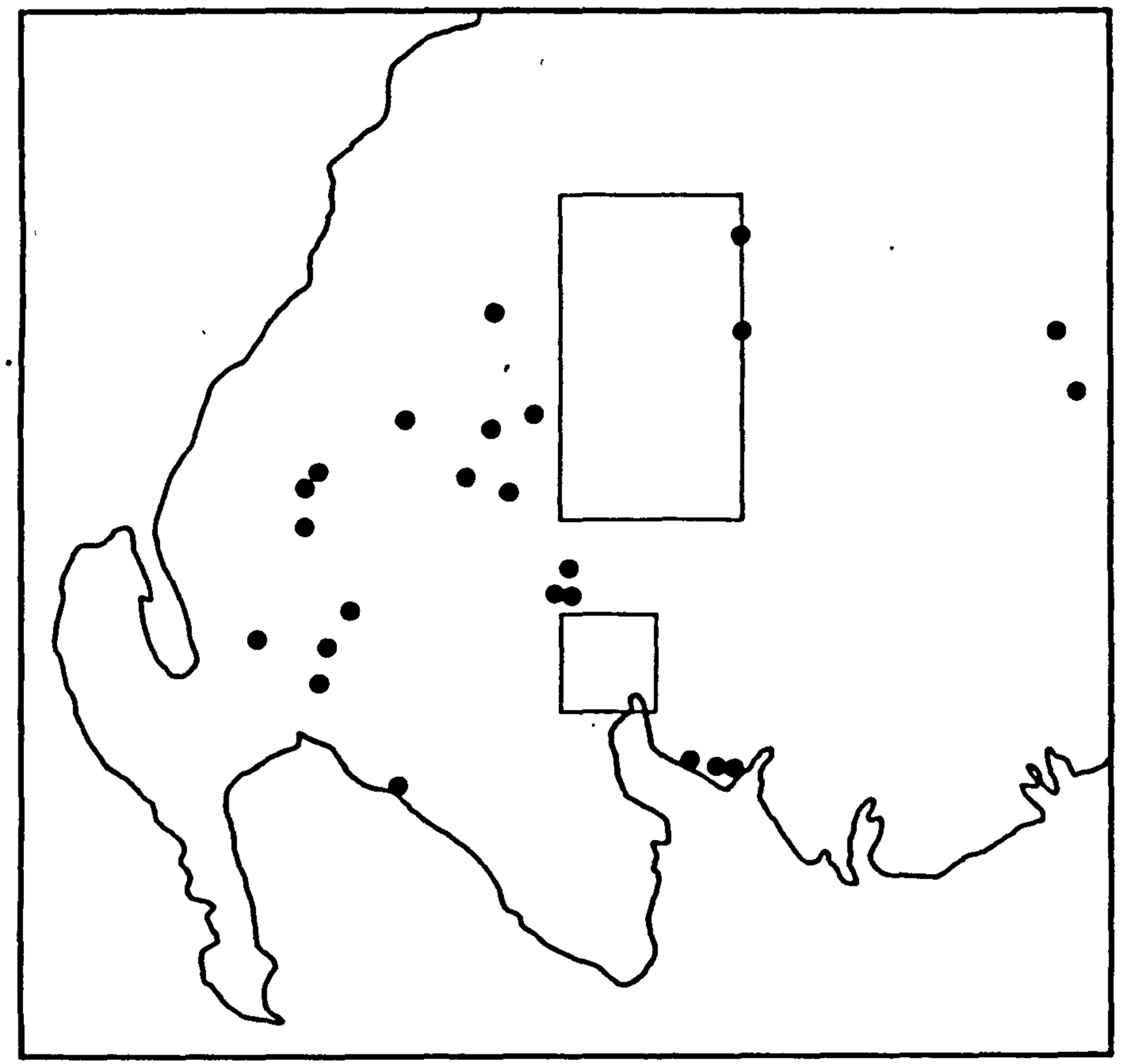


Fig. 3.11a. The distribution of Earlier Neolithic burials. (Both after Hunt 1987.)

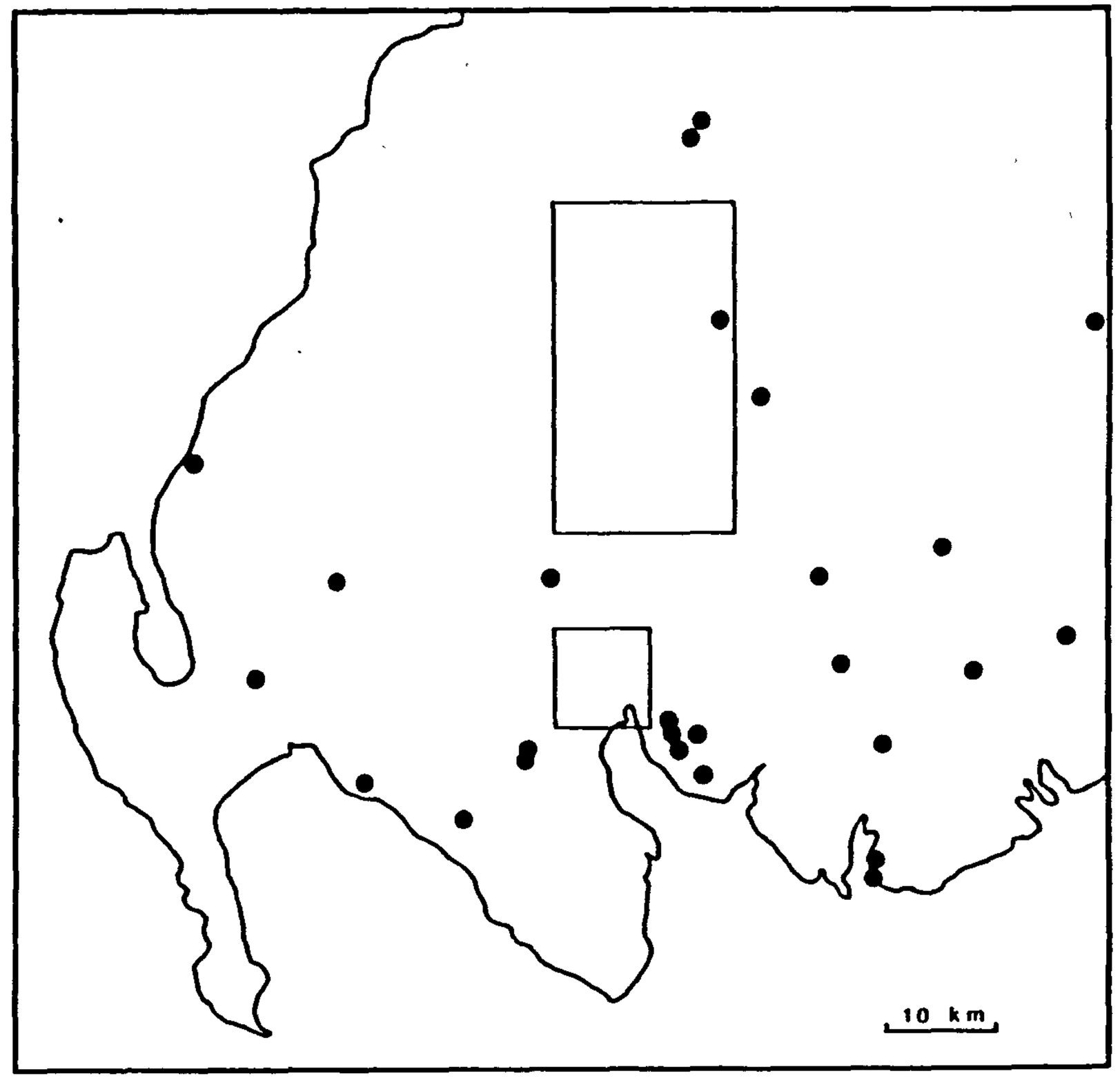


Fig. 3.11b. The distribution of stone circles.

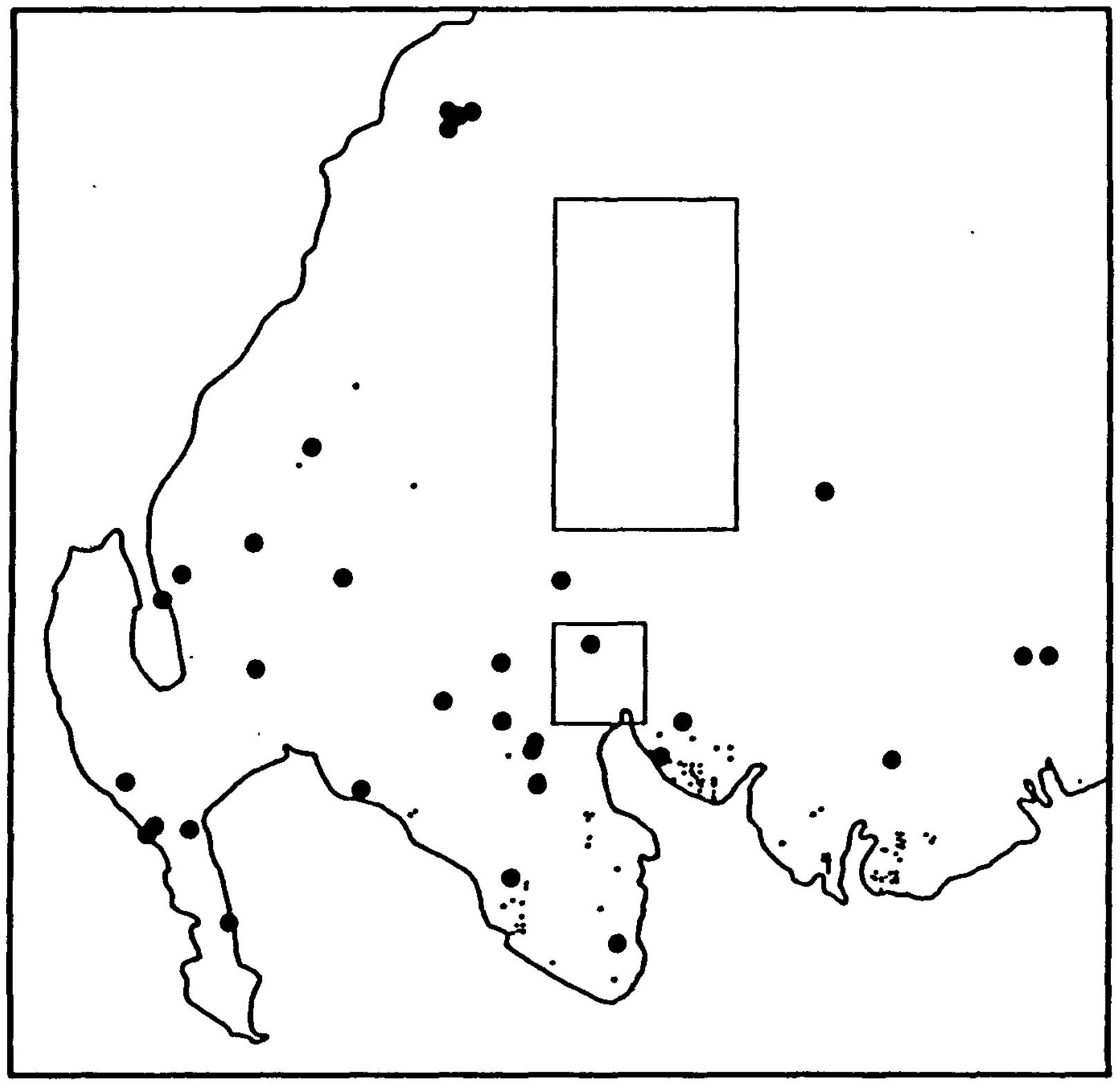


Fig. 3.12a. The distribution of standing stones (large dots) and cup-marked stones (small dots).
(Both after Hunt 1987.)

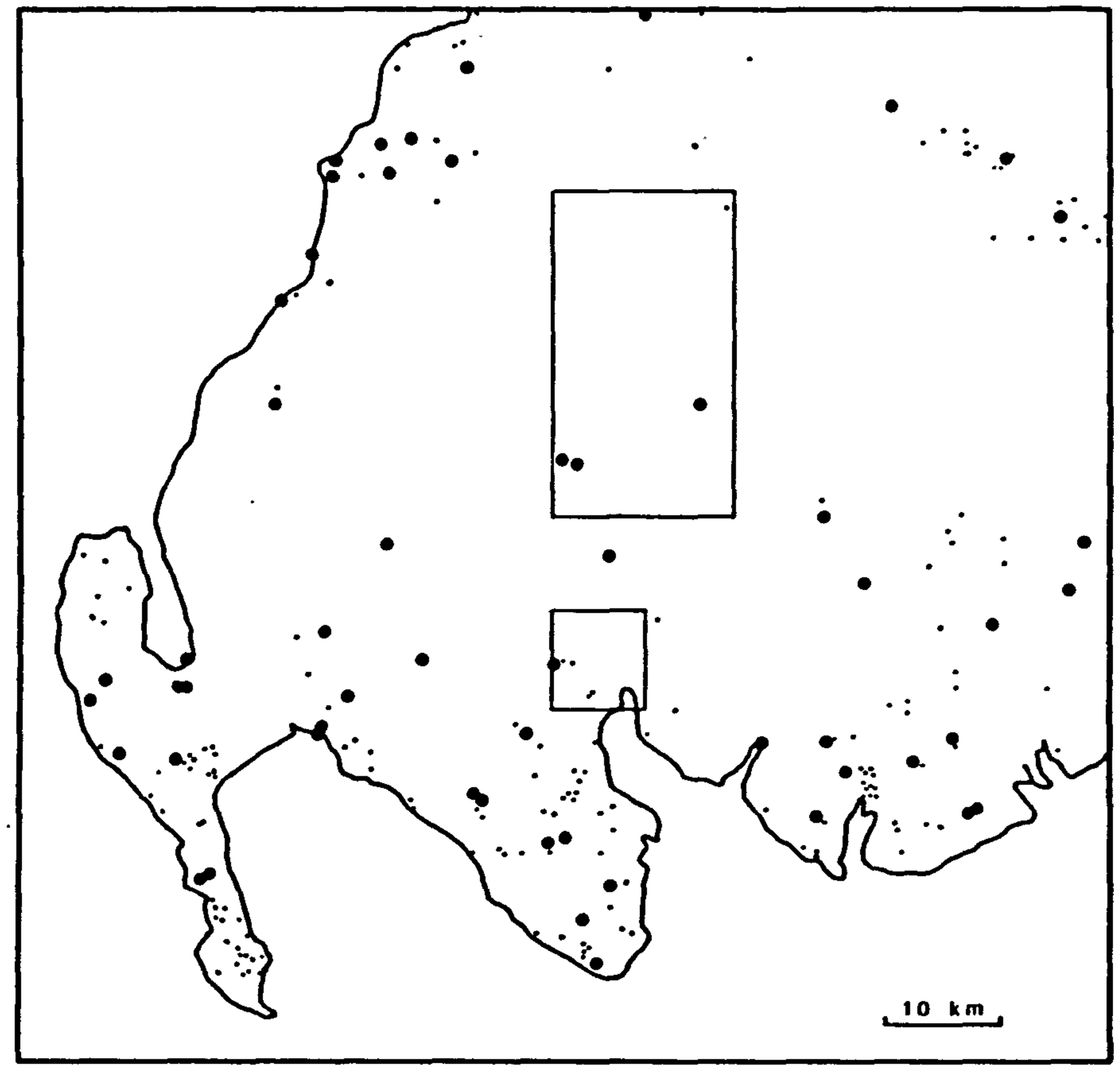


Fig. 3.12b. The distribution of stone axes (small dots) and bronzework (large dots).

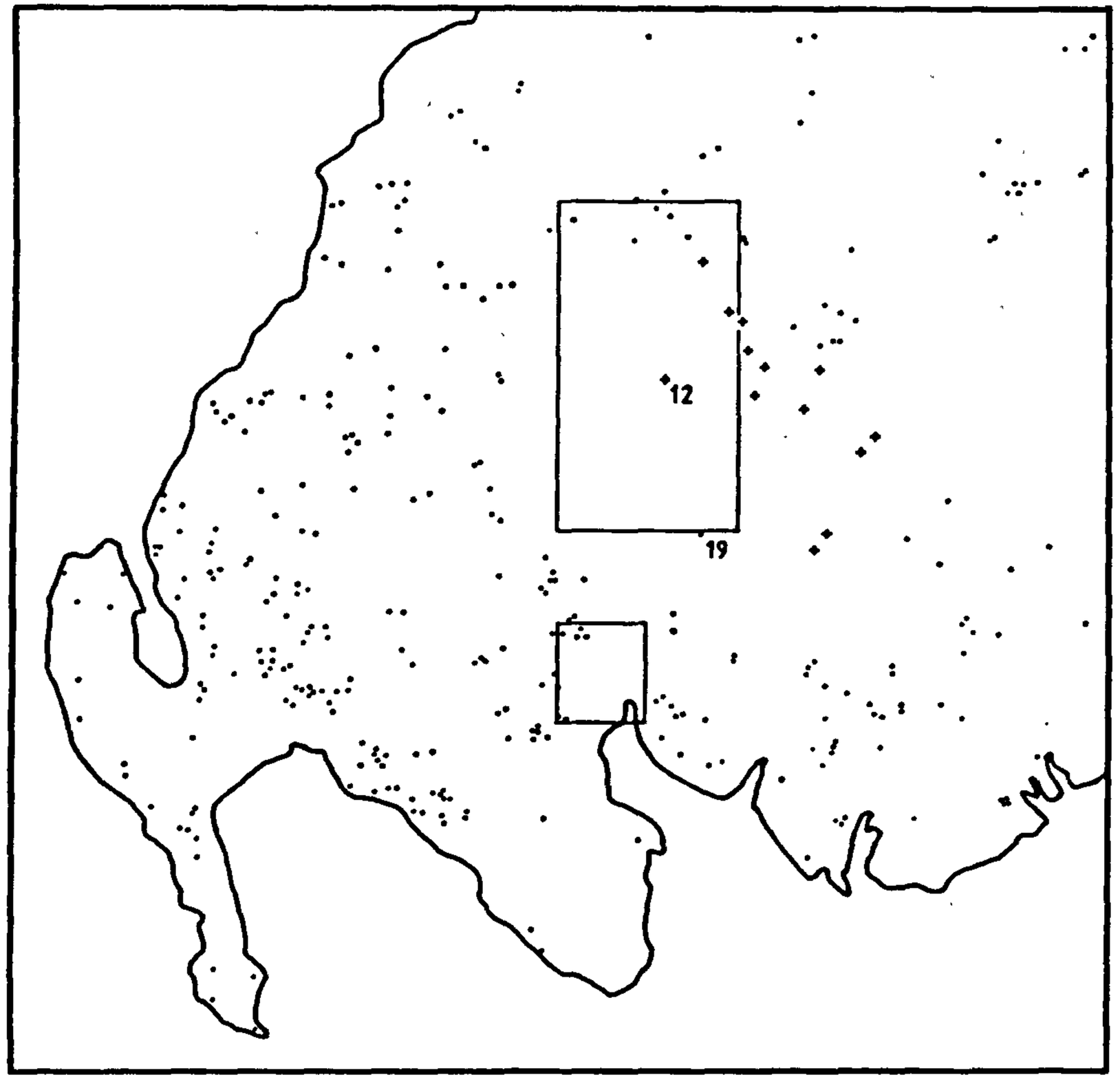


Fig. 3.13a. The distribution of cairns and cists (unaccompanied), shown by dots (after Hunt 1987). Additional cairns (+), selected from Yates (1984), show a penetration to the east of the principal study area extending to within it. 12 = Carlin's Cairn; 19 = White Cairn.

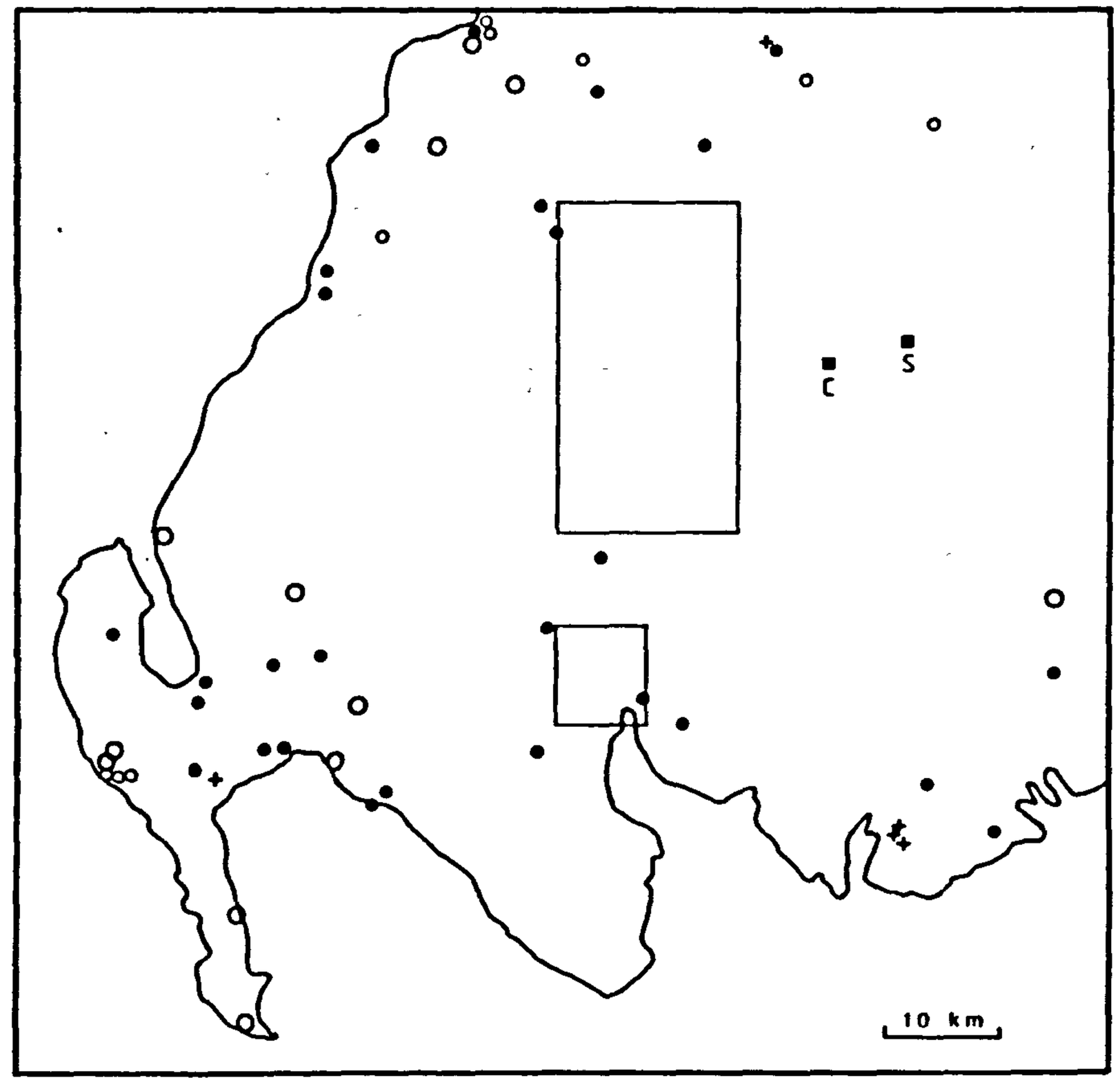


Fig. 3.13b. The distribution of accompanied burials (Bronze Age).
• = cinerary urn
o = urn
o = food vessel
+ = beaker (After Hunt 1987.)
Hillforts (▪), from RCHAM (1914): C = Carminnow
S = Stroanfreggan

(>3 acres [1.2ha] Rivet 1966; cf. Hogg 1975, 117), with the 'minor' forts becoming predominant in south-west Scotland, west of the river Nith. These are mainly distributed along the coast and in the lowlands. There are few brochs in this region. Close to the main study area two forts are recorded by the Royal Commission (RCHAMS 1914; see Fig. 3.13b). The hillfort at Burnswark Hill to the east of the River Annan dates from the beginning of the 6th century B.C. (Stell 1986).

The distribution of crannogs is essentially lowland or coastal (Morrison 1985, 10). Radiocarbon dating suggests that the crannog at Milton Loch was built in the middle of the 5th century b.c. and artefactual evidence shows later occupation in the 2nd century A.D. (Morrison 1985, 6-8). In his 'Notices' of evidence for crannogs, Stuart (1868) instances the finds of canoes at Loch Doon. A canoe found near Castle Island, Loch Doon has been radiocarbon dated at 509±110 a.d. (Mackie 1984). The hut circle at Moss Raploch, by Clatteringshaws Loch showed occupation dated, by two glass ring fragments, to have been in the 1st-2nd centuries A.D. (Condry and Ansell 1977-1978), but the nature of the Iron Age domestic settlement of this time is still relatively unknown (Stell 1986).

The impact on the landscape by the Romans (from 80 A.D. under Agricola) is seen in the road systems at Nithsdale and Annandale and the military structures such as camps, forts and fortlets. The most westerly of these is at Gatehouse of Fleet, although Roman influence is reflected in their cartographic knowledge of Loch Ryan (Stell 1986, 117) and in the cremation at Torrs Warren, Luce Sands (Breeze and Ritchie 1980).

The periods of the British kingdom of Rheged, Anglian, Gaelic, Norse and later settlement, with the establishment of Christianity are related in terms of the archaeological record by Stell (1986).

terms of the archaeological record by Stell (1986).

Within the upland study area, the castle at Loch Doon, removed from Castle Island prior to the raising of the loch in the 1930's, was first referred to in 1306 and belongs to a group of 13th-century castles (Stevenson 1985, 69), though MacArthur (1952, 23) recounts that it was built towards the end of the 12th Century. A mediaeval site on Donald's Isle, Loch Doon was excavated by Fairburn (1937) and a hoard of silver pennies was hidden in c.1335 on the north-east shore of the loch (PSAS 1973).

Enclosure began in the 18th century A.D. and as an example of a farm of this period, Stell (1986; 65,68) considers the township of Polmaddy, close to the confluence of Polmaddy Burn and the Water of Ken, to be perhaps typical. Founded from at least the 16th century A.D., the later enclosure walls may be seen with the ridges and furrows of earlier cultivation around. It was abandoned in the early 19th century.

Boatman (1983, 178-181) has little documentary evidence on which to reconstruct the extent of former forest around the Silver Flowe, but there were probably substantial areas of forest there, perhaps even in the valley of the Cooran Lane, until the Middle Ages. The method of muirburn was known at least as early as 1424, though in Scotland sheep farming was generally introduced in the reign of James VI (1567-1625) and muirburn practised to improve grazing. The technique was doubtless known to John McKie who from 1699 owned the forest of Buchan, part of which extended around the area of Loch Enoch to the west of the Loch Doon-Loch Dee basin. Reported to be one of the 'greatest grasiers in Britain' (Macky 1722), his flocks and herds would have had a marked effect on the regeneration of woodland and in Loch Trool felled trees were remarked on in 1726. On the

Rhinns of Kells there may have been mixed deciduous woodland at least until the end of the 18th century (Statistical Account of 1792).

In the uplands sheep farming predominated from the early 19th century when widely-spaced hillfarms managed areas of at least 1000 acres (400ha). The population decreased in the hills but was absorbed into the lowland settlements, which expanded to meet demand. The population of Wigtownshire and Kirkcubrightshire rose from 38 000 in 1755 to 87 000 in 1851. There has been a fall with the lack of new industry and less labour-intensive farming, so that the population has reached 58 000 (Edlin 1974, 15). The afforestation of much of Galloway since 1920 has been the most significant change in the landscape in recent times.

CHAPTER 4

METHODS

4.1 Field Methods

In the first instance it was decided to search for suitable peat deposits in areas of lithic find spots considered to represent Mesolithic activity. In one case, excavations carried out beside Loch Doon by the late Thomas Affleck provided the opportunity to attempt to obtain a terminus ante quem for assemblages. The discovery of lithics is made more likely by the large-scale exposure of soils and peat by fluctuating water levels as at Loch Doon, Loch Dee and Clatteringshaws Loch; and by the work of the Forestry Commission, as by Loch Dee, where roads for access were cut into a hillside mantled by blanket peat and by Loch Doon, where drainage was needed for a plantation.

Where peat was exposed in section, both this and some of the underlying soil could be sampled as monoliths. If the peat deposits nearest to lithic sites graded from topogenous to ombrogenous blanket peat, the shape of the underlying ground was described by a series of probes, using coring rods, along transects selected to give the best impression of the sub-peat topography. The importance of determining the sub-peat topography for such studies is stressed by Caseldine (1983). Cores for pollen analysis were extracted with a Russian-type corer, preferably one with an 8.0cm diameter chamber, but where this proved impossible, a corer having a chamber diameter of 4.5cm was used. The top of the transects was levelled to a site datum and, if required, a map of the outline of a given study area, with important breaks of slope and spot heights, was made on the basis of a theodolite survey. The surveying was carried out using an automatic level (Sokkisha B2C) and Watts theodolite. The nomenclature of vascular plants recorded in the

descriptions of the present-day vegetation follows Clapham et al. 1981.

Because of the expense of conducting fieldwork at a long distance from laboratory facilities, it is a great advantage to be able to assess the approximate age of deposits before leaving the area. Simple methods were therefore devised to concentrate the pollen content of peats for preliminary microscopic examination at the place of accommodation. Peat was deflocculated using 10% NaOH which was warmed by placing the sample and solution, both contained in a glass vial (25cm^3), in a bath of hot water. The peat was broken up by vigorous stirring and when deflocculated, passed through a 180µm sieve held in a plastic funnel, into a second vial which was then left for about two hours to allow the pollen and spores to settle at the bottom. The solution of humic acids made the supernatant comparatively opaque, but it was possible to distinguish it sufficiently well from the sediment to enable it to be drawn off using a Pasteur pipette. The residue was mixed with glycerol and some of the preparation was placed on a microscope slide, the coverslip held by nail varnish at the corners. It was often possible to attain a count of 250 grains per slide; there was not excessive obscuring of grains by other detritus and although the sculpturing is not enhanced as it is after acetoloysis, the degree of identification is not greatly impaired. If a measure of the pollen concentration was required, the samples were extracted with a modified plastic syringe, to obtain a volume of 0.5cm^3, and then added to a solution of tablets and a minimum amount of 10% HCl, before the treatment with 10% NaOH. The pollen and spore content could be concentrated further by using a hand pump attached to a flask to reduce its internal pressure and into which the filtrate from a fine mesh sieve (10 µm) was passed. The sieve residue was kept for the pollen preparation. In this method some small grains may have been lost (cf. Cwynar et al. 1979).

4.2 Laboratory methods

4.2.1 Sediment description

The sediments have been described using the system of Troels-Smith (1955), except for those of the Starr Cottage excavations, where the excavator's descriptions are followed. In all other cases the descriptions were made in the laboratory rather than in the field and so the degree of humification cannot be so easily assessed by inspection since samples from peat deposits have oxidised by that time. The cores have been left substantially intact in case further analyses should be required. The descriptions are made on the basis of visual examination and after handling a thin strip of sediment removed from the edge of the core, or scraped from the surface. If macrofossils were apparent these were noted, but routine examination of the sieve residues of the pollen preparation was not carried out, although some were looked at. In the sediment description the term 'lim' refers to the boundary at the top of the stratigraphy unit (i.e. limes superior, Troels-Smith 1955, 57). The Troels-Smith description is written onto the stratigraphic column (cf. Andersen 1984).

4.2.2 Loss-on-ignition determination

The organic content of sediments was assessed by combustion of small samples in a muffle oven. The samples were first dried in an oven at 105°C overnight and combusted at 550°C for two hours (for the Palnure samples) or five hours (for the sample from the Loch Dee Road profile). The samples were cooled in a desiccator. A control of two empty crucibles, to estimate the error in the measurement (to 10^{-4}) due to incomplete drying of the crucibles, was used during the combustion of the Palnure samples. A maximum variation of 0.013% was obtained.

4.2.3 Pollen preparation

The standard procedure for all samples began with the subsampling of the peat or soil to obtain a known volume of sediment. If the pollen concentration was low a 1.0cm³ sample was taken, being measured by displacement of 10% HCl in a measuring cylinder of 12mm diameter graduated in 0.2cm³ divisions; in some cases the same volume was measured in a narrower (10mm diameter) measuring cylinder graduated in 1.0cm³ divisions. This size of measuring cylinder was used for obtaining samples of 0.5cm³, which was generally adequate to provide a sufficiently large microfossil concentration. For the analyses of the core LDPBI and certain of those concerned with the Alnus rise by Loch Doon a modified plastic syringe (graduated in 0.1cm³ divisions) was used (see Sections 6.5.1 and 7.4.1 below) to extract 0.5cm³ samples. The thickness of the samples was one cm unless the syringe was used; it has an internal diameter of 8mm. A number of Lycopodium tablets (cf. Stockmarr 1971) were added to the measured volume of sediment which had been decanted into a 15cm³ polypropylene centrifuge tube. When greater numbers of tablets were required (e.g. 10 tablets) a 50cm³ centrifuge tube was used. After stirring the sediment and solution of Lycopodium spores thoroughly, the mixture was centrifuged and, after decanting the supernatant 5 - 10cm³, of 10% NaOH was added and the tubes placed in a boiling bath for about 10 minutes, stirring occasionally to assist the deflocculation of peat.

The disaggregated and suspended peat was poured into a 180μm sieve and washed through with distilled water. At least two washes with distilled water followed, to dilute the humic acids. At this stage siliceous samples were treated with 40% HF; either with cold acid overnight, or for 15 minutes using a boiling water bath. A wash in glacial acetic acid preceded the acetolysis of two minutes duration, with the tubes in a boiling water bath, using about 8cm³ of a mixture of concentrated

sulphuric acid and acetic anhydride (1:9 by volume) for each sample. Glacial acetic acid was then added to the acetolysis mixture to fill the tubes, now removed from the water bath. The samples were centrifuged whilst still hot and after pouring away the supernatant, they were washed with glacial acetic acid. Following a wash in distilled water the samples were dehydrated using 10cm³ tertiary butyl alcohol (TBA) and then transferred in TBA to small glass vials containing a volume of silicone oil (2000cS, cf. Andersen 1960), which was approximately the same as the volume of the pollen preparation pellet. In some cases two washes with ethanol were used to dehydrate the sample before the treatment of TBA prior to the transfer to vials. The excess TBA was driven off in an oven at 60°C; for some samples much of the TBA had been removed by Pasteur pipette after gently centrifuging the samples in the glass vials.

The final preparation was spread on a microscope slide, having a square (22 x 22mm) already drawn on paper beneath it, to the edges of the square. A No.0 or No.1 coverslip (22 x 22mm) was placed on the preparation, the escape of air potentially trapped under the coverslip was made easier be creating small radial furrows in the preparation from the centre to the edge using a sealed Pasteur pipette. If the pollen concentration was too high extra silicone oil was added to the microscope slide with an appropriate amount of the preparation and the two mixed and spread. Nail varnish held the corners of the coverslip. By the use of a square coverslip and by spreading the preparation before emplacing the coverslip, the uneven distribution caused by the migration of smaller grains to the edge is minimised (cf. Brookes and Thomas 1967).

4.3 Pollen analysis

4.3.1 Pollen counting and identification

Routine pollen counting was carried out at a magnification of x500 using a Zeiss binocular microscope with x10/18 oculars. Complete and evenly-spaced traverses were made. Normally more than 500 TLP were counted. More critical examination required an oil-immersion objective giving a magnification of x1250. The eye-piece graticule had divisions of 0.8μm at x 1250 (i.e. 2μm at x500). Identifications were made with reference to the keys of Erdtman et al. 1961, Faegri and Iversen 1975, Moore and Webb 1978; to Andrew 1984, the descriptions in Birks 1973, van Geel 1978 for rhizopods, and modern material, unstained and mounted in silicone oil. The types recorded on the diagrams may therefore have descriptions deriving from a number of authors, but may be easily traced to their sources. Nomenclature is after Clapham et al. (1981). Cerealia type is defined as a Gramineae grain having a minimum of 38μm as its greatest dimension (usually measured at x500, with an estimate of its true length made if folded) and an annulus of 8μm or more (cf. Andersen 1979); pore size was noted.

4.3.2. The pollen diagrams

Pollen diagrams on the sum of AP and AP + taxa for NAP types are presented first since these approximate to the diagrams of Birks (1972) and enable reasonable comparisons to be made. She used the sums of AP, and AP + Group (where Groups were Corylus/Myrica, Shrubs, Dwarf Shrubs, Herbs, Spores, Aquatics, Sphagnum etc.), where if the taxon is NAP it belongs to a Group. The AP and Coryloid curves are directly comparable with the published diagrams, as is the Calluna curve when there are few other dwarf shrubs. Discrepancies will be most marked when there is more than one abundant herb type e.g. both Gramineae and Cyperaceae, which

would belong to the same Group in Birks's calculation, but are treated separately here. These diagrams make the zonation into Flandrian chronozones most easy, especially where the representation of Ulmus is low in Fl II. Summary diagrams are drawn of the individual pollen curves and the group (Trees, Shrubs, Herbs) to which each taxon belongs is shown at the top of the diagram. The grouping has also been influenced by Birks's criteria, although here the ericaceous ('dwarf') shrubs are included in the group of herbs. The shrub status given to Corylus in order to follow Birks (1972) may be misleading in terms of the canopy vegetation (see Section 3.7). The herb types are not explicitly grouped as belonging to specific communities of habitat type e.g. woodland, moorland/heathland, mire types, nor any selected as ruderals and grouped together on the AP, AP + taxon diagrams because of the potential overlap in habitats. However, an order of tree, shrubs, ericaceous types, other herbs, aquatics, spores and rhizopods is followed.

The pollen diagrams have been drawn using a plotting program POLGRAPH which creates suitable instructions for Gino plotting routines. It is based on an original program POLLDATA Mk. V written by Prof. H.J.B. Birks and Dr. B. Huntley, but has been much revised by Prof. A.G. Smith and L.A. Morgan. From this revised program new subroutines are called; which incorporate the Gino commands. The raw data was ordered using the program POLDAT which includes facilities for numerous calculation sums and editing. This program was written by Prof. A. G. Smith and L.A. Morgan and is compatible with POLGRAPH. An additional subroutine called from POLDAT has been written by the present author to calculate pollen concentrations, the number of herb types at each level and calculate the ratio of microscopic charcoal to total pollen. All the programs were run on the Birmingham University Honeywell mainframe computer on the Multics system. The diagrams were plotted on a Hewlett Packard Hp 7220 flat-bed plotter. Saw-

edge plots were preferred as it is considered that trends in the pollen values are more readily discerned. Where clumps of more than one grain were encountered during the counting of the Loch Doon profiles these have been marked on the diagram. The labelling of individual levels is the depth to the base of the sample.

The zonation of the AP diagrams is not normally based on numerical thresholds; only in the case of the diagram showing the rise of Alnus at Loch Doon (based on AP) is an actual percentage threshold defined. The boundaries are given the depth values corresponding to those on the diagrams, i.e. halfway between the measurements to the base of the one-cm thick samples, which makes them 0.5cm lower than if measured to the centre of the samples. The rises of Corylus (West's [1970] lower boundary of Fl Ib), Alnus (Fl I/II), and the Elm Decline (Fl II/III) are marked. For the first two the somewhat arbitrary definition of Smith and Pilcher (1973) for the 'rational' limit is applied, although the criterion of the 'rise to sustained high values' may be considered to have been interpreted as occurring earlier than the definition might demand. Accepting Bennett's (1988b, 556) comment that it is likely that particular trees have been present in the landscape in a more significant way than suggested by the conventional zoning of diagrams, implicitly corresponding to the expansion of the species, these boundaries must be seen as a primarily biostratigraphical division (cf. West 1970). They are useful for the division of subsequent discussion of forest history in the catchment, and Birks (1989, in press) has used the empirical limit as a minimum arrival time. The Elm Decline boundary is defined after Hirons and Edwards (1986), i.e. placed before the first reduced value in Ulmus from its assumed maximum.

The diagrams are further zoned into 'Local Pollen Assemblage Zones' (LPAZ; cf. West 1970) and Subzones (LPAS), the latter facilitate discussion

of ecological changes at the mire and outwith it and so they may overlap. (They are perhaps more accurately 'Cozones'.) The epithet 'Disturbed' (D) (cf. Simmons and Innes 1988a,b,c) is used to highlight events implied in changes in tree or shrub taxa curves, but it does not necessarily carry the connotation of anthropogenic influence. Exact correlation with Birks's (1972) 'Regional Pollen Assemblage Zones' are not made, but they are referred to. The zonations from the AP diagrams are also drawn on other diagrams e.g. those based on TLP and those showing pollen concentrations. Plots of the number of herb taxa at each level are provided alongside the curve representing the calculation sum. These are interpreted as measures of change in floristic diversity (cf. Moore [1973], though the particular index hs been considered inappropriate [Birks et al. 1988]; cf. also Rull [1987] and Innes and Simmons [1988]). Diagrams based on dry-land sums are presented to clarify the fluctuations of selected taxa, since local potentially wet-land trees may affect these. Certain dry-land plots can be compared with similar ones constructed by Birks (1972).

4.3.3 Errors associated with the preparation technique and counting statistics

No estimate of errors is given with the results of pollen and spore concentration. Maher (1981) discusses these, which come from the uncertainty associated with counting the number of Lycopodium spores in each tablet (here the batch supplied has tablets containing 11329±400 spores per tablet, at one standard deviation), the number of tablets added and the error intrinsic to the counting statistics being dependent on the ratio of fossil: exotic microfossils counted (cf. Stockmarr 1971, Bonny 1972). An additional potential error is the possible differential loss of either fossil or exotic palynomorphs, but by adding the exotic at the beginning this is assumed to be overcome. Maher (1981) recommends a

ratio of fossil to exotic of 2: 1 as providing a reasonable precision for the effort of counting exotics. In the present work, the recommended ratio of 2: 1 was approximately achieved in many, but not all, cases. There is a counting error associated with the relative calculation of pollen abundance (cf. Moore and Webb 1978, Rull 1987); again this is not calculated here. For the absolute calculation, the sources of error and an estimate of their magnitude are:

> the measurement of volume (by displacement): for $0.5cm^3$, reading the $0.1cm^3$ divisions to the nearest $0.025cm^3$ = 5%;
>
> the measurement of volume (by syringe): at least 5% (as above), because of the potentially heterogeneous and deformable peat.

(Cloutman [1987] obtained a coefficient of variation of 4.6% [at one standard deviation] for a monolith cutter slicing $1.0cm^3$ samples of processed cheese; Maher's [1981] experiment, using a similar syringe as that employed here, achieved 1.8% on $0.2cm^3$ samples of modelling clay.)

> The error associated with the number of Lycopodium spores in one tablet = 400/11329 = 3.5% (at one standard deviation).

For many samples in this research 4 tablets were used (the range is 1 - 20) and a volume of $0.5cm^3$.

> The error associated with 4 Lycopodium tablets is Ns/N = 800 and for the group is then 800/45316 = 1.8% (i.e. half that for one tablet) and it is always improved by the addition of more tablets(Maher 1981, 158f.)

From Maher's (1981, 170) formula for 95% confidence limits for a taxon count of 200 (i.e. 40% in a TLP sum of 500) and an exotic count of 100 (the minimum for Maher's calculation), a mean concentration of 18.1×10^4 grains/cm^3, with a range of 14.0×10^4 (-23%) to 23.5×10^4 (+30%), is obtained.

This gives an indication of the total error associated with the value of a numerically significant taxon in an assemblage, when the exotic count is at the minimum for the calculation and a 'worst case' insofar as

it is possible to derive a value. In practice less than 100 exotics were counted in some samples. The arguments for change in concentration may be based on changes of magnitude of over several hundred percent (over a number of samples in some cases) and so are interpreted as being valid at this level (and at somewhat lower values, particularly where a trend over a number of samples can be seen).

4.4 Charcoal analysis

Since it was intended to show the pattern of the variations of charcoal input to an individual site over time and to compare any broad patterns with those from other sites rather than comparing absolute areas or influx, charcoal was recorded as the total number of fragments per volume. All the charcoal had passed through the 180μm sieve of the pollen preparation procedure and pieces estimated to be less than a quarter of an eye-piece grid square (having 10 x 10 squares of 24.6 x 24.6μm each) were not recorded (i.e. those less than about 10μm x 10μm were omitted, the lower limit of Corlett's [1984] analysis, cf. Patterson et al. 1987). The preparations therefore belong to Clark's (1988) classes of pollen-slide charcoal (0 - 80μm) and thin-section charcoal (50 - 10 000μm); but fragments of 130 - 150μm are most easily lifted by wind, and the effect of convection will make the representation of pollen-slide charcoal predominant (Clark 1988). A 'skip distance' between source and site is likely (see Section 2.3.5). A note was made of abundance within categories of size, but these are not presented. It is suggested by Patterson et al. (1987) that the number of fragments may be linearly proportional to the total area of charcoal and for one lake site it is shown that over 90% of pollen-slide charcoal was of the order of 9 - 26μm in length (p.11).

The pollen preparations were not identical: some involving HF treatment, some only proceeding as far as a treatment with 10% NaOH. Although an amount of very fine charcoal may be decanted off during the preparation, the smallest particles (less than about 150μm²) were not counted in any case. For particles of a size close to that of many pollen grains (i.e. 10 - 35μm in diameter) and the exotic, the same argument of assuming constantly proportionate losses of grains and exotics for the pollen concentration derivation may apply equally to microscopic charcoal. In the same way, errors relating to the volume measurements and counting statistics should also be borne in mind in ascribing meaning to the changes in charcoal frequencies (cf. Maher 1981).

Since preparations were primarily made up for pollen counting the ratio of numbers of charcoal fragments to those of exotics may be far from ideal (e.g. the worst case from Loch Doon IV is at 32cm, where from a preparation containing two tablets in 1.0cm³, 6 exotics were counted and 292 charcoal fragments. Generally for this profile the number of fragments is greater than 200, but the number of exotics counted is often less than 100. For the Loch Dee Road profile the numbers of fragments and exotics are low (i.e. means 43, 25; ranges 4 - 161, 6 - 62). The calculation of fragments/TLP has been derived from the charcoal fragment concentration (determined after the pollen analysis) and the TLP concentration (both contributing an error term). It is thought that trends showing changes of an order of magnitude or more could be discerned by this measure of charcoal abundance, given the uncertainties in the method. It would at least compensate for differences in sedimentation rate, assuming a constant input of TLP, though with a reduction of nearby trees or shrubs this will not be so (cf. Bennett et al. 1990). It is stressed

that there are few studies including a quantitative measure of the charcoal in peat. As indicated in Sect. 2.3.5, whilst recorded from limnic sediments (e.g. Swain 1973), where a wide catchment and comparatively uniform sedimentation is often likely, there are uncertainties in the replicability of the representation of charcoal in a mire possibly due to autochthonous burning (Robinson and Dickson 1988) and/or heterogeneous sediment.

The possible variation of the sediment laterally within the core would certainly affect the concentration of microfossils. Balmer (1987) found considerable differences in replicate samples from the same levels of a peat core (from Snibe Bog, south-west Scotland) when the microscopic charcoal (less than 180μm) content was recorded (following R.L. Clark 1982). Sampling three levels each four times, the greatest divergence for a level was x14; the least was x3.7 from another level sampled four times. A second factor, that would lead to differential absolute representation vertically, is a change in sediment type through time. Magnetic studies on the collection of particles in hollows as opposed to hummocks of mires, have indicated that perhaps as much as 10x as many may collect in the former (e.g. Richardson 1988). Both these factors might be overcome by the choice of the ratio of charcoal: pollen.

A third factor, of differential preservation, would not be circumvented in this way, although Wilkinson and Huntley (1987) on examining cores taken from a topogenous mire observed no charcoal in samples where the pollen content was prohibitively low for counting, but charcoal was present when pollen was well preserved. They considered that the nature of the peat-forming vegetation may remain the same for millennia at a particular coring site; also, that fire would spread along

hummocks, and that these may be the best sites for pollen and charcoal preservation.

The results given here will contribute to the published studies in that at least general trends may be open to comparison with these and future work, even if interpretation at a local level concerning the significance of the variation remains uncertain. Studies of charcoal in peat in Scotland have been published by Robinson (1987, Robinson and Dickson 1988). The curves (based on cm^2/cm^3) have been broadly interpreted as a measure of vegetational disturbance (cf. Carter 1986).

4.5 Radiocarbon dating

Most of the conventional radiocarbon dates were determined at the Groningen laboratory under the direction of Prof. W.G. Mook. An additional date for the Loch Doon IV sequence came from Teledyne Isotopes, New Jersey, where the three determinations for the Loch Doon loch core were also made. The pretreatment of peat samples at Groningen consists of two washes in a 4% HCl solution interspersed with an extraction with 0.5 or 3% NaOH to remove fulvic acids, carbonates and humic acids (Mook and Waterbolk 1985). At Teledyne Isotopes the samples are pretreated to remove carbonates.

No attempt has been made to calibrate the radiocarbon dates. For the long post-glacial sequences (Loch Doon IV and Loch Dee Peninsula Bog II) the basal dates are beyond the range of the most comprehensive curve (Klein et al. 1982, which is limited to 7240 b.p.; Gillespie 1986, 28-30). The main purpose of calibration would be to provide calendar years for calculating deposition rates for periods after 7240 b.p., but unless sufficiently close dates are available for a critical evaluation of the timescale of an event (which may at times have wider limits after

calibration) or for calculating the sediment-accumulation rate itself, calibration is hardly meaningful. Plots of time against depth are constructed on the basis of uncalibrated radiocarbon dates. Interpolated dates of zone boundaries are made on the basis of the depths as they are drawn on the diagrams, the 0.5cm difference due to the convention of labelling the sample depths (see Sect. 4.3.2) is not considered to be significant. Deposition times are expressed as yr/cm (after Barber 1982, 107), since they are more easily envisaged than the reciprocal expression.

Two 'accelerator' dates have been determined by the Oxford University Radiocarbon Accelerator Unit and were from samples too small to be measured by conventional means. The details are given in Sect. 6.6.1.

4.6 The presentation of concentration values

The diagrams showing concentrations of selected taxa are presented to help evaluate whether the changes in relative curves are a statistical artefact of a percentage calculation; whether for example, an increase in one taxon may be explained as the result of the local expansion of a population thought to be close to the sampling site; or whether concomitant increases in taxa indicate a change in sedimentation (cf. Middeldorp 1986, 18-27). Where a combination of factors may be operating a decision has to be made as to the weight given any one in the eventual inference. It may be judged from a relative value on the basis of a particular sum, that the relative representation of that taxon is probably not changing so change in absolute terms may be used as a measure of a change in sedimentation rate in assessing the greater or lesser absolute changes in other taxa. Conversely, if total pollen concentration, or a single taxon is considered to be steady over a number of levels (or a group of taxa is consistently

changing), indicating fairly constant deposition rate (or the expected range and directions of variation) then larger changes in other taxa can be evaluated in terms of 'relatively' changing concentration which is not statistically induced.

Pollen influx has not been calculated because it is felt that there are not enough radiocarbon dates for the periods of the dated portions of the diagrams, given that the placing of dating horizons should relate to changes in concentration reflecting sedimentation rate of the sediment stratigraphy, or be sufficiently numerous to date increments of a changing rate. The following figures (used to calculate influx values) from sites of the Somerset Levels show how variable the rates may be. Nine determinations for c.2200 radiocarbon years were available for the Abbot's Way diagram; six (one of these was subsequently rejected) for a similar timespan on the diagram from Mere Heath (Beckett 1979). At the first site the variation in accumulation times in the lower part of the profile (which became less highly hummified Sphagnum peat towards the top (cf. Beckett and Hibbert 1979) was 7 to 62.5 yr/cm; two times from the top part were 11.4 and 28.6 yr/cm.

CHAPTER 5

PRELIMINARY INVESTIGATIONS

5.1 Introduction

This chapter describes the work carried out on deposits from three areas (Clatteringshaws Loch, Loch Doon and Loch Dee), which proved to be largely later than 5000 b.p. and hence not able to provide adequately detailed vegetational histories relating to possible Mesolithic activity. They give additional insights into the vegetational development at later times, and will be referred to in subsequent chapters.

5.2 Moss Raploch (NGR: NX 55097707)

5.2.1. Introduction

The position of the sampling site is shown on Fig. 5.1. This site of fossil pine stumps became apparent due to the erosion of the peat surrounding Clatteringshaws Loch (cf. Photo. I), an artificial reservoir created in 1937 (Birks 1975). The reservoir has flooded an extensive area of peat, which was previously mapped by the Geological Survey (originally published in 1893 and the basis of one-inch Sheet 8, 3rd edn., Ordnance Survey 1962) and their delineation of it is indicated on Fig. 3.6. It may be seen as a continuation of the peat deposits of the Loch Doon-Dee Basin. The site was of interest in that lithics ascribed to the Mesolithic had been found around the Loch (Fig. 3.9) and the previous investigation of Birks (1975) on the northern edge of the loch (Fig. 5.1) showed a decline in Pinus pollen just above the position of a pine stump in the peat stratigraphy (about 90cm from the surface). The pine stump was dated to 5080±100 b.p. Within 10cm beneath the stump the peat had a discordant date of 4815±80 b.p. and since the growth of peat was on average about one cm in 50 years it was concluded that younger roots had likely caused a rejuvenated date (Birks 1975, 213f.). The accumulation rate is

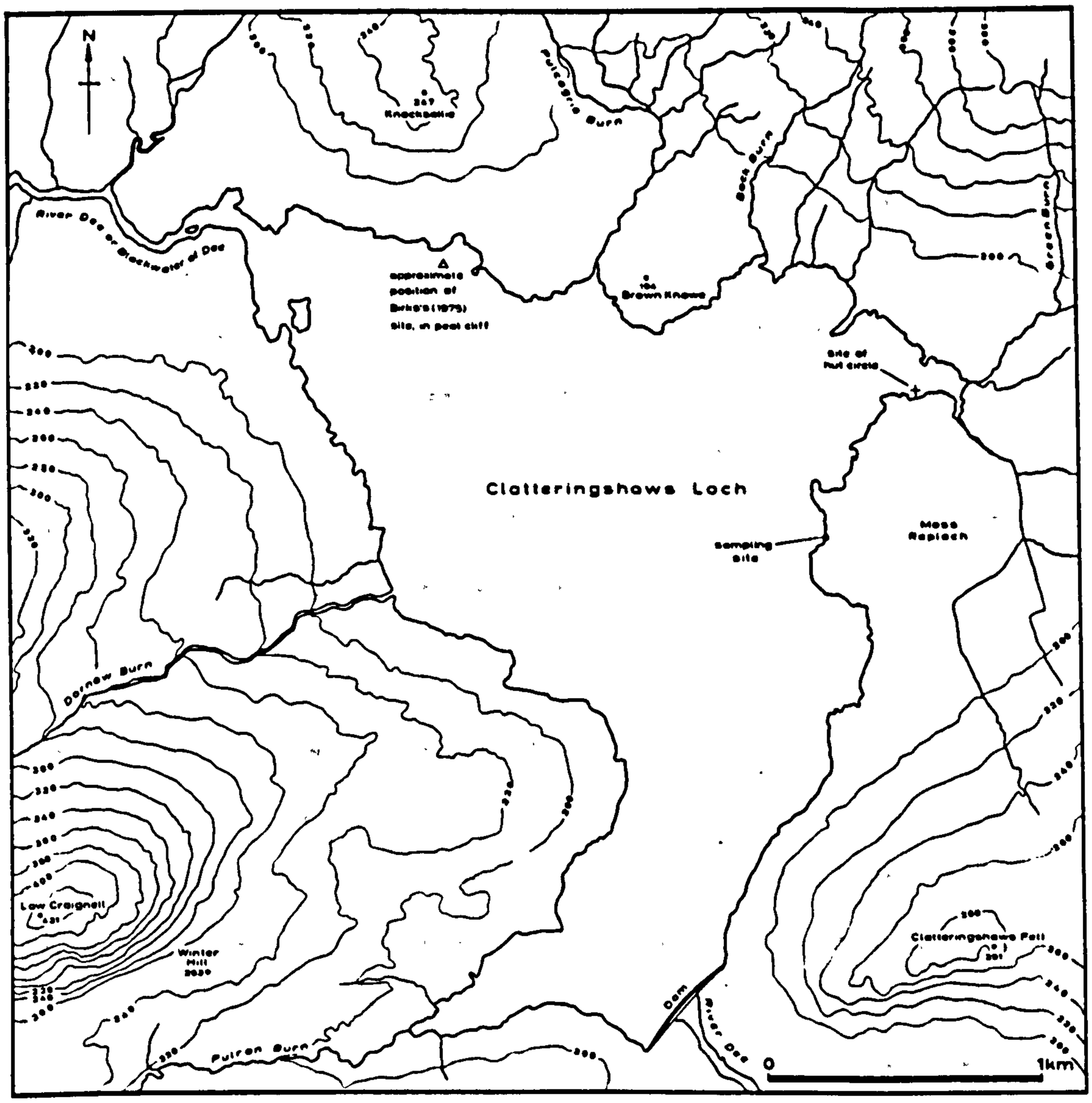


Fig. 5.1. Map showing the position of Moss Raploch, by Clatteringshaws Loch, and the locations of previous pollen-analytical and archaeological investigations.

interpolated between the present day and 5080±100 b.p. The base of the sequence at 190cm was determined as 6820±180 b.p., where Alnus pollen is low before expanding. Interpolation between this and 5080 b.p. gives an estimated rate of 1cm in 20 years.

A preliminary study of the pollen stratigraphy at Moss Raploch by Carter (1986) showed a marked decline in Pinus pollen and although this this occurred between 48-64 cm of a profile of 145cm, clearly of post-Alnus-rise age at its base, it seemed worthwhile to date the Pinus decline at Moss Raploch in case it should correspond to that of Birks's site, where the Ulmus curve gave no good clue as to a Decline and Plantago lanceolata was recorded before 5080 b.p. If it was found to correlate, this would make the peat below of interest for Mesolithic studies and in any event the date would help to elucidate the local history of Pinus on the mire.

5.2.2 Site and sediment stratigraphy

The peat deposit of the reservoir basin lies over Silurian and Ordovician rocks, with granite of the Cairnsmore intrusion to the south (see Fig. 3.4). Predominant around the peat are the complexes of organic, and organic and mineral soils of both Ettrick and Dalbeattie Associations, as mapped by the Soil Survey. Birks (1975) inferred that a community requiring a relatively high base status characterised the earliest vegetation in which Phragmites was able to flourish, albeit under a canopy of birch-alder fen carr and latterly willow. Pine may have been growing on the peat nearby, but was considered to have definitely colonised the site as local conditions became more acid; an indication of the increasing acidity being the representation of Calluna, Melampyrum, Potentilla type and Sphagnum spores. After 5080 b.p. some refreshment of the site by base-rich water was thought to have caused the demise of pine, with alder, birch. and willow becoming established. A final stage of decreasing tree pollen was the result of the

decline of the trees on the mire surface and more regionally as blanket peat spread and clearance became an important factor. Recently, drainage and fertilisation of the peat by the Forestry Commission have affected the mire community now dominated by Molinia.

At the western edge of Moss Raploch, Molinia is abundant, on the top of the cliff which borders the loch, until it meets the plantation of sitka spruce some 10m to the east. Small bushes of Myrica gale and also Calluna occur sporadically in the grassland, the former becoming dense towards the plantation. On the ground below the cliff to the west and on the shore Molinia is dominant and again there are occasional Myrica bushes and some Calluna; Juncus spp. also occur.

The peat of the cliff was sampled using plastic guttering pressed into a cleaned face (sections 0-55 and 55-110cm) alongside the pine stumps. The basal section was sampled with an 8cm-diameter Russian-type corer (Carter 1986).

Sediment stratigraphy

Depth (cm)	Description
0- 35	Nig3 strf0 elas1 sicc3; Sh4 Th+
35-145	Nig3 strf0 elas1 sicc3; Sh3 Th1 Dl+; lim0
35-39	Eriophorum remains
55	Level of base of pine stumps
62-64	Eriophorum remains
85-97	3 large wood fragments (each about 3 x 5 cm)

Radiocarbon date: 53.0-54.5cm; 2930±60 b.p. (GrN-13137)

5.2.3 Pollen zonation (Diags. 5.1.1, 5.1.2)

For the sake of consistency of results the levels of Carter (1986) have been re-analysed. Greater resolution prior to submitting samples for

radiocarbon dating at the decline of Pinus has enabled a more precise boundary to be placed between the two zones previously identified.

MR-1 (145-53cm; before 2930 b.p.)

This zone is characterised by relatively high values of AP (36-65%), with Pinus reaching 32% as Betula falls to a minimum of 24%. There are no other marked fluctuations in the AP curves. Calluna rises from values ranging from 3 to 14% to a maximum of 27% towards the end of the zone. Melampyrum reaches 20%.

MR-2 (53-0cm; after 2930 b.p.)

The AP values decline (to a minimum of 6% at the top of the zone) and at the zone boundary Pinus falls to <1%, then is absent from the record until the surface sample where it achieves 19%. With the decline of Pinus, Betula expands to a maximum of 77%. Again there are no comparable fluctuations among the other AP types. Calluna, Gramineae and Cyperaceae increase as AP declines.

5.2.4 Dating of the deposit

On the basis of the steady Ulmus curve in MR-1, the presence of Plantago lanceolata at the beginning of the zone, and the occurrences of Fraxinus, the entire sequence is tentatively placed in Fl III, although the last two types were recorded in a Fl II context at Clatteringshaws Loch (Birks 1975). A cereal-type grain is recorded in the basal sample. Assuming that the peat has not been disturbed, an accumulation time of 54.5yr/cm for the peat above the radiocarbon-dated horizon is obtained by linear interpolation, which is close to Birks's (1975) estimate of c.50yr/cm. Using the rate of 54.5yr/cm to extrapolate a date for the basal spectrum (in this case for peat that was apparently less highly humified than the top 35 cm of the profile), a figure of c.4920 b.p. is obtained. This further suggests that the sequence be referred to Fl III and is thus

unsuitable for a study of vegetational history in the Mesolithic period.

5.2.5 The history of Pinus

It is clear from the evidence of stumps at 55cm in the stratigraphy and the maximum Pinus values that pine was able to colonise the peat surface to become locally established by 2930 b.p. Thereafter it was locally absent and the pollen values imply that it was probably not present more regionally before recent planting (the sampling interval at this site does not allow a more definite conclusion as to its reintroduction). That the reduction of Pinus is not a statistical artefact of increased Betula and Quercus is indicated by the concentration values (Diag. 5.1.2). This Pinus decline is not the same as the one dated by Birks (1975) at c.5080b.p., but it is of interest to note that there followed a further expansion of Pinus at the Clatteringshaws Loch site (to >40% AP) before Pinus declined again to negligible values until the time of the essentially treeless landscape preceding the plantations. The fall of tree pollen and collective predominance of Calluna, Gramineae and Cyperaceae after the second fall of Pinus is similar to the pattern at Moss Raploch.

From the values of Pinus at Moss Raploch prior to 2930 b.p., it seems reasonable to assume that Pinus was growing in the vicinity of the mire (although it has a value as low as 4.6% AP and the percentages are all lower than those before the earlier expansion at Clatteringshaws Loch). Such a low value would be in keeping with a later relatively local expansion from a population represented by about 5% AP as the explanation for the second peak of Pinus, which receives no comment from Birks (1975, 214). Using the very approximate accumulation time of 50yr/cm, the second decline to negligible values of Pinus at Clatteringshaws Loch occurs at c.2500 b.p.

Durno's (in Condry and Ansell 1977-78) diagram from a site adjacent

to the hut circles on the north side of Moss Raploch (see Fig. 5.1), also shows a marked decline in Pinus values, at the level of 1.7m of a profile 2.7m deep. This horizon is interpreted as the sub-Boreal/sub-Atlantic transition, presumably partly on the basis of the rise in Betula and Ericoid pollen that follows somewhat later. The conflicting correlation with Birks's first Pinus decline (c.5080 b.p.) in the main text (Condry and Ansell 1977-78) is unlikely to be correct, as appreciable amounts of Plantago lanceolata are present from the base of the core and the Ulmus curve shows no decline, in spite of the comparatively close sampling (about 5cm intervals). After the Pinus decline, the values are frequently at around 5% or less, until a peak at the top representing modern planting.

Taking the results from the three sites together, it seems as if Pinus grew in the area of Clatteringshaws reservoir until at least 2900 b.p., but from then it was not present on the west side of Moss Raploch (as extant today) and probably disappeared elsewhere in the area during the third millennium b.p. only reappearing as part of the recent afforestation.

Birks (1975, 214) inferred that the demise of pine after c.5080 b.p. was due to a raised water table. The stump itself was not recorded as burnt and no carbonised fragments were found at levels across the Pinus decline. The pollen stratigraphy of Moss Raploch presented here has peaks of Cyperaceae and Sphagnum at the decline, which also suggest a locally wet surface that caused pine to become waterlogged. Whilst there is a slight rise in the ratio of microscopic charcoal, higher values are recorded earlier and the pine stumps were not burnt. Conspicuous peaks of both Cyperaceae and Sphagnum accompany the Pinus decline of the profile to the north (Durno in Condry and Ansell 1977-78).

5.3 Loch Doon (NGR; NX 48339390)

5.3.1 Introduction

Excavations on the shore of Loch Doon were undertaken by T.L. Affleck in August 1984 following the discovery of scatters of lithics (see Fig. 5.2) and areas of burnt soil, earlier in the year. The preliminary excavations were supplemented by work in 1985 (Affleck 1986). Initially, four small trenches were opened in an attempt to find a secure stratigraphical context for the lithics and to record their spatial distribution (see Fig. 5.3; Trench 2 was not excavated). Samples of peat and soil were taken from three of the trenches (T1, T3 and T4) in the hope of demonstrating a Mesolithic age for the lithics underlying the peat and to provide some insight into the vegetation at the site, even if it would be impossible to directly correlate the finds with the vegetational record as the lithics were not deposited onto a growing peat deposit. Later, an AMS date of 6230±80 b.p. (OxA-1596) was obtained from hazel-wood charcoal from a hearth-like context on the shore.

5.3.2 Site and sediment stratigraphy

The most fundamental aspect of the sites is their proximity to a fluctuating loch level (cf. Photos. IV, V). This has been controlled at the dam at the north end since 1935 at least as part of the Galloway Hydroelectricity system (Hill 1984, 23). According to MacArthur (1952, 23f.), in 1319 an heroic, but fatal, breach of an embankment of earth and stones reinforced with hides was achieved by one McNab, after a swim of five miles. It had been built by the English to drown out the Scots in the castle on Castle Island. The dam is perhaps the first instance of the water level being raised, even if it proved to be ephemeral. Wilson (undated, though its latest information appears to be of 1855) records that at some time the Earl of Cassilis and the late Mr. M'Adam of

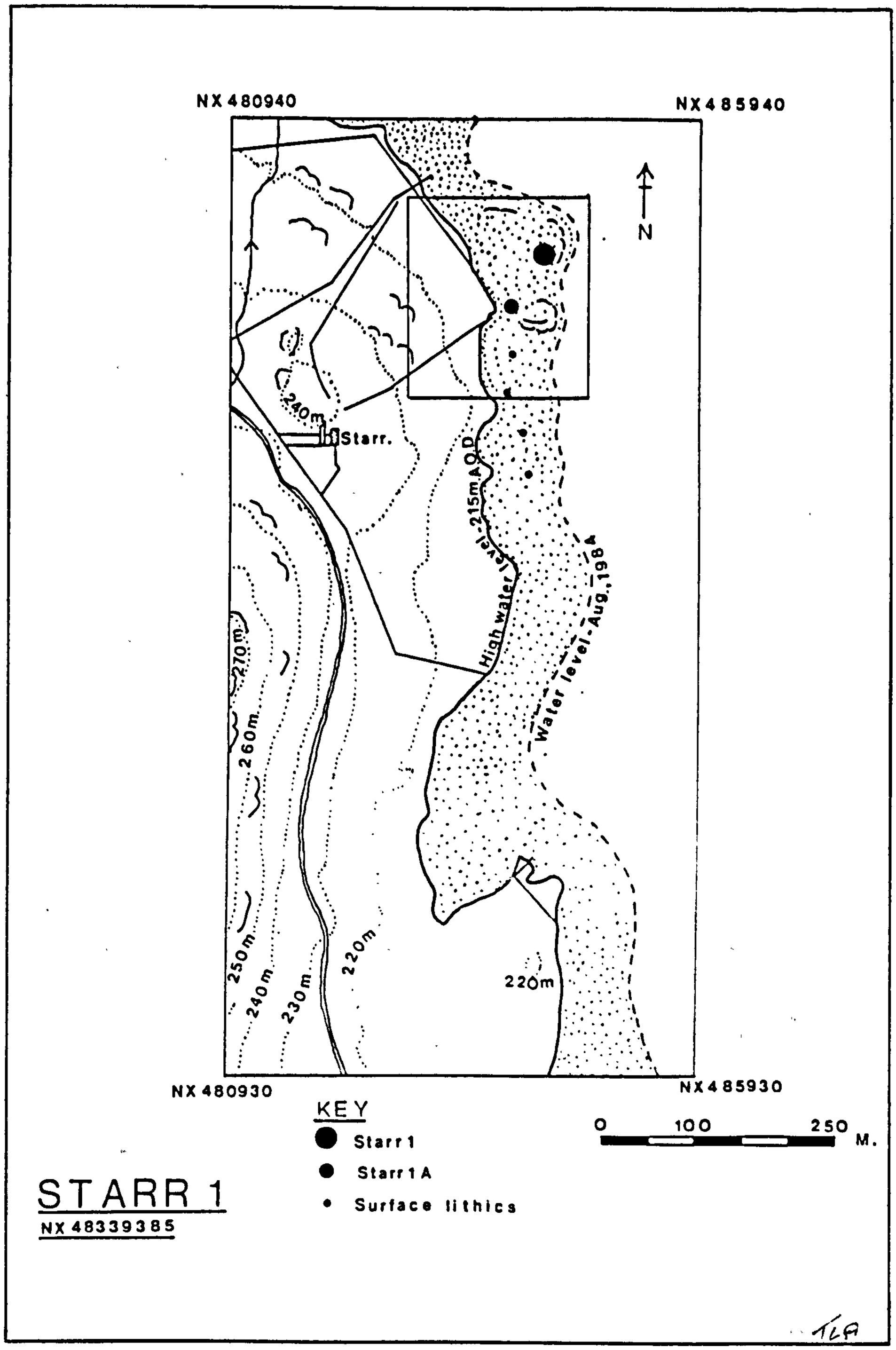


Fig. 5.2. Map showing the distribution of Mesolithic sites near Starr Cottage, by Loch Doon (from Affleck 1986). The inset refers to Fig. 5.3.

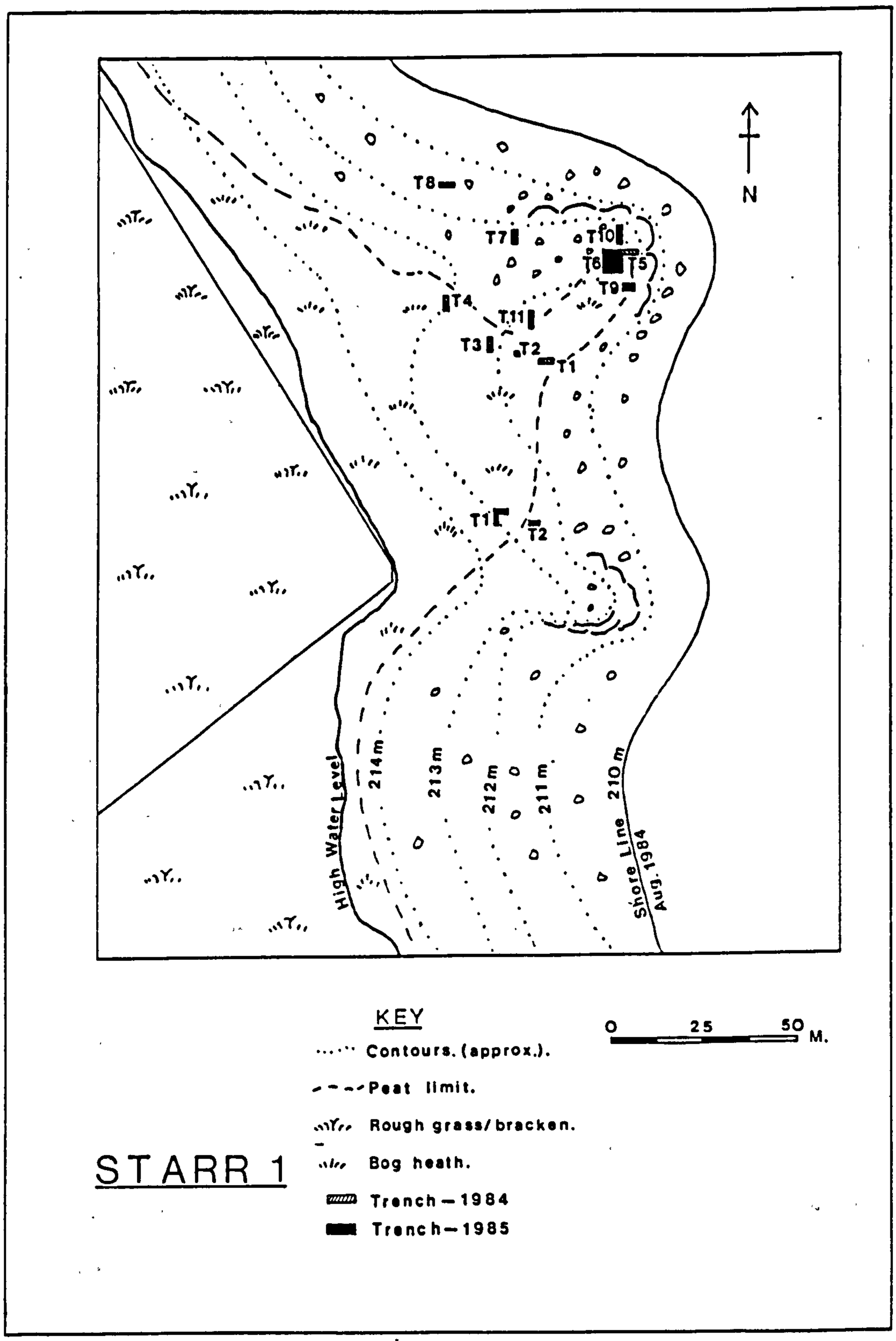


Fig. 5.3. Map showing the positions of the Starr 1 excavation trenches, by Loch Doon (from Affleck 1986).

Craigengillan lowered the water level by tunnelling the rock, over which the loch used to discharge. Sluices were erected to control the outflow, in order to preserve the meadow-ground fringing the river Doon that flooded after heavy rain. The results were described as 'beneficial', compared to those of a project at Loch Leven, and the damage to the grounds prevented. The project, carried out in 1823 was the one referred to by MacArthur (1952) and Mackie (1984, 132). It was a later attempt than the one recorded by M'Myne (1792) as having been unsuccessful. In this case the cut meant that there was no longer 'a beautiful natural cascade at the foot of the loch'. It was stated that the loch was nine miles long; Wilson (Ibid.) had it as about eight miles in length.

The report of the bathymetrical survey made in July 1903 (Murray and Pullar 1910) indicated a dam and a sluice at the outflow. The level at this time was 205.2m A.O.D., 'considerably higher than when it was surveyed by the Ordnance Survey' (the outline of the south-west shore of the loch is virtually identical as shown on the original six-inch survey of 1856 and the revision of 1893-4, and both annotate the south-west shore as liable to floods), but this is lower than the level of 215m for the highest water recorded on the recent 1: 10 000 Ordnance Survey map (see Fig. 5.4).

The implication for the surface distribution of lithics around the shore is that lithics may have been eroded from contexts further away from the loch when at lowered levels as previously higher water cut away peat and soils. With regard to the setting of Mesolithic activity, the sites may not have been as close to the loch side as they are at times today, although the excavations by Starr Cottage were conducted when the water level was very low. It can be seen from Figs. 5.3 and 5.4 that the level of August 1984 approximates to the floodline of July 1903, but is further from the edge of the loch drawn on the Ordnance Survey revision of 1893-4). Since it appears that the outflow had been reduced in depth

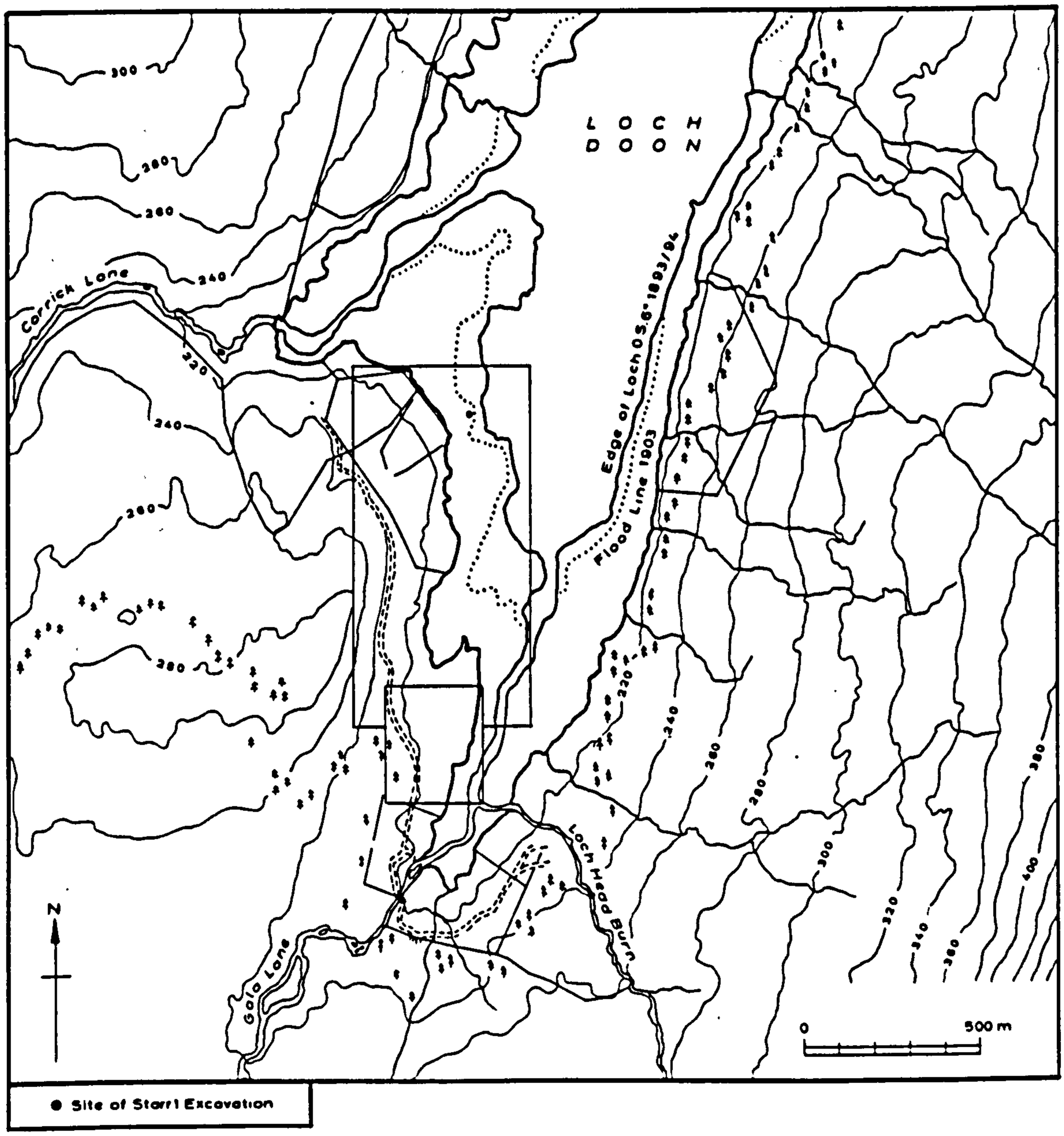


Fig. 5.4. Map showing the location of the Starr 1 excavation with respect to Loch Doon and the level of the loch as mapped by the Ordnance Survey (1893/94). The upper inset refers to Fig. 5.2, the lower to the map of Fig. 6.2.

before the modern surveys by an unknown amount, it is not possible to estimate the distance from the sites to the edge of the loch in prehistory. However, the sites by Starr Cottage may not have been much further from the edge than at times of low water today. The former presence of the late-12th century castle on Castle Island, now usually flooded, clearly indicates that the level has been naturally lower in the past and the configuration of the southern end of the loch would have been markedly different (cf. Fig. 5.4).

The stratigraphies of the trenches that were sampled for pollen analysis are shown on Figs. 5.5 - 5.7.

5.3.3 Starr 1 Trench 1

5.3.3.1 Sediment stratigraphy

A monolith was taken from the east-facing section of the trench and the sampling position is shown on Fig. 5.5. The sediment description follows that of the excavator and the boundaries measured are those seen on the north-west face of the bulk sample (cut out as a V-section) along the line of the sequence of pollen subsamples.

Depth (cm)	Description
0.0-15.0	Redeposited sand and peat
15.0-27.5	Red/brown unhumified peat
27.5-33.0	Black humified peat
33.0-34.0	Black organic; high carbon
34.0-40.0	Grey/brown leached (mineral soil)
40.0-45.0	Brown, fine-textured (mineral soil)

The central position of the lithic equivalent to that drawn by T.L. Affleck (Fig. 5.5) is at 35.5cm.

Radiocarbon date: 32.0-34.0cm; 2415±25 b.p. (GrN-13135).

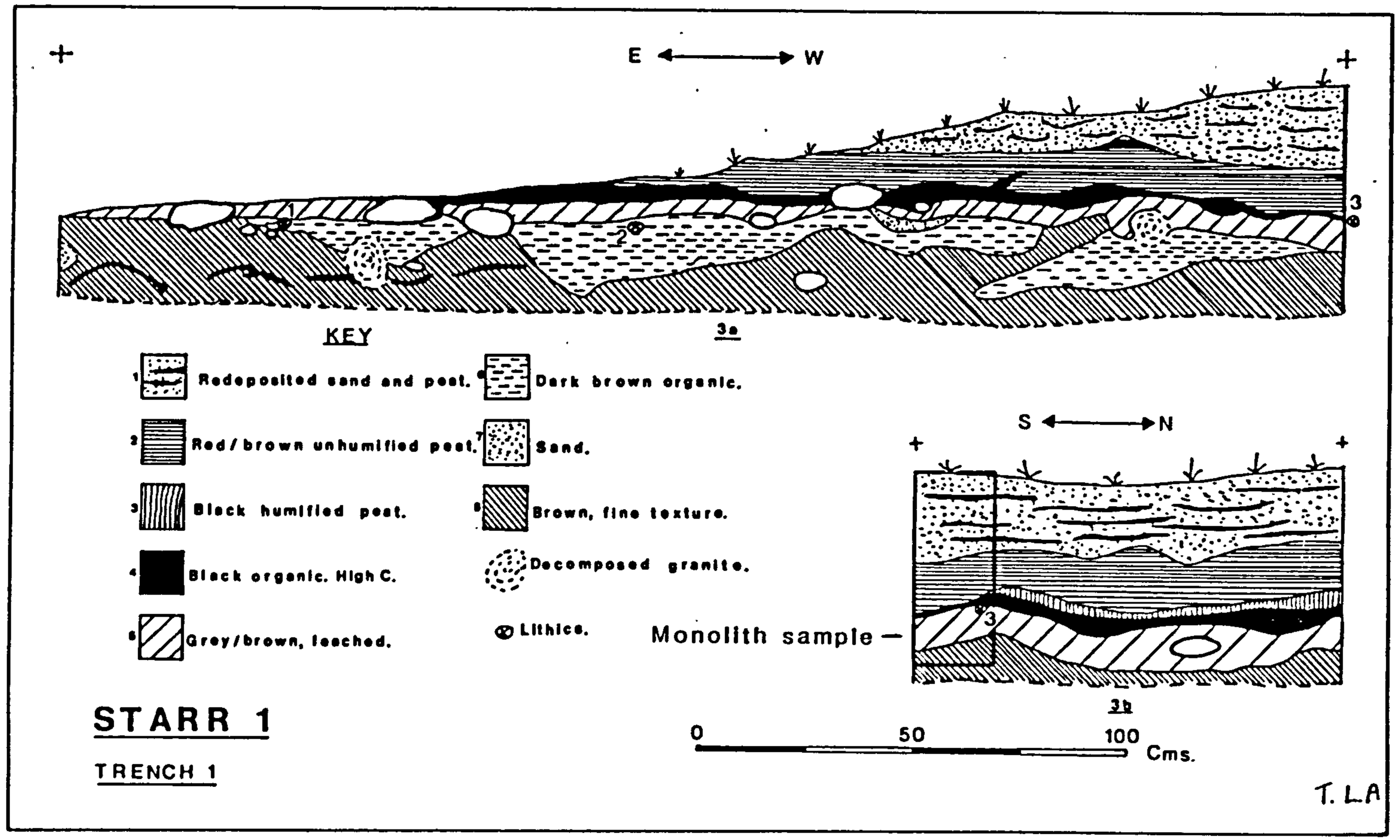


Fig. 5.5. Starr 1 excavation: section drawings of Trench 1 (S1T1). (From Affleck unpub. MS.)

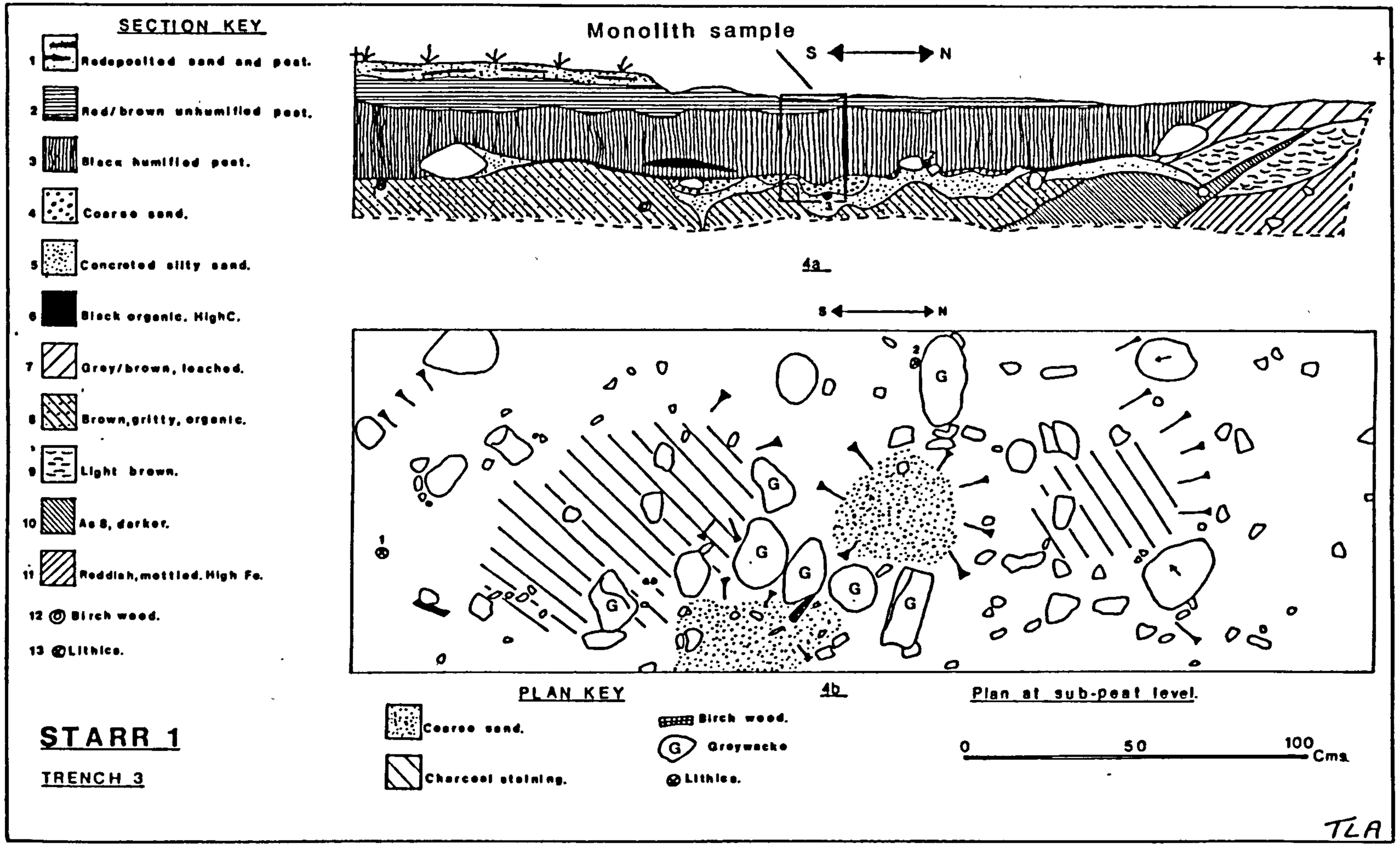


Fig. 5.6. Starr 1 excavation: section drawing and plan of Trench 3 (S1T3). (From Affleck unpub. MS.)

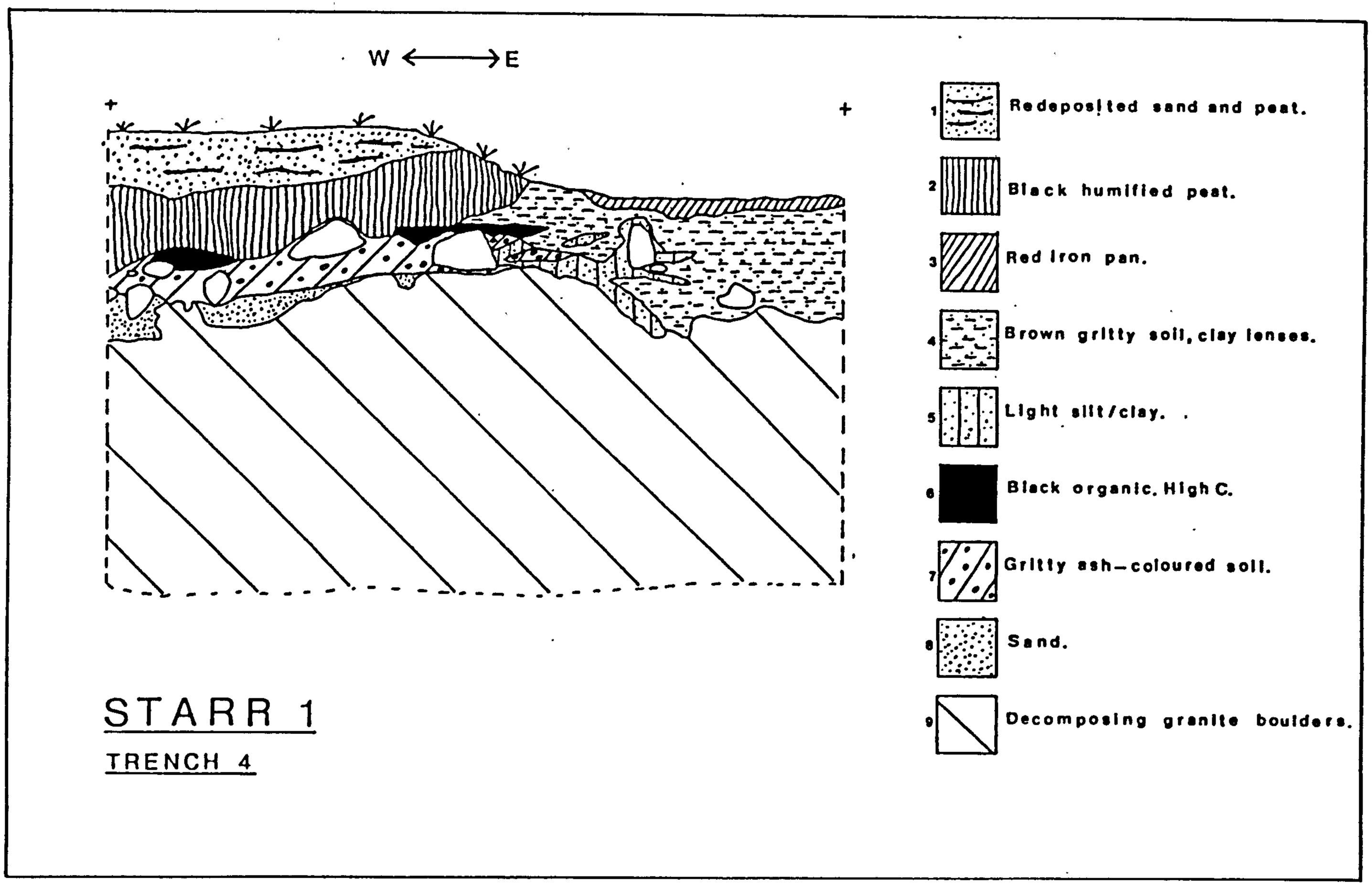


Fig. 5.7. Starr 1 excavation: section drawing of Trench 4 (S1T4). (From Affleck unpub. MS.)

5.3.3.2 Pollen zonation (Diags. 5.2.1, 5.2.2)

S1T1-1 (41-25cm; ?before, and from 2415 b.p.)

Tree pollen percentages range from 51 to 76%; Betula and Alnus are the most abundant types. Shrub pollen is almost entirely Coryloid (10 -30%). Herb pollen is 11 to 34%, mainly Calluna and Gramineae. There are few spores.

S1T1-2 (25-16cm; after 2415 b.p.)

This zone consists of one level. AP has fallen dramatically to 7%, the proportions of the low AP sum (37) are essentially unchanged, although Ulmus is recorded at 5%. The fall is mostly shown in contrast to the rise of herb pollen (90%), especially due to Calluna (92%), Gramineae (48%) and Plantago lanceolata (20%). Pteridium is 14%.

S1T1-3 (16-11cm; after 2415 b.p.)

The single level of the zone has 43% AP; 16% shrubs; 41% herbs. AP is less than in S1T1-1, but much higher than S1T1-2; Betula and Alnus remain predominant. Calluna, at 36%, is considerably higher than in S1T1-2.

5.3.4 Starr 1 Trench 3

5.3.4.1 Sediment stratigraphy

The sediments collected from the east-facing section of Trench 3 as a monolith (see Fig. 5.6) are described below. The depths of the boundaries correspond to those observed in the sampling box along the axis of the pollen subsamples taken from the west face.

Depth (cm)	Description
0- 4	Red/brown unhumified peat
4-22	Black humified peat
22-31	Coarse sand and concreted silty sand

The lithic of the section drawing is centred on 29.5cm.

Radiocarbon date: 20-22cm; 2395±25 b.p. (GrN-13136).

5.3.4.2 Pollen zonation (Diags. 5.3.1, 5.3.2)

S1T3-1 (29-14cm; ?before, and from 2395 b.p.)

The zone is characterised by comparatively stable values of AP, shrub and herb pollen. AP averages 70% (range 66 - 74%); Betula and Alnus are dominant. Most of the shrub pollen is Coryloid (average 15%; range 11 - 20%). Herb pollen averages 18% and is mainly Gramineae. Cerealia type is recorded at both levels of the zone.

S1T3-2 (14-5.5cm; after 2395 b.p.)

Compared to the previous zone AP values are reduced (to an average of 52%); Betula and Alnus are dominant; the principal increase is in Calluna. Herbs average 36%.

S1T3-3 (5.5-3cm; after 2395 b.p.)

Tree pollen is further reduced to 24% and is in similar proportions as before. Gramineae has risen to 59% and Calluna remains high. Herb pollen is 65%; Cerealia type is recorded.

5.3.5 Starr 1 Trench 4

Two samples were taken in glass vials from the base of the 'black humified peat' exposed in the north-south cutting of Trench 4 (only the west-east section was drawn, but the layer of peat may be seen as its continuation, before being truncated, to the east; Fig. 5.7). This layer sealed seven lithics found 'on, in or just under', the gritty, ash-coloured soil beneath (Affleck unpub. MS). The lowest sample is of the basal centimetre of peat; the upper sample is from the top centimetre of peat lying under the 'redeposited sand and peat'.

The diagrams (Diags. 5.4.1, 5.4.2) are not zoned; the basal sample has affinities with S1T1-1 and S1T3-1, having 65% AP, mainly Betula (45%) and Alnus (52%), with Ulmus 0.3%; Calluna is 4%, Gramineae 17%. The top sample has only 3% AP, Coryloid is extremely high (94%, and noted during analysis

as in part comprising grains referable to Myrica), as is Calluna (91%). Gramineae is 70%.

5.3.6 Discussion

The three trenches lie within 35m of each other. The dates from the basal peat of Trenches 1 and 3 were determined from samples within 20m of each other; they are 2415±25 and 2395±25 b.p. respectively, and statistically inseparable at one standard deviation. The pollen spectra of the basal samples, including three taken from mineral soil, show low levels of Ulmus pollen, as does the lowest spectrum from Trench 4. It is evident that the profiles are not of use for providing an environmental context for Mesolithic activity, as probably represented by the lithics. The topmost sample from Trench 1 is unreliable since reworked sediments have probably been incorporated into the layer. The analyses from the red/brown unhumified peat of Trenches 1 and 3 indicate a largely treeless landscape, especially at the former. The upper spectrum from Trench 4 may have been to some extent contaminated by pollen from redeposited peat, and also indicates an open landscape; the red/brown humified peat recorded at the other two sites may have been removed by erosion. The blanket peat that accumulated over the mineral soils at these sites is in situ and began forming at c.2400 b.p., although the possibility of root contamination makes this a minimum date. To outline and fix the times of change of the subsequent vegetational history on a relative scale prior to flooding would require further analysis.

5.4 Loch Dee Road I (NGR; NX 46557816)

5.4.1 Introduction

Loch Dee Road I is one of two sites by Loch Dee, where struck flints have been found (by T.L. Affleck) within mineral soils, which were overlain with

peat. The other site is named Loch Dee Peninsula Flint and is the subject of Section 5.5.

5.4.2 Site and sediment stratigraphy

The site, exposed by a road cutting, is to the south of Loch Dee (see Fig. 5.8). The road runs across the slope of the hillside that descends to the loch (cf. Photo. II); to the south the gradient of the slope rises towards the peak of the hill, one of a series partially enclosing the loch, and here bare rock outcrops. The bedrock is norite (see Fig. 5.9). Blanket peat, and complexes of organic soils, or organic and mineral soils have developed. A peat-alluvium complex occurs along the sides of the White Laggan Burn as it nears the loch (Soil Survey Map, Bown 1973). The primary aim of the pollen analysis at the site was to ascertain whether the profile was of sufficient age to give information concerning the vegetation at the time of Mesolithic activity and to provide a terminus ante quem for the flint.

The vegetation of the hillside above and below the road is dominated by Molinia caerulea. South of the road Vaccinium myrtillus may be locally abundant, with Nardus stricta, Polytrichum sp. and Sphagnum sp. in patches; on the lower slopes areas of Calluna vulgaris and Myrica gale occur. Vaccinium was seen to be more abundant higher up where Huperzia selago and Racomitrium lanuginosum were noted. On the east-facing slope about 6m above the sampling site Molinia grassland gave way to Pteridium aquilinum and then a plantation of sitka spruce and some larch. Pteridium also dominates the open ground to the south of the plantation. On the higher slopes above the road and beyond Forestry ploughing, mineral flushes were observed; in some cases a handful of sand had become trapped by the vegetation.

Three monolith sections were collected at the position of the buried

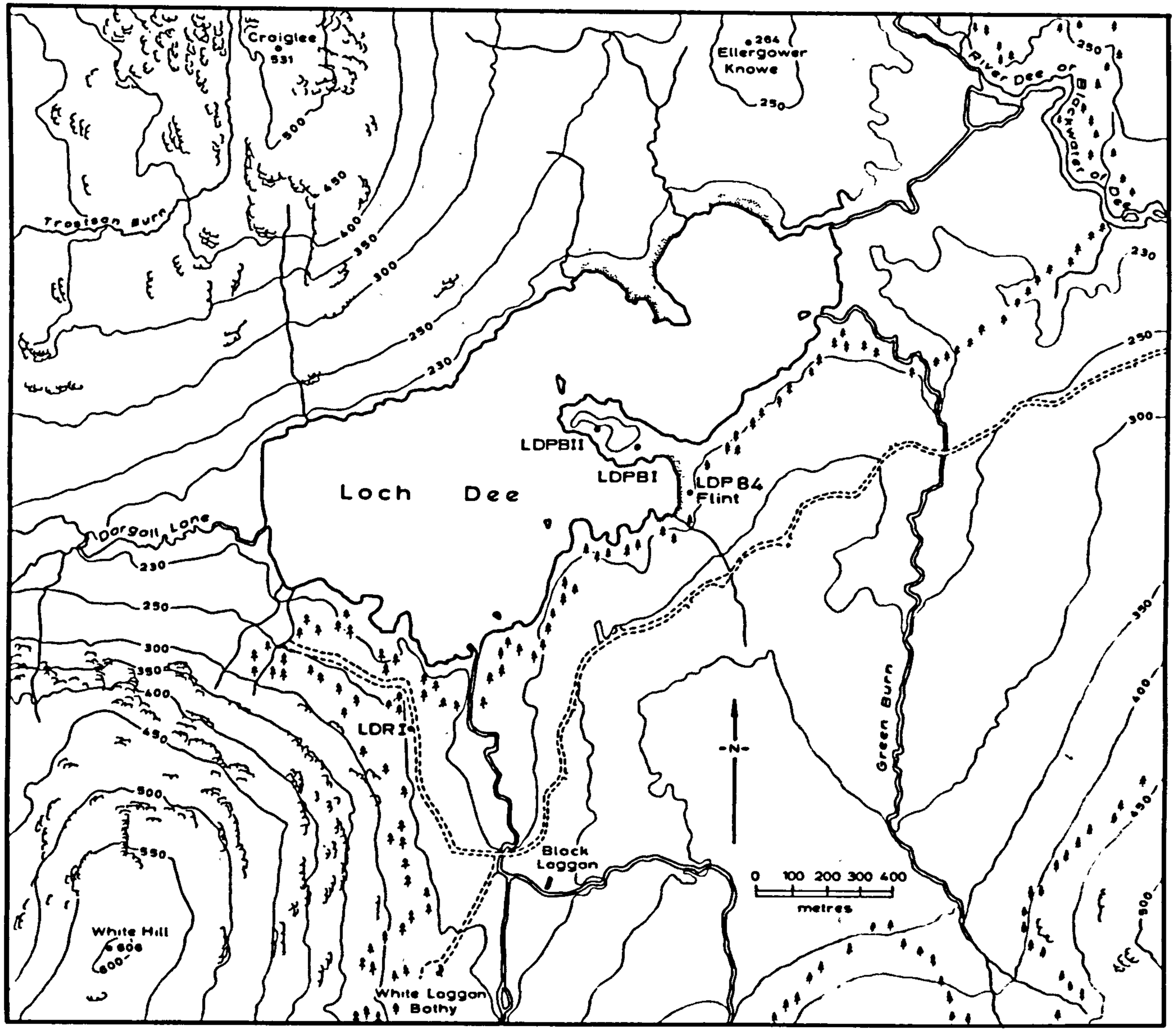


Fig. 5.8. Map of Loch Dee also showing the Loch Dee Peninsula Flint site (LDP84), the Loch Dee Road site (LDRI), and other sites investigated.

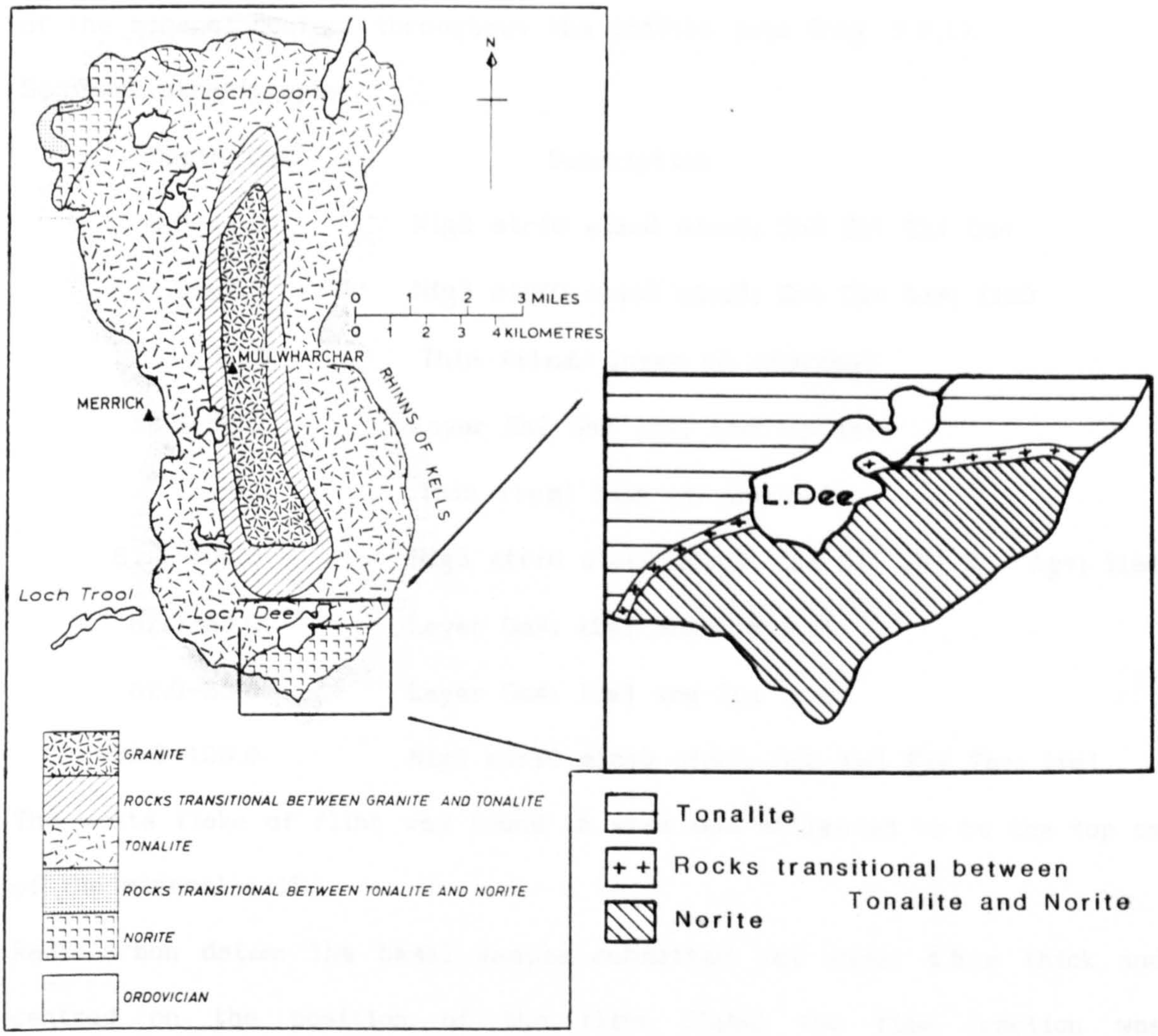


Fig. 5.9. Map of the Loch Doon intrusion (from Greig 1971, after Gardiner and Reynolds 1932). The inset is expanded to show more detail for the environs of Loch Dee (after Gardiner and Reynolds 1932).

flint. Samples for pollen analysis, 1cm thick, were also taken at the level of the flint and at two contiguous levels above and below. A sketch of the local stratigraphy is shown on Fig. 5.10 (cf. Photo. III). In the laboratory the sediment was described as follows, with loss-on ignition determinations of contiguous 1cm-thick samples giving a clear indication of the mineral content throughout the profile (see Diag. 5.5.1).

Sediment stratigraphy

Depth (cm)	Description
0.0-41.0	Nig2 strf0 elas0 sicc3; Sh3 Dl1 Th+ Ga+
41.0-61.0	Nig3 strf0 elas0 sicc3; Sh4 Dl+ Ga+; lim0
52.5	Thin (±1mm) layer cf. charcoal
54.5-56.0	Layer Sh2 Ga2 lim1 and lim inf1
60.0	Thin (1mm) lens cf. charcoal
61.0-102.0	Nig3 strf0 elas0 sicc3; Sh4 Dl+ Th+ Ga+ Ag+; lim0
62.5-63.0	Layer Ga4; lim3 and lim inf3
82.0-83.0	Layer Ga4; lim3 and lim inf3
02.0-108.0	Nig2 strf0 elas0 sicc3; Ga2 Ag2 Sh+ Th+; lim1

The waste flake of flint was found in what was estimated to be the top cm of the mineral soil.

Radiocarbon dates: the basal sample submitted was about 4.5cm thick and centred on the position of the flint flake; the fine fraction was determined as 5340±40 b.p. (GrN-13130), the coarse fraction as 2090±60 b.p. (GrN-13282). The date of 2600±50 b.p. (GrN-13131) was from a sample taken from 58.0-60.0cm.

5.4.3 Pollen zonation (Diags. 5.5.1, 5.2.2)

Pollen analysis of the samples at the level of the flint and the adjacent levels are drawn as the basal three spectra and are strictly slightly separate from the stratigraphic column to which the analyses of higher

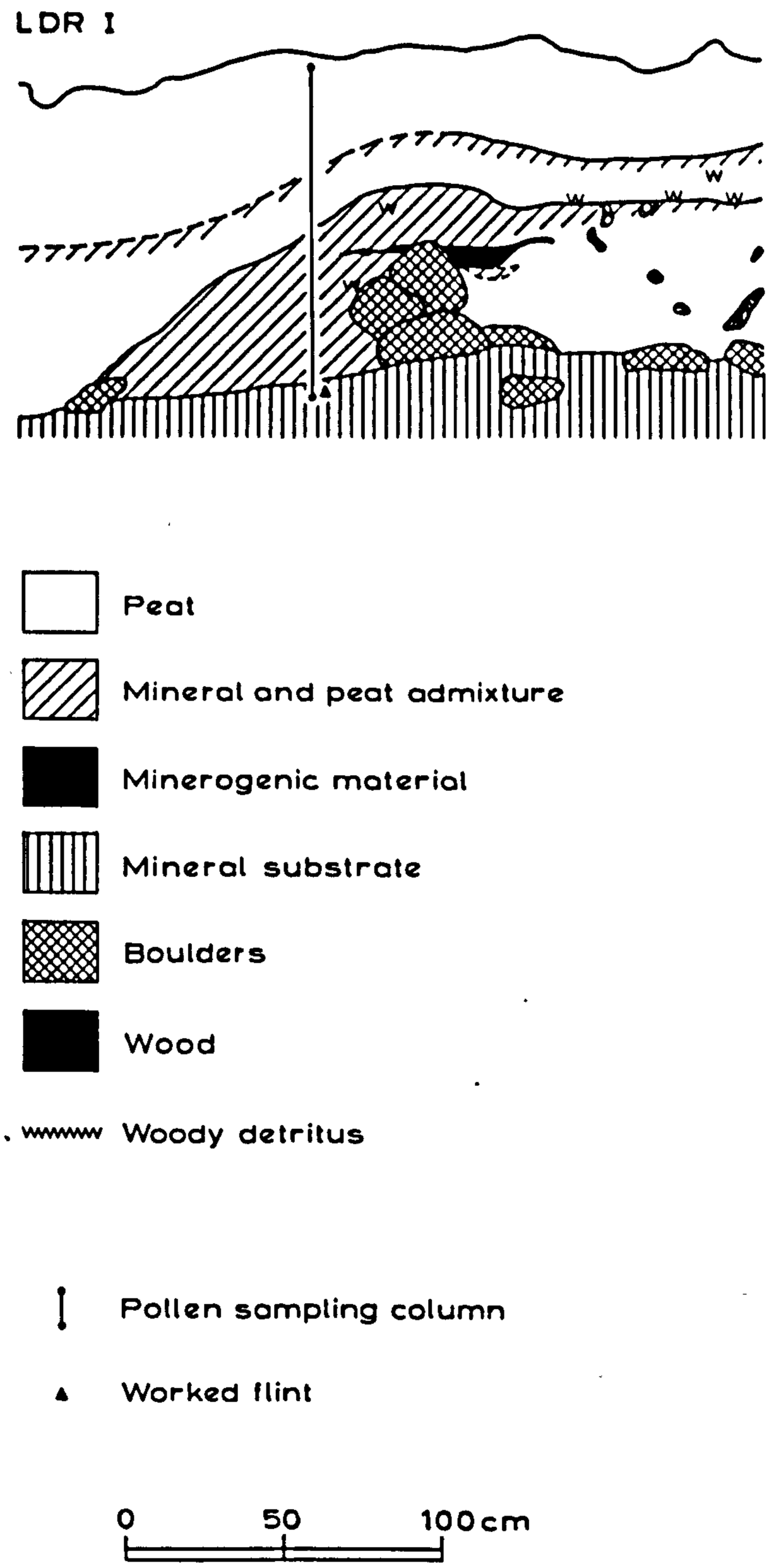


Fig. 5.10. Sketch (by K. R. Hirons) of the section from which the monolith of Loch Dee Road I (LDRI) was taken.

levels belong.

LDRI-1 (106.0-61.5cm; from c.5340 b.p. - before c.2600 b.p.)

On average AP is 76% of which Alnus and Quercus predominate, with Betula taking low values (<10% until the last spectrum of the zone where it rises to 27%). Coryloid ranges from 16 to 24%. Herb pollen, mainly Gramineae, increases towards the end of the zone (to 15%), but is otherwise <10%. The mean number of herb types is 5.7. Filicales is comparatively high (14 - 44%); Polypodium ranges from 2 to 10%.

LDRI-2 (61.5-18.0cm; from before 2600 b.p.)

The average AP is 65% and following a large increase in Betula this taxon generally remains higher than in the previous zone, whereas Quercus is reduced, as is Coryloid. The expansion of herbs is shown individually by rises in Calluna, Gramineae, Cyperaceae and Plantago lanceolata. The number of herb types per level for the zone is 10.6. Filicales and Polypodium are reduced compared to LDRI-1.

LDRI-3 (18.0-2.0cm; after 2600 b.p.)

The zone is characterised by a pronounced fall in AP values (from 42 to 11%) . Herb types are dominant with Calluna, Gramineae, Cyperaceae, Plantago lanceolata, Potentilla type and Succisa showing significant expansions. The average value for the number of herb taxa per level is 14.0. Pteridium, Filicales, Polypodium and Sphagnum are relatively high.

5.4.4 Loss on ignition

There is a close correspondence between the division of zones LDRI-1 and LDRI-2 and the change to higher loss-on-ignition values, which are interrupted by two major episodes of increased mineral input in zone LDRI-2. In LDRI-1 the change from mineral to organic soil is shown (102cm), but there is still a considerable mineral component (almost as much as in the episodes of increased mineral sediment in LDRI-2) and this becomes a

still greater quantity following the maximum deposition of mineral material approximately halfway through the zone.

5.4.5 Charcoal

Microscopic charcoal is present throughout the profile; a conspicuous peak occurs at 100cm.

5.4.6 Pollen concentration

The total pollen concentration curve shows a reduction from generally higher to lower values at the LDRI-2 boundary. The peak in LDRI-2 is most likely in part determined by a time of slow accumulation rate, although a relative increase in Coryloid occurs at this level.

5.4.7 Radiocarbon dating

The basal date of the fine fraction resulting from the pretreatment process is probably more reliable than the coarse one (cf. Dresser 1970, 91-94; Birks 1982). A comparatively high proportion of more modern material from later plants growing on the peat and contributing to the coarse fraction could explain the discrepancy. Younger humic acids which could have percolated through the peat and moved down the slope should be removed (as is intended) during the pretreatment.

5.4.8 Discussion

There is no evidence of an Ulmus decline until shortly before 2600 b.p. and if the date of 5340±60 b.p. from a comparatively thick sample (4.5cm) including material derived from a mineral soil is accepted, then the peat profile belongs to Fl III. If the date is representative of the time when the flint flake was deposited, then unless the flint has been further buried since it was deposited by activity on the surface of the soil or by earthworms, and after the associated and dated organic material was incorporated, it could well represent a Mesolithic presence. Nevertheless,

assuming a Decline would be discernible, the low amounts of Ulmus at the level of the flint and 1cm below it perhaps suggest some downward movement of pollen and therefore other organic material, but how much younger than the Decline it would be, and in what quantity compared to older sediment in the sample submitted for radiocarbon dating, would be impossible to say.

Certain points can be made about the vegetational history represented by the diagram of Loch Dee Road I. The nature of the site, being on ground where trees could grow, would make it one having a local catchment (cf. Dimbleby 1976, 1985), as the high values of AP and shrub pollen in LDRI-1 support. The input of minerogenic material, however, means that it is quite possible that pollen from a wider catchment has been introduced, the amount of mineral shown on the loss-on-ignition curve, perhaps being related to the flow of water downslope at this point, as well as the availability of exposed substrates upslope.

The percentages of alder suggest that during LDRI-1 alderwood was established at least very near the site, whether as an isolated stand, a continuation of fen woodland formed along the edges of the Laggan Burn and loch, or a 'finger' of alderwood spread along the course of a flush cannot be ascertained. It likely had an understorey of ferns, with Polypodium growing epiphytically. Oak and hazel probably occupied more freely-drained ground on the hillside, perhaps with birch constrained to occupying the most acid soils. Some open areas, away from the site are hinted at by the records of Plantago lanceolata near the beginning of the zone; and later, when Melampyrum and Potentilla are present from the time of the increased Gramineae. These last types may have been derived from more open woodland upslope, the loss-on-ignition curve registering more mineral arriving at the site from the level of 87cm. Hardly any organic deposition occurred between 84 and 82 cm and a further minimum is present

at 64cm, very close to the upper zone boundary. Oak is slightly reduced from 82cm and the 'open indicators' referred to above, may have been in woodland where oak was growing and the canopy less complete. Because the increased downwash represented by the mineral component may have been in a very local runnel, it is not possible to confidently extend the idea of greater wetness to postulate that any wider area would have been affected.

Evidence for agricultural activity comes from the last two levels of the zone: Rumex acetosa/acetosella is first recorded, Plantago lanceolata begins a nearly unbroken curve and Cerealia type is then present with Artemisia. Total tree pollen is scarcely altered with these additions to the herb record, although alder has begun a marked decline to be immediately succeeded by birch. It may be giving too great an emphasis to the loss-on-ignition values, which may be altering due to local drainage, but the abrupt rise in the quantity of organic accumulation points to some stabilisation of surface conditions, perhaps with runoff temporarily directed elsewhere. Alder may have been unable to regenerate (it requires damp soils in spring for successful seed germination (McVean 1955a), allowing the more tolerant birch to replace it. Whilst Filicales and Polypodium are known to be resistant to deterioration (cf. Havinga 1984), their relative and absolute declines are more extreme than those of Indeterminable types and the total input of palynomorphs, so neither differential preservation, nor a reduced input from upslope can account for the decline; as with alder a lessened ability to reproduce in drier soil, seems likely, or the absence of a host. It is of interest to note the succession by rowan (probably represented by the Sorbus-type pollen) that McVean (1964; 154, 161f.) considered to be limited in recent times by heavy grazing.

During the period of the events recorded across the zone boundary of LDRI-1/2, higher quantities of charcoal compared to pollen were found

and a thin lens of charcoal was observed in the sediment at about 60cm and a charcoal layer (also about 1mm thick) at 52.5cm. The changes of the local succession were already underway by 60cm and certainly the more organic accumulation has begun at the first record of increased charcoal, although the latter was not analysed in the same detail as the loss-on-ignition. There is no clear indication of a local fire contributing to the interplay of tree species at the site.

Of greater relevance to the development of the cultural landscape and the integration of the vegetational history inferred from the sites on the peninsula (Sect. 5.5 and Chapter 7) is the possibility of clearance opening areas for the greater representation of herb types in LDRI-2. Of the dry-land trees, oak and hazel suffer reductions across the lower boundary of the zone in absolute terms and there is an increase in grass following; this is more or less sustained during the rest of the zone. The smaller increases of heather and sedges (perhaps Eriophorum) could be a result of some acidification of soils. The further reduction of oak is not marked by signs of more areas having been opened and is in part the consequence of the rise of alder that follows another episode of greater downwash. Whereas the period of LDRI-2 witnessed opened areas in the more regional catchment, locally some alderwood was re-established, but this time with more birch; the brief local dominance of rowan was taken over by these trees. The higher amounts of charcoal may be associated with occupation of the area from shortly before c.2600 b.p. when the openings were probably used for grazing and at least some cereal growing, presumably on the flatter ground such as that bordering the loch or the Laggan Burn.

At some time between levels 22cm and 14cm a greater degree of clearance probably took place, a process that was repeated, so that by the 8cm level, a virtually open landscape may be envisaged and grazing was

intense. The representation of widespread moorland development culminates with Calluna at its greatest value. From the end of the previous zone no large inputs of mineral material are registered at the site. No cereal-type grains were found during the zone.

5.5 Loch Dee Peninsula Flint Site (NGR: NX 47347885)

5.5.1 Site and sediment stratigraphy

A piece of worked flint was found near the south-eastern part of the peninsula that extends into Loch Dee on its eastern side (the site is called LDP Flint, see Fig. 5.8). It was buried in the mineral soil about 6 to 7cm below the junction of this soil and the overlying peat. The peat has accumulated over the whole peninsula, being deepest between the ridges that are the most obvious feature of the local topography (see Fig. 7.2; cf. Photos. X, XI). At the sampling site, at the back of the shore, the peat is about 50cm deep and forms a cliff that is eroded by high water. A monolith was taken after first sampling the soil at the level of the flint and at adjacent levels above and below. Approximately the top 10cm of the cliff were not collected; this was part of the relatively unconsolidated humose mineral soil, the mineral coming from the beach. The base of the peat has formed over stony sand. The bedrock is norite (Fig. 5.9).

The vegetation of the peninsula at the site is of Molinia and Calluna. Elsewhere on the peninsula bog communities principally comprise of Myrica gale, Calluna, Tricophorum caespitosum, Eriophorum vaginatum and Sphagnum (see Sect. 7.2).

Sediment stratigraphy

Depth (cm)	Description
0- 5	Nig2 strf0 elas0 sicc3; Sh2 Ga2 Gs+ Th°+
5-31	Nig3 strf0 elas0 sicc3; Sh3 Ga1 Gs+ Th°+ Dl+; lim0
29	Wood fragment
31-42	Nig3 strf0 elas0 sicc3; Sh4 Ga+ Gs+ Th+; lim0
42-45	Nig1 strf0 elas0 sicc3; Ga3 Sh1 Gs+ Th+; lim1 (pale buff)
45-54	Nig2 strf0 elas0 sicc3; Ga2 Gg1 Sh1 Th+; lim1 (orange/brown).

Radiocarbon date: 5190±80 b.p. (GrN-13129) was obtained from 2cm directly

above the interface of the mineral soil and peat (40-42cm); and thus the sample overlay the flint.

5.5.2 Pollen zonation (Diags. 5.6.1, 5.6.2)

LDP-1 (50cm; ?before 5190 b.p.)

This zone has only one level. AP is 28%, with herbs as the predominant group (68%); Ericoid, Gramineae and Cyperaceae make up most of this percentage. Filicales is 17%. The sum of total pollen at this level is 90. The number of herb types is 8.

LDP-2 (49-32cm; ?before, and after 5190 b.p.)

Tree pollen is on average 74% TLP and dominated by Quercus and Alnus. Herb pollen ranges from 4-22% with Calluna, Gramineae and Melampyrum taking the highest values. There is a maximum of Filicales (39%), but its percentages are otherwise moderate (1-5%). The average number of herb types per level is 7.3.

LDP-3 (32-18cm; after 5190 b.p.)

AP is reduced (average 53% TLP); Betula has increased and Quercus declines. Coryloid pollen is effectively unchanged. There is a significant rise in herbs (average 34%), chiefly reflected in the curves of Calluna and Gramineae. Pteridium has increased. The number of herb types averages 9 per level.

LDP-4 (18-6cm; after 5190 b.p.)

A further decline of AP, to a minimum of 8% accompanies a rise in herbs to 76%. Calluna and Gramineae expand; at the top of the zone Cyperaceae, Plantago lanceolata and Potentilla achieve highest values, as does Pteridium. The number of herb types averages 10.

5.5.3 Discussion

The occurrence of the flint in the stratigraphy implies activity at the site before c.5190 b.p., the date of the basal peat. Its association with

the pollen spectra below this is uncertain due to the problems of pollen and lithic incorporation discussed with regard to the site of LDRI (see also Section 6.6.2). Because of the low pollen concentration (1.8×10^3grains/ml), the spectrum of LDP-1 is only based on 90 grains (TLP). The contiguous level above has a concentration of 19.4×10^4grains/ml. There is no earlier level with which to compare the low tree percentage of the bottom of the sequence, which could have suggested clearance, and the low concentration is possibly the combination of a relict assemblage, scarcely surviving, and a superimposed microfossil input at the limit of its downward movement. The basal spectrum (LDP-1) may well then have a mixture of assemblages: one of an early postglacial flora when tracts of the landscape were open, with herbaceous communities in which grasses and sedges were dominant, though perhaps birch and pine had begun to colonise; the other a much later spectrum in which others of the Flandrian trees are present in some quantity.

During LDP-2 birch and pine are relatively less important and the extent of open communities is reduced. The low percentages of elm below the horizon dated 5190±80 b.p. may mean that much of the pollen has been transported down the mainly mineral part of the soil (thus diluting a potentially higher proportion of the tree), although a local catchment is likely once the site had become predominantly wooded (as the total AP percentages indicate) and the soils in the near vicinity could well have been unsuitable for elm.

Alder no doubt skirted the edges of the loch; of the dry-land trees, oak was more important than hazel, being the most recorded tree at around the middle of the zone. Some degree of open canopy, or the registration of plants at the edge of the woodland is implied by the occurrences of Melampyrum, Potentilla, Succisa and other herbs, but grasses and heaths are low compared to the next zone.

In LDP-3 oak is much lower and absolute increases in heather, grasses and bracken show that some clearance has probably taken place; the formation of ombrogenous peat and associated communities may have ensued. Alder and birch are relatively more significant. Plantago lanceolata is first encountered at the end of the zone.

In the last zone further clearance has most likely effected the decline of tree pollen taxa to their lowest percentages overall and widespread blanket peat has developed by the top of the profile. That other, drier areas were also available for grazing is indicated by the values of Plantago lanceolata and Artemisia.

Having only comparatively widely-spaced analyses from the end of LDP-2 and no further radiocarbon dates above the basal two cm of peat, firm conclusions about the chronology of the changes inferred above are precluded. The majority of the profile belongs to the chronozone F1 III.

CHAPTER 6

LOCH DOON - DETAILED INVESTIGATIONS AND SYNTHESIS

6.1 Introduction

An area to the south of the Starr Cottage excavations, and close to the present high water mark of Loch Doon (Fig. 6.1), had already attracted attention as a possible focus of Mesolithic activity when lithics were found on a small hillock on the edge of Forestry ploughing (Edwards et al. 1983; Figs. 6.2, 6.3; Photos. VII, VIII). The plough had excavated into the mineral soils and exposed faces on either side of the furrow from which lithics could then be dislodged (site LDFSIE; Fig. 6.3, inset). A preliminary study of peat deposits from close to this site had been undertaken (Carter 1986). The pollen analysis and radiocarbon dating indicated that peat had accumulated from around the time of the Alnus rise until the present day. The nature of the Alnus rise was not looked at in detail as it was clear that the surface of the peat at the sampling site had been cut over (site II, Fig. 6.2; Carter's LDA). The detailed analysis was confined to the site where there was a remnant of the bog surface surviving as a small hag (site I, Fig. 6.2, Photo. IX; Carter's LD, Appendix 2). The radiocarbon date of 4850±60 b.p. close to the base of the bog at this site and the few basal levels of relatively high values of Ulmus pollen (as a percentage of AP) show that almost the entire sequence is within Fl III.

The initial purpose of the present investigations was to survey the peat deposits to the west of the original sites in the hope of finding older sediments than had been recovered hitherto, preferably where peat cutting had not truncated the stratigraphy. Probes along suitable transects would establish the shape of the basin. In addition, the site of the lithics to the south of the bog was excavated on a small scale and a

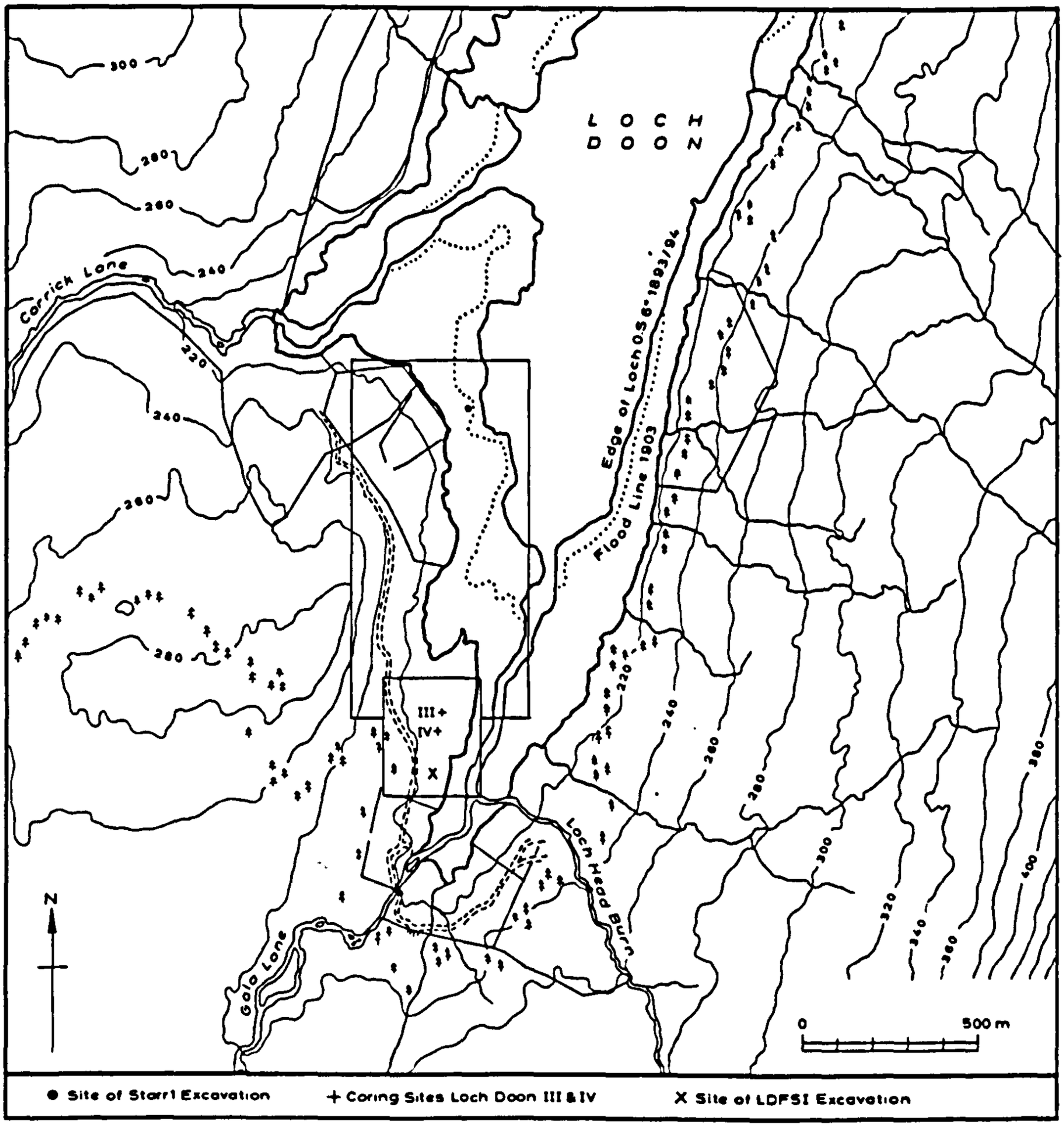


Fig. 6.1. Map of the southern end of Loch Doon also showing the area of detailed palaeoecological investigations and location of the LDFSI excavation (lower inset, which refers to Fig. 6.2). The upper inset refers to Fig. 5.2.

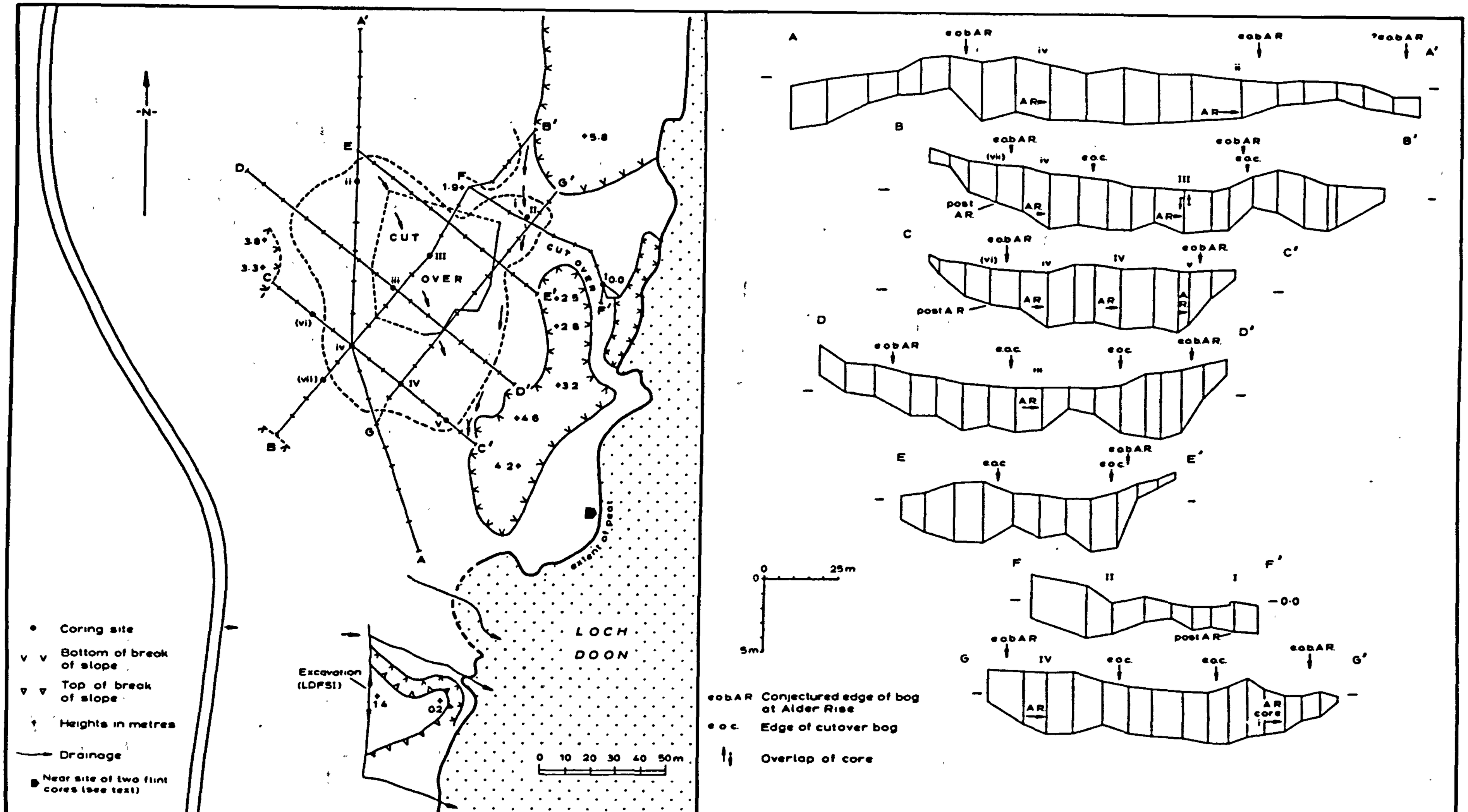


Fig. 6.2. Map of the area of detailed palaeoecological investigations showing the locations of the coring sites and transects, and the situation of the LDFSI excavation. The transect profiles are drawn within the common datum of site LDI (0.0).

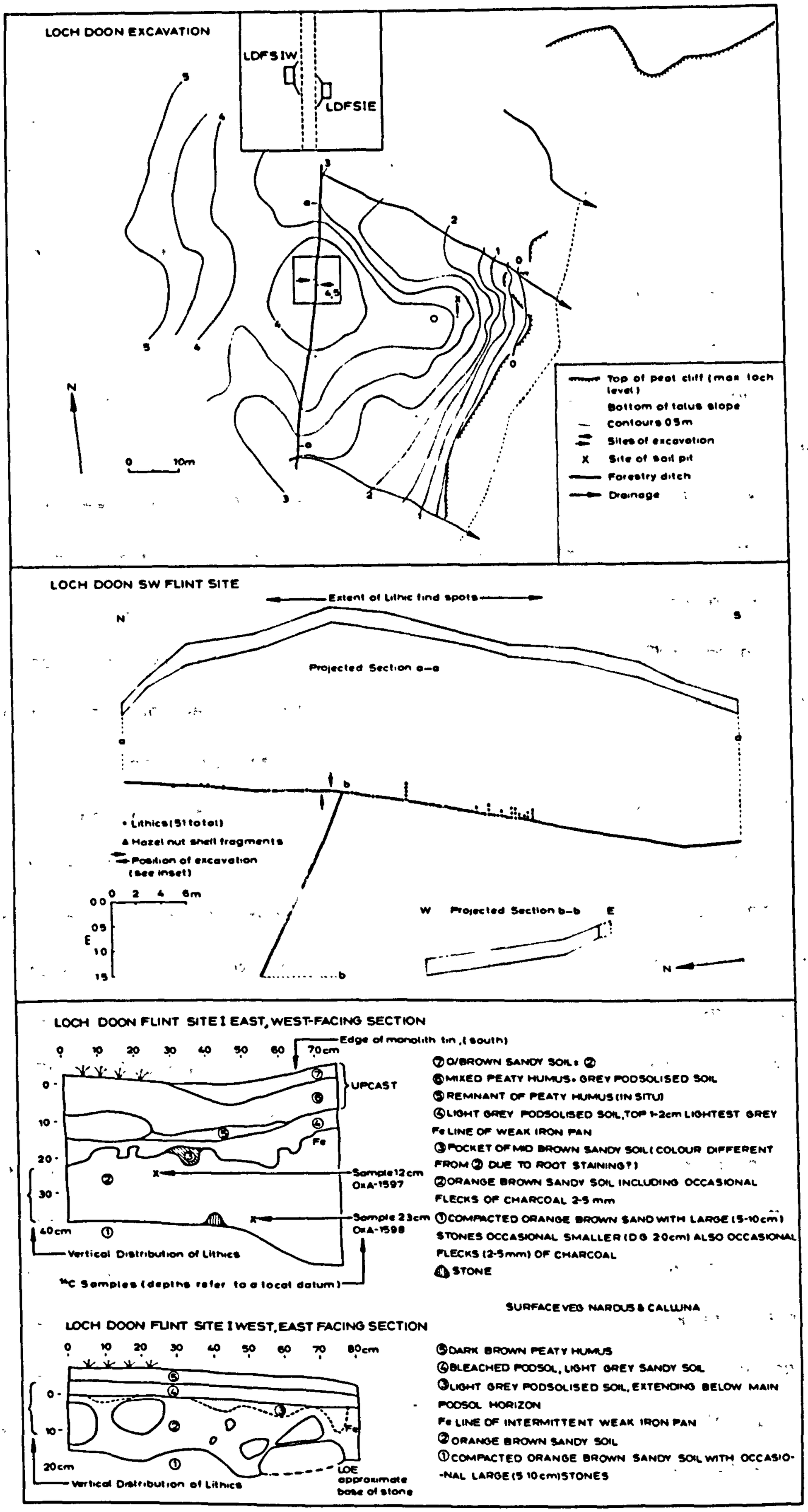


Fig. 6.3. Map of the hillock on which the small-scale excavations LDFSIW and LDFSIE were carried out. Profiles of the hillock and the extent of the lithic distribution are illustrated as well as the excavation sections.

measure of the extent of the distribution of lithics obtained. Pollen analysis of the soil and overlying peat might also show a record of Mesolithic disturbance.

6.2 The study area (NGR; NX 48259300)

The peat deposits that were surveyed lie towards the southern end of Loch Doon and to the east of the gravel road by the western side of the loch (Fig. 6.2). The solid geology is of tonalite, although to the north the edge of the Loch Doon intrusion is met some 2.5km away (see Figs. 3.4 and 6.4). The maximum level of the loch is at 215m A.O.D. and the change in its outline compared to earlier times has been indicated above (Sect. 5.3.1; Fig. 6.1). Today field walls run right to the edge of the water and are submerged - a vivid sign of the flooding of useful land. The ground rises steeply from the eastern side of the loch, where the effects of the inundation on potential farmland are not great, but on the western side and southern end the loss of land area may be considerable, particularly near the study area. The sides of the valley above the southernmost part of the loch ascend to more than 620m and 280m on the east and west respectively. The inflow of the loch from the south is by the Gala Lane, rising at the watershed of the Silver Flowe (see Figs. 6.1, 6.5 and 3.2).

The Soil Survey (Bown 1973) has mapped the study area (Fig. 6.2) as peat (a continuation of the peat of the Loch Doon-Loch Dee basin to the south) and as an organic soil complex of the Dalbeattie Association. The soil and peat cover within the area is more complicated than the map is able to show. The organic soil complex extends around the shore of the loch to the Carrick Lane inflow. To the south of the study area, a similar soil characterises the ground by a short stretch of the Gala Lane and an area fringing the southeastern shore of the loch (as shown in Fig. 6.1). The two distributions are interrupted by an area of poorly-drained peaty

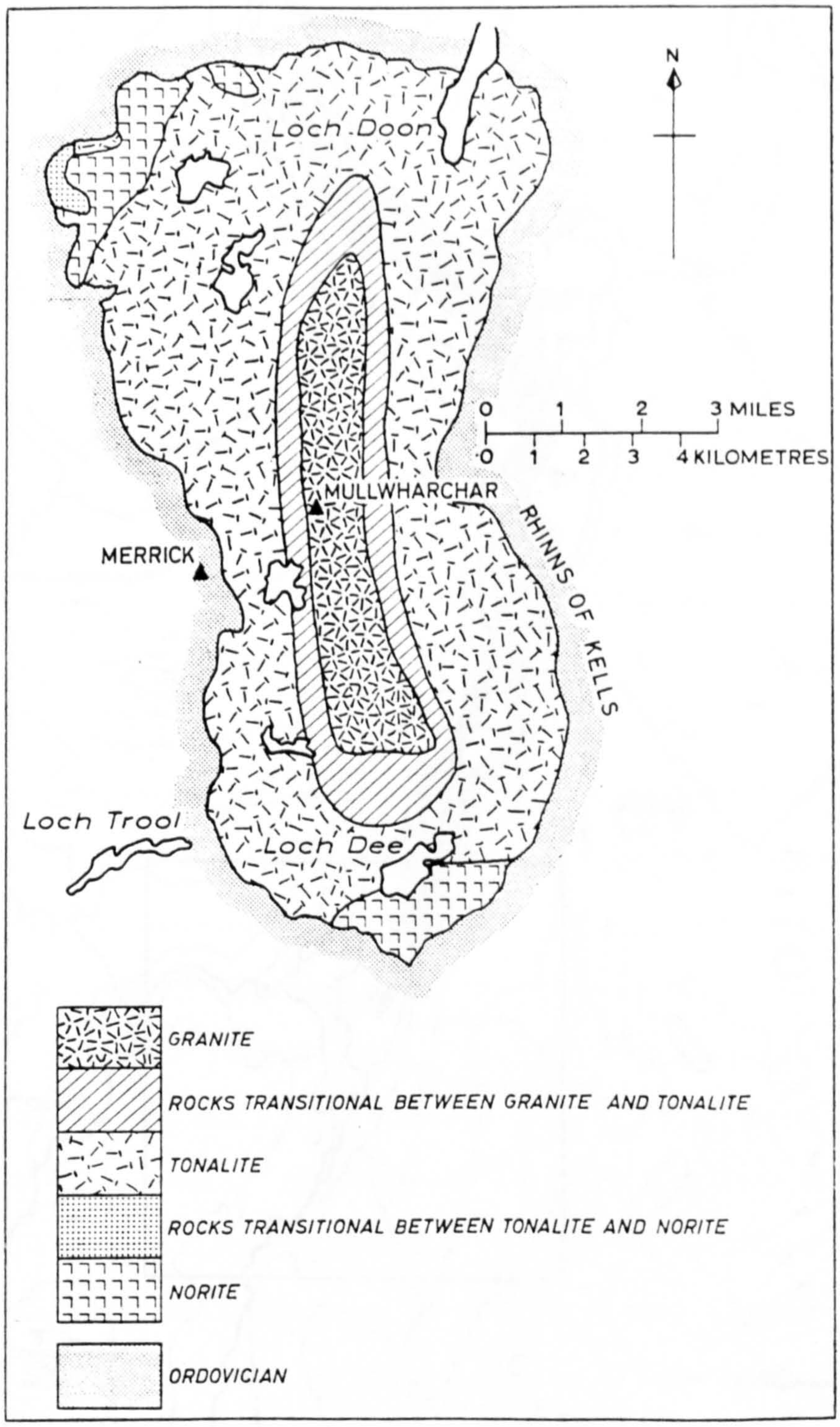


Fig. 6.4. Map of the Loch Doon intrusion (from Greig 1971).

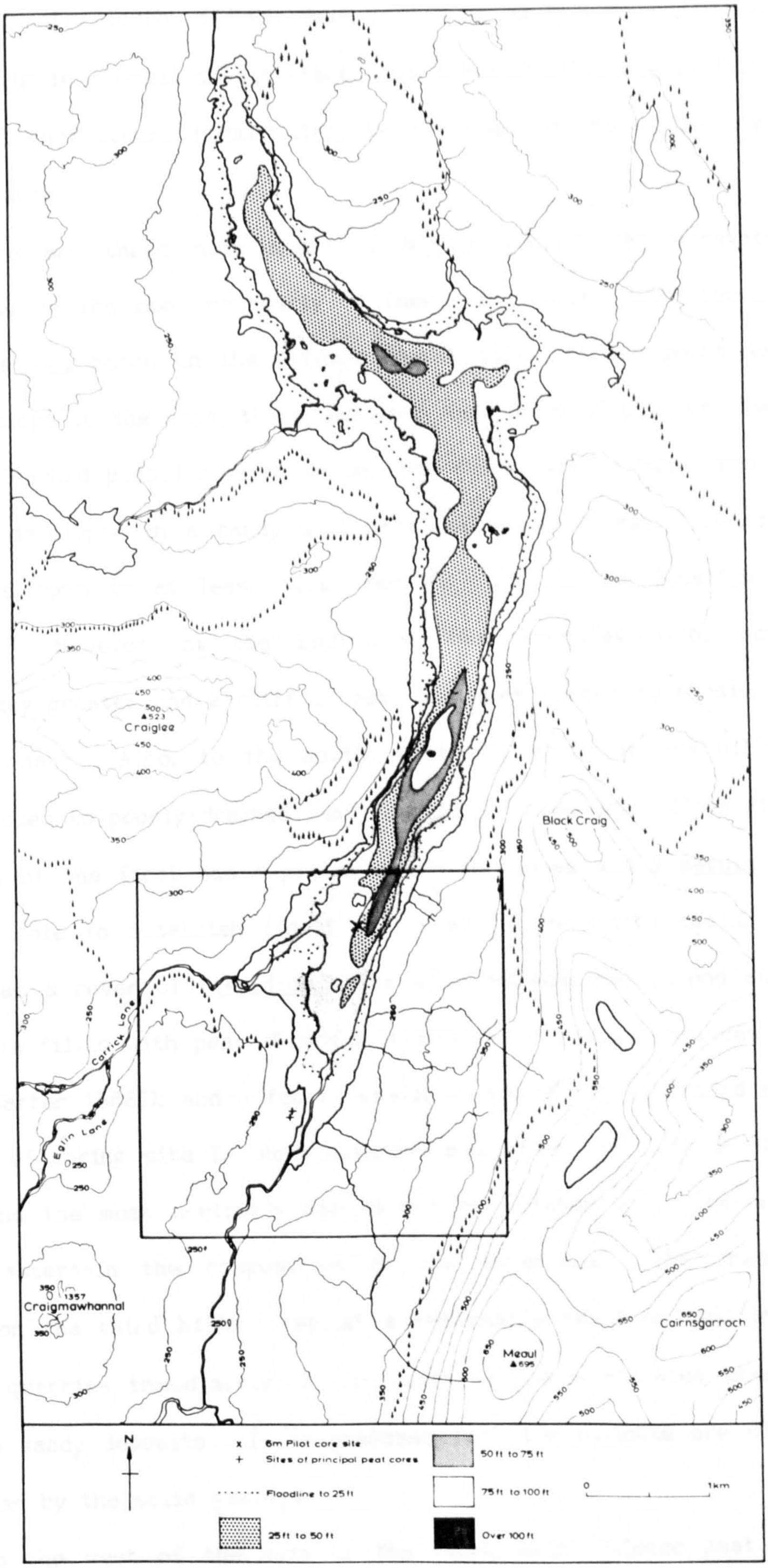


Fig. 6.5. Map of Loch Doon showing bathymetry and floodline after Murray and Pullar 1910). The inset refers to Fig. 6.1.

gley soil, mostly south of Loch Head Burn. An exception to the peat and organic soils is a small extent (about 200 x 500m) of freely-drained brown forest soil that occurs immmediately to the west of the northern part of the study area.

There are three main areas of higher ground; the excavation of lithics was on the most southerly of these (Fig. 6.2). Here there is an area of Calluna heath on the hillock (Photo. VII). At one point near the break in slope to the east, there was only some 10cm of peat or raw humus above a bleached podsolic layer (about 5cm thick) with a weak iron pan at its base, developed in a sandy soil with occasional stones. Living roots were noted down to at least 40cm (see Fig. 6.3 for the location of the soil pit). However, at the loch side the accumulation of peat was considerably greater and a cliff of peat has been formed by erosion at the high watermark. Also, to the south, west and north of the hillock the ground slopes to poorly-drained peaty deposits. A second hillock rising to the north of the first has a grassy sward in places and a Betula sapling has been able to establish itself. Further to the north again, a third hillock has a cover of Pteridium. The area between the second and third hillocks is filled with peat (Fig. 6.2, transect F-F', which includes cores I and II [Carter 1986]), and a fourth smaller area of higher ground rises to the east of coring site I. Rock outcrops along the loch side in this area and around the most northerly hillock but no further soil pits have been dug to ascertain the composition of the substrate. The presence of bracken on the third hillock implies a reasonable depth of soil and there are two quarries immediately to the south of the study area where there are deep sandy deposits. It is presumed that the hillocks are ultimately determined by the solid geology.

To the west of the axis of the three main hillocks peat deposits reach more than 4m in depth. The subsurface topography shows a variation

that is not always reflected in the shape of the growing surface of the peat. Again it is not known to what extent this is the result of the solid geology, or the dumping or collection of drift. The peat has been ploughed by the Forestry Commission to approximately the foot of the third hillock, the western edge of the second and the brow of the first. The drainage of the bog is conducted through channels; the directions of flow are indicated on Fig. 6.2. At least two areas of peat have been cut (see Fig. 6.2).

The recent vegetation of the peat is principally Molinia, Myrica, and Calluna. Calluna flourishes especially where the peat is uncut. In the largest cut-over area the peat is regenerating and there are small areas of Sphagnum lawn. The plantation of sitka spruce extends from the hillocks in the east, across the bog, and to the west up the slopes of the hillside to the west of the road (Fig. 6.2).

Cores were collected from the bog to three main ends: to provide a record of the pollen rain for at least the duration of possible Mesolithic activity and preferably for most of the Flandrian; to gain an insight into the potential spatial variation of the vegetational record; and to investigate the variability of the Alnus rise as a further indication of differences in pollen catchment at a number of sites within the same bog, at a horizon perhaps influenced by Mesolithic activity (cf. Smith 1984). Peat cutting meant that the most complete profile (Loch Doon IV) could only come from a site towards the bog margin and LDIV is described first, followed by Loch Doon III (LDIII; Fig. 6.2 and Photo. VIII).

6.3 Loch Doon IV

6.3.1 Sites and sediment stratigraphy

The longest transect (A-A' on Fig. 6.2) shows that close to the site of Loch Doon IV there is a small hump in the sub-peat surface which may form

part of an area of ground which was proud of the accumulating peat during the earlier part of the Flandrian. The presumably dry ground of the central hillock to the east would have provided a soil suitable for tree growth. An indication of the extent of the bog at the time of the Alnus rise is given on Fig. 6.2, the basis for the delineation is discussed below (Section 6.5.1).

Due to a layer of Sphagnum peat in the upper stratigraphy it was impossible to sample the top 50 cm of peat with the large Russian corer (used for the rest of the profile) and two overlapping monolith tins were used for the purpose. The correlation of the stratigraphy with that of the top core has resulted in the surface of the peat in being labelled 2 cm. The correlation of the two overlapping basal cores is described in Appendix 1. The volumes of peat extracted for pollen analysis was measured by displacement.

Sediment description

Depth (cm)		Description
2.0- 3.5	Nig3 strf0 elas1 sicc3	Sh3 Tb'(Sphag)1
3.5- 11.0	Nig2 strf1 elas2 sicc3	Tb'(Sphag)3 Th(Erioph)1 Tl(Calluna)+; lim1
11.0- 39.0	Nig3 strf0 elas1 sicc3	Sh2 Th(Erioph)2 Tb'(Sphag)+; lim0
39.0- 53.0	Nig2 strf0 elas2 sicc3	Tb'(Sphag)4 Th(Erioph)+; lim0
53.0-106.0	Nig4 strf0 elas0 sicc3	Sh3 Th(Erioph)1 Dl+; lim2 cf.Betula frags. at 106-108cm 123-124cm
106.0-269.0	Nig4 strf0 elas0 sicc3	Sh3 Th1 Dl+; lim0 wood frags. at 161, 174, 201, 215, 228, 233, 236-8(large frag.), 255, 269cm
269.0-308.0	Nig3 strf0 elas0 sicc3	Sh3 Th1; lim0
308.0-332.0	Nig4 strf0 elas0 sicc3	Sh4 Th+; lim1
332.0-401.0	Nig3 strf0 elas0 sicc3	Sh4 Th+ Dl+; lim0 wood frags. at 332, 346, 355, 356, 363, 365, 368-370 (large frag.), 376, 377, 383, 395cm
401.0-408.0	Nig3 strf0 elas0 sicc3	Sh4 Th+; lim0

6.3.2 Radiocarbon dating

Eight radiocarbon dates were determined from Loch Doon IV and are tabulated below.

Table 6.3. Radiocarbon dates from Loch Doon IV.

Depth (cm)	Years b.p. (error at one s.d.)	Lab. No.	Interpolated deposition time (yr/cm)
101-105	3250±70	GrN-13844	15.7
201-205	4820±110	GrN-13847	12.9
252-256	5480±100	GrN-14662	20.0
303-307	6500±90	GrN-13845	?
352-356	9150±200	I-15157	
390-394 (basal core)	9280±140	GrN-14663)	
391-395	9200±110	GrN-14664)	23.5
404-408 (basal core)	9610±150	GrN-13846)	

The plot of time against depth (Fig. 6.6) shows two periods - c.9200 to 6500 b.p. and c.3250 b.p. to the present day - when it is considered that the possible uncertainties of the peat accummulation rate are too great to allow the interpolation of dates. A detailed consideration of the first of these periods is given here so that it is not interposed during the discussion of the vegetational history inferred from the site. The relevant sections of the profiles of LDIV and LDIII are drawn on Diags. 6.3.4-6 and 6.4.4-6, the LPAZ and LPAS are described in Sections 6.3.3. and 6.4.2,

The dated profile of LDIV has the apparently anomalous date of 9150±200 b.p. (352-356 cm) compared to those below it (see Fig. 6.6). At face value this suggests an extremely rapid accumulation of peat prior to this from the date of 9280±140 b.p. (390-394 cm), i.e. using the mean dates and depths, 130 years to build up 38cm of deposit (1cm in 3.4 years, or 0.3 cm/year). Taking the standard deviations into account this could be expressed as 'no time at all'. Using the date of 9200±110 b.p. (391-395cm on the same core segment) for the calculation makes this even more apt. The time then is 1.3 years/cm or 0.8cm/year. These times contrast with

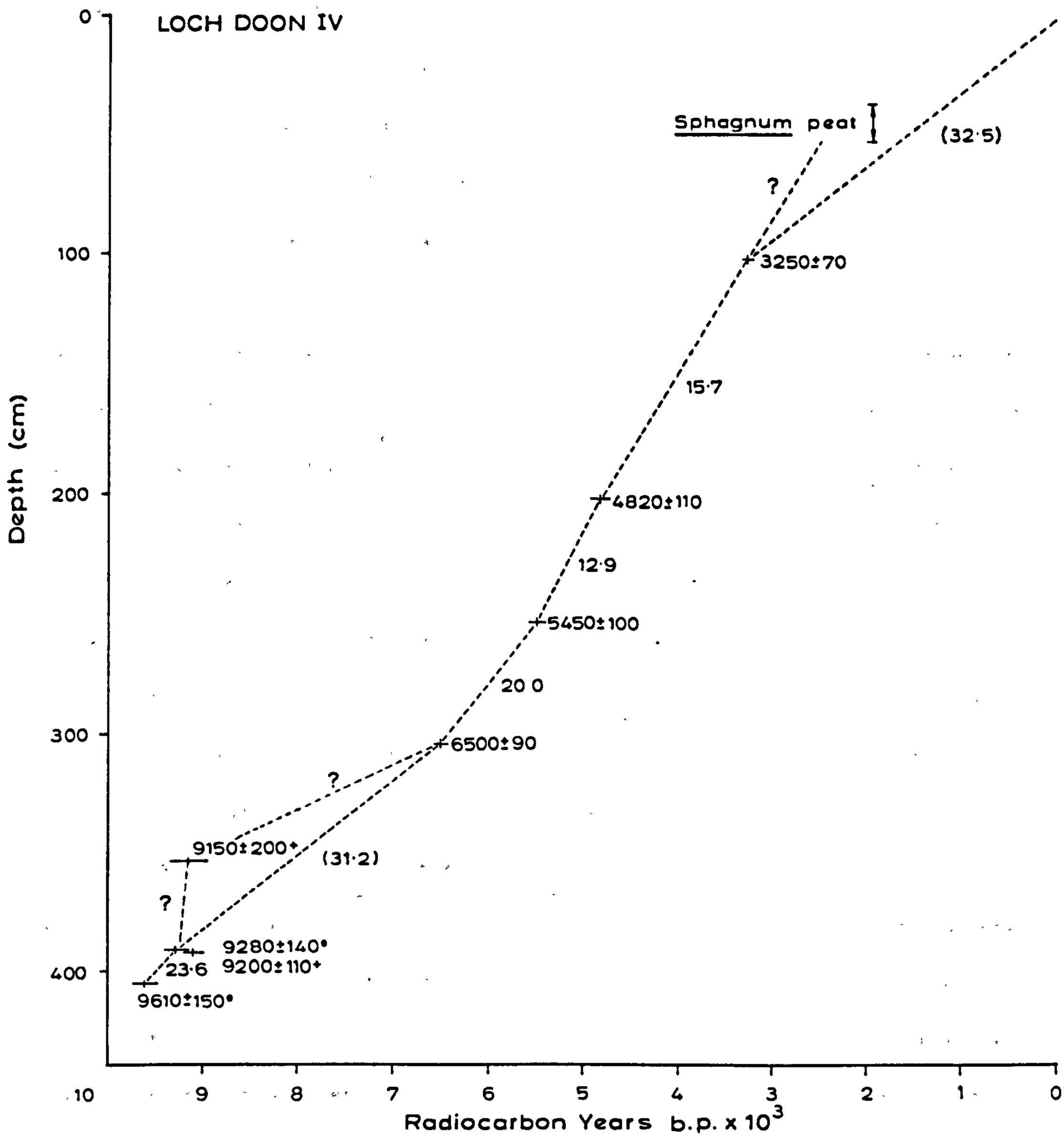


Fig. 6.6. Plot of radiocarbon dates (b.p.) against depth for the profile of Loch Doon IV (LDIV). + = from core 350-400 cm; o = from core 358-408 cm. Interpolated deposition times (yr/cm) are also given.

23.6 years/cm between the two dates on the basal core (6910±150 b.p. and 9280±140 b.p.) when the pollen concentration is of the order of half that early in LDIV-3. It might be expected that given a constant pollen input, with slow peat growth the concentration would be high (if well preserved) and the deposit well humified.

Inspection of the sediment did not suggest poorly humified remains and no Sphagnum leaves were found in sieve washings at five levels from the Sphagnum subzone at LDIV (and three from LDIII). The concentration of all pollen and spores shows an increase with the rise of Coryloid to high values but, thereafter, with no significant additions to the local pollen rain, it remains approximately steady until the end of the Sphagnum subzone at LDIV and beyond it at LDIII. At LDIV there is then a rise to very high values, which is mostly dictated by the Betula curve, but at its start Coryloid rises as well. Whilst the concentration of Betula is still very high, peaks of Coryloid, Filicales and Indeterminable types and a rise in Gramineae, not apparent on the relative diagram, suggest a drying of the surface and a slow rate of accumulation. The possibly advantageous preservation of Filicales and amounts of Indeterminable types (seen in the relative diagram too) would support this (though Wilkinson and Huntley [1987] present evidence for poor preservation in wet situations). It may also be noted, however, that for much of the time of the Sphagnum subzone at LDIV, representation of Indeterminable types is higher than at the time of the proposed slower accumulation rate; in this case it may have been the result of pollen having been washed into the basin from the slopes of any small mounds of higher ground which towards the end of the zone became engulfed by the growing peat and so the potential for focusing pollen into the basin in this way was lost.

The large peak of total pollen concentration at 323cm has fallen at 325cm to values comparable with those after the Sphagnum subzone and

before the rise of Betula. Following this there is another, smaller peak - perhaps the result of a slowing in the rate of sedimentation, since the most represented taxa increase together in spite of some differing trends in the relative curves. After a fall over the next centimetre, the subsequent rise is associated with the start of the dramatic rise of Alnus dated at 6500±90 b.p.

From what has been said of the differences of apparent accumulation rate and not least because of the time between 9150 b.p. and 6500 b.p., interpolation to date events during this period has not been attempted. There are admittedly great fluctuations of pollen concentration, which may imply change in sedimentation rate, between the levels dated to 6500 and 5480 b.p.; however, the timespan is c.1000 years with a difference in depth of about 50cm. In order to interpolate dates between the determinations of 9280 and 9150 b.p. it would be necessary to be convinced that the basin had been so productively infilled during the first part of the zone. If the basal deposition time of 23.6 years/cm is accepted, the beginnings of LDIV-3 is 9000 b.p. by extrapolation. The beginning of LDIV-4 is 6600 b.p., also by extrapolation, from the average of 20.0 years/cm.

6.3.3 Pollen zonation (Diags. 6.3.1-6, 6.7.1-2)

In the first place local pollen assemblage zones (LPAZs) were identified (based on AP, AP + taxon) and salient features of both are described below. For the local pollen assemblage zones within chronozone F1 III particular attention has been given to the form of the total tree and shrub pollen curve. The analyses are more widely placed in this part of the diagram and it will be argued below that the representation of the regional pollen at this site increased during this chronozone, and with the emphasis of interpretation on landscape change this factor makes it appropriate to

stress the criterion of total tree and shrub pollen. For the spectra of the chronozones Fl I and II, the local pollen zones could similarly reflect woodland change in a wider setting than the immediate area of the bog (for example, in the arrival or expansion of trees). In addition, local pollen assemblage subzones (LPASs, Sect. 4.3.2) highlight features of the more detailed analyses from the 180cm level to the base of the profile. They are shown on Diags. 6.3.4-6 where the vertical scale is expanded compared to Diags. 6.3.1-3 for the sake of clarity. The chronology of radiocarbon years is derived from the interpolated sedimentation rates of Table 6.3 and are approximate, especially where boundaries are at some depth from a dated horizon or the spacing of dated samples wide.

The assemblage zones with affinities to Birks's (1972) regional pollen assemblage zones (RPAZs) are shown on Diag. 6.3.1. Because the pollen catchment for tree pollen is potentially so much more local than for the sites of Snibe Bog and Loch Dungeon, a great difference in the recruitment of arboreal pollen is to be expected, especially due to the high abundance of birch at Loch Doon IV, which could affect the representation of other, principally dry-land trees (Ulmus and Quercus). The transect across Snibe Bog (Birks 1969, p.34, Fig. 28) shows that the main basin of the deposit was possibly of the order of 200m across for the earlier Flandrian, with its present extent being about 360m across the same east-west transect. The coring sites are towards the centre of the bog. According to Jacobson and Bradshaw's (1981) model the amount of local pollen has fallen to near its asymptote at this diameter, with 'extra-local' pollen predominant and the amount of 'regional' pollen increasing its abundance for diameters greater than 200m. Woody detritus in the peat at Loch Doon IV and the site's marginal position in the early Flandrian bog suggests that the pollen catchment area is mainly 'local'. The numerical criteria for the boundaries are not the same as

those of Birks (1972); the discrepancy of overlap is greatest in chronozone Fl I, where the rise in Coryloid pollen is considered as a boundary at an earlier time compared to the beginning of the Birks's Betula-Corylus/Myrica zone. The same applies to the rise of Alnus here, compared to the beginning of the Alnus-Ulmus regional pollen assemblage zone. The zone with affinities to the preceding Ulmus-Quercus zone is here defined by the point from which both taxa have continuous records. The contact for the beginning of the Alnus-Quercus-Plantago lanceolata zone (Birks 1972) at the Elm Decline is in this sense comparable.

LDIV-1 (408.0-395.0cm; c.9600 - 9300 b.p./7650 - 7350 b.c.) Fl I

The zone is characterised by a predominance of Betula of the tree pollen (average 96%); Pinus averages 3%. Of the shrubs, Coryloid is present at one level; Salix rises from 5 to 10%; Juniperus has a mean value of 2%. Herb pollen rises, primarily due to Cyperaceae (7 to 28%); Gramineae is comparatively stable (average 11%), but there is a peak of Calluna associated with those of Empetrum and Ericales at 400 cm. Filipendula averages 4%, Menyanthes is present and Sphagnum fluctuates between 19 and 55%.

LDIV-2 (395.0-383.0cm; c.9300 - ?9000 b.p./7350 - 7050 b.c.) Fl I

The lower contact of this zone is defined by the first level of the continuous curve for Coryloid, ranges from 8 to 36%. Betula remains the dominant tree pollen, although Pinus has increased to an average of 7%. Ulmus and Quercus are again present; Alnus and Sorbus are additional records. Salix averages 10%, the maximum of the previous zone. Juniperus is recorded at one level, for the last time. Cyperaceae and Gramineae have values averaging 30 and 14% respectively, but they do not fluctuate widely. Filipendula attains a maximum of 20%; Sphagnum is on average 35%. The number of indeterminable grains or spores increases (average 27%).

LDIV-3 (383.0-308.5cm; 19000 - c.6600 b.p./7050/4650 b.c.) Fl I

The lower boundary is placed just below the beginning of the continuous curve for Ulmus and where Coryloid has risen to sustained higher values than the previous zone (the lower contact of the Coryloid subzone). Betula is still the dominant tree type; Pinus falls to 1% at about the middle of the zone, recovering towards the end, but not to the values of LDIV-2. Ulmus and Quercus have maxima of 17 and 9%, but average only 4 and 3%. Coryloid declines markedly towards the end of the zone (the upper contact of the Coryloid LPAS); Salix reduces somewhat later. Gramineae exhibits four peaks, the last of these occurs as the first in the subzone (Gramineae) including three Gramineae maxima analysed in greater detail. Cyperaceae falls abruptly as Filipendula declines during the first half of the zone (the upper contact of the Cyperaceae-Filipendula LPAS; the start of the LDIV sequence is its lower contact). Melampyrum has an almost continuous curve during the zone; its maximum is 20%. Sphagnum is particularly high for most of the first part of the zone, its demise is indicated as the top of the subzone of Sphagnum (begun at the base of the profile), where it coincides with a reduction in the percentage of the Indeterminable category.

LDIV-4 (308.5-203.5cm; c.6600 - 4800 b.p./4650 - 2850 b.c.) Fl II

The essential features of this zone are the rise of Alnus values to become the most abundant tree type and its status as generally the most represented tree pollen after Betula. Quercus assumes a greater significance than in LDIV-3, but Ulmus still has low values. The lower zone boundary is drawn before the level where Alnus is first ≥2%. At the level 2cm above this, the subzone Alnus-Filicales begins (1cm above the end of the first Gramineae peak of its subzone) and describes the period when relatively higher values of Alnus and Filicales occur during the zone. The time of the three Gramineae peaks is defined from the start of the

first rise in values until the fall in values after the third peak. The Salix subzone begins at this latter boundary persisting until the decline of Salix values in zone LDIV-5.

LDIV-5 (203,5-168,5cm; c,4800 - 4300 b,p,/2850 - 2350 b,c,) F1 III

The Elm Decline defines the position of the lower contact, which is also seen when Ulmus is plotted both as a percentage of Ulmus and Quercus, and of TLP. The Decline is accompanied by reductions in Pinus, Quercus, Alnus, Coryloid, Calluna and Gramineae as Betula increases sharply. The first record of Plantago lanceolata occurs in the initial spectrum of the zone. The higher values of Potentilla define a subzone on Diag. 6.3.4. After the Decline, Ulmus rises, but is still at very low levels. Quercus, Alnus and Coryloid also increase as does Calluna. Pteridium has a continuous curve. Overall, tree pollen is comparatively stable from 198cm (average 56%), after the peak of Betula.

LDIV-6 (168,5-120,0cm; c,4300 - c,3500 b,p,/2350 - 1550 b,c,) F1 III

A fall in AP marks the start of the zone and the first four levels average 42%. Calluna expands at this point. The values of the last two spectra show a recovery of trees due to Betula, as Quercus, Alnus, Coryloid, Calluna and Gramineae decline. Plantago lanceolata is present at two levels (maximum 1.6%), Potentilla is continuously recorded, and Pteridium, with one exception. The first Cerealia-type grain occurs at 156cm.

LDIV-7 (120,0-64,0cm; after c,3500 b,p,/c,1500 b,c,) F1 III

This zone sees a further reduction in AP whilst Calluna increases to a maximum of 69% when AP is 26%. Tree pollen rises following this minimum, with Calluna declining at first as Quercus expands; then Alnus and finally Betula increase with Calluna approximately unchanged, but Coryloid falls at the end of the zone. Plantago lanceolata is more consistently present achieving 12%; the Pteridium curve continues unbroken from the previous zone. Two Cerealia-type grains are recorded at 92 cm.

LDIV-8 (64,0-25,5cm; undated) Fl III

After the rise of tree pollen culminating with a maximum at the end of the previous zone this zone commences with another fall in AP ultimately to 17%. Pinus has a maximum of 14%. An initial expansion of Calluna takes place at the reduction of AP. Here the expansion is followed by pronounced rises in Gramineae and Cyperaceae. Plantago lanceolata, Rumex acetosa/acetosella and Pteridium increase concomitantly, and to a lesser extent, Potentilla. The percentages of Sphagnum become high with those of Amphitrema and Assulina. Cerealia-type grains are present at most levels and the number of herb types attains its maximum.

LDIV-9 (25,5-4,0cm; undated) Fl III

There is a final decrease in AP, eventually to the minimum in the profile (6%). There are increases in Ericales and Calluna, Gramineae, Cyperaceae, Plantago lanceolata and Pteridium. Pinus and Fraxinus also rise. At the topmost level Pinus is 53% and Coryloid 50%, with herb pollen somewhat reduced. Cerealia-type occurs at each level.

6.4 Loch Doon III

6.4.1 Site and sediment stratigraphy

Loch Doon III is about 50m north of Loch Doon IV (Fig. 6.2). It is situated where the bog has been cut over and it is not possible to obtain a profile for the entire Flandrian here. The large Russian corer was used for most of the coring, with the basal 50m and uppermost metre taken with the small diameter corer. The peat sub-sampled for pollen analysis was measured by displacement to be consistent with the method used for the profile of Loch Doon IV.

Sediment description

Depth (cm)		Description
0,0- 31,5	Nig2 strf0 elas1 sicc3	Sh2 Th2(Erioph) Dl+
31,5-309,0	Nig4 strf0 elas1 sicc3	Sh3 Th1 Dl+ Tl+; lim1

Th/Dl/Tl(at specific levels (cm)): 73-88, 105; Erioph; 139-140; Dl; 154, 179; cf.Calluna; 218, 220; Dl(cf.Betula), cf.Calluna; 223-226; Dl(cf.Betula); 231, 237-241; cf.Calluna; 241; Corylus nut shell, Dl; 250, 254, 258; Dl(cf.Betula); 262;cf.Calluna; 263; Dl; 268, 275, 276; cf.Calluna; 280, 282, 284, 304, 307; Dl

6.4.2 Pollen zonation (Diags. 6.4.1-6, 6.7.3-4)

Local pollen assemblage zones (based on AP, AP + taxon) are defined that show sufficient correspondence to LDIV to allow later discussion under the same heading. LPASs are also used. The points made concerning the RPAZs with affinities to Birks's (1972) zones with respect to LDIV, apply equally here. There are no radiocarbon dates from this profile. It should be noted that the analyses are in general less closely spaced and the counting sum less than for LDIV.

LDIII-1 (308.0-296.0cm) Fl I

Increasing AP values, mostly of Betula, characterise the two spectra of the zone. In the lowest spectrum Pinus is 9%, falling to 2% as Betula rises. There is no other AP type represented. Salix and Juniperus dominate the shrub pollen being 19 and 22% at the base, though both decline as AP increases. Similarly, Empetrum (maximum 30%), Gramineae, Cyperaceae, Filipendula (maximum 38%) and Filicales (maximum 37%) decrease with the ascendancy of AP. Sphagnum rises from 1% to 49%, the lower contacts of the Sphagnum and Cyperaceae-Filipendula LPASs occur within the zone.

LDIII-2 (296.0-282.0cm) Fl I

The lower boundary is placed below the first value of the increase of Coryloid, which characterises the zone. Ulmus and Quercus are recorded for

the first time. Betula (average 94%) continues to dominate the tree pollen, but Pinus (maximum 7%) rises slightly compared to the end of the previous zone. At the start of the zone Calluna begins its curve that continues throughout the profile. Cyperaceae is the principal herb type. Sphagnum remains high.

LDIII-3 (282.0-197.0cm) Fl I

The beginning of the zone is defined below the first of the continuous records for both Ulmus and Quercus. Betula remains the principal tree, with Ulmus mostly greater than Quercus and Pinus. Ulmus averages 6.9%, Quercus 4.5%, and Pinus 3.8%. Alnus is represented at three levels towards the end of the zone. Coryloid is at higher values from the initial spectrum until level 208 cm, before which the LPAS Coryloid terminates. Cyperaceae is the predominant herb type until ericaceous pollen becomes more important towards the middle of the zone and Gramineae expands at its end (the start of the Gramineae LPAS). The mostly higher Cyperaceae and Filipendula values to those subsequently define the LPAS named after them and this shares an upper contact with the Sphagnum LPAS.

LDIII-4 (197.0-33.0cm) Fl II

The lower contact is beneath the first Alnus value ≥2.0%. The zone is characterised by the rise of Alnus and its eventual dominance of the tree types. Quercus becomes more highly represented (4.4 - 30.7%) than Ulmus (2.8 - 10.9%), but for the most part it is less so than Betula (20.1 - 74.8%). Pinus has consistently greater values (maximum 14.4%) during the early part of this zone. Calluna is generally the most abundant herb type, followed by Gramineae, though Cyperaceae may be equal to, or greater than, both in the second part of the zone. Two LPASs delimit higher values of Gramineae and Calluna; Salix is not strictly stratigraphically defined in terms of pollen percentages but indicates a period within which Salix reappears and is drawn for the purpose of discussion with reference to the

LPAS Salix of Loch Doon IV.

LDIII-5 (33.0-8.0 cm) F1 III

The zone begins at the start of the sharp reduction in AP as firstly herb pollen and finally shrub pollen attain their highest values. At 32cm AP is 50.1%TLP; at 38cm it is 5.2%. Pinus expands, then Fraxinus; there is a maximum of Quercus, but the calculation sum for AP for the last four levels of the profile is extremely small (average 10). The maximum of Coryloid is 84%. Of the herb pollen, Ericales, Calluna, Gramineae, Cyperaceae, Plantago lanceolata, Rumex acetosa/acetosella, and Potentilla exhibit marked increases. The number of herb types is more at each level than in LDIII-4, with one exception. Pteridium and Sphagnum also rise, the latter to high values. Indeterminable and Concealed types become numerous. Cerealia type is represented for the first time.

6.5 Investigation of the Alnus rise at Loch Doon

6.5.1 Sites and sediment stratigraphies

In addition to the cores of LD III and LDIV, seven other cores were taken with the small-diameter Russian corer (they are labelled i - vii on Fig. 6.2). The site of the third of these cores was chosen so as to be near to the middle of the bog as envisaged at the time of theAlnus rise, and to provide a comparison with Loch Doon III. Four others (i, ii, iv and v) are situated very near the edge of the bog and in this sense are more similarly positioned to Loch Doon IV than to III. Two sites (vi and vii) had a pollen record that post-dated the Alnus rise at their bases. Following this observation the extent of the bog has been drawn on the assumption that the sides of the basin are sufficiently steep in most places to have prevented the lateral spread of peat at the levels above those at which the Alnus rise was detected in nearby cores. This assumption is weakest where the gradient of the underlying topography is

gradual and probably less well drained; for instance the peat may have begun to spread more extensively to the northwest than is indicated on Fig. 6.2. The resulting reconstruction shows a mire some 115m (approximately north to south) and about 75m (east to west), with an embayment of peat to the northeast. Loch Doon III is roughly 20m from the nearest (northeastern) edge, core iii about 30m from the closest edge, which is to its west. The 'edge cores' are at distances of between 4 and 10m from the edge, with Loch Doon IV being about 13m from the defined perimeter.

As well as the present-day drainage provided by channels cut into the peat (Fig. 6.2), water is presumed to be flushed in a southerly direction over the peat between the higher ground lying on either side of the most southern end of Transect F-F'. The pollen stratigraphy of a core taken during an exercise to test the 'rapid' preparation method from the approximate vicinity of the southern end of Transect A-A', where low-lying ground separates the hillocks, proved to be of post-Alnus rise age.

The core from Loch Doon itself was taken using a 6m Mackereth corer at a point where the loch is approximately 25ftdeep (8m, see Fig. 6.5). The preliminary analyses have indicated changes in pollen and spore stratigraphy from a time that is probably close to the Alnus rise to beyond the Ulmus Decline and are supported by three radiocarbon dates (see Table 6.5 and Diags. 6.5.1-3).

Table 6.5. Radiocarbon dates from Loch Doon (loch core).

Depth (cm)	Years b.p. (± one s.d.)	Lab. No.
506.5-521.5	4950±210	I-15178
561.0-571.0	6010±240	I-15177
580.0-593.0	7160±240	I-15176

A modified plastic syringe was used to determine the volumes of the samples from the loch core and the additional cores from the bog

(as distinct from the volumetric method used for Loch Doon III and IV). Samples from the loch core and core ii were acetolysed (as for Loch Doon IV), other samples were treated only as far as the stage of dispersal by NaOH (See Sect. 4.2 above). The less complete treatment may favour the preservation of clumps of pollen. These are noted on the diagrams (cf. Janssen 1986, Brown 1988; Florin 1958, where Alnus pollen clumps from a preparation (of 1934) using only NaOH are recorded).

Sediment descriptions

Site	Depth (cm)	Description	Notes
LD core	475-595	Loss-on-ignition values only available	Loch core
LD III	164-212	Nig4 strf0 elas1 sicc3 Sh3 Th1 Dl+ Tl+	179cm Dl/Tl(cf. Calluna)
iii	233-258	Nig4 strf0 elas0 sicc3 Sh4 Th+ Dl+	±113cm Dl+
ii	205-200	Nig4 strf0 elas0 sicc3 Sh4 Th+ Dl+	200, 205cm Dl+ 207-210cm Dl(frag.)
i	174-189	Nig4 strf0 elas0 sicc3 Sh4 Th+ Dl+	172-173cm Dl(frag.)
v	278-297	Nig4 strf0 elas0 sicc3 Sh4 Th+ Dl+	293-306cm Dl(many small frags.)
IV	300-308	Nig3 strf0 elas0 sicc3 Sh3 Th1	
	308-319	Nig4 strf0 elas0 sicc3 Sh4 Th+; lim1	
iv	240-273	Nig4 strf0 elas0 sicc3 Sh4 Th+ Dl+	242-246cm 2xlarge wood frags. 261-264cm 1xlarge wood frag.

6.5.2 Pollen zonation (Diags. 6.5.1-3)

The pollen stratigraphy of the loch-core analyses is divided into local pollen assemblage zones (based on AP, AP + taxon). The spectra of LDIII and LDIV are zoned as described above. For each of the remaining analyses the point before the percentage of Alnus ≥2.0% AP (for at least 3 subsequent levels) is drawn on the diagrams and arbitrarily defines the beginning of the alder rise.

Zonation of the core from Loch Doon

LDC-1 (595-590cm; 7160±240 b.p. [593-580 cm]) Fl I

For the sake of consistency of presentation the upper contact is placed as described above for the Alnus rise (although if older sediment were present, further analysis might put the boundary at a lower level). The third and final value of Alnus in this zone is 1.6%. Betula, Pinus and Quercus are the principal trees, the last level of the zone has the highest tree percentage of the profile (79.%TLP), when herb pollen is 5.2%. Coryloid averages 17.5%, Filicales 13.3% and Isoetes lacustris 44.6%

LDC-2 (590-570cm; c.7300 - 6100 b.p.) Fl II

This is characterised by markedly fluctuating values of Betula, Pinus, and to an extent Alnus, Filicales and Isoetes. The zone has an overall rise in Alnus with a decline in Betula. Quecus remains high (average 27.2%), Pinus averages 31%, Ulmus 4.2%, Coryloid 22% and Gramineae 4.7%.

LDC-3 (570-515cm; c.6100 - 4950 b.p.) Fl II

The lower boundary is put at the sharp rise to generally sustained higher values of Alnus. There are abrupt changes in the values of Betula, Pinus, Alnus, Filicales and Isoetes. Quercus is the predominant tree type towards the end of the zone. Pinus has a lower average value (16.6%), whereas Ulmus now averages 7.2% and Gramineae 9.6%, Coryloid has an average of 24%. Filicales and Isoetes are well represented.

LDC-4 (515-448cm; from c.4950 b.p.) Fl III

The zone begins with a decline in Ulmus. Quercus is usually the most abundant tree type. There is a maximum of Coryloid (33%), but its average is 25%. Filicales and Isoetes are significantly represented. Plantago lanceolata is recorded.

6.6 Excavation of the lithics site to the west of Loch Doon

6.6.1 Excavation

The position of the site of unstratified flint and chert artefacts on the brow of the small hillock to the south of the coring sites is shown as No.18 (Edwards et al. 1983) on Fig. 3.9 above. The lithics were in the drain along the eastern limit of a Forestry plantation. Further east the ridge of the hillock is dominated by Calluna (Sect. 6.2). To the west of the ditch the hillock slopes down to a poorly-drained depression with Molinia and Myrica growing on the peaty ground that extends and rises to the road (Figs. 6.2 and 6.3).

The aims of the small excavations conducted on both sides of the ditch were to systematically record any additional lithics and/or charcoal and to ascertain the soil profiles. A small soil pit (Sect. 6.2) was dug to the east of the excavations in order to compare the profile with those of the excavations. It was intended to collect samples from an excavation profile and the soil pit for pollen analysis, radiocarbon dating and identification of charcoal. A section cut by the ditch, and its floor, and a drain to the west were examined to attempt to evaluate the lateral extent of the lithic distribution.

After cutting back the face of the ditch on each side two trenches (75 x 50cm east, 80 x 50cm west side) were excavated. On the east side, two flints and three chert flakes were found in vertical positions from just above the weak iron pan at the base of the podsol to well within the orange-brown sandy soil above the limit of excavation (see Fig. 6.3). Charcoal from the two locations indicated on Fig. 6.3 was dated as part of the Oxford University Radiocarbon Accelerator Unit's programme and follow determinations for a similar purpose made on charred hazel nuts from the Mesolithic site of Longmoor, Hampshire (Gillespie et al. 1985). In the case of the stratigraphy from the Loch Doon section, the earliest charcoal

sample (OxA-1598, 8000±100 b.p.) is just below the deepest lithic; the latest (OxA-1597, 3150±70 b.p.) is slightly below the uppermost part of the vertical distribution of lithics (Fig. 6.3).

On the west side six pieces of chert and three of flint were found. Their vertical distribution is from the junction of the humus and main podsolised soil to within the orange-brown sandy soil beneath the iron pan. There was very little charcoal seen during the excavation compared to the eastern section. Three fragments were noted and come from the base of the pocket of podsolised soil principally in the northern half of the section or at the top of the underlying orange-brown soil.

No evidence of any structures was found nor were any discrete areas of burning such as might imply a hearth; although before excavation an initial inspection of the soil within the orange-brown sand suggested an extent of apparently burnt soil or organic material at about 15 cm below the base of the humus layer.

By contrast, the soil pit (50 x 75cm) revealed no charcoal or lithics. Fifteen samples for pollen analysis were collected from the 40cm profile in glass vials. A metal box was used to take a column of soil from the eastern section of the excavation on the brow of the hillock (Fig. 6.3).

The east side of the ditch was cut back a little with a spade along its length to the peaty ground near the junction with the west-east ditch running towards the loch at the north, and almost to the junction of a similar ditch to the south. The floor of the ditch was also spaded and trowelled so as to achieve an approximately equal depth of section as depicted on Fig. 6.3. The excavation proceeded to within the unpodsolised brown soil i.e. 5-15cm below the base of the podsol. This process resulted in additional finds which were measured to an arbitrary datum at the initial excavation trench. The distribution is shown on Fig. 6.3. The

finds were numbered and collected and together with the previous finds will be described and published elsewhere. A few finds of carbonised hazel nut shell were made (Fig. 6.3).

The same procedure was adopted along the north edge and floor of a ditch running approximately west-southwest of the boundary ditch. The podsolisation was deep in places and the minimum depth of brown soil excavated was only a centimetre, but elsewhere the maximum was 13cm. The podsolisation was greatest and iron pan most strongly developed in the low-lying ground at the western end of the section.

Whilst fieldwalking, two flint cores were found amongst pebbles and boulders below the eroding peat at the high-water line of the loch on the edge of the hillock to the north (see Fig. 6.2).

6.6.2 Discussion

Considering the two excavations together there is evidently a vertical distribution of lithics from the top of the podsolised soil (just at the boundary with the overlying humus) to 18cm beneath, within the orange-brown sandy soil. It may be that the lithics represent repeated use of the site, although some vertical displacement of artefacts in the past is likely (Dimbleby 1985, 121-127). Barton (1987) discussed three principal mechanisms for this: trampling, bioturbation, and drift and deflation processes. His own experiment on trampling gave a result at odds with previously published conclusions. Little vertical movement was noted and two separately stratified assemblages remained so. The degree of moisture was thought to be important. Damper (and also vegetated) soils would provide greater resistance to vertical movement. A six-stage model devised by Collcutt was outlined in which the processes of bioturbation and deflation combined to give a final stratification of assemblages that would fit that of the Mesolithic and later lithics recorded at Hengistbury

Head, a coastal site of podsolised soil derived from windblown sand. At Loch Doon deflation might have occurred after clearance, but the accretion of a significant amount of mineral soil would not be expected at the top of the hillock. The position of the upper dated charcoal sample within the orange-brown sand implies that podsolisation probably began after c.3150 b.p. The lower dated charcoal shows local burning of rosaceous wood at c.8000 b.p.

Regarding the date of the lithics the relative movement of the charcoal fragments with respect to the lithics make conclusions as to the timespan of the assemblage (whether of one or more occupations) impossible. In Collcutt's model (Barton 1987), the larger lithics were moved more rapidly down the profile by bioturbation than the smaller, but the generalised model is used to explain the stratification of about 35 000 flint artefacts over an area of 78 square metres. At the sites described here only very small excavations were carried out and local root penetration or former earthworm activity, causing differential movement of incorporated material may have occurred within the excavated areas. Strictly speaking until the typological study is undertaken there is no reason from the radiocarbon dates to assume that the lithics are Mesolithic. As elsehwere, the assumption is made that they probably will prove to be of Mesolithic type by analogy with other finds from south-west Scotland and secure dating of a number of assemblages in the future. The date from the hazel-wood charcoal from the hearth-like context at Starr I (6230±80 b.p., see Sect. 5.3.1) likewise shows burning of that species (in the later part of the 7th millennium).

6.7 Inferred vegetational history by the southwestern shore of Loch Doon

6.7.1 Introduction

It is intended to discuss the vegetational history of the catchment of the small basin to the west of Loch Doon by taking the evidence of the stratigraphic records from all the relevant cores together, rather than to describe them separately and then make comparisons. There are only radiocarbon dates from the loch core and Loch Doon IV so that only tentative absolute correlations can be made and in any case it has been seen (Sect. 6.3.2) that there are difficulties in interpolating even approximate dates from the radiocarbon determinations. The dates given in the headings are calculated from the LDIV profile. The pollen sum of LDIV is usually about twice that of LDIII.

6.7.2 Vegetational history

LDIII-1 and LDIV-1 (c.9600 b.p. - 9300 b.p./7650 - 7350 b.c.)

The basal spectrum of LDIII is probably representative of earlier vegetation than the first level of LDIV (e.g. the greater maximum of Juniperus at LDIII); it certainly has a more open aspect. NAP is initially higher in LDIII-1 than at the first level of LDIV-1, although there is more Salix at LDIII. Grasses and sedges were presumably growing at the site perhaps together with Empetrum which has poor pollen dispersal (Birks 1972, 198) and somewhat erratic representation (Moore et al. 1986). Tall-herb (Filipendula) and fern (Filicales) communities were also present locally and since Sphagnum is not yet recorded, relatively rich fen is indicated in spite of the possible presence of Empetrum (cf. Birks 1972, 198). In view of the uneven floor of the basin (as defined by its conjectured extent at the time of the Alnus rise), it would seem likely that at the incipient stage of peat accumulation the actual area of poorly drained ground around the site of LDIII would have been relatively small

and a mosaic of drier mounds above wetter hollows would have characterised the generalised basin area of later (Alnus-rise) time. There may have been interconnecting flows of water, either at periods of an average height of water table or otherwise. It would be expected that elements of a mosaic of vegetation would be represented at the bases of the two sites and the possibility of inwashed pollen should be taken into account.

Empetrum may indeed have been extremely local but a component of heath in the landscape is suggested by the high Juniperus and also the presence of Huperzia selago. Clumps of willow perhaps associated with ferns and meadowsweet (Filipendula) were a feature near the site (cf. Bradshaw 1981) and birches were evidently established at least in the environs so that as they expanded (see AP in summary curve) to the second spectrum of LDIII Juniperus, is almost eclipsed. Given the uncertainty of the configuration of the areas of peaty ground it is difficult to apply the simplified model for pollen transfer (Jacobson and Bradshaw 1981) to a site based on a single basin. It proposed that willows were 'local', but birch may have invaded 'extralocal' areas of heath. Unless the catchment for Juniperus is extremely local, the record of LDIV perhaps begins during the period of reduced Juniperus at LDIII.

The first two values (TLP) of Betula at LDIV are higher than that of LDIII at its last value of the zone, but Betula is seen to decline to a similar value towards the end of the zone as sedges increase to compare with those at LDIII. The area of peaty ground around LDIV may have been enlarging, with wetter and more acid conditions witnessed by Menyanthes and Sphagnum respectively. These taxa appear at the second level of LDIII-1. The highest values of Filipendula and Filicales at the base of LDIII are not recorded at LDIV. However, an element of heath is shown here by Calluna in addition to Empetrum. The representation of Salix is

slightly higher by the end of LDIV-1 than at the close of LDIII-1.

In summary, the early Flandrian landscape in the study area as it may first be inferred was probably a mosaic of tall herbs and ferns in fen communities, and some heath. Birches and willows were present, distributed over unevenly drained ground on which peat was beginning to form in the wettest areas. Birch may have become more prevalent in the heath. The peat continued to grow and perhaps spread within the communities of poorest drainage. Pine was sporadically present in a larger catchment but not local in any significant sense. The incidence of burning as evidenced by the number of particles of microscopic charcoal: total pollen is low and assumed to be of 'regional' derivation.

LDIII-2 and LDIV-2 (c.9300 - ?9000 b.p./7350 - 7050 b.p.)

The main feature of the zone at each site is the spread of Coryloid (presumed to be Corylus) until it is the most represented tree or shrub in the next zone (see summary diagram). Juniper is no longer recorded after this zone (2). As explained (4.3.2), Coryloid is designated a shrub to make easier comparison with the previously published diagrams of Birks (1972). In the landscape, however, it is considered as a tree of equal status to birch with which it formed mixed birch-hazel woodland. Willow continued to grow in places around the coring sites (its curve shows no clear influence of the expansion of hazel, cf. the concentrations of Diags. 6.3.6 and 6.4.6); at this point the sites were likely to have remained in discrete basins in that the higher ground still stood above the local water table.

The peat-forming vegetation continued to be comprised of sedges, grasses, and bog moss (whose values, like those of willow, are unaffected by the rise of hazel); Filicales and Filipendula have greater representation at LDIV, but at each site, if growing together, would be on damp ground. Calluna is an addition to the record at LDIII which indicates drier areas

on the peat or even at the edge of woodland communities which must have bordered the peat.

The number of samples of the first two zones at the sites is small, but there is no suggestion of an increased incidence of burning (as registered by the microscopic charcoal) in the landscape during this period. There is no reason, therefore, to attribute the rise of Corylus locally to any favourable factor due to fire. It is interesting to note the early records of Alnus in LDIV-2.

The inference of an early heath in which juniper and possibly crowberry were present before birches invaded larger areas within the period of LDIII-1, and with birch expanding as juniper declined fits the generalised description of events at the earliest stage of the Flandrian proposed by Moar (1969); that juniper then almost disappeared from the Flandrian record at the Corylus rise may be seen in the diagram from Loch Dungeon, where it is only occasionally represented after this, as at Snibe Bog (Birks 1972).

LDIII-3 and LDIV-3 (?9000 - 6000 b.p./7050 - 4650 b.c.)

Although both Ulmus and Quercus were registered previously, the beginning of their continuous curves at the start of zone 3 at each site is taken to imply their arrival in the region. Ulmus has the larger values to begin with and so may have become established more widely at first. It is clear that for the entire zone birch and hazel remained dominant of the trees and were probably growing almost to the edge of the peat at the sites since a hazel-nut shell was found at LDIII (241cm; Fig. 6.7) and wood fragments were recorded at both sites, some of those at LDIII resembling Betula. The plot of pollen percentages on the sum of TLP indicates that the highest value of Ulmus (conspicuous on the AP diagram) at the site (LDIII) is due to a decrease in Betula. Neither elm nor oak were able to

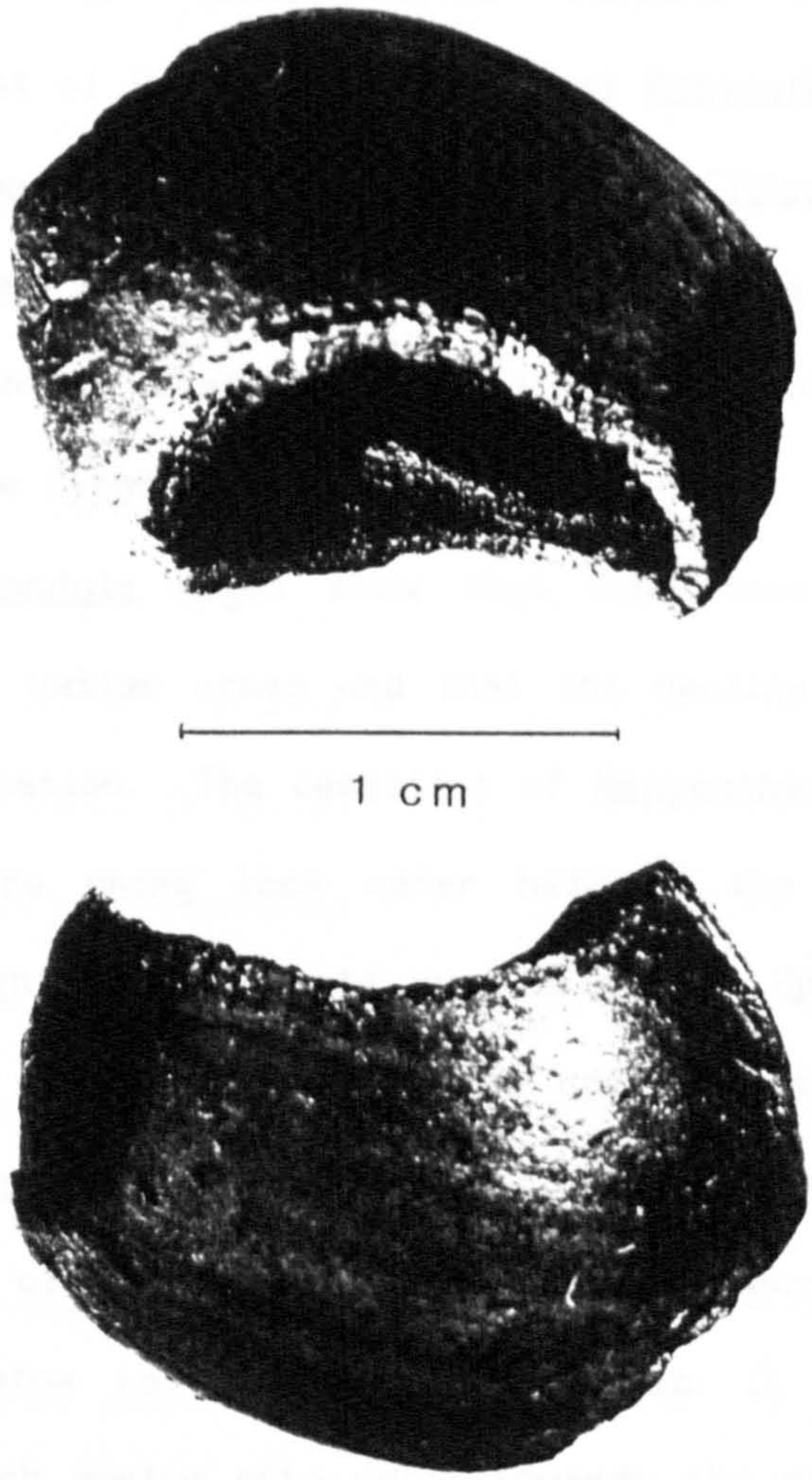


Fig. 6.7. Hazel nut shell recovered from the Loch Doon III core (241 cm). The gnawed hole resembles that illustrated in Caseldine (1984), where the regularly-shaped hole, smooth gnawed edge and tooth-marks below the edge of the hole on the shell suggested 'attack' by a dormouse (Muscardinus avellanarius).

penetrate the birch-hazel woods during the zone. The balance of birch and hazel is tipped in favour of birch towards the close of zone 3 at LDIII and LDIV.

Concerning the sites themselves,the subzone of Cyperaceae-Filipendula ends with that of Sphagnum at LDIII and Menyanthes occurs only once after this subzone; in contrast, at LDIV Filipendula remains continuous, though reduced, after the Cyperaceae-Filipendula LPAS until the end of the Sphagnum subzone. Similarly, Menyanthes is recorded once after the upper boundary of the Cyperaceae-Filipendula subzone.

The fall of Filipendula might show that conditions had generally become more acid in the wetter areas and that the decline of sedges was also a result of acidification. The cessation of Menyanthes in the record is probably due to there being less water held on the peat deposits. Sphagnum persists in significant amounts even after the Sphagnum subzone at both sites until near the Alnus rise at the upper contact of the zone. The longer record of Sphagnum and the continuation of Filipendula may mean that there were places of high water table for a longer time at LDIV, though there are no dates to confirm or deny this. It is likely that willows grew near to each coring site until towards the end of the zone. By this time the reconstruction of the extent of bog has the form shown in Fig. 6.2 and it is considered that although the depth of peat or organic soil would differ according to the topography of the substratum the basin would have begun to have the aspect of a unitary focus of blanket peat. Predominantly mineral soils would have characterised the small mounds to the northeast of LDIII and southwest of LDIV (see Transects B-B', A-A' and G-G') as well as the three hillocks in line with the present loch shore. It is not known when peat began to fill the gully to the south of Transect A-A', but it may have been after the Alnus rise (see above, Sect. 6.5.1).

If the basin as a whole was infilled then surface water running

over the ground to the west, in particular, might have been carried further and more quickly across the bog than in the early Flandrian and the bog itself become a more water-shedding site. Possible outlets could have been to the southwest of the central hillock, where water from the basin may have been thus far impeded by the substratum (see Transect A-A') and later to the north and east where Transect F-F' perhaps indicates a possible barrier to earlier drainage between the central and north hillocks.

At LDIII Calluna assumes greater importance as a local plant (occasional macroscopic finds [cf. Calluna wood] attest to its presence) than at LDIV although at both locations it is associated with Empetrum. Melampyrum is also considered to be local (cf. Andrews 1986, Fig. 13), and like Empetrum, its pollen was recorded as a clump (LDIV). Melampyrum is more consistently present and in higher amounts at LDIV and it may have been growing at the edge of woodland (cf. Mitchell 1988, 427) to the south of the site, within the woodland (cf. Pilcher and Smith 1979, 354), or on the bog itself (cf. Mamakowa 1968, Birks 1975, Pilcher and Smith 1979). Melampyrum pratense is the most probable species (cf. Moore et al. 1986, 213). The demise of Succisa at both sites towards the end of the zone may be due to the fewer locations of minerogenic peat in their catchments. The Gramineae exhibit higher values at LDIV in the first part of the zone but are then reduced before expanding to a peak at its end. A peak is also seen at the same time at LDIII. The ratio of microscopic charcoal: pollen takes increased values in the second half of the zone at both sites.

It was put forward (Sect. 2.2) that the only way of directly discerning appreciable influence of Mesolithic man on the vegetated landscape was to assess any response of light-demanding plants to a decrease in the tree canopy. Burning of the ground-layer vegetation would not necessarily affect the canopy. Clearly it is implied that the change

occurs in the same area (usually on drier ground) and so in this instance expansions of herbaceous types should be accompanied by falls in those of trees. In the first three zones of LDIII and IV the principal drier-land trees were birch and hazel, with some willow close to. Any disturbance of the first two would most likely result in a response from grasses, heaths or perhaps bracken; if maintained, more herbs and shrubs might colonise or increase flowering.

At LDIV there are four peaks in the record of these herbs (one of Calluna, three of Gramineae) before the first of the peaks in the Gramineae LPAS (they are marked with a cross on Diags. 6.4.4-6 and 6.7.1). At the first of these there is a decrease of Coryloid, unrelated to the AP sum. At the second, of Calluna, there is no appreciable change in the trees but Gramineae falls; at the third, Coryloid falls; and lastly Betula declines, and the concentration of Gramineae increases. These effects all occur before any significant peaks in the charcoal: pollen curve.

The pollen stratigraphy of LDIII shows five peaks of Calluna (Diags. 6.4.4-6 and 6.7.2). These are all seen on the plot of pollen concentration and so are not affected by the AP or TLP sums. In the first, second, fourth and fifth instances, a drop in Betula may be observed (at the fifth it is very slight) but at the third where the value of Calluna is greatest, Betula is effectively unchanged, though it does fall during the rest of this Calluna peak. Coryloid declines slightly at the first of the Calluna maxima, but elsewhere the values are peaks (as they are in terms of concentration) or following a rising trend (where Betula concentration is falling and Coryloid concentration is little changed). Higher values of charcoal occur at times after the first three Calluna peaks, but then the fourth and fifth peaks are associated with minima in the charcoal: pollen curve.

The record of LDIV may be reflecting a change at the peat surface

when Calluna exceeds Gramineae; at other times when Gramineae is high Coryloid declines on two occasions, Betula once. At LDIII the generally higher values of Calluna than at LDIV noted above have maxima when both Betula and Coryloid decline in one instance, but at other times it is Betula that does so. Making a causal connection between the events witnessed in the tree and herb records may be unfounded even if the peaks of the selected herbs in most cases are not matched by decreases in the other types possibly representing peat-forming plants, which would have suggested local change. There is a tendency for the peaks to be associated with higher values for the total number of herb types, but this is not always so; changes of similar magnitude in the curve are manifest before and after any rise in charcoal concentrations. Peaks (or minima) of a single value of a taxon are not a strong basis for arguments for vegetational change (cf. Faegri and Iversen 1975; and Sect. 2.3.4). It is doubtful, on the evidence available, whether local Mesolithic disturbance is demonstrated in terms of the vegetation cover as recorded.

At both sites the most conspicuous alteration in the composition of the tree taxa towards the end of the zone is the reduction of Coryloid as Betula rises in terms of TLP. This may be deduced from the summary diagrams (for LDIII and IV) where 'trees' increase, the absolute diagram (for LDIV) and from the plot using a dry-land type sum (Diag. 6.7.1, LDIV). At LDIV the concentration of Coryloid remains almost static then falls slightly as Betula increases markedly. The concentration diagram of LDIII shows Coryloid reducing as Betula is little altered. Both concentration and relative diagrams from LDIII suggest that Coryloid was less affected at this site than at LDIV and the dry-land plot of LDIII (Diag. 6.7.2) does not show Coryloid falling until a level later than on the AP and TLP diagrams.

The beginning of increased charcoal is just before the fall of

Coryloid at each site so it may have been that hazel was burnt (or there was clearance associated with burning) and birch favoured. Some opening of woodland canopy may be suggested by the cluster of records for Hedera (cf. Godwin 1975) at or after the declines in Coryloid at both sites. It may have been that with the spread of blanket bog (thought to have been drier and forming slowly at this time), birch was able to colonise more acid soil nearer to the coring sites than hazel; the charcoal not being related to the vegetational change. Because the increase in charcoal is not a discrete peak to very much higher values it is less likely to represent a single local burning which affected the tree cover, perhaps seen against a continued lower presence due to activities of occupation more generally, e.g. regular domestic fires, or burning elsewhere in a more regional area as regards catchment.

Pteridium is first registered just before the higher charcoal values at LDIII; but has marginally higher values when the amount of charcoal is negligible for three levels (216, 220, 233 cm). At LDIV, there are two records of Pteridium before charcoal rises, but as at LDIII a continuous record for bracken is sustained over a number of more closely-analysed samples towards the end of the zone when charcoal concentrations are consistently above the values of the first part. The possibilty of Melampyrum being locally present on the bog or in undisturbed woodland habitats has been referred to and Potentilla (likely P. erecta) and Succisa would similarly be likely in communities on the mire or woodland edge.

The principal feature of the herb representation at the end of zone 3 is a rise in Gramineae pollen. This occurs with a different form at each site. A difference of sedimentation rates would account for the apparently gradual change in Coryloid at LDIV compared to the more sudden one at III. The apparent delay in the rise of Gramineae could also be thus explained, if the Gramineae peaks of LDIII and LDIV are to be

correlated, but not the difference in form.

The peak of grass at LDIV corresponds with a pronounced fall in the concentration of Betula but much of this effect is probably the result of a faster peat accumulation rate after a period of pronounced dryness (cf. the plot of total pollen concentrations). The reduction in terms of percentage AP is slight because Betula forms such a high proportion of the sum, it is more noticeable on the plots of TLP, and dry-land taxa (Diags. 6.3.5 and 6.7.1). The presence of clumps of Gramineae pollen at LDIII and LDIV argues for local changes at the bog surface. Gelasinospora is now increased and may be an indicator of drier surface conditions or associated with local burning (cf. the rise of charcoal at each site); conversely, Amphitrema and Assulina are not recorded (cf. van Geel 1978). The occurrence of higher Gramineae at both sites may represent a widespread distribution of the grassy vegetation, or that local dominance was merely coincidental. Since there were no changes within the taxa of likely mire communities comparable with the grass peaks, it is plausible that some birch was cleared, an inital decline of Betula is apparent at both LDIV and LDIII (in terms of AP and TLP; but at a later level, based on DLP, at LDIV), or that some local effect of drainage or peat growth has caused a reduction of birch.

In summarising the various strands of possible evidence for Mesolithic disturbance during the first three zones of LDIII and LDIV it may be concluded that no neat model (such as that for 'landnam' and forestation; or its Mesolithic forbears 'disturbance' and 'stability') can be claimed. The major vegetational change is the reduction of hazel, more clearly recorded in LDIV-3 than LDIII-3. Pteridium has already begun to rise by this time at LDIV, so too has charcoal. At LDIII Pteridium is at higher values well before hazel declines during which period there are significant peaks of charcoal, having values in excess of those just after

the Coryloid LPAS, when Hedera occurs more frequently than previously at each site. There is no clear pattern of disturbance effecting responses in Calluna or Gramineae. As birch rises subsequently, two indicators of open canopy, Hedera and Pteridium, are unaffected. That bracken and higher charcoal records occur from around the middle of the zone may represent Mesolithic activity in the region. Since LDIII is not radiocarbon dated and the time-depth curve for LDIV-3 is uncertain it is not possible to meaningfully estimate when such activity began. The expansion of grass at the close of the zone is envisaged as local but may follow some clearance of birch, unless its decline is related to local hydrological change.

LDIII-4, LDIV-4 (c.6600 - 4800 b.p./7050 - 4650 b.c.), LDC-1 to 3, and profiles LDi - v

The Alnus rise

The major differences in the composition of local woodland between the fourth zone of LDIII and LDIV and the previous one are the addition of Alnus (and its establishment) and either the addition or expansion of Quercus. A comparison of the local dynamics of the former in particular is possible through the extra pollen profiles obtained from sites LDi - v as well as those of LDIII and IV. The pollen stratigraphy of the loch core allows some inferences to be made about the vegetation of a regional catchment (see Diags. 6.5.1-3).

On the basis of the conjectured extent of peat in the basin at the time of the Alnus rise (Fig. 6.2), LDIII had assumed a position that is further away from the edge than LDIV, although Transect B-B' suggests that there might still have been some drier ground above the general peat surface. LDIV, on the other hand, is located near to where the break of slope (mapped as it is today at the southwest of B-B') and subsurface topography of Transect A-A' indicate that a greater area of ground nearby

been above the peat surface of the basin and where the edge of the basin may have been more clearly delineated.

At LDIII the rise of Alnus (AP sum) is accompanied by slightly increased Pinus percentages and a fall in Betula. The total pollen concentrations have reduced by the start of the zone and may imply a more rapid rate of peat growth. The concentrations of Betula suggest that it is unaffected by Alnus as it rises; initially Betula increases slightly with Alnus and after a peak, which is probably due to a brief period of slower sedimentation, it remains virtually constant until just after the Calluna subzone (e.g. Diag. 6.4.6) when higher relative values of Alnus occur and a clump of Alnus grains is recorded. Quercus increases slightly later than Alnus to attain similar values at first but is then third in abundance after Alnus and Betula, once Betula has risen to its higher values.

The Alnus rise at LDIV assumes a markedly different form to that at LDIII (see also Diags. 6.5.1-3). Alnus increases modestly across the zone boundary to the first level of the zone and changes little for the next two. At the first level Calluna has a significant peak at the time of a minimum Betula value (AP and TLP). After the first level Gramineae and Coryloid drop abruptly and Betula shows a small increase. The concentration of Calluna at its peak indicates that it is a real increase against a trend of falling concentrations. Following the same line of reasoning for the discussion of the first Gramineae peak, if there is no change in other likely mire plants of similar magnitude, either soil conditions have effected more prolific flowering or rapid spread, or there has been a reduction in the shading from a former canopy. The very sharp initial fall in Betula concentration is in large measure reflected in the sudden drop in most of the concentration curves. However, the plots of Betula against selected DLP (Diag. 6.7.1) and TLP (Diag. 6.3.5) amplify the

small reduction of the AP diagram (diminished as Betula contributes by far the most to that sum) at the last level of the previous zone. Within c.20 years (by interpolation) Betula has resumed dominance so the response was short-lived. A brief episode of disturbance is perhaps the explanation as there is unlikely to have been a change in soil conditions alone that would have been detrimental to Betula and good for Calluna.

A small peak of Calluna occurred at LDIII at the first level of the zone, followed by a recovery of Betula (particularly in terms of DLP), but here heather could be increasing due to the fall of grasses. At both sites Coryloid, Calluna and Gramineae are reduced when Betula expands. The northern-edge sites (ii and i) also have peaks of Calluna at the first level of the rise, at a fall of Betula and Coryloid especially (TLP; at ii and i respectively), followed by increases in these. The curves of the most central site (iii) have similar characteristics, with clumps of Calluna pollen suggesting at least some very local growth. To the southeast at LDv the sequence shows that oak and some hazel may have been disturbed. There is no peak of Calluna, but there is a small increase in Gramineae. At LDiv there is a possibility that the fall in Betula (at its neighbour, LDIV) is registered; its earlier position with respect to the Alnus rise is likely a consequence of the rise being placed at a later level because of the filtering effect by local willow. Bracken is recorded at all the sites before the Alnus rise.

At the fourth level of LDIV-4 there is a dramatic increase in Alnus with Filicales, and Betula declines; these events are reflected in the absolute diagram. The subsequent oscillations between Alnus and Filicales, and Betula at a periodicity of alternate levels are also seen to be changes in concentration until the eighth level. The relative and absolute fluctuations of Coryloid are not of the same periodicity and are in general of a smaller order than those of Alnus and Betula and are assumed not to

be part of the same dynamic of competition. Clearly very local changes are taking place: perhaps alder carr with ferns and some grasses eventually becoming established (note pollen clumps on Diag. 6.3.4) rather than birchwood, either by some replacement or perhaps in an area fringing the bog where surface water ran. The plot of total pollen concentration does not suggest that there was a break in the rate of sedimentation at the sharp rise of Alnus so it may be that the apparently rapid invasion at this point was due to seed being set along the edge of birchwood into which it may in time have spread. Using the interpolated peat accumulation rate a centimetre of sediment represents 20 years.

An alternative to supposing increased soil moisture, would be to follow Smith's (1981b) explanation for local events at the Alnus rise at Newferry. The reduced representation of sedges and absence of spores of ferns of fen communities, led him to postulate that the ferns were colonising cleared woodland, noting their response in such areas along streamsides today in north-east Ireland. At the south edge of the small basin at Loch Doon, the rapid (perhaps within 20 years) success of Alnus implies it was already locally present, but it may have been given greater opportunity if birch had been disturbed, as suggested above, allowing firstly some heath to develop and then a succession involving birch and alder, and a field layer of ferns.

Some insight into how local the behaviour of Alnus was at LDIV may also be had by comparing its curve with those of cores iv and v on either side of LDIV and near to the edge of the bog. At LDiv, only 18m away, where the edge of the basin shelves less steeply than at v, the local presence of willow is represented by comparatively high percentages and clumps of Salix pollen. Sorbus type too has high values for a generally poorly represented type (cf. Birks 1980) and a pollen clump is recorded. Clumps of Betula and Gramineae pollen and of Dryopteris spores also occur.

Before alder expanded an open willow carr with grass and fern understorey appears to have developed and on drier ground birchwood was probably associated with rowan (rather than hawthorn). When alder enters the record grasses decline and it probably competes with willow until the last level of the profile when it has ousted both birch and willow. As at LDIV it is possible that alder seed was first set in a wetter area, perhaps already detrimental to some local grasses, alongside existing carr and woodland. In view of the possibility (raised above) of some birch (or hazel near LDv) having been disturbed, anthropogenic influence may have initiated the changes, willow responding more quickly than alder (as at Newferry [Monolith II]; Smith 1981b, 1984).

The Gramineae curve at LDv (15m away from LDIV) also exhibits a decline as Alnus rises, no local willow carr is indicated and ferns are less well represented than at LDIV and iv. The steep-sided basin is defined by the central hillock to the east and it was probably on this that oak was able to grow with rowan and birch (there are clumps of pollen representing each of these), after alder had colonised the edge of the hillock or the lip of the basin now covered by peat, but perhaps as suggested by Transect A-A' to have been a continuation (to the west) of the higher ground of the hillock. In this case, it may have been the establishment of oak that has partly caused the decline in birch (see concentration diagram, Diag. 6.5.3).

Cores LDi and ii are also from near the perimeter of the bog. LDi comes from near the northern and central hillocks and Transect F-F' indicates raised ground under the peat now formed between them and also to the west. Again a fall in Gramineae occurs just before the Alnus rise, and there is the brief expansion of ericaceous plants noted earlier. As grasses rise subsequently, so latterly do ferns, and alder is by now well grown with the representation of birch lowered, independently of the

calculation sums (AP and TLP).

The pattern of change is very similar at LDii. A brief episode of ericaceous dominance over grasses as Alnus begins to rise is then followed by an ascendancy of grasses, but not accompanied by ferns this time. Alnus concentrations increase as those of Betula decline and a fairly rapid establishment seems likely. If disturbance of birch or hazel woodland eventually gave alder its chance, then such activity was not confined to south side of the basin.

Finally, the pollen stratigraphy of the core nearest to the centre of the bog (LDiii) shows greatest similarities to that of LDIII, 14m away. There is significantly more Coryloid recorded at these sites than others and the amount of Calluna is on average higher. Gramineae falls sharply near to the rise of Alnus at these sites as at others; neither LDiii or III show any rise of Filicales. The concentrations of Alnus and of total tree pollen are on average less than those at the other sites which are nearer to the edge of the bog. The shapes of the relative Alnus curves at LDIII and iii do differ, however, in that Alnus took longer to achieve dominance over Betula as recorded at LDIII (the plot of total pollen concentrations do not imply a slower growth of peat here as compared to LDiii). The ground between cores LDii and i may have been inimicable to alder, whereas it was more suitable to the west, south and east, albeit as a part of a fringing community, and so more readily detected at LDiii than LDIII. The higher proportions of Pinus and Ulmus at these two sites suggests that a greater regional component is present and this may be true for Coryloid.

The pattern of the Alnus rise (sum of AP) from the loch core displays considerable fluctuations. These fluctuations expressed as concentrations (Diag. 6.5.3) are shared in kind by all the other major trees (except Pinus which is comparatively stable) and Coryloid, Gramineae and Indeterminable. The pollen concentrations imply that none of the major

trees, nor Coryloid are affected by the Alnus rise and so it is possible that Alnus is colonising a niche unsuitable for the other trees (in contrast to Bennett's [1984] suggestion for sites elsewhere that Alnus replaced Pinus). Quercus does not increase alongside the Alnus rise at any stage but from the beginning of the rise has appreciably higher percentages than at LDIII. Pinus also has a greater representation, but Coryloid is lower.

From the dates on the loch core the time between the initial rise (as defined) and later expansion of Alnus was approximately a millennium; whereas as it is registered locally at the site of LDIV, a century may separate the lower contact of LDIV-4 and the large expansion.

Regarding the possible influence of Mesolithic occupation on the rise of Alnus, the incidences of increased amounts of microscopic charcoal before the rise has already been referred to in discussion of LDIII-3 and LDIV-3. The extra short profiles of LDi - v do not offer the same longer context in which to place the records of Diags. 6.5.1-3. Unless there was one very local and effective firing of the vegetation around the basin it is difficult to conceive that Alnus would be favoured as a direct consequence of burning and the pattern of the charcoal curves gives no indication that such a firing took place. There are no conspicuous and demonstrably coincident peaks. All the sites have a record of charcoal and a more general effect may have been some clearance more regionally causing or contributing to a raised water table (cf. Moore 1975, Moore et al. 1986). Burning of the bog surface itself causing local drainage impedance (Mallik et al. 1984, Moore 1988) might have been repeated or been a unique event, but even without a record of macroscopic charcoal abundance such burning should probably have been seen as a definite increase of microscopic particles, in view of the 2cm sampling at a number of sites (and contiguous levels at LDIV).

It has been tentatively suggested above that some disturbance of birchwood, in particular, and oak and hazel may have enabled Alnus to expand and records in LDIV-2 and LDIV-3 imply a restricted source in the vicinity previously. It is easy to assume that the arbitrarily defined threshold of 2% AP was exactly contemporaneous, although this was called into question in discussion of LDiv. It was noted that as birch, oak, or hazel declined there was a rise in heather or grasses. The significance of these rises is difficult to assess, as for the charcoal record, because of the temporally restricted context and it was not necessarily the case that each event occurred simultaneously. It was also pointed out that as registered at LDIII, the expansion of alder proceeded without a later decline of birch suggesting that a habitat that was available to alder, but not to other trees, was being colonised. Elsewhere, competition with birch seems to have been the norm (on the basis of pollen concentrations), but whether further disturbance is indicated is uncertain. The persistence of fern (undifferentiated) spores at LDIV, i, iv, and v may denote some open canopy.

Post-Alnus rise (including the 2nd and 3rd Gramineae peaks of LDIV)

Continuing to describe the vegetational history of the environs of the basin as inferred from the records of LDIII and IV, the second peak of Gramineae at LDIV begins as Alnus emerges as pre-eminent over Betula and the other trees, and whilst Filicales also increase. It appears that the sedimentation rate has again slowed up. As Gramineae reaches its highest value it does so in absolute terms against a very large drop in Alnus. The rise of Gramineae starts as alder succeeds birch and at the mire surface, grasses may be replacing heather initially. Latterly, the demise of alder with no immediate major expansion in birch indicates some

disturbance to which grasses (and ferns) have responded and increased. Whether due to local autogenic change of surface water conditions at the edge of the mire or some clearance of alder cannot be convincingly resolved; there is no marked increase of 'ruderal' types (Artemisia and Pteridium are present) to suggest maintenance or use of a cleared area nearby, though the field layer may have been dominated by grasses and ferns. As Gramineae declines at the end of the subzone, Betula recovers more rapidly than Alnus, but Alnus again re-asserts its dominance (seen in absolute and relative terms), and Calluna almost disappears from the record, before the third peak of Gramineae.

For the third peak, the concentration of grasses increases as Alnus concentration falls, but on this occasion Betula also increases (see Diag. 6.7.1, DLP). Gramineae is still high at the second level of the peak when both Alnus and Betula are reduced. Thereafter, as Gramineae declines Alnus responds more vigorously than Betula, but after the end of the third Gramineae peak Betula is again dominant. Some disturbance initially may have occurred as birch succeeded alder and is more likely when both birch and alder are reduced. There is a small peak of Melampyrum, though this taxon was recorded between the first and second Gramineae peaks. Pteridium reappears, but the percentages of Filicales are less than during the second peak. There is no clear episode of an increased number of herb types, nor probably of a significantly higher representation of charcoal suggestive of local burning.

By the third Gramineae peak there are signs, in the decrease of total pollen concentration and increase in Sphagnum, that peat accumulation is proceeding more quickly. It is during this stage that the sporadic records of Salix become a continuous curve, though it is steady whilst Betula increases to be dominant over Alnus.

At the end of the Gramineae LPAS Salix rises rapidly and absolutely.

This represents the establishment of willow very close to the coring site and has apparently no effect on the balance between alder and birch (as inferred from the percentage and concentration diagrams). After its initial peak, however, Alnus expands in absolute terms as Salix and Betula decline. This is succeeded by the supremacy of Betula, but the Salix concentrations show an increase over Alnus. Alnus then rises proportionately over both Salix and Betula, as Salix is reduced.

The subsequent expansion of Salix and then its demise towards the end of LDIV-4 is independent of the fluctuations observed between Betula and Alnus. Although some competition between birch and alder is implied, willow was probably present where alder was no longer able to compete as it apparently did at the Salix minimum earlier in the zone. At the maximum of Salix a single grain of Frangula represents a further woody element in the willow scrub which is interpreted as occupying an outlying position in the vegetation of the bog edge where the substratum was possibly too wet and too peaty for alder. Ferns were perhaps in the understorey of both the birch-alder and willow communities. As this scrub declined, ericaceous plants and grasses increased whilst the trees, mainly birch and alder, show little change and perhaps a drying of the bog took place, with the spread of heather and grass associated with tormentil (the likely species represented by Potentilla type). It is considered that elsewhere in the pollen catchment of LDIV oak and hazel were essentially unaffected by the dynamics of the woodland at the edge of the bog. A small peak in each of their pollen types, and one of Pinus, when the Alnus curve plunges at the commencement of the third Gramineae peak, probably allowed a greater proportion of more regional rain before alder recovered.

The profile of LDIII shows that once the high values (around 35 %AP) of Alnus are achieved, the degree of change in its abundance is generally less than at LDIV. As at LDIV where there is variation, it is reciprocated

by Betula with Quercus and Coryloid comparatively constant; but two peaks of Quercus (at 160 and 94cm) correspond with troughs in Alnus and Betula respectively. It is not possible to see the second and third peaks of Gramineae recognised at LDIV. Instead there are only small fluctuations of Gramineae. The bog at LDIII predominantly supports Calluna. The subzone of Gramineae can perhaps be correlated between the two profiles, and following it the resumption of the Salix curve may be recording some of the same Salix pollen rain so clearly represented at LDIV.

The pollen stratigraphy of LDIII-4 is perhaps best interpreted as representing a larger catchment than that of LDIV. The higher and more steady values of Alnus once established then indicate the cumulative rain of fringing alder rather than a predominantly local source. The same argument of there being more non-local pollen in the record probably applies also to oak and hazel, which was perhaps growing on the hillocks. Similarly, pine could have been on poorer soils on higher ground and elm on the best soils in a wide catchment. Birch is seen to be less important than at LDIV, either due to the belt of alder or more likely because it is over-represented at LDIV in respect of its abundance elsewhere. Concerning the coring site, there was probably a drier surface. This was probably so for all of LDIII-4, when Calluna was prevalent, as well as for the time of the Gramineae subzone within which Calluna became especially dominant. The rapid decline of Calluna at the end of the Calluna LPAS just as Alnus increases may represent the encroachment of alder onto the edge of the bog nearest the site (and elsewhere). Alnus rises absolutely at this point as Calluna concentrations fall, but no further decrease of Calluna occurs as Alnus rises slightly more, in competition with Betula. This suggests that alder did not invade the mire to shade out heather, and such a habitat would not be a usual one for alder.

Once alder is well established the ratio of charcoal: total pollen

decreases, at a time of sustained or decreasing pollen concentrations so that a real decrease is implied. The ratio remains higher than that recorded at LDIV after the Gramineae subzone, and at LDIV the local presence of willow is suppressing its value and may also be filtering out the charcoal rain. There are two peaks of charcoal in the latter part of LDIII-4, but none similar are recorded in LDIV-4. In terms of anthropogenic influence during this time, the presence of Plantago lanceolata before a definite decline in Ulmus is specific to LDIII, but because of the later peat cutting it is impossible to be certain whether a Decline has begun towards the end of LDIII-4 (Diag. 6.4.1). From the end of the Gramineae LPAS at both sites no definite signatures suggesting local disturbance to woodland canopy have been detected, though the continuing charcoal record and perhaps the occurrence of bracken may be a reflection of more regional activity. The Elm Decline and subsequent vegetational history is only documented at LDIV and partly by the loch core pollen stratigraphy. Comparisons between the mid-Flandrian woodland represented by the Loch Doon sites and previously published diagrams is dealt with in the final Section (6.7.3).

LDIV-5 and LDC-4 (c.4800 - 4300 b.p./2850 - 2350 b.c.)

By the time of the Elm Decline the extent of peat had probably grown to cover almost all of the ground encompassed by the transects of Fig. 6.2 and possibly further towards the northwest. Where the present breaks of slope have been mapped the peat was likely to have been within 20m of these boundaries of higher ground. The position of LDIV would therefore have remained close to the edge of the bog to the east and southeast and only slightly further (say 30 m) from the edge to the west; but to the south the gully between the central and southern hillocks had probably already begun to be infilled.

As elm reduces there is a slight relative increase in alder compared to birch but the change in other trees is negligible; ash is recorded at the initial decline. Very soon afterwards there is a pronounced increase of birch, seen also in absolute terms, and this causes the percentage representation of other types to be suppressed. Plantago lanceolata, Vicia type and Artemisia are recorded at the Elm Decline and the total number of herb types increases before a maximum of birch. When birch declines from this peak, the proportion of tree pollen reverts to the level achieved before the decline, although elm is now at reduced values. Oak, alder and hazel then increase compared to birch, during which phase Plantago lanceolata is again recorded and also Urtica; Calluna expands and Potentilla is at increased values. By the end of the zone birch has recovered at the expense of alder.

There is no rise of charcoal compared to total pollen at the Elm Decline, although later as Calluna expands so does the charcoal curve. The Decline only affects elm, but the immediate rise of birch suggests a connection. An initial opening of the canopy is indicated by the presence of Plantago lanceolata for the first time and the greater number of herb types. It is possible that birch took advantage of the openings and in the absence of sustained grazing flourished briefly before being succeeded by oak, which then was more prominent than previously. The extremely high maximum of birch (with a clump of Betula pollen grains) means that it had certainly expanded very locally. Birks (1972) drew attention to the increase of Alnus following the Elm Decline and whilst unable to distinguish a change in the composition of woodland from the statistical effect of the trees declining, nevertheless referred to the interpretation of Oldfield (1963) suggesting a temporary colonisation of forest openings by alder. Perhaps nearer to the site alder was for a time at advantage over birch as oak expanded.

Such an explanation of increased birch in the region cannot be sustained from the pollen stratigraphy of the loch core at the Elm Decline. Regarding the peak of Betula the sampling interval may be too wide to register it; the first presence of Plantago lanceolata and Fraxinus are later, but this may be due to a lower counting sum. Oak rises at the Decline, but alder is little changed. An expansion of Calluna occurs after the Decline, but is short-lived. At Loch Dungeon (Birks 1972), Calluna rises at the Elm Decline; the first Plantago lanceolata is later there, when Ulmus is at a minimum.

The Decline in Elm as defined at LDIV occurred within 100 years. Because the catchment of the coring site has a large local component it is possible that a more regional Decline in its early stages is obscured here. This might mean that the LDIV-4/5 boundary is placed somewhat above a regional Decline, perhaps registered at 214cm at LDIV (cf. Diags. 6.7.1 and 6.7.2). If this were the case, the duration of the Decline is calculated as about 220 years. Either way, the event is shortlived in the context of woodland history. Possible causes are discussed in Chapter 9 with reference to other palaeoecological evidence from in and around the Loch Doon-Loch Dee basin and that for Neolithic settlement.

LDIV-6 (c.4300 - 3500 b.p./2350 - 1550 b.c.)

The increased percentages of Calluna and Gramineae (Diags. 6.3.1-3; 6.7.1) probably relate to the further extension of mire communities. The percentage fall in trees at the start of the zone is due to the greater expansion of herbs in absolute terms, which since it is not associated with other open-canopy types is best interpreted as a response to more favourable conditions by the mire plants, particularly heather. Since Plantago lanceolata is intermittently present, areas suitable for its growth are maintained and at the penultimate level of zone LDIV-6, a small

peak is matched by a greater one of Pteridium. Fraxinus is continuosly recorded in the zone and with Plantago lanceolata and Pteridium suggests more open woodland and mid- to late Neolithic activity regionally (Diags. 6.7.1 and 6.7.2). An increased amount of burning in the region is perhaps marked by the peak of charcoal as compared to pollen and this is repeated in the absolute amount of charcoal arriving at the site. This could in part be due to a wider catchment being available to the coring site. A single grain of cereal-type pollen may indicate arable farming in this area, but lacks associated 'ruderal' types. By the end of the zone a presumably local expansion of birch has caused the representation of other types to become reduced.

LDIV-7 (after c.3500 b.p./1550 b.c.)

Similarly to the commencement of the previous zone it is Calluna that rises at the start of LDIV-7 and the proportional decrease in trees is mostly due to the absolute increase of the former. Comparable too is the increase of Sphagnum towards the end of the zone when pollen concentrations are very low. A locally drier mire surface at first may be implied. The existence of open areas away from the mire are again suggested by the now more consistent and sometimes higher values of Plantago lanceolata and Pteridium. As in the previous zone there is a record of cereal-type pollen. Here it more probably points to agricultural activity, in the Bronze Age, occurring with Plantago lanceolata, Rumex acetosa/acetosella and Pteridium. Charcoal is again well represented. An expansion of birch concludes the zone as before and this accentuates the representation of the values (AP, AP + taxon) of oak, alder and hazel (Diag. 6.7.1)

LDIV-8 (undated)

The pattern of change at the start of the previous zone is echoed here: there is an absolute increase of herb types with respect to trees which is the result of an increase in Calluna . This is followed by expansions of Gramineae and Cyperaceae, of which the latter could be an expression of a wetter mire surface witnessed also by the higher Sphagnum values, those of Amphitrema and Assulina, the sediment stratigraphy and marked reduction of total pollen concentrations. The greater incidence of cereal-type grains and herb types that are possible indicators of agriculture expand (e.g. Plantago lanceolata, Rumex acetosa/acetosella, Ranunculus, Cruciferae and Pteridium) imply cultivation of cleared ground and in this instance the rise in Gramineae is probably a component of the dry-land vegetation. Charcoal values are higher after the tree pollen curve has declined and perhaps corresponds to the increased activity witnessed by the herb indicators. The greater percentages of Pinus may be the consequence of an increased regional input; the pine either having not been cleared at the same rate, or perhaps left intact at higher altitudes. That clearance has taken place on dry ground is suggested by the decline of Quercus and later Coryloid (probably hazel; see Diag. 6.7.1). Increased runoff may have caused the bog to have become much wetter in parts (cf. the sediment stratigraphy of 39-53cm); some disturbance of the bog subsequently may have caused the first occurrences of Hyalosphenia subflava spores (van Geel 1978).

LDIV-9 (undated)

The percentage of trees as a proportion of total land plant pollen falls to its minimum at the penultimate level when weed pollen and Pteridium are at maximum values on the sum of selected dry-land types (Diags. 6.7.1 and 6.7.2). The cultivable land around the area of bog continued to be

essentially cleared with some additional clearance of woodland remnants (or it may be that the regeneration of senescent trees is now prevented by grazing). Betula has declined to its lowest level since the episode of competition with Alnus at the start of LDIV-4. Cereals were still grown. Near to the surface of the profile (level 4cm; 2cm from the surface) the planting of pine in the region has given rise to the maximum of Pinus, and the lower values in the zone might represent the beginning of that process or the registration of the rain from relict populations. The peak of Coryloid is considered to be mainly of Myrica pollen from the morphology of the pollen pores (cf. Moore and Webb 1978; but certain identification may be difficult, e.g. Edwards 1981). The drop in Plantago lanceolata and Pteridium and also in charcoal compared to total pollen may indicate less intensive land use for pasture, at least locally, in recent times.

Comparison of Fl III at Loch Doon IV with Fl III of Loch Doon I

Carter's (1986) diagram (Appendix 2) from the site of LDI begins at an extrapolated date of 5290 b.p. It is difficult to discern exactly where the fall in Ulmus occurs but from around 4850±80 b.p. (centred on 190cm). Calluna is consistently recorded at slightly higher values and shortly before this the first instance of Plantago lanceolata is registered. A total of 204cm of sediment was analysed and so overall the peat accumulation is very similar to that of LDIV for the same period. There are, however, no suitable signatures in the pollen stratigraphy by which to correlate the two sequences for most of the period. The situation of LDI must make its record one dominated by local pollen if it is assumed that the ridges to the west and east of the site were suitable for tree growth. Any such stands of woodland on the ridges to the west would cause a barrier to pollen transfer from the east that might otherwise have carried to LDIV. The greatest variations in tree pollen are between Alnus and

Betula which together are the most abundant types. Quercus, however, also fluctuates quite widely, as may Coryloid. There is generally less Coryloid pollen at LDI until about the last quarter of the diagram. The contiguous 1cm sampling at LDI shows fluctuations at a much more detailed scale and both Quercus and Coryloid have changes that would not be detected at LDIV.

At the depth of 56cm in the LDI profile (dated as 870±60 b.p./1080 a.d.) there is a pronounced fall in tree pollen from which time Fraxinus and Plantago lanceolata are at increased percentages and there is a peak of Pinus pollen. Gramineae then attains its highest values. There is a rapid expansion of Sphagnum at the dated horizon. Trees recover a little after the fall but decline again at between 30 and 40cm from which time Sphagnum increases again and remains at high values. The first event may correspond to the reduction of trees after the second level of LDIV-8 and the second decline to that across the boundary of LDIV-8/9. Although no Pinus is recorded at LDI from the time of the first decline in trees until the sample at the bog surface, Fraxinus increases at the second decline. Further analyses of both LDI and LDIV would be required to make a more secure correlation, but if the first major clearance of land around the bog occurred in the Middle Ages, this would be in keeping with the admittedly sketchy history derived from a number of sources (see above Sect. 3.8.1). Presumably the areas of best grazing were by the loch side to the north where there are numerous field walls; and other ground, where drainage was good.

Comparison of Fl III at Loch Doon IV with Fl III at the Starr Cottage sites

The two profiles of S1T1 and S1T3 have both been dated at the base of the peat to c.2400 b.p. (Sects. 5.3.3.1 and 5.3.4.1). It is not until the second zone of each profile that tree pollen falls; and at S1T1 the reduction of tree pollen is striking. On the basis of the peat stratigraphy the second

zone of S1T1 is later than that of S1T3, since it occurs during the accumulation of relatively unhumified peat which overlies the more humified peat assumed to correlate with that in which S1T3-2 is defined. The analysis of S1T1-3 is from an at least partially allochthonous deposit. The pollen catchment of the two profiles cannot be surmised since no transects are available by which to estimate the extent and depth of peat at any time. The values of tree pollen in S1T1-1 and S1T3-1 and 2 are slightly higher than those of LDIV-7 before the fall in trees in the next zone (LDIV-8). By the time of S1T1-2 and S1T3-3 tree pollen is at the levels of LDIV-9 and LDIV-8 respectively. The stratigraphies from the Starr Cottage sites indicate that for the beginning of peat formation (or accumulation of mor humus) tree growth was unaffected, but after only a few centimetres of accumulation tree pollen fell and heather and grasses in particular expanded. There was a greater accumulation of humified peat at S1T3 where the concentration of pollen is less than the single level analysed within the same deposit at S1T1.

The number of analyses at each of the three sites is inadequate for any detailed correlation. The presence of cereal-type grains in S1T3-2 and 3 probably imply cleared ground nearby, as the cereal grains are usually poorly dispersed. However, peat was accumulating by the loch at the Starr Cottage sites and to the south around the basin of Loch Doon IV some time after 2400 b.p. which would only provide rough grazing. Previously there were highly organic soils developing at the Starr Cottage sites and the occurrence of roots in the mineral soil and woody detritus seen elsewhere in eroded peat by the loch make it probable that the soils were forming under open woodland, since indicators of open ground are already present in the lowest analyses. Since there was at least some agricultural activity in the catchment, deforestation by deliberate clearance with subsequent grazing is a more likely explanation for the

spread of moorland than that climatic conditions alone gave rise to widespread ombrotrophic peat.

6.7.3 The composition of the mid-Flandrian woodland around Loch Doon in a regional setting

The hydrological catchment of Loch Doon is delineated on Fig. 3.9. The loch core taken in 1985 towards the south end of the loch was in a position (Fig. 6.5) such that its sediment would most likely be carried in the inflowing rivers of the Gala Lane and Carrick Lane, and also the many small streams that drain the more immediate catchment. The outline of Fig. 3.9 shows that sediment and airborne pollen falling into the upland lochs and water courses around the southern part of Loch Doon could have been derived from a large area, including a diversity of solid and drift geology, and altitudinal range (see Figs. 3.4, 3.5, and 6.4).

The generalised reconstruction of McVean and Ratcliffe (1962, Map B) referred to in Section 3.6, proposes a belt of pine above the predominant oak of the southernmost slopes rising from the loch. It extends to the south beyond the watershed above the Silver Flowe, and on a contour to the southwest and southeast. The pine then gives way to birch and hazel. Directly to the west of the loch it is suggested that there was no pine dominance between the oak and birch-hazel woodland (see Fig. 3.7).

By the time of the Elm Decline the pollen rain collected in the loch core (Diags. 6.5.1-3) illustrates the relative regional importance of pine compared to its lower, more local, representation at the small peat bog. As alder was expanding there was relatively more pine although, as noted, the concentration values suggest that the variation is mainly occurring in the other tree taxa. Peaks of these coincide with peaks of Indeterminable grains and were thus possibly carried by increased surface runoff compared to the component entrained directly from the atmosphere (cf. Hall 1981; Hirons and Edwards 1986). The inverse relationship of the

Isoetes curve to tree taxa on the relative diagram is due to the calculation sum of AP, the concentrations of this type indicate some, but not complete, correlation with those of trees. Two processes potentially at work could have the opposite effect. Increased runoff might promote the transfer of pollen into the centre of the loch (cf. Bonny 1978) and initial eutrophication favour the growth of Isoetes (Vuorela 1980); but continued disturbance of the lochside sediment might make establishment of Isoetes more difficult or reduce its productivity because suspended sediment lessened the available light (cf. Pennington 1964, 240; Birks 1972, 212; Vuorela 1980).

The pollen stratigraphy from the neighbouring hydrological catchment around Loch Dungeon (Birks 1972; Fig. 3.9) also shows the importance of pine, especially before the first expansion of alder when it appears to replace birch; it reduces from being the most represented tree type, whilst oak increases and alder expands further. Elm and hazel attain higher percentages than is the case at Loch Doon. At Snibe Bog (Birks 1972) too, elm is a greater component than at Loch Doon and pine is generally more significantly represented than oak and elm, until alder rises to its highest values. Hazel has about twice the percentages here than for the same period at Loch Doon. At Loch Doon and Loch Dungeon the amount of heather pollen is usually below 3% (AP, AP + taxon) and 5% (AP + Dwarf Herbs) respectively before the Elm Decline.

Seen in this context it is clear that the small bog by the side of Loch Doon was receiving very much less pine pollen; oak evidently did not become a significant part of the woodland until after the rise of alder, whereas it was well established more regionally early in the Flandrian. Elm was particularly well established in the catchment around Snibe Bog; and also hazel, which compares with the smaller bog by Loch Doon, as distinct from the lake sites where hazel is less abundant during the

Flandrian II chronozone. At all sites ash is represented in the records of this period (and at one level in the Flandrian I at LDIV); Sorbus (or Sorbus type) occurs before Fl II at all sites discussed, except Snibe Bog.

CHAPTER 7

LOCH DEE - DETAILED INVESTIGATIONS AND SYNTHESIS

7.1 Introduction

Four areas of bog on the more southerly peninsula of Loch Dee were investigated (Figs. 7.1, 7.2; sites LDPBI - IV respectively label each area). Additionally to the flint site described in Section 5.5 (LDPB84 Flint, Fig. 7.2), a lithic was discovered along the north edge of the peninsula (Fig. 7.3). The same strategy of survey and coring was followed as for the Loch Doon peat.

7.2 The area of study (NGR: NX 47157900 [peninsula])

Aspects of the geology and soils around the loch have been referred to in connection with the sites LDRI and LDP84 (Sects. 5.4 and 5.5). The loch lies within the Loch Doon intrusion (Fig. 6.4), which has a variable base status (Sect. 3.3), the boundary between the norite to the south of the loch and the tonalite to the north bisects the peninsula on an east-west axis (Fig. 5.9, inset). Cornish (1982) depicts striae, indicating the southerly flow of ice on the peninsula (cf. Fig. 3.6) and, with Charlesworth (1926), shows striae implying a southeasterly direction of ice movement down the valley of the Blackwater of Dee. Charlesworth also illustrates, at a small scale, and so in a generalised way, a moraine lying on the peninsula and continuing away from the loch for some few hundred metres eventually trending to the south to make a 'dog-leg' configuration.

Peat has mantled much of the land around the periphery of the loch, but where morainic deposits and bedrock are near to the surface various soil complexes have developed (Bown 1973). The peat to the north and east of the loch is an extension of the Silver Flowe and is only broken in its distribution along a short stretch of the Blackwater of Dee before filling the lower slopes of the rest of its valley and the basin that is now the

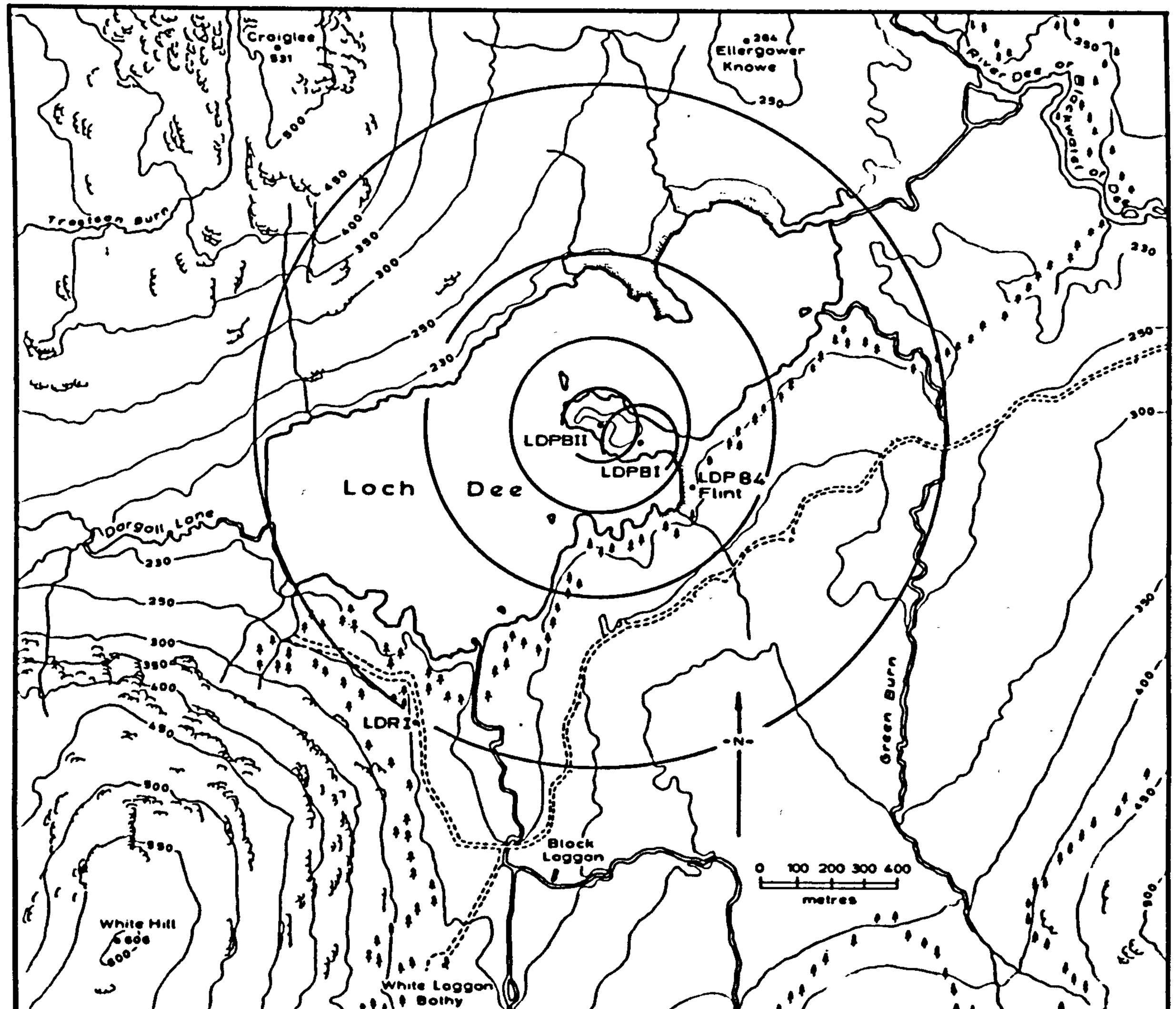


Fig. 7.1. Map of Loch Dee showing the principal coring sites (LDPBI and LDPBII) on the peninsula, and other sites investigated. Circles of radii: 100, 250, 500, and 1000 m centred on LDPBII are drawn. A circle of 100 m radius is centred on site LDPBI.

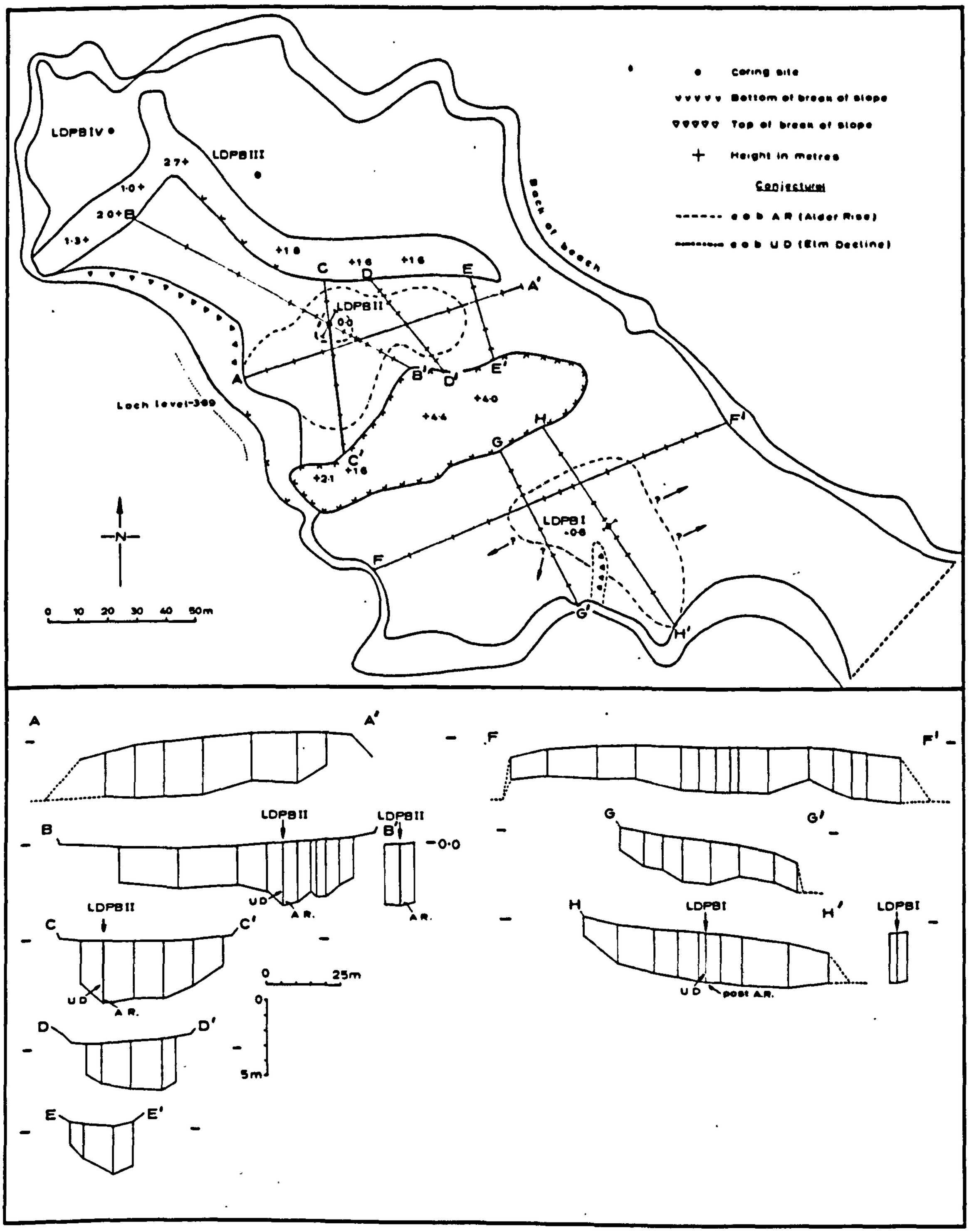


Fig. 7.2. Map of Loch Dee peninsula showing the locations of the coring sites and transects. The transect profiles are also drawn, between the common datum of site LDPBII (0.0).

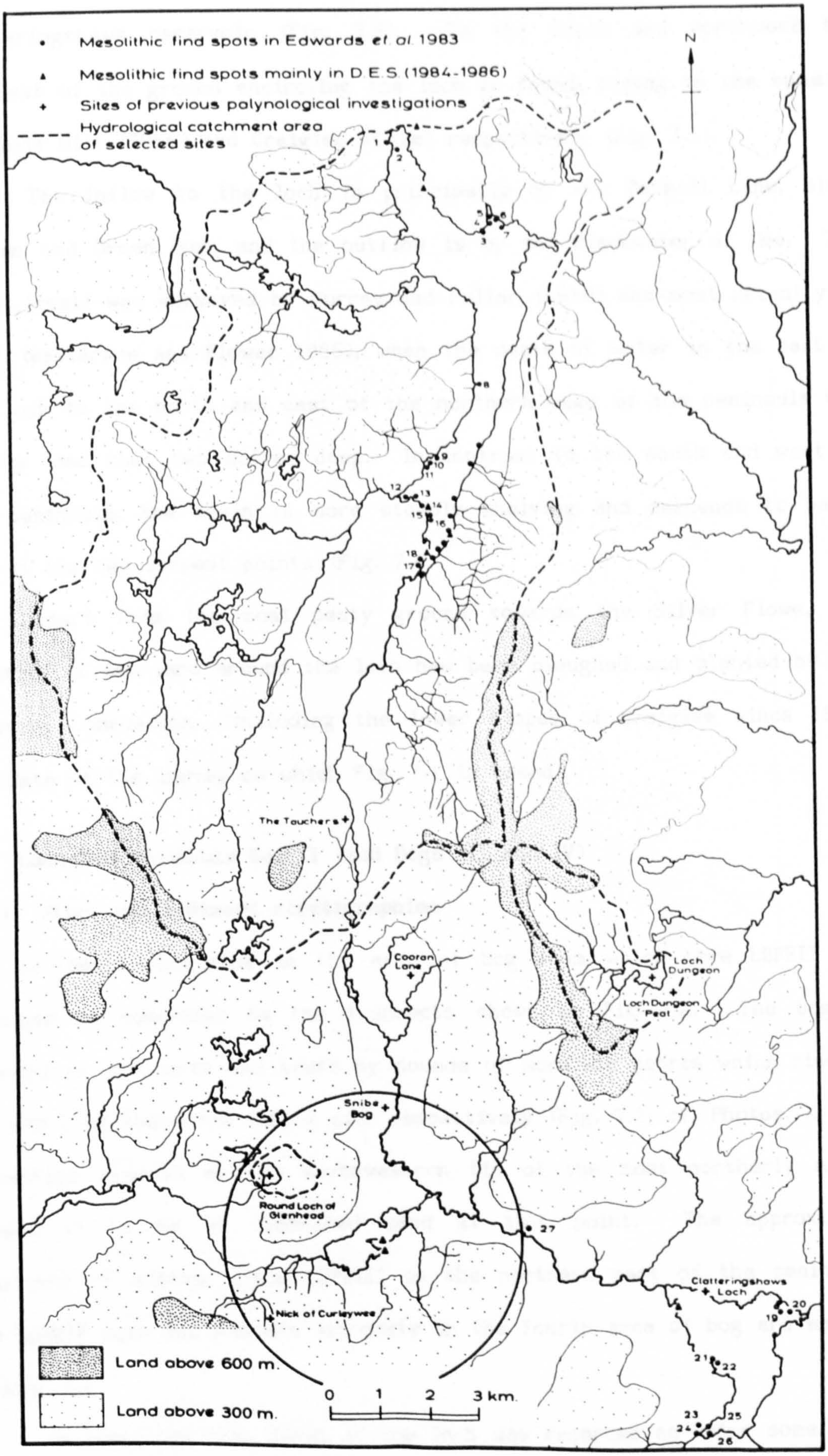


Fig. 7.3. Map of Loch Doon, Loch Dungeon and Round Loch of Glenhead showing their hydrological catchments. A circle of radius 3 km is centred on site LDPBII. The sites of previous pollen-analytical studies and Mesolithic finds are also shown.

Clatteringshaws reservoir (Fig. 3.6). To the south and northwest the steepest of the ground encircling the loch is found, rising to the summits of White Hill (606m) and Craiglee (531m) respectively (Fig. 7.1).

The inflow to the loch is principally by the Dargall Lane, Black Laggan and Green Burn and the outflow is by the Blackwater of Dee. The basin itself was surveyed by Murray and Pullar (1910) and most recently in 1983 (Battarbee and Flower 1985), when the depth of water in the part of the loch to the north and east of the northern edge of the peninsula was mostly less than two metres deep. In contrast to the south and west of the peninsula, the basin is more steeply shelving and descends to below 14m at its two deepest points (Fig. 7.4).

Apart from the most peaty ground towards the Silver Flowe, the majority of the land around the loch has been ploughed and planted by the Forestry Commission, (including the lower slopes of Craiglee since 1973, the date of the survey on which Fig. 7.1 is based).

7.3 Loch Dee Peninsula Bog II (and Bogs III and IV)

7.3.1 Sites and sediment stratigraphies

The sub-peat topography in the area of bog from which core LBPBII was obtained is described by the transects shown on Fig. 7.2. The bog is bounded to the north and south by mounds of morainic debris which rise to 4.4 and 2.7m above the coring site respectively (Fig. 7.2; cf. Photos. X, XI). A section exposed at the southwestern tip of the most northerly mound showed it to be of compacted sand at this point. The approximate positions of another core, LDPBIII on the northern part of the peninsula and LDPBIV near its western extremity in the fourth area of bog are marked on Fig. 7.2.

In April 1987 the level of the loch was recorded as being some 25cm above the base of the deepest core (LDPBII), assuming the peat to have

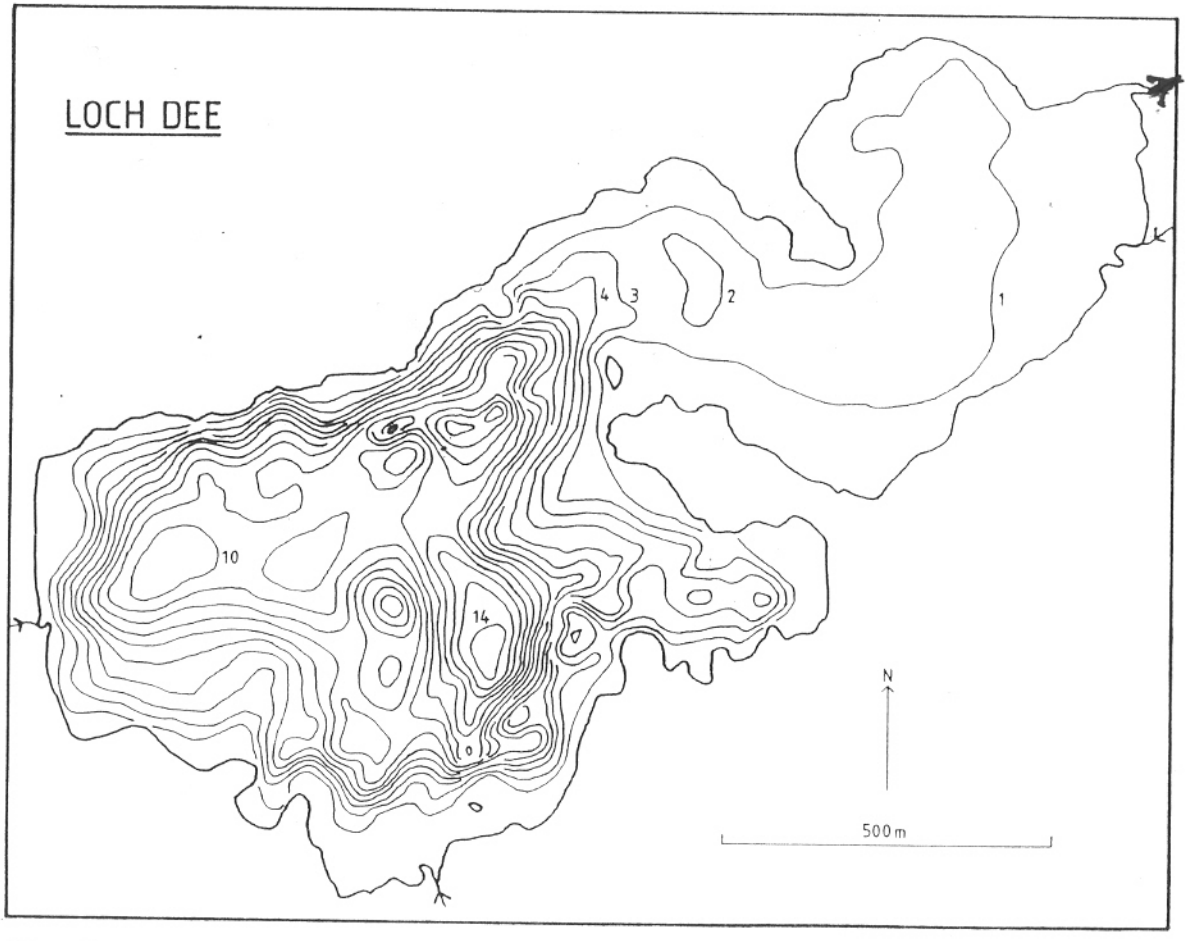


Fig. 7.4. Map of Loch Dee showing the bathymetry of the loch (after Battarbee et al. 1985). The contour interval is one metre.

been of the same depth (4.14m) as that originally measured in August 1984. The records made by the Solway River Purification Board (Sept. 1982-1986, C.P. James pers. comm.) show a greatest fluctuation of 1.7m over this period; 0.86m above and 0.84m below the level shown on Fig. 7.2. On the basis of the depth being 4.14m at LDPBII, by correlation with the same datum, the bottom of the LDPBII sequence is about 1.5m above the 1m contour of the 1983 bathymetric survey (Fig. 7.4); about 0.6m above the lowest recorded loch level (but about 1.1 below the highest).

The Blackwater of Dee is a feeder to Clatteringhsaws Loch, a part of the Hydroelectricity Scheme, though Loch Dee itself is not dammed. Any effect on the water level of the loch due to the scheme would presumably be to raise the loch level through the maintenance of Clatteringshaws Loch, whilst it, in turn, feeds Glenlee Power Station via a tunnel at its eastern extent (Hill 1984). Transect A-A' (Fig. 7.2) indicates a virtually flat substrate to the peat to the west of its intersection with Transect C-C' so that given the same mean loch level and fluctuation as today, this part of the pre-peat land surface could have been periodically inundated. Because the northern part of the loch basin is shallow, a reduction in mean loch level could have given a markedly increased land area to the peninsula and might have included the island off its western end if there was a lowering of 1m compared to the level of the bathymetrical survey (Fig. 7.4). The degree of fluctuation of the loch level at present must have been increased by the runoff promoted by recent ploughing and any previous deforestation.

The vegetation around the coring site was predominantly of Calluna, Tricophorum cespitosum, Myrica gale and hummocks of Sphagnum sp., with Narthecium ossifragum and Erica tetralix locally and some Eriophorum vaginatum. Running down the long axis of the peninsula is a swath where the vegetation was burnt to create a fire break; this is now dominated by

Tricophorum. The freely-draining ridges are emphasised by the dominance of Calluna growing on them (Photo. XI). Pine saplings, probably seeded from the trees on the island off the end of the peninsula, have established themselves on the most northeastern ridge.

The cores of LDPBII (Fig. 7.2) were collected from two points 50cm apart, alternately sampled. The large-diameter Russian corer was used to the depth of 400m; the small-diameter corer was able to penetrate the bog to 4.14m. An unsuccessful attempt was made to obtain a sample of the mineral substratum with a Hiller borer. A single small-diameter core was taken at LDPBIV, the position of the deepest of four test probes within a radius of about 20m using the coring rods (the depths obtained were: 1.70, 2.05, 2.19, and 2.21m). The core was subsampled, close to the base, between the depths 205 and 206m. In locating LDPBIII a similar procedure was carried out. The core was obtained at the site of the deepest of three probes (depths: 3.12, 2.95, and 2.36m), which was the nearest to the morainic ridge, the other two were at 10m and 20m respectively from this, measured along a line approximately perpendicular to the ridge. The core was subsampled at 304-306cm.

Sediment stratigraphy (LDPBII)

It was not possible to sample the uppermost 13cm of sediment from LDPBII since it was too unconsolidated. A surface sample of Sphagnum was collected from near the site and its pollen content is shown at level 0cm on the pollen diagrams (e.g. Diags. 7.3.1-2)

Depth (cm)	Sediment description
13- 88	Nig2 strf1 elas2 sicc3; Sh2 Th2 Th°+
88-246	Nig3 strf0 elas0 sicc; Sh3 Th1 Dl+; lim0
246-400	Nig3 strf0 elas0 sicc; Sh4 Th+ Dl+; lim0 Wood frags. at 310-311; 313-317; 345-352; 362-366; 390-398cm Other woody remains at 317-320; 362-366cm
400-414	Nig4 strf0 elas0 sicc3; Sh4; lim0

7.3.2 Radiocarbon dating

Five radiocarbon dates were obtained from the profile of LDPBII (Table 7.3.)

Table 7.3. Radiocarbon dates from Loch Dee Peninsula Bog II.

Depth (cm)	Years b.p. (error at one s.d.)	Lab No.	Interpolated deposition time (yr/cm)
140.0-144.0	1680±80	GrN-14129	14.4
280.0-284.0	3700±60	GrN-14130	20.5
339.5-343.5	4920±60	GrN-14665	49.9
392.0-396.0	7540±70	GrN-14666	77.7
408.5-414.0	8880±100	GrN-14131	

A plot of depth against time is given as Fig. 7.5, on which the interpolated deposition times are also marked.

7.3.3 Pollen zonation (Diags. 7.3.1-6, 7.5.1-2)

Local Pollen Assemblage Zones (LPAZs) and Subzones (LPASs) have been identified by inspection of the pollen stratigraphy based on AP, AP + taxon. Only approximate correlation is made of the LPAZs with Birks's (1972) Regional PAZs (Diag. 7.3.1). The pollen catchment of the Loch Dee site was probably less regional than for Birks's until the spread of open communities on the peninsula.

Peaks in the representation of Pteridium, Gramineae and the occurrences of Plantago lanceolata are identified. The peaks of the first two taxa are numbered; the occurrences of Plantago lanceolata are marked by a cross. The numbers and crosses annotate other curves of the diagrams (of selected levels and having a vertically expanded scale) to facilitate their interpretation (Diags. 7.3.4-6). The LPAZ of chronozone F1 III have been defined on the basis of changes in the representation of Gramineae, Plantago lanceolata and Pteridium in particular. Towards the end of the chronozone the decline of AP and expansion or reappearance of

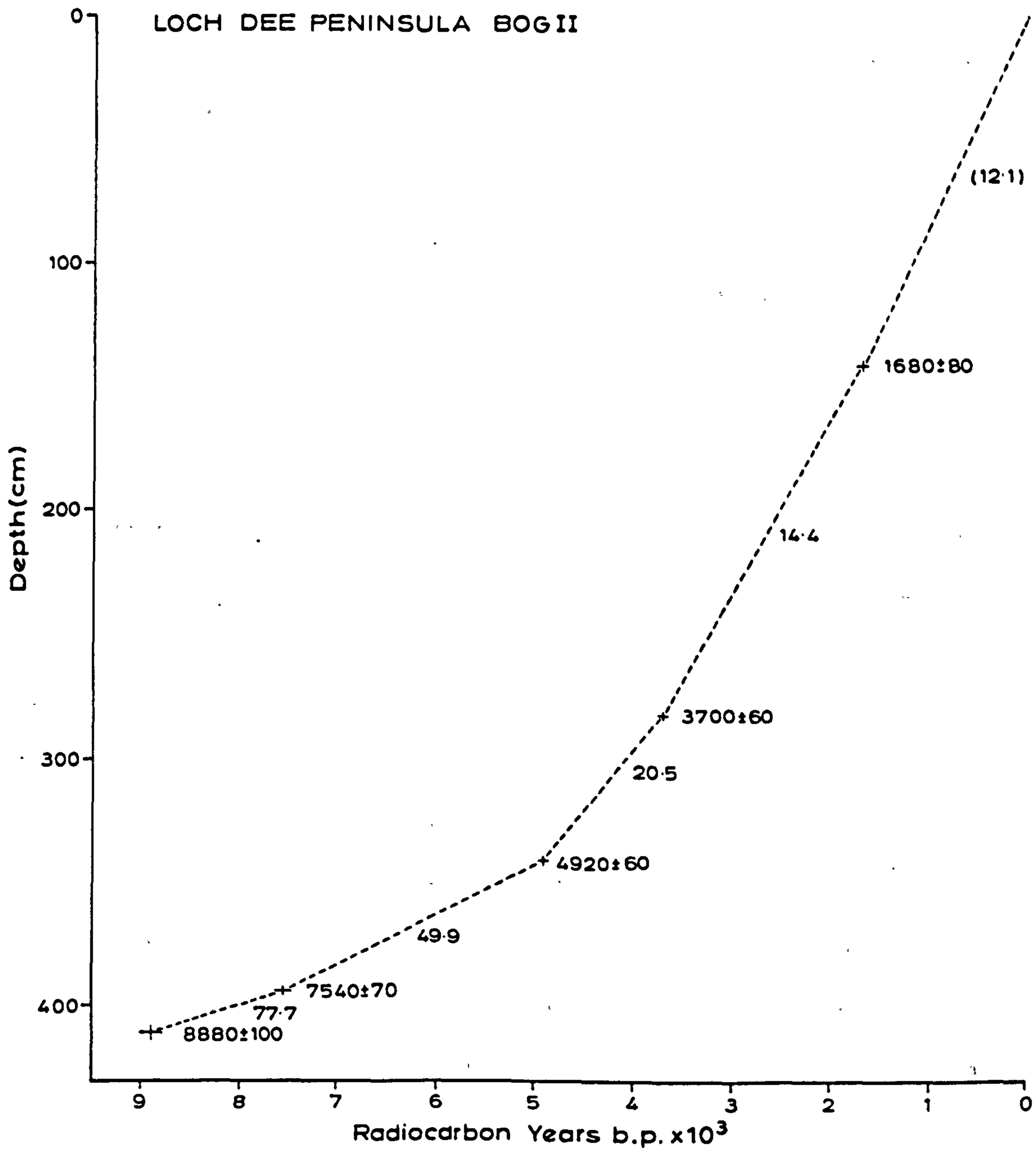


Fig. 7.5. Plot of radiocarbon dates (b.p.) against depth for the profile of Loch Dee Peninsula Bog II (LDPBII). Interpolated deposition times (yr/cm) are also given.

Pinus and Fagus are defining criteria respectively.

LDPBII-1 (413.0-405.0cm; c.9000 - 8400 b.p./7050 - 6450 b.c.) Fl I

Betula is the predominant tree pollen, Pinus is also present (average 2%), and there is a peak of Sorbus at the end of the zone. Coryloid has a maximum of 5%, whereas Salix rises to 18%. The subdivision into the LPASs Betula and Ericoid is defined by the marked increase of the latter at 408cm (first Calluna, then Ericales); from this point AP averages 28%, as opposed to 75% for the first two spectra. At 406cm there are maxima of Lotus (14%) and Filipendula (51%) and a rise in the charcoal curve.

LDPBII-2 (405.0-395.0cm; c.8400 - 7600 b.p./6450 - 5650 b.c.) Fl I

The dramatic increase in Coryloid (from 3% at 406cm to 62% at 404cm) delimits the beginning of the zone. Coryloid remains high (49-65%) throughout and characterises the Coryloid LPAS. Salix falls at the lower zone boundary. Ulmus and Quercus start to rise at the lowest spectrum of the zone with Betula declining, although it is still the dominant tree. The Pinus subzone has its lower contact at the last level of LDPBII-2. Herb pollen (mainly Calluna) is significantly reduced (average 17%). Melampyrum rises from the lower contact to a maximum of 10% and has a continuous curve during the zone. Pteridium is first recorded and then begins a curve that is unbroken until LDPBII-4; the maximum for the zone, at its close, is 40%. Charcoal rises after the start of the zone.

LDPBII-3 (395.0-344.0cm; c.7600 - 5050 b.p./5650 - 3100 b.c.) Fl II

The zone is characterised by the addition of Alnus in significantly greater amounts. Towards the end of the zone it is generally the most represented AP type and this status is the basis of the division of a fourth LPAS, which continues to the next LPAZ. Previous to this LPAS, the high Coryloid values sustained from LDPBII-2, and the peaks of Pinus, then Quercus have given rise to the other three subzones. There is a pronounced fall in Calluna, Pteridium and Sphagnum at the time of the Quercus peak. Maxima

of Gramineae and Pteridium are identified within the LPASs and numbered, fluctuations in other curves are correspondingly numbered. Plantago lanceolata is first recorded at the first level of the zone and later for four consecutive levels in its second half. The zone terminates at the decline in Ulmus. The ratios of charcoal to pollen have a wide range of values.

LDPBII-4 (344.0-274.0cm; c.5050 - 3600 b.p./3100 - 1650 b.c.) F1 III

Ulmus declines (from 14.1 to 3.8%) almost linearly for six levels until it approaches low values (0.9 - 3.7%) in the zone, when Plantago lanceolata is again present, for five contiguous samples. After a rise, Ulmus falls steadily to before the level where the continuous curve for Plantago lanceolata begins, the upper contact of the zone. Further peaks of Gramineae and Pteridium in the Alnus LPAS are noted for the first part of the zone, but thereafter both taxa are reduced. The charcoal values are highest near the start of the zone and at its end.

LDPBII-5 (274.0-250.0cm; c.3600 - 3250 b.p./1650 - 1300 b.c.) F1 III

At the lower contact Coryloid has fallen (from 59.2 to 49.2%) and there is a rise in herb pollen. With the beginning of the continuous Plantago lanceolata curve at the lower zone boundary, Gramineae and Pteridium also increase.

LDBPII-6 (250.0-218.0cm; c.3250 - 2800 b.p./1300 - 850 b.c.)

There is a decline in Coryloid at the lower boundary and increases in Plantago lanceolata (1.2 to 6.9%) and Pteridium (3.6 to 14.4%). The highest values of Gramineae (17.0%), Plantago lanceolata (7.6%) and Pteridium (15.6%) for the zone are attained at 234cm; Rumex acetosa/acetosella and Urtica are also recorded at this level. Thereafter Gramineae, Plantago lanceolata and Pteridium decline to minima at the end of the zone as Ulmus is at its maximum (4.6%). Cerealia-type pollen is present in two spectra.

LDPBII-7 (218.0-200.0cm; c.2800 - 2500 b.p./850 - 550 b.c.) F1 III

The lower contact is the start of a decline in Ulmus (to 0.0%)and the beginning of expansions in Gramineae, Plantago lanceolata and Pteridium. The zone is characterised by reductions in Quercus and Coryloid (as Alnus, then Betula increase) and their subsequent recovery. Fagus is first present in LDPBII-7. After maxima in Gramineae (22.0%), Plantago lanceolata (11.4%), and Pteridium (11.4%) at 210cm, these taxa are much reduced at the end of the zone.

LDPBII-8 (200.0-160.0cm; c.2500 - 1950 b.p./550 - 0 b.c.) F1 III

The start of the zone is marked by rises in Gramineae, Plantago lanceolata, Pteridium and Rumex acetosa/acetosella. The first three of these have higher values in the second half of the zone, when Coryloid is diminished.

LDPBII-9 (160.0-86.0cm; from c.1950 b.p./from 0a.d.) F1 III

The zone begins with low percentages of Gramineae, Plantago lanceolata and Pteridium, with higher values ensuing. Very little pollen was present at 110cm. The upper contact is placed at the fall in AP and shrubs, accompanied by substantial increases in herb types. Cerealia type is present.

LDPBII-10 (86.0-54.0cm; undated) F1 III

Rises of Ericoid, Gramineae and Cyperaceae pollen occur with increases of Sphagnum, Amphitrema and Assulina. Likely indicators of open ground such as Plantago lanceolata, Rumex acetosa/acetosella, Artemisia, Ranunculus and Compositae also rise; as do Pteridium and Filicales. Cerealia type occurs at the second level.

LDPBII-11 (54.0-23.5cm; undated) F1 III

This is defined at its lower contact by the increase of Pinus. Tree and shrub pollen continues to fall; at their minima, Plantago lanceolata is at 71% and the total number of herb types is 21. Cerealia type is registered

at each level.

LDPBII-12 (23.5-0.0cm; undated) Fl III

In the final zone Fagus reappears and at the bog surface Pinus is 79% AP; by contrast Plantago lanceolata is at 2%. Cerealia type is not recorded and herb pollen is somewhat reduced compared to its values in the previous zone.

7.3.4 Sites LDPBIII and LDPBIV (The full analyses are set out as Appendix 3)

The spectrum from LDPBIII (305cm) is post-Alnus rise and probably earlier than LDPBII-5 because of the absence of Plantago lanceolata and the percentage of Ulmus (7%), which is above those of LDPBII-5 to 11. The high value of Betula (50%) and low value of Calluna (5%) contrast with all the spectra of LDPBII for the suggested time interval with the exception of level 382cm, just before the large rise of Quercus in LDPBII-3; here Betula is 58% and Coryloid 21%, but Ulmus 2% and Pinus 12%. At level 349cm Betula is 43%, (Ulmus 10.7%, Pinus 2.4% and Coryloid 27%), but Calluna is 35%. In terms of total AP the value of 65% from LDPBIII is higher than those of LDPBII other than the time of the Quercus subzone of LDPII-3. Clearly if the spectrum is to be placed during this closer interval, unless the correlation is made to the single level of 382cm (and the discrepancy in Ulmus and Pinus has been referred to), then there is a local difference in woodland with birch being more important than oak at this site.

At LDPBIV (206cm) Betula is again the most-represented tree type. The spectrum occurs at a time after the Alnus rise and there is no Plantago lanceolata. In this case, however, Calluna is 44%. The comparatively shallow depth of peat suggests that the assemblage would come from late in the period of LDPBII-4, but against this are the high value for Pteridium (17%) and the absence of Fraxinus. It may then belong

to a time around the Ulmus Decline when Plantago lanceolata was not recorded at LDPBII and its earliest values in LDPBII-4 are low. The percentages of total trees are quite close at the two sites (on average less at LDPBII) by this correlation. As at LDPBIII, however, birch is represented in a greater amount than at LDPBII.

7.4 Loch Dee Peninsula Bog I

7.4.1 Site and sediment stratigraphy

The coring site of LDPBI is at the deepest peat encountered on the transects south of the largest morainic ridge. The core was collected using the large-diameter Russian corer except for the sediment from 12-50cm when the smaller one was used. It was impossible to sample the top 12cm. Only levels from the base (230cm) to 206cm have been pollen analysed covering the pre-Ulmus decline stratigraphy until shortly after the beginning of the period thought to correspond to LDPBII-5 (c.3600 b.p.).

Sediment stratigraphy

Depth (cm)	Sediment description
12- 30	Nig3 strf0 elas0 sicc3; Sh2 Th2
30- 70	Nig2 strf0 elas0 sicc3; Sh2 Th2 Tl+(cf. Calluna); lim0
70-247	Nig3 strf0 elas0 sicc3; Sh3 Th1 (184cm: cf. Erioph. vag.); lim0
247-311	Nig3 strf0 elas0 sicc3; Sh3 Th1 Dl+; lim0 Dl at specific levels (cm): 247,255: Dl; 272,287: Dl(cf. Betula); 292-300: wood frag.; 308-309: wood frag.
311-330	Nig strf0 elas0 sicc3; Sh4 Th+; lim0 charcoal frags.: 312.5-313, 313.5-314, 320 cm

7.4.2 Pollen zonation (Diags. 7.4.1-3)

Whilst the LPAZs are defined by the pollen stratigraphy of LDPBI, the numbering of the zones is chosen so as to correspond to that of the pollen stratigraphy of LDPBII, which assumes an adequate correlation.

LDPBI-3 (330-296cm) Fl II

Alnus is 36% at the start of the sequence. Subzones designated by peaks

of Pinus and Quercus are recognised. The latter is followed by an Alnus LPAS when this taxon generally dominates the AP. The pronounced reduction in Alnus before the Quercus LPAS occurs within the subzone 3a. This reduction is followed by a value of Alnus of 37% at the end of LPAS 3a. At the minimum for Alnus, Ericoid pollen is 70.2%.

LDPBI-4 (296-226cm) F1 III

The lower contact is defined by the beginning of the fall in Ulmus (from 10.2 to 0.6%). Calluna has consistently high values and Pteridium is reduced, with a peak towards the middle of the zone, to be followed by lower percentages. Plantago lanceolata is highest (1.6%) at the minimum of Ulmus. The curve of charcoal: pollen has low values in the second half of the zone. Melampyrum is no longer present after the low values in its first half.

LDPBI-5 (226-206cm) F1 III

The zone is characterised by the continuous curve for Plantago lanceolata. Fraxinus has higher percentages and Coryloid declines across the lower boundary, when Pteridium increases.

7.5 Inferred vegetational history

LDPBII-1 c.9000 - 8400 b.p./7050 - 6450 b.c.

The basal two spectra of the Betula LPAS, with Betula values at 97% AP and tree pollen is 75% of TLP indicates birch woodland very close to or at the site (cf. the criterion of 70% AP+S [TLP], adopted by Smith and Cloutman 1988, following Goddard 1971, as a threshold over which local woodland is represented). Some measure of open canopy allowed a ground layer of crowberry, heather, grasses and sedges. These probably would have grown in a basin that may have been smaller than 10m in diameter (see Transect B-B', Fig. 7.2). Acid conditions are indicated by the values of Sphagnum, but away from the basin herb types associated with a higher base status,

Rumex acetosa/acetosella and Filipendula, are present.

The next subzone sees firstly Calluna, then Ericales pollen dominating the herbs. Although Betula is the predominant tree, AP averages only 28% so an enlargement of the open ground has occurred as the birch woodland is reduced. Calluna or Ericales + Calluna attain values of greater than 20% TLP, taken by Smith and Cloutman (1988, after Evans and Moore 1985) to be a maximum value for Calluna as an indication of its local presence in a still wooded landscape. Since it is Calluna that rises so dramatically at the start of the reduction of Betula it is unlikely to have been a higher water table causing water-logging of the woodland; Sphagnum declines and the rise of Cyperaceae is an artefact of the calculation sum and is not apparent in terms of TLP. Similarly, the percentages of Indeterminable types are comparatively constant for the assemblages of the Betula subzone and it is probably because of a slower rate of organic accumulation during the Ericoid subzone that their concentration has increased (Diag. 7.3.6). This being the case, the small rise in the Betula concentrations at the start of the Ericoid LPAS should be seen against a trend of greater total concentrations (cf. Indeterminable types) in the subzone; i.e. in the first LPAS Betula averages 3.8×10^4 grains/cm^3, in the second, 6.1; whereas for total pollen the figures are 5.6 and 24.3 respectively. Using the interpolated sediment accumulation rate the change was effected within 150 years, which may account for its abrupt depiction on the diagram; at a sampling interval of 2cm the detail of the transition may have been missed, but the deposition time is a crude estimate and the total pollen concentration curve suggests it to be high for this zone. An episode of disturbance seems possible, but from the ratio of microscopic charcoal to total pollen it was not assisted by local burning.

The peak of Sorbus-type pollen implies that probably rowan was able

to colonise new ground near to the peat basin (its role as a pioneer was noted above [Sect. 5.4.8]). Willow was more common and evidently a tall-herb community was present, mainly of Filipendula, but perhaps with Valeriana officinalis present (cf. the lists in McVean and Ratcliffe 1962, 22f., Table A). The high value for Lotus (perhaps L. corniculatus) may also indicate a more nutrient-rich facies to the local vegetation even on the heath with which it was probably associated (cf. Gimingham 1964, 247f.). Hazel was present in a regional context, with a highest value of 4.5%AP at 408cm when at 1.5%TLP.

LDPBII-2 c.8400 - 7600 b.p./6450 - 5650 b.c.

Again using the coarse timescale, the very marked rise in Coryloid pollen took place within c.150 years. Having values of above 30% TLP the hazel is most likely local (cf. Smith and Cloutman 1988, Goddard 1971). Birch recovers slightly from the previous zone (see summary diagram), but it is hazel that has been able to succeed best and it appears to have colonised areas of heath. These may have developed as a consequence of the disturbance suggested to have taken place during the time of the previous zone and could have developed on relatively freely-draining substrates away from the hollow infilling with peat, across the 'floor' of the peninsula; or on the morainic ridges. An element of heath perhaps still persisted at the site and the absolute increases of trees and shrubs together at the start of the zone point to a slower peat accumulation rate, though Sphagnum continues to be important locally.

The ratio of charcoal is increased across the lower zone boundary and the first record of Pteridium is at the first level of this zone. Two levels later there is an initial large peak of Pteridium when Coryloid is reduced. Some disturbance of the hazel canopy, perhaps by fire since the charcoal ratio is further increased, has allowed bracken to flourish nearby

(cf. Tinsley and Smith 1974, 564). At the second occurrence of a notable peak of Pteridium, it is birch that is affected and Calluna also responds. From the first expansion of Pteridium open birch and hazel woodland can be envisaged for the remainder of the zone. Melampyrum is comparatively high during most of LDPBII-2, but expanded to a maximum before the marked increase of Pteridium. Being very local, it was perhaps an element of the bog (or peat-edge) flora (cf. Sect. 6.7.2, LDIII-3 and LDIV-4, by Loch Doon), perhaps as well as part of the woodland field layer (e.g. Berglund 1966, 94,126f.) As at Loch Doon it is not possible to assess the extent to which birch and hazel grew together or in discrete stands. The disturbances of each suggest some separation of niches.

The zone is concluded by the rise of Alnus. By this juncture elm and oak are already established and pine has begun to expand. The high percentage of Coryloid and Betula at the beginning of the zone (80% TLP) and similar values for most of the zone thereafter, means that birch and hazel were growing on the peninsula, but it is more difficult to estimate the provenance of the elm, oak and pine pollen. They were clearly increasing in the region but were probably not part of the vegetation of the peninsula, arriving as 'rainout', and perhaps 'canopy' components (Tauber 1965) as these trees spread more locally.

Concerning the date of the sharp Corylus rise as recorded here (c.8400 b.p.), it is considerably later than the rise at Loch Doon (e.g. 9280±140 b.p. or 9200±110 b.p.) and other sites in south-west Scotland (Table 3.7). Since the deposit was accumulating slowly (i.e. on average 78 years/cm) the contribution of later humic acids would tend to make dates from this part of the profile younger than from a faster-growing peat elsewhere.

As to the interpretation of the Coryloid curve, because of the local origin of the pollen the dramatic rise of Coryloid at the LDPBII-1/2

boundary may not be the regional phenomenon witnessed from larger-diameter sites. Coryloid pollen is present in the basal spectrum of the sequence which may be nearer 9000 b.p. and is still, by definition (Smith and Pilcher 1973), at least the empirical limit. It was argued that the spread of Corylus may have been encouraged due to previous disturbance of birchwood, which created openings that hazel was able to colonise more successfully than birch. In this respect there may have been an anthropogenic influence (cf. Smith 1970). The record of charcoal does show an increase just before the LDPBII-1/2 boundary and conceivably fire was an important factor in promoting the spread of hazel from the environs, but the initial postulated disturbance of birch has a slight amount of charcoal associated with it. The charcoal record is significantly higher from about the middle of LDBPII-2.

LDPBII-3 c.7600 - 5050 b.p./5650 - 3100 b.c.

The rise of Alnus occurs when Coryloid markedly reduces (in absolute terms too), Calluna continues to expand, Betula rises briefly, then falls. It would seem that some further disturbance of hazel has occurred and even though it remains more important than birch it has clearly suffered considering its representation in LDPBII-2. The percentage of AP+S is still above 50% TLP in spite of the expansion of heather, so that there remained woodland fairly locally (cf.Tinsley and Smith's [1974] criterion of 50% AP of TLP as suggestive of nearby woodland). It is interesting to note the presence of Plantago lanceolata at the demise of hazel, an additional indicator of open ground, not associated with a heathy vegetation, nor directly with bracken beneath a more open canopy. The curve of charcoal: total pollen remains as high as the previous zone across the zone boundary and is seen to increase in later levels. It may be that as well as local hazel being disturbed, a more regional component is

reflected so that by a thinning of the hazel-dominated woodland opportunities have been given for the expansion of Alnus (cf. Smith 1984 Smith and Cloutman 1988) in which burning was instrumental.

By contrast to the classical decline of Pinus at the Boreal-Atlantic Transition it here enjoys a subsequent expansion, and has been shown to behave as a pioneer species by Bradshaw and Browne (1987). At its maximum, before the Quercus subzone, Pinus (22% AP) has just crossed the threshold of 20% for defining its local presence (Bennett 1984), which was adopted by Bradshaw and Browne (1987). The latter consider that below this figure pine is not necessarily associated with the other trees of the area, whose pollen may reach the site. At the lowland site of Lough Aisling (Co. Mayo, the north of Ireland), Pinus apparently replaced Corylus at the Alnus rise, at a time of increased burning. It is contended that Pinus is favoured by low-intensity fires, whereby 'Quercus, Corylus, Betula and other potential rivals' are poorer survivors (Bradshaw and Browne 1987, 245). It may have eventually entered local woodland. Its decline corresponds with the expansion of oak and a time of lower charcoal values.

The third peak of Pteridium is perhaps to be correlated with reductions in both Quercus and Alnus, but more likely with Coryloid. The fourth peak coincides with a fall in Quercus, when Betula is at a minimum following a decline as Coryloid reaches its maximum for the zone. Again some disturbance effects are perhaps being registered. At the end of the Coryloid subzone Calluna has fallen slightly, suggesting that hazel has overgrown some areas of heathy ground, perhaps with grasses, and differentiation in the field vegetation of the catchment may then be implied, with some bracken growing distinctly apart from other areas (of heather domination).

Quercus subzone

The pattern of change in the assemblages that opens this subzone is not only abrupt, it also reverses some trends commented on at the end of its predecessor. Whereas Betula was at a minimum it expands sharply to a conspicuous peak as Coryloid, equally sharply, falls from its maximum. The decline of Calluna is dramatic and, with Coryloid and Pteridium, Calluna remains comparatively low for the remainder of the subzone. The diagram of pollen concentrations illustrates how the change is not a product of its relative representation. A succession has likely occurred whereby birch expanded into areas of open ground dominated by heather to be followed by oak. Each stage lasted approximately 100 years. The representation of hazel has clearly been reduced in the process, though not as significantly as heather.

The reduction of Sphagnum is absolute and the peaty hollow may have become sufficiently filled for it to become more water-shedding, but with birch and oak growing very near the site, transpiration would be increased and lessen the amount of water available to the hollow. The reduction of hazel would then be partially explicable as due to a filtering effect of firstly birch and latterly, mainly oak. The summary diagram shows that the curve of AP+S is at its maximum (95% TLP) at the invasion of birch. That some open canopy still remained is indicated by the continued record for bracken, and perhaps Melampyrum. A regional rain of Ulmus pollen is swamped by that from more local trees and it stays at low levels throughout (cf. the concentrations). Pinus declines gradually, indicating a different cause, related to the dynamics of the tree populations. It is not possible to clearly correlate an expansion of any other tree at its decline, although Quercus is still rising.

Why should such a succession of birch to oak woodland take place? A relaxation of burning or grazing (or both) has perhaps allowed the

succession, and a field layer of ferns apart from bracken has developed to an extent not evident since the earliest part of the sequence. The curve of microscopic charcoal abundance is at low values for the first three levels of the subzone, but a small peak at the fourth is reflected in the representation of Gramineae and Pteridium. Filicales is reduced at this point. The rise of Quercus is interrupted and some damage may have been sustained by oaks. If the association of the behaviour of grasses and bracken is valid, then their response was independent of heather, which is unaltered, so again some distinction between areas of the field layer may be perceptible.

At the close of the subzone, when oak drastically declines, (within c.100 years), it is Calluna that expands. There is a reciprocal change in their pollen concentration curves. Some disturbance is implied in the sharp reduction, which takes place as the charcoal curve expands.

Alnus subzone in Fl II

Although heather is able to spread at the time of the lower boundary of the subzone, some competition for open ground may have existed between it and birch, again showing its opportunistic characteristic (cf. Dickson 1984). Hazel, also able to colonise relatively rapidly, does not do so until the third level. There may also have been competition amongst the field layer plants in that both Gramineae and Pteridium expand with Calluna, but since this first peak of Gramineae (with Pteridium) is declining as Coryloid and Calluna increase, this may point to another instance of a separate parts of the field-layer under hazel being recorded, with areas of hazel woodland being maintained in a more open condition. The same difficulty of distinguishing changes in the ground-layer vegetation (of the bog or under woodland) persists in the interpretation of the remainder of the subzone before the Ulmus Decline. Expansion in

grass and bracken (peaks 2 and 3) are associated with decreases in heather and in hazel. There are signs that the bog may have become wetter in that the total pollen concentrations are lower than in the Coryloid and Quercus subzones from just before the rise of Cyperaceae and thereafter. Calluna, Gramineae and Pteridium may have belonged to a mosaic of communities within Corylus-dominated woodlands on drier ground, as well as areas of open heath (see values of Empetrum of local origin, cf. Moore et al. [1986]).

At the third peak of Pteridium there is a decline in Coryloid and also Alnus which is not solely explicable as a statistical effect of the increase of Betula (see absolute and dry-land summary diagrams, Diags. 7.3.6 and 7.5.1). Since by the start of the subzone alder must have been a locally common tree and there is an unusually high peak of charcoal, more local activity may be represented.

At the fourth level of the subzone the highest of four values for Plantago lanceolata (marked x) occurs when Ulmus is low. These values of Plantago lanceolata are interpreted as due to some opening of woodlands in which Ulmus was present and the pollen has come from a wider source area than much of that of birch, oak, alder and hazel. Artemisia was recorded at two levels when Plantago lanceolata is present. The four levels may represent some 200 years. Before Ulmus rises to its maximum value before the Decline, Chenopodiaceae pollen is registered twice and this too may be derived from the wider catchment, as it first occurs before a possible disturbance of Corylus.

Loch Dee Peninsula Bog I

LDPBI-3

The analyses at this site are not as detailed as they are at LDPBII and so accurate correlation is impossible. The increased Quercus values (with low

Calluna and Pteridium), that follow increased Pinus are considered to represent the same subzones as those of LDPBII. The curve for Gramineae follows a different form here, but the most distinctive features are those within subzone 3a.

Subzone 3a (LDPBI)

The sequence begins with higher Alnus percentages than precede the Quercus subzone at LDPBII (i.e. 36 and 34, as opposed to 21 and 27% AP), but then Alnus undergoes a very sharp fall to 1% over 2cm. The response of Coryloid and Calluna is exaggerated by the relative calculation, but their concentrations show a less significant fall compared to that of Alnus as it reaches its minimum. Initially Calluna appears to replace some Gramineae before Alnus falls. That Alnus recovers so rapidly makes it impossible that its decline was due to soil deterioration, which would have produced a sustained retrogressive succession. It therefore appears that alder and its undercover of ferns were disturbed along with some oak, and pine perhaps. A continued expansion of heath ensued, perhaps encouraged by burning, and hazel (and ivy) may have increased flowering at the edge of a more open area.

When alder regenerates it does so at the expense of heath, whilst the proportion of hazel in the pollen rain is effectively unchanged. A situation whereby fire has damaged alder growing at the edge of the heath may be envisaged; this may have been accidental in that its supression was not long continued and a result of firing woodland routinely to maintain a more open field layer. The peak of charcoal: pollen at the minimum of alder is enhanced by the drop in land pollen, nevertheless an absolute increase in charcoal is recorded. The increase of Deteriorated grains could be a result of local burning (cf. the 'crinkled' pollen noted by Smith and Cloutman 1988, 170). The rapid response of alder compared to other

trees may have been because of sprouting from burnt stumps (cf. McVean 1956b, 322).

Quercus subzone (LDPBI)

Arguing in the same way as for the sequence of the same subzone at LDPBII, without grazing or local burning, other areas of heath were invaded by birch and then oak, with alder continuing to expand at the transition to the Quercus subzone. When heather is largely eclipsed, grasses, perhaps with Melampyrum, dominate the open vegetation of the peat (or mor). The shapes of the curves for Quercus during the subzone at LDPBI and II are clearly different and larger values are attained at the latter; this may be due to a difference in the cover of oak at the two sites, or a result of the sampling interval.

Alnus subzone in F1 II (LDPBI)

It is assumed that some disturbance must have occurred to cause the demise of oak, as it was for its decline at LDPBII. This may well have been associated with fire damage since the charcoal curve is rising at the lower boundary of the subzone and charcoal fragments were found in the peat whilst describing the sediment. New areas of heath were again created and from the concentrations of Alnus pollen, alder either found new niches to expand into, or, more likely, its pollen was better transported from untouched stands around the edge of the peninsula and loch, with the trunk space of oak now reduced.

Generally, the tree cover becomes less during the remainder of the period under discussion and although birch and alder have times of expansion, oak follows a steady decline. Bracken was abundant and may have responded to disturbance of alder and hazel canopies. There is no rise of Cyperaceae such as as was noted at LDPBII. The reduced total pollen concentration indicates a more rapid rate of peat growth, but its

surface must have predominantly supported grasses and heather.

LDPBI-4 and LDPBII-4 c.5050 - 3600 b.p./3100 - 1650 b.c.

A decline in Ulmus is clearly seen at both sites. The declines are presumed to correspond to the classical Decline of c.5000 b.p., dated at LDPBII to 5050 b.p. Subsequent correlations are subject to the same caveat discussed above, due to the discrepancy of detail between them. Using the concentration of total pollen as a measure of deposition rate, it was during the second part of the zone that peat was accumulating more quickly than the first. Unfortunately, there are only radiocarbon dates for near the beginning and end of the zone. At LDPBII the Decline from the maximum to the minimum Ulmus percentages lasted some 160 years on the interpolated rate, but it is likely to have been greater given the lower concentrations of total pollen in the latter part of the interval of interpolation. At each site Plantago lanceolata is first recorded a short while after the initial Decline. There is little to note with respect to the representation of other herb types. Rumex, acetosa/acetosella type is recorded at LDPBII and somewhat earlier at LDPBI. The recovery of Ulmus is briefly interrupted at LDPBII when there is a further record of Plantago lanceolata; this interruption was not detected at LDPBI, although a brief 'secondary decline' is discernible. As after the first decline, Ulmus does not regain its maximum values of zone 3 in the second part of zone 4, but there is no indication that ground was being utilised for arable or pastoral agriculture in the sense of open plots, yielding a more diverse flora. Even the taxa associated with open canopy woodland, as inferred for earlier in the sequence, e.g. Calluna, Gramineae, and Pteridium, no longer exhibit marked peaks; the drop in Calluna at each site at the end of the zone is accompanied by a rise of Coryloid. After a reduction in charcoal: pollen at the Decline at both sites, followed by an increase, in

the main the charcoal curve has relatively low values in the zone. There is some evidence of a rise at the end.

In the first part of the zone, conversely, at the fifth of the Gramineae peaks identified during the Alnus subzone at LDPBII, some disturbance of hazel woodland seems likely when the Coryloid curve is at a minimum and there is a concomitant peak in Pteridium. A similar assemblage is observed at LDPBI. However, the fourth peak at LDPBII is after a large expansion of Pteridium. It is the culmination of an increase over two previous levels and not readily correlated with any other curve. The reduction in Calluna may have been the result of some invasion of heath by birch. The large peak of Pteridium is equally difficult to equate with any clear reduction of tree or shrub canopy and may relate to a change in the field layer under a comparatively open canopy. The values of Coryloid are low at this point. Wherever its source, much charcoal is recorded here and at the previous level.

The principal features showing possible impact on the vegetation history during the Mesolithic and Neolithic (before c.3600 b.p.)

There is evidence for Mesolithic disturbance of the early-Flandrian birchwood established on the peninsula before the rise of hazel pollen when there was more herb pollen represented (mainly from heath) than at any time before late Bronze Age times (LDPBII-7). It is unlikely that this was due to the burning of woodland as the proportion of microscopic charcoal was small. Some increase in this record occurs at the hazel rise, which may in a regional context have contributed to open areas into which hazel could have migrated. A more marked rise of charcoal is observable at the first disturbance of hazel-dominated woodland.

Subsequently, disturbance of hazel, birch, oak and later possibly alder, has been inferred in zones 2 and 3 when bracken, grass and heath were generally more common. The fairly close parallelism in the summary

curves for LDPBI and LDPBII for zone 3 gives the impression that the pollen stratigraphies are recording the histories of similar woodland, with regard to the openness of their canopies. The overlap of their extralocal catchments would tend to enforce this (see Fig. 7.1). However, there is the event when alder almost disappears from the record of LDBPI, which has not been detected at LDPBII and is likely to have been very local. Also, there may have been a wetter bog surface at LDPBI at the time of oak-dominated woodland thereafter, which was unsuitable for oak. The most local vegetation was probably mainly of grasses (perhaps chiefly Molinia). The representation of Quercus is less than at LDPBII. Pinus may have colonised areas of local woodland at each site. There is no sign of increased burning causing its decline which corresponds with the expansion of oak; rather the reduction of burning may have taken away its competitive advantage.

The more detailed analyses of LDPBII showed a single grain of Plantago lanceolata at the Alnus rise, possibly hinting at some disturbance in a regional context at this time, (given it can be transported into a clearing from a catchment beyond woodland [Andrews 1986]), further records occurred when the elm canopy may have been affected before the classical Elm Decline. There is an apparent reduction in burning across the Decline at each site, but this may not be related to the catchment of the Ulmus pollen. The amount of Pteridium is not as great as the highest values of pre-Elm Decline times, but is still present in significant quantities and may represent Neolithic activity (see Chapter 9). Both sites then show a discontinuity in its representation, followed by an expansion at a time of woodland disturbance. In the second part of zone 4 disturbance is not inferred again and there is some tentative evidence from less detailed analyses for a reduction in the frequency of burnings (if the charcoal curve is representative of a number of potential source areas of firing).

No clear indications of a change in land use are therefore shown across the Elm Decline, but decreased activity seems to characterise the second part of post-Elm Decline stratigraphy and in particular hazel is again above 30% TLP. At the nearby site of LDP84 where a flint flake was found the woodland was apparently more dense with AP+S more than 70% and Calluna below 5% TLP, for all of the zone at the time of the Elm Decline and after (i.e. from 5190 b.p.) LDP-2. Oak was more abundant, but hazel considerably less so than at the sites to the west on the peninsula.

About a kilometre away on a lower slope of White Hill, the sequence of LDRI shows an even higher proportion of AP+S at around the Elm Decline (5340±60 b.p.) and it remains at more than 70% (with Calluna less than 2% TLP), until soon after the horizon dated to 2600±50 b.p. In this case it is alder that is more abundant than at LDPBI and II at the Decline and for a time thereafter (to the equivalent of the end of zone 7 at LDPBII, which is approximately 2600 b.p.). Birch is more poorly represented at the hill site until its expansion at c.2600 b.p. (see Sect. 5.4.8); when some disturbance approximately coincides with the earliest Iron Age in the region of south-west Scotland. Before this time there is only the slightest suggestion of any woodland disturbance (Sect. 5.4.8), which may not have been local to the hillside site. As might be expected some variation characterised the woodland canopy of the catchments investigated at Elm Decline times and although the evidence for comparison is small, the degree of disturbance seems to have been greatest as recorded on the peninsula at this horizon.

LDPBII-5 to 12 from 3600 b.p.

Unless ombrogenous bog has begun to develop it is likely that by this time the topogenous peat is at its maximum lateral extent, being bounded by the ridges to the north and south and the sub-surface topography, although a

spread to the northwest may now have begun. The basin may be considered to be of the order of 40 x 80m at the time of the Elm Decline (Fig. 7.2), but the distance of LDPBII from the north edge is probably within 20m. Some peat (or mor) may have begun forming prior to the Elm Decline at LDPBIII, but this may have been under birch-dominated woodland (Sect. 7.3.4). At LDPBIV the basal sample has 58% AP+S and with a high value of Calluna was probably locally heath. In the absence of Plantago lanceolata, but low Alnus, a tentative dating to the equivalent of LDPBII-4 was made and so it may have been that heath was prevalent on the extreme north-western tip of the peninsula at this time, similarly at LDPBI and II such communities were characteristic by the end of that zone. It is unfortunately not possible to infer when the canopy at LDPBII opened out with the spread of peat. All this is stated by way of background to assessing the pollen catchment of the site of LDPBII from c.3600 b.p. onwards.

The local and extralocal components may have remained high, but from 100m to 250m, when Jacobson and Bradshaw's (1981) model suggests a roughly equal contribution of extralocal and regional pollen, the shape of the peninsula and the length of its projection into the loch make for a bias in the regional component, the area of water being 'void' as a pollen source (see Fig. 7.1).

A general discussion of the vegetational history from LDPBII-5 may be divided into two parts: from zones 5 to 9, when some dating control is provided by the radiocarbon determinations and AP is usually above 20% TLP; and zones 10 to 12, when there are no dates and AP is usually below 20% TLP. That an increase of open canopy habitats has occurred for the whole of the period from LDPBII-5 may be supported by the observation that from zones 1 to 4, 9 out of 55 levels (16%) have more than 7 herb types, whereas from zones 5 to 12, 25 out of 33 levels (76%) have more than 7.

Firstly, when Coryloid falls at the start of zone 5 (c.3600 b.p. - 3250 b.p.), Plantago lanceolata becomes a continuous record and AP+S (TLP) goes below 50% and trees (including Corylus) are less than 95% selected dry-land pollen (Diag. 7.5.1; cf. Diag. 7.5.2). Some local clearance may be implied since Calluna expands. A resumption of burning nearer to the site than was the case during the period of lower values of charcoal in the mid- to late part of zone 4, may have been instrumental in this, and there is a response from Pteridium. The values for Pteridium are less than those in previous zones and it may be that the record of the spores is from a wider catchment. Zone 6 (c.3250 - 2800 b.p.) sees the first phase of significantly higher Plantago lanceolata values with Pteridium and Gramineae. Of the dry-land trees, hazel is again reduced and ash becomes more important. Cereal-type grains are first recorded and may represent early attempts at cereal cultivaton, the second incidence occurs at a time of a lowered percentage AP+S, but dry-land trees are well represented (Diag. 7.5.1). After some recovery the pattern is repeated in zone 7 (c.2800 - 2500 b.p.), when elm also may have been cleared; the charcoal curve is reduced compared to the first part of zone 6 (c.3250 -2800 b.p.). In cultural terms these changes broadly correspond to Bronze Age activity. The earliest cereal-type grain found at LDRI below White Hill occurred at c.2600 b.p., slightly later than those of zone 6 at LDPBII, on the basis of the interpolated timescale and may be associated with Iron Age activity. Only loose stratigraphical and cultural correlations are possible. The resolution of the sampling interval is c.60 or c.120 years, so that the detail of Turner's (1965, 1970) diagrams for lowland Ayrshire covering the period is not reproduced here. Zone 8 (c.2500 - 1950 b.p.) and much of 9 (from 1950 b.p.) repeat the pattern during Iron Age and later times. Regeneration, as indicated by the percentage of dry-land trees, appears to have been at least as complete between clearance phases as during zones

5,6 and 7. Some cereal cultivation may have been practised in zone 9.

The decline of AP and shrubs that characterises most of the remaining three zones begins in the last part of zone 9. It follows a time when the total pollen concentration had become so low that it was not reasonably possible to count the level at 110cm when an order of magnitude of the content was found to be 6 x 10^2 grains/cm^3. The slide had an abundance of the rhizopod Hyalosphenia subflava, indicative of a disturbed bog surface (van Geel 1978). Whether this was due to an abrupt hydrological change consequent on tree removal (e.g. hazel and birch) shown at the previous level when pollen concentration is falling, or to some other change of drainage or cause it is impossible to say. There can have been few trees on the peninsula at the start of zone 10 when in addition to indicators of increased grazing in the region, the rises of Cyperaceae, Sphagnum, Amphitrema and Assulina show increasing wetness at the site (see also the sediment stratigraphy, e.g. Diag. 7.3.3, where less-humified peat is shown between from 88 to 13cm). Alder has probably been unable to regenerate from the end of zone 10 and is absent from the surface-sample spectrum. Regional reafforestaton is witnessed by the increase in pine (now growing on the islands in the loch) and reappearance of beech. The number of herb types is especially high in zone 11 when grazing pressure in the catchment was presumably greatest and AP at a minimum. The decline of trees and spread of heath communities is represented at the site of LDP84 (zones LDP-4) and at LDRI (zones LDR 1-3) making the inference of widespread deforestation in the basin more certain.

7.5.1 Summary of the possible impact on the Flandrian vegetation by Loch Dee

The assessment of the scale of possible human impact on the vegetation by Loch Dee is hampered by the difficulty of estimating the source area of the pollen, such as has been plain during the discussions above. 'We are

still confronted by the problem cited by Oldfield (1970), namely that we cannot distinguish between a few individuals near the pollen site and many individuals at a greater distance' (Jacobson and Bradshaw 1981, 82f.). Even using a dry-land sum such as Birks's (1972) summary diagram, from the point of view of clearance effects it is possible for the results of local clearance to be overestimated with respect to a regional picture, for the potential clearance away from the site to be masked by the dry-land types near to the site, particularly if a small-diameter basin is providing the sedimentary sequence. Discrepancies will also occur if there is variation between dry-land tree populations near to, or far away from, the site.

As previously (for Loch Doon), the dry-land sum including Coryloid has been used (Diag. 7.5.1) since hazel was probably an important constituent of the dry-land woodland. Near the top of the sequence grains resembling Myrica were noted (cf. Edwards 1981). The supposition that the pollen rain had a greater regional component from zone 5 was made on the decline of AP+S of TLP. If so, hazel was still the predominant dry-land tree and whilst oak remains approximately constant in its range in Fl III, ash becomes better represented during this time.

Concerning the reconstruction of possible changes in 'fire regime', it may be said that there is a rise in microscopic charcoal just before the Corylus rise, the values have increased by the Alnus rise and may reach higher values again on either side of the Elm Decline after lower ratios when oak was locally present. After a short time following the lowest value of the Decline, there are minima in the record of Neolithic times and then an increase preceding the evidence of renewed disturbance in the (early) Bronze Age. Considerably higher values than in Fl II may occur from now on, although minima coincide with a high percentage of dry-land tree pollen at the end of zone 7 and beginning of 9. Because of the conclusions of Clark (1988) cited in Section 2 (2.3.1 and 2.3.3), no definite

correlations are made between peaks of charcoal, individual burns and vegetational change; some correspondence may relate to levels of activity in the regional catchment.

The dry-land summary excluding Coryloid (Diag.7.5.2), the most closely analogous to Birks's (1972) diagram, may be contrasted with the latter in its high dry-land herb representation in Fl II. It is made more noticeable than on the diagram including Coryloid in the sum, but in both diagrams the magnitude of change is as great during the Mesolithic as for most of the subsequent prehistoric record. Clearly at least local disturbance of the vegetation has occurred in Mesolithic times by any conventional measure (cf. Turner 1964b), but because of the supposed change of catchment through time it is impossible to compare 'like with like' in terms of pre- or post-Elm Decline activity. Pre-Corylus rise disturbance was also suggested. From the Corylus rise it may be warrantable to distinguish periods of fire disturbance in the Mesolithic that continued into Fl III, followed by a time of reduced activity (later zone 4) in the Neolithic. Further activity may be marked by increased evidence of fire, eventually with sporadic cereal cultivation in the Bronze Age. Not until within the last two millennia did the woodland begin to be irrevocably destroyed and cereals assumed a greater importance. In recent times only grazing may have been practised. The statistical base for inferences in the representation of cereals is, however, quite small.

7.5.2 Early to mid-Flandrian vegetational history by Loch Dee in a regional setting

There are three sites within a radius of 3km of LDPBII (Fig. 7.3). The Nick of Curleywee is at the highest elevation (410m, according to the map reference in Moar (1969), where c.1500m (457m) is given and the description of the drainage (p.447) is apparently at variance with the O.S. 1:10000 map [1978]). At this site there are marked contrasts with the

record from the peninsula, but some similarities. It was assumed by Moar (1969) that the earliest herbaceous vegetation was never completely replaced and thus whilst the rise of Corylus in terms of AP is to c.80%, it only represents c.20% TLP. At the peninsula the rise is to over 50% TLP. Subsequently Corylus is always less than 40% before the Alnus rise, and can be as little as 10% (Moar 1969). There are large swings in its representation during this time when birch is by far the most recorded tree type. The presence of Pteridium is detected from just after the Corylus rise, and Plantago lanceolata is present during the chronozone F1 II, but is first registered before the Corylus rise. Whether in the light of inferences made at the peninsula these alterations in tree and 'shrub' percentages were due to burning nearer to the treeline is especially difficult to say since there is no record for charcoal at the Nick of Curleywee, and the a priori possibility of a more open aspect to the vegetation at altitude makes the occurrence of light-demanding herbs more likely. The basin edge may have been at least 120 - 150m from the site during F1 II and the basin subject to considerable inwash. The early and continuous record (from Godwin zone IV) of Alnus before F1 II has already been remarked on (Sect. 3.7.1). No such record occurs at the peninsula and the record at the Nick of Curleywee may be from a wider catchment than can be easily detected from a smaller basin, or from a population of Alnus above its present altitudinal limit (305m) (McVean 1955b; cf. McVean 1956a, 332; 1964, 161). There is a peak of Pinus (about 30% AP from about 15%) as Alnus rises, but because of the short interval of F1 II and the few samples within it, the behaviour of Pinus cannot be equated with that at the peninsula. It is as Ulmus declines (from maximum values of around 10% AP) that Plantago lanceolata reappears, which compares with the representation at LDPBII, but, in contrast, the curve is then uninterrupted.

The second site, the Round Loch of Glenhead, is at 300m, although it

may receive water that is shed from as high as Craiglee (531m) to the east. Its hydrological catchment is drawn on Fig. 7.3. The summary diagrams (Jones et al. 1986; Jones et al. 1989, the sum here is TLP) show Alnus well before the rise dated at 7250±70 b.p (from c.8600 b.p., Jones et al. 1989). The peak of Pinus (about 25% TLP) is just after this date and Pinus remains above 10% for some time in Fl II. Ulmus is less than 10% before its Decline. The curve of 'peatland' indicators rises before c.5200 b.p. to high values by c.4000 b.p. There is support for the existence of local Pinus corresponding to the peak during Fl II at the peninsula, and some also for the development of local heath during Fl I and II. Pteridium first appears before c.8600 b.p. and Plantago lanceolata is recorded at one level certainly before Fl III (c.6000 b.p.). The diagram from the Nick of Curleywee recorded low heather percentages (TLP) until Fl II, when there is a rise, but the main expansion starts at the Elm Decline.

The third site, Snibe Bog (250m, Birks 1972) is probably recording a regional tree pollen rain. It also has Pinus in significant quantities (above 20% AP) persisting beyond the Alnus rise, the values of Ulmus in Fl II are never above about 20% AP and is in keeping with the conclusion that the representation at the peninsula is perhaps typical of woodland on better soils in such a catchment. There is no expansion of oak in Fl II of the magnitude observed at LDPBII; Calluna was never as low at Snibe Bog as as it was on the peninsula in the Quercus subzone at LDPBII. Heather was considered a local plant at Snibe Bog taking comparable higher values to those of LDPBII in Fl II. Generally, Coryloid is higher at Snibe Bog, both in Fl II and III, where it is often close to or above 50% AP+Coryloid, a level crossed only when periods of regeneration of hazel are inferred at LDPBII and at its initial rise.

CHAPTER 8

INVESTIGATIONS AT PALNURE

8.1 Introduction

The distribution of Mesolithic finds (Fig. 3.10) shows sites on the eastern and western sides of Wigtown Bay, which seen in the context of south-west Scotland is part of an extensive coastal distribution. As illustrated by Jardine and Morrison (1976, 188) the typical position of such finds is above the raised beach of the main Holocene transgression, suggesting occupation at least from the period of highest sea level. In order to investigate coastal deposits suitable for pollen analysis and contemporaneous with Mesolithic occupation, it is necessary to find sites where the configuration of Holocene or earlier sediments have prevented incursion for a period before c.5000 b.p. or where regression has begun before this date. According to Jardine (1975a,b) the site of Palnure, near the head of Wigtown Bay, provided a local instance of the latter; an example of the former may be the blocking of the Lochar Gulf (cf. Jardine 1975a, 183), though the possibility is questioned by Haggart (1988, 137f.). A further situation may exist such as at Racks Moss, where organic sediments were accumulating prior to the maximum extent of the sea, but with marine transgression these sediments were interrupted by the deposition of 'carse clays' (Nichols 1967).

It was considered that the site of Palnure would offer a continuous sequence from c.6500 b.p. (Jardine 1975a, 185), which was likely close to the 'woodland edge' from this time. Although no lithics had been found close to the site, its position in the wider coastal distribution of such finds and the inference of Robinson (1983b, 5) for firing of vegetation around a basin filling with reedswamp at Machrie Moor during the Mesolithic might also be the case at the coastal, though mainly freshwater,

marsh at Palnure. Even if such burning had not taken place locally the charcoal record would give comparative data to those of the inland sites.

8.2 Area of study

The settlement of Palnure lies at between 5 and 10m A.O.D. just to the west of the Palnure Burn, which flows into the River Cree below Newton Stewart (Figs. 8.1 and 8.2; the outline of Fig. 8.1 is the southern frame within Fig. 3.10). Palnure is underlain by marine alluvium (carse clay) of the earlier embayment of the sea, whereas Newton Stewart near the northwestern extremity of this bay is situated on glacial deposits overlying Silurian greywackes and shales (I.G.S. Scotland Sheet 4 [S & D] 1:63 360, 1964). The high ground above Palnure, which rises to 176m at Larg Hill, is founded on Silurian rock. On alluvium to the south, the Moss of Cree and Muirfad Flow are the most northerly of four areas of peat. Jardine (1975a) has summarised the findings that have allowed a preliminary reconstruction of Holocene events at the head of Wigtown Bay. Radiocarbon determinations from the base of carse clays at Bargaly (7960±350 b.p., Birm-188) and Little Park (7450±200 b.p., Birm-219) in the valley of Palnure Burn (Fig. 8.1), which were deposited after the thicker sediments of the bay at similar altitudes, indicate marine transgression into Wigtown Bay before c.7900 b.p. with the arm of the Palnure Burn infilled some time after this date. A local interruption probably occurred somewhat after 7450 b.p. at Little Park (the date is from likely transported woody detritus). The Palnure borehole was sunk through 4.73m of peat overlying estuarine clays, the top of which lay at 6.38m A.O.D. A 5cm-thick sample comprising peat and wood from the base of the core was extracted and these constituents dated separately to give ages of 6540±120 b.p. (Birm-415) and 6240±240 b.p. (Birm-189) respectively. The mean of these (6480±107 b.p.) shows the peat formation to have commenced

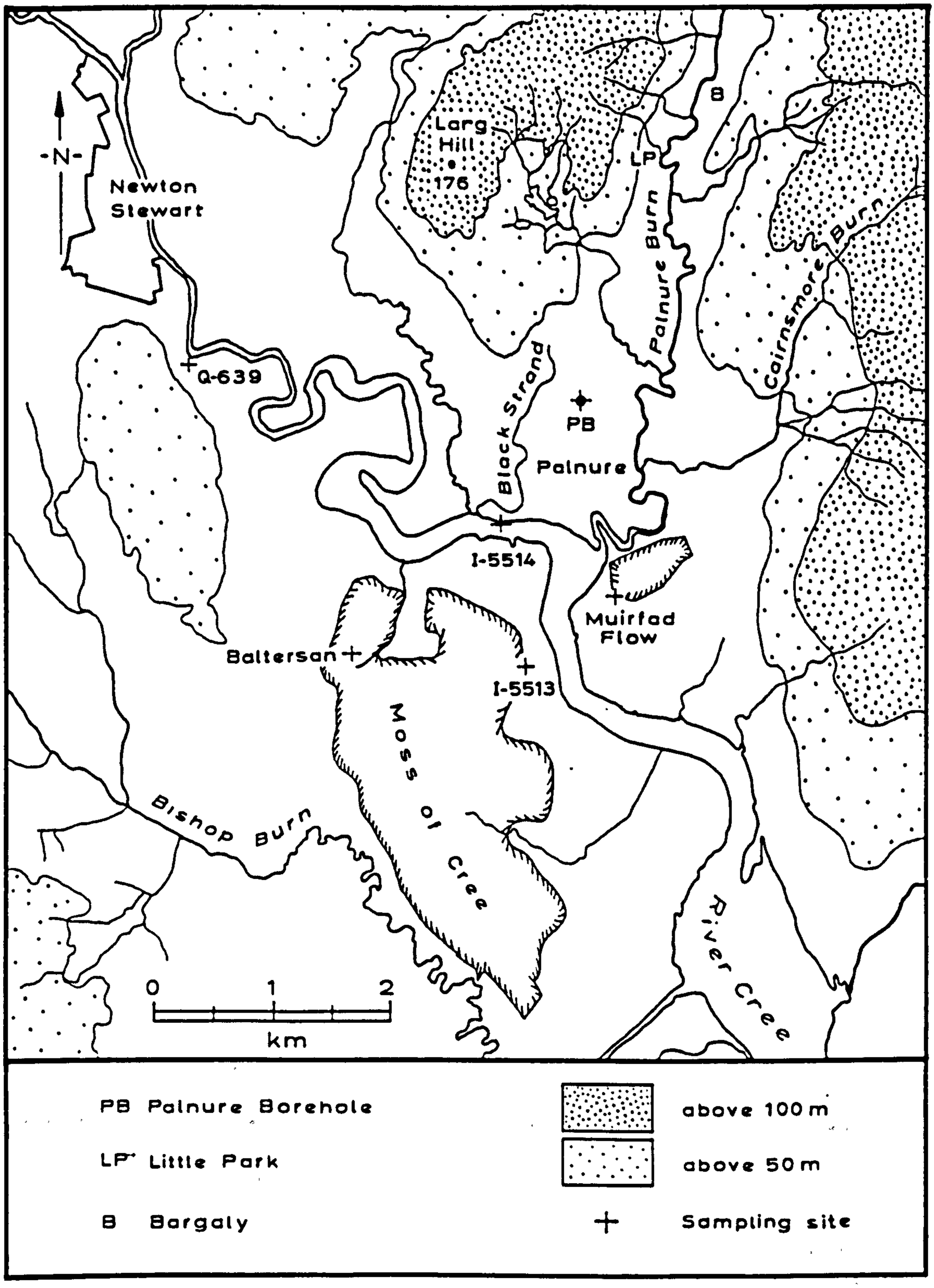


Fig. 8.1. Map of the study area including Palnure.

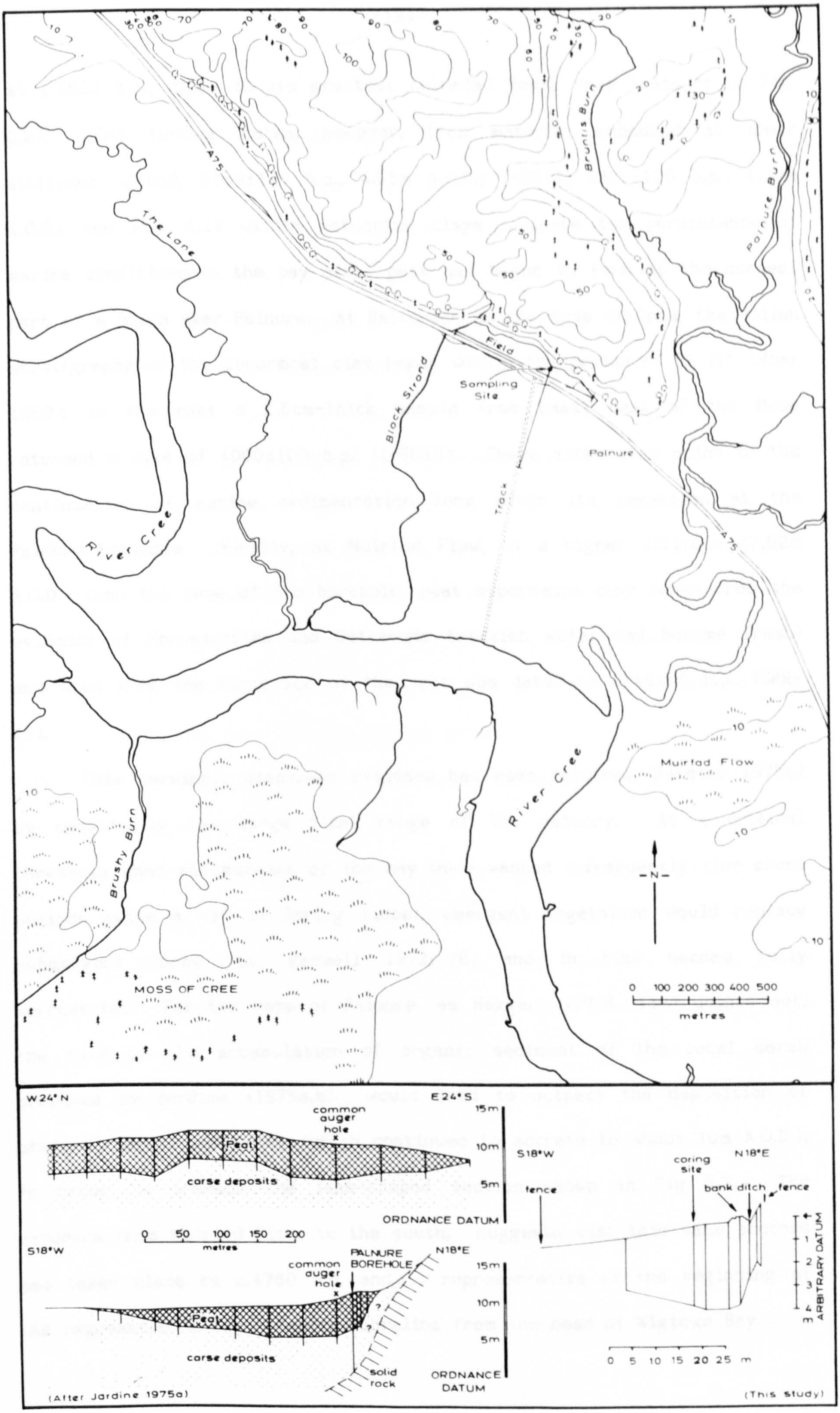


Fig. 8.2. Map of the River Cree estuary showing the location of the Palnure coring site and transects (after Jardine 1975a). The transect profiles are also shown.

at c.6500 b.p., close to its greatest recorded depth (see transect on Fig. 8.2). Two further dates, however, from material embedded at lower altitudes (Q-639, 6159±120 b.p., 4.25m A.O.D.; I-5514, 6325±120 b.p., 4.30m A.O.D.; see Fig. 8.1) within estuarine clays indicate the persistence of marine conditions in the bay after peat had begun to form at the deepest part of a basin near Palnure. At Baltersan on the Moss of Cree, the pollen stratigraphy of the uppermost clay began within the period of Fl III (Moar 1969); to the east a 2.5cm-thick sample from basal peat of the Moss returned a date of 4000±100 b.p. (I-5513). These dates also point to the continuation of marine sedimentation long after its cessation at the Palnure borehole. Finally, at Muirfad Flow, at a higher altitude (7.92m A.O.D.) than the base of the borehole, peat superseded clay (when from the evidence of Foraminifera and Ostracoda brackish water had become fresh) and wood from the first 5cm of the peat was dated to 4746±50 b.p. (SRR-26).

This seemingly disparate evidence has been resolved (Jardine 1975b) by considering the large tidal range of the estuary. At a critical threshold when the margins of the bay were washed infrequently (for short periods twice a day at Spring tides), emergent vegetation would replace submergent forms (cf. Ranwell 1972, 76) and in time become fully terrestrial. For the case of Palnure, as Haggart (1988, 138) points out, the rate of the accumulation of organic sediment of the local marsh proposed by Jardine (1975a,b) would need to outpace the deposition of other estuarine sediments (which continued to accrete to about 10m A.O.D.), in order to produce the lens-shaped section shown in Fig. 8.2. The evidence from Muirfad Flow, to the south, suggests that this same process had taken place by c.4750 b.p. and is representative of the beginning of the regression of the Holocene shoreline from the head of Wigtown Bay.

8.3 Palnure (NGR; NX 45006367)

8.3.1 Site and sediment stratigraphy

Using a field sketch from the time of the original coring at Palnure (Jardine 1975a and pers. comm.) the site of the borehole was relocated to within 10m. A transect across the peat recording depths to the underlying clay was made from the northeastern edge of the small field approximately bounded by the break of slope close to the 20m contour, to its opposite side along the A75 road. It was orientated to coincide with the much longer transect of the published survey that extended beyond the road to the edge of a track (see Fig. 8.2). The junction of recent deposits and bedrock occurs between the 10 and 20m contours, running around the edge of the field and approximately along the course of the main road to the northwest, and to the southeast before turning north to flank the Palnure Burn and create a spur at this point. Mineral soil complexes of the Ettrick Association have formed on the ground above this junction (Bown 1973) and the hillsides support deciduous and coniferous woodland. The field is of grazed grassland.

At 15m from the northern fence a core was collected (February 1984) with a small-diameter Russian corer after excavating a small hole to a depth of 25cm, as the surface peat was dry and the turf of the grass sward was difficult to penetrate, although at a later date (April 1987) the ground was trampled and puddled and grazed rushes were noted. It proved possible to core the clay beneath the peat and 24cm of this was retrieved. A single transect was later levelled from the site to the nearest bench mark that could be found, at Muirfad farm some 1200m away. On the basis of the original depth of peat recorded when coring a height of 6.81m A.O.D. was obtained for the top of the underlying clay, some 40cm above that of the original survey (Jardine 1975a), but perhaps acceptable as of the same order of magnitude. The peat on the far side of the road has been much

cut and drained.

Sediment stratigraphy

Depth (cm)	Sediment description		
0.0- 25.0	not sampled		
25.0-351.0	Nig4 strf0 elas0 sicc3; Sh4 Dl+ Th+		
		37.0- 38.0	Wood frag.
		93.0- 94.0	Wood frag.
		103.0-104.0	Wood frag.
		157.0-161.0	Wood frag.
		250.0-255.0	Wood frag.
		258.0-261.0	Th(Phrag.)
		286.0-287.0	Wood frag.
		288.0	Th(cf. Phrag.)
		310.0-310.5	Clay (As4) pocket
		312.2-313.7	Clay
			Th (cf. Phrag.)
		321.0-322.0	Clay
		324.0	Th (cf. Phrag.)
351.0-375.0	Nig1 strf0 elas0 sicc3; As4 Th+; lim1		Grey clay (inc. ?Phrag.)

Above the grey clay at the base of the sequence the amorphous peat contains woody detritus, the larger pieces observed are noted above. Pockets of grey clay occurred above the main junction between estuarine clay and peat and as well as recording their visible presence, loss-on-ignition values at the levels sampled for pollen analysis helps to clarify where re-working of the peat may have occurred. The results are plotted alongside the pollen diagrams (Diags. 8.3.1-3).

In addition, the sediment stratigraphy of a metre of the basal deposits from the adjacent point on the transect and its neighbour, at 12.5 and 7.0m from the northern fence respectively was recorded in the field as follows:

At 12.5m: 3.25-3.45m Brown woody peat

3.45-3.76m Mid-brown/grey woody peat
including : 3.45-3.47m band of clay
3.67-3.68m charcoal
3.75-3.76m charcoal

3.76-4.25m Grey ('banded') clay with cf. Phragmites

4.25-4.75m Grey ('banded') clay

At 7.5m: 3.25-3.79m Brown woody peat including occasional bands of clay from 3.50m

3.79-4.25m Grey/brown ('banded') clay with cf. Phragmites remains

8.3.2 Radiocarbon dating

Three radiocarbon dates were determined (Table 8.3). The earliest was to indicate the age of the first significant organic deposition at the site and was taken from just above the clay. A second sample (302-310cm) was to provide a date from which to interpolate the deposition rate of the peat formation between it and the third date, since some disturbance of the earliest peat was likely on the evidence of the pockets of clay encountered in the stratigraphy. The sample from 302-310cm was above such disturbance.

Table 8.3. Radiocarbon dates from Palnure.

Depth (cm)	Years b.p. (error at one s.d.)	Lab. No.	Interpolated deposition time (yr/cm)
242-250	5820±80	GrN-14657	6.8
302-310	6230±90	GrN-14658	
342-350	6300±130	GrN-14659	

8.3.3 Pollen zonation

Pal-1 (350cm-314cm; c.6300 - before c.6200 b.p./4350 b.c. - 4250 b.c.) F1 II

The zone is characterised by comparatively low values of AP (average 49% TLP) of which Pinus may have higher percentages (maximum 12% AP) than in subsequent zones. Gramineae is at greater values than at any time later in the profile. Of the other herb types, Vicia type and Mentha type are exclusive to the zone; Tubuliflorae and Chenopodiaceae are consistently present, the former with Caryophyllaceae achieve maximum values; as does Hydrocotyle. Pteridium occurs at each level after the first.

Pal-2 (314-152cm; before c.6200 - c.5200 b.p./4250 - 3250 b.c.) F1 II

The lower contact of the zone is the pronounced rise in Alnus and increase

in AP compared to TLP; Quercus, Coryloid and Gramineae decline at the contact. The Cyperaceae-Filicales subzone defines the assemblages having higher values of these types, which decrease at its upper boundary at 250cm. After this level the Betula subzone signifies a rise of this taxon to its maximum (63%). AP + shrub pollen is at its highest value before the last zone. This subzone is succeeded by one in which Gramineae and often Pteridium are above the percentages of the previous LPAS. The upper contact of the zone is placed at the decline in Ulmus.

Pal-3 (152-38cm; after c.5200 b.p./3250 b.c.) Fl III

The first level of the zone coincides with the beginning of an increased occurrence of Plantago lanceolata. The Gramineae-Pteridium LPAS continues until 114cm, above which the values of these defining types are generally reduced.

Pal-4 (Level 30cm; undated) Fl III

This zone is dominated by Alnus (89% TLP; 94% AP). Herb pollen is 4%, having fallen from 42%.

8.4 Inferred vegetational history

Introduction

The transect (from Jardine 1975a, shown in Fig. 8.2) illustrates the general shape of the peat deposit that was cored, from approximately north to south. Whilst sampled in the deepest area of the peat, its depth becomes increasing less towards the south coming to a 'feather edge' over 350m away from its northern limit, which is comparatively steep-sided. Accepting Jardine's (1975b) model discussed in Section 8.2, then in the most simple terms, a more rapid growth of peat than the build up of carse deposits would be required in order for the 'feather edge' shape of the basin to develop. Considering the process of basin formation with regard to the local pollen catchment area, the northern basin edge was essentially

constant and the area of peatland habitats between the coring site and the edge would have remained similar. Towards the receding sea there would have been be a progressive initial development of salt-marsh. Overall, a transition to terrestrial habitats would have prevailed.

Pal-1 (c.6300 - before c.6200 b.p./4350 - 4250 b.c.)

Until the site was free from the influence of seawater conditions, it would have been unsuitable for tree growth and its proximity to the break of slope at the foot of the hillside would always have tended to have made it a water-receiving site, even once tidal waters no longer reached it. The present-day field is drained by a ditch at this junction (Fig. 8.2). Pollen analyses have only been undertaken on the predominantly-organic sediment and so the change from a largely salt-marsh vegetation to a mainly non-halophytic one around the site is probably not recorded. The Gramineae values are thought to be representative of Phragmites to a large extent, especially since material resembling Phragmites rhizome fragments was noted in the stratigraphy (the fragment at about 260cm, higher up in the profile, was checked microscopically [Grosse-Brauckmann 1972]). The basal sample in particular, however, may also contain Gramineae pollen from a lower-growing salt-marsh sward. By the time of the second sample of the sequence, the loss-on-ignition curve denotes a much-increased organic component and net mineral deposition either by tidal water or perhaps runoff from the landward hillslope, is now less. The sedimentary conditions are evidently not yet stable since further clay was observed in the stratigraphy and is clearly picked out at the end of the zone by the LOI curve. The radiocarbon dates from sediment at the start of the zone and just after its close are statistically inseparable at one standard deviation and some reworking of mineral (and other) sediment may have occurred (see increased Gramineae and Indeterminable pollen, and reduced

Filicales, which compare with the basal sample), but whether by landward or lateral freshwater drainage, or by exceptional tides is impossible to deduce. Other evidence for later clay deposition above the main clay-peat junction was observed in basal cores from 7.5 and 12.5m on the transect (see Sect. 8.3.1).

During the zone the records of Chenopodiaceae and possibly Artemisia suggest that salt-marsh vegetation remained in the catchment area of the site (halophytic plants belonging to these types are respectively: Suaeda maritima and Artemisia maritima), the beginning of reedswamp and then perhaps fen characterised the most fully-emergent communities below the break of slope. Within these communities tall sedges grew with reeds and ferns (cf. Spence 1964, 336), other herbs being registered by e.g. Filipendula, Rubiaceae (Galium type [Moore and Webb 1978] and perhaps from G. palustre), Tubuliflorae (Bidens type [Moore and Webb 1978], with one exception, at 334cm, being referable to Aster type, perhaps from Senecio aquaticus), Mentha type, Lythrum, Potentilla, and Hydrocotyle, with Typha especially showing swampy ground. Willow, alder and birch may have grown near the hillslope. Of the dry-land trees, oak and hazel (inter alia) may not have formed closed-canopy woodland since Pteridium and Melampyrum are present. The cereal-type grain may well have come from fen vegetation (e.g. Glyceria maxima, cf. Dickson 1988).

The ratio of charcoal: pollen shows an increasing trend towards the end of the zone. No charcoal was noted in the sediment when it was examined in the laboratory but the peat was by that time well oxidised. However, in the field, smears of charcoal were observed in the cores collected from the adjacent point on the transect (12.5m) at the main junction of the clay and peat and also 8cm higher up in the profile, before a band of clay another 20cm higher again. Whilst there is no pollen stratigraphy or radiocarbon dating it seems very possible from their

proximity, similar depth and signs of clay deposition above the principal clay-peat boundary that the earliest sediment of the cores is approximately contemporaneous. No such charcoal was recorded from the base of the profile collected at 7.5m, also including sediment to a similar depth. Clearly a continuous lens of charcoal is not in evidence so that local burning of the herbaceous fen communities may not be inferred, though perhaps burning of the dry-land woodland or any fenwood at the base of the hillslope, or of the understorey of the former may have occurred. The presence of Melampyrum and Pteridium has been commented on.

Pal-2 and Pal-3 (before c.6200 - after c.5200 b.p./4250 - 3250 b.c.)

Cyperaceae-Filicales LPAS

The loss-on-ignition curve shows a decreasing input of mineral at the beginning of the zone. Assuming the date of 6230±90 b.p. to be representative of the stage of autochthonous organic sediment, which seems reasonable, interpolation between this horizon (302-310cm) and that dated to 5820±80 b.p. (242-250cm) gives an average deposition time of c.7 years/cm. The spacing of the samples is generally 8cm and thus fluctuations in the pollen rain are being measured at around 60-year intervals. The approximate dating of the Ulmus Decline at the end of the zone depends on the extrapolation of this rate over a similar depth of sediment, to give the estimate of c.5200 b.p.

At the outset there is an enormous rise of Alnus pollen concentration (x 24), against a background of a much smaller increase (less than x 2) of non-Alnus pollen, to the extent that it forms 86% AP (66% TLP) and it must have dominated fen woodland near the site. The reductions of Gramineae, Filicales and less so Cyperaceae also suggests that woodland encroached close by, to the exclusion of the tall herbaceous

communities. The latter may have been able to occupy newly-emerged flats in the seaward direction and the absence of the supposed halophytic types from salt-marsh also supports the idea of the retreat of the upper tidal limit.

Within the next 120 years or so some adjustment ensues whereby sedges and ferns recover as alder recedes (the concentration of Alnus is markedly reduced at first), but then the input of tree pollen is fairly stable, although birch is briefly slightly more in evidence as inferred by comparison with its earliest values of the zone. The dry-land tree proportions show little fluctuation during the Cyperaceae-Filicales LPAS; there is a brief reappearance of Pteridium. Apart from a conspicuous peak of charcoal, its representation is generally less than in the previous zone.

Betula LPAS

In contrast to the beginning of zone 2 when alder was favoured, albeit that its earliest and greatest success was relatively short-lived (perhaps 60 years), conditions from the start of this LPAS were such that birch was able to expand fairly steadily (in terms of its relative representation). The expansion is superficially obscured on the absolute diagram perhaps due to a brief change in sedimentation rate; the concentrations of Betula and Alnus suggest a spread of birch into or above the herbaceous vegetation, which is shown by the decline of grasses, sedges and ferns, with the possiblity of competition with alder represented only at the last level of the LPAS. Here, however, a 'swamping' effect of local birch may well be the case. The duration of the rise to the greatest birch dominance is of the order of 300 years. Since at the start of the LPAS 'aquatic' indicators (i.e. Hydrocotyle and Potamogeton) are no longer recorded until after its close, it may have been that the fringe of herbaceous fen vegetation became sufficiently dry for birch to become

established, but the evidence is slight.

Gramineae-Pteridium LPAS (in zones 2 and 3)

There is a very significant fall of Betula concentration, but in terms of percentage AP its first value of the LPAS (26.4% AP) is more than for most of the Cyperaceae-Filicales LPAS, and its initial value of the Betula LPAS. On average it remains higher than these values. There is apparently a response from the principal herb types and a failure of birch to regenerate close to the site is indicated, but it is generally better represented than alder before the end of zone 2.

The greater charcoal values presumably denote an increased incidence of burning compared to earlier in the zone, if they are taken to represent a non-local catchment. Nevertheless, some open canopy of the local dry-land woodland is shown by the percentages of Pteridium which achieve maxima during the LPAS, coinciding with charcoal peaks, but the values of the latter are not generally as high in zone 3 as in the Gramineae-Pteridium LPAS in zone 2. The reduction in charcoal occurs shortly before the upper zone boundary.

Local changes are indicated by the rises in Cyperaceae and Filicales. Since the percentages of Gramineae are largely independent of them a component may be derived from grasses of the woodland floor on the hillslope, the presumed origin of the bracken spores. The maxima of Cyperaceae occur when Betula, and to a lesser degree Alnus, are comparatively low, so the cover of birch-alder woodland fringing the hillslope may have have been variable, with the local watertable an important determining factor. The curve of Hydrocotyle shows it to have been persistently high.

The plot of dry-land types (including Coryloid; Diag. 8.5.1) illustrates the greater oscillations of Betula compared to Alnus. The

decline of Ulmus is marked by the reappearance of Plantago lanceolata. Its previous occurrences could easily have been from plants in unshaded situations around the coast or along watercourses. Here they probably signify the colonisation of new openings in the dry-land woodland.

Remainder of zone 3

The fall of Gramineae and Pteridium is accompanied by a rise in Coryloid which suggests that hazel was able to infill some open woodland. Towards the end of the zone the peat-forming communities dominated by sedges and ferns flourished as the fen woodland receded and oak was thus better represented.

Pal-4 (undated)

The previous trend of a diminished wet woodland is completely reversed when alder expands to occupy the site. The relative values for all other pollen are now negligible, although the concentration of Cyperaceae are much less reduced than Filicales implying that growth of sedges could continue, either beneath the alder and/or beyond it.

8.5 The dry-land woodland and the possibility of Mesolithic impact

The diagrams of selected 'dry-land' taxa are presented so as to allow an assessment of changes in the woodland that was more likely to have been affected by fire. The sums, including Coryloid and of its exclusion, enable comparison with the inland diagrams, the latter with Birks's (1972) diagram of selected types, as previously (Diags. 8.5.1 and 8.5.2). Clearly the effect of dry-land herbs (and shrubs) on the curve of trees may be large compared to the AP and TLP diagrams because of the generally small sum of dry-land trees. On the diagram that includes Coryloid (Diag. 8.5.1) the space between levels where Pteridium rises significantly to make a 'peak' are marked with 'D' and for the most part these are matched with a

decreasing trend in Coryloid rather than Quercus. At the point marked '1' Ulmus is most affected in this way, at point '2' it is Quercus. Another instance of Quercus declining occurs towards the end of the Gramineae-Pteridium LPAS. The diagram excluding Coryloid (8.5.2) is more likely to show conspicuous troughs in the representation of Quercus at times of Pteridium peaks because of the relatively increased amount of Pteridium in the sum.

Concerning the possible impact of fire on the woodland canopy there is some correspondence between the times of higher charcoal and increased dry-land herbs in zones 1 and 2 but it is not a contingent relationship (e.g. at 292cm there is a peak of charcoal, but an absence of dry-land herbs). There is a period of increased burning at the end of zone 2, but the herb curve remains relatively high to the end of the Gramineae-Pteridium LPAS. The possible connection between the high Gramineae values during this subzone and a decreased dry-land canopy was raised previously; compared to the wetland trees the Gramineae curve here does not always follow a reciprocal relationship, suggesting it is not simply a case of these overgrowing grasses or allowing them to thrive; but neither is it the case that the grasses expand when bracken does.

In general terms the amount of burning seems to have been greatest before the Elm Decline, that is to say, taking the arbitrary datum of the charcoal: pollen ratio being 100 (i.e. 10 on the scale), this is crossed more often before the Decline than after and in particular there is a period of c.300 years near the Decline within which this 'baseline' is consistently crossed. The overall range of values is not dissimilar to those recorded at the inland sites on the same basis. An argument for some Mesolithic disturbance, perhaps of hazel, by fire, may apply as for the inland sites, though the pollen record for disturbance is not as pronounced as by Loch Dee; the absence of lithics in the immediate vicinity

may lessen the inference of local disturbance, but they may yet be found. The wider distribution has been referred to (8.1.1).

8.6 Comparison with previous work

Compared to Moar's (1969) diagram from Baltersan, across the estuary, there are some conspicuous differences. The earliest levels (dated to Godwin's VIIb; i.e. during Fl III) have very high values of Alnus (above 80% AP) which are only encountered at the start of zone 2 (Fl II) and as zone 4 (Fl III) at Palnure. These occur before the clay gives way to woody peat at Baltersan, and as at Palnure are clearly a result of local alder. Later in the sequence the shrub curve (almost entirely of Corylus) is much higher than at any time as it is recorded at Palnure and fluctuates from about 50 to 160% AP, indicating the potential importance of Corylus in the dry-land pollen rain. It is not possible to say whether any portion of this period in the diagram is contemporaneous with the sequence corresponding to Fl III at Palnure. Durno's diagram from Moss of Cree (in Bown and Heslop 1979) likewise shows basal high values of Alnus and comparable Coryloid percentages. It may also be noted that there is no Fraxinus, Plantago lanceolata, or Pteridium during the time of the first metre of sedimentation at Baltersan, though for much of this period the site was probably supporting alder and birchwood. However, these taxa were recorded at the eastern side of the estuary when such woodland was certainly at least very close to the site (both in Fl II and Fl III), so their occurrence may be due to its proximity to the main landmass of the coast.

Concerning the validity of Jardine's (1975a,b) model for the explanation of the development of peat at Palnure whilst fully marine conditions continued in the area of Wigtown Bay (Sect. 8.2), additional support may be tenable from the following estimates of the rate of peat

growth at Palnure. Taking the interpolated time of 6.8 years/cm, it has been illustrated that the Elm Decline occurs at c.5200 b.p., which is of an expected order (the date from the lowland site at Scaleby Moss is 4925±134 b.p., Godwin et al. 1957; see Table 3.7) and so the time may well be typical for the deposition overall, provided the Ulmus Decline has been correctly placed. A younger age for the Decline would result in an overall estimate of less than 6.8 years/cm. Using Jardine's (1975a, 189) figures for Y (the difference between high tide and mean sea level at the given locality at the given time) and H (the measured height of the coastal sediments dated), then :

at Palnure, for the superjacent date of 6480±107 b.p.,

H-Y = 6.38-4.2m = 2.18m)
)
at Muirfad (4746±50 b.p.),) a difference of 1.54m
) (= $H_{Pal}-H_{M}$, since here Y was assumed
H-Y = 7.92-4.2m = 3.72m) to be common to both sites in spite
of the difference in time)

This implies that between c.6500 and c.4750 a net depth of 1.54m of marine sediment accumulated at Muirfad at a time of 10.6 yrs/cm (0.094 cm/yr), which as Jardine's model demands, is less rapid than the peat at Palnure (6.8 years/cm; 0.147 cm/yr). If erosion of the Palnure sediment had occurred then clearly the rate was actually faster than this figure.

CHAPTER 9

DISCUSSION AND CONCLUSIONS

9.1 Introduction

The final chapter is divided into two main parts, the first is concerned with a discussion of the findings of research in the context of the aims outlined in Section 2.4, the second is conclusions regarding the suitability of the methods employed, with suggestions for further work.

9.2 Discussion

9.2.1 The possibility of Mesolithic disturbance

By analysing early to mid-Flandrian deposits at Loch Doon and Loch Dee at a resolution of 20 - 160 years, depending on the deposition rates and closeness of sampling, it has been possible to infer vegetational change that suggests anthropogenic disturbance. The sequence from the site at Palnure is temporally more limited (c.6300 - <5000 b.p.), but at a resolution of sampling such that sediment representing c.60 years has accumulated between each analysed level, there is again some evidence for disturbance.

The strengths of the inferences for all the sites from the pollen stratigraphy alone are variable. Perhaps the most convincing are from the sequences at the Loch Dee peninsula, where changes from birchwood, and predominantly alderwood to heath communities have been envisaged as having occurred respectively in the 9th millennium b.p. (LDPBII, cf. Smith and Cloutman's [1988] site B125N) and within Fl II (the base of LDPBI). Later in Fl I and in Fl II, at LDPBII reductions of hazel and oak, again with expansions of heath are also marked. The reduction of hazel late in Fl I immediately precedes the alder rise. From the sites at Loch Doon the demise of hazel some time before the alder rise, with increases of ivy and bracken, can be singled out as the most conspicuous signature that could

suggest Mesolithic disturbance. At both areas of study the index of total numbers of herb types has not proved sufficiently discerning for detecting or necessarily enforcing the inference of a more open canopy within the pre-Elm Decline sequences. The general trend of increasing values as woodland was cleared or opened from the start of Fl III to the present day has been demonstrated.

9.2.2 Fire history during Fl I-II in relation to vegetational change

The early Flandrian sequences from Loch Doon and Loch Dee both start before the major expansion of Coryloid; those of LDIV and LDPBII continue to the present day. For both sequences the charcoal curve has been constructed on the same basis (charcoal x 10/TLP). For the pre-Elm Decline parts of the diagrams the range of values at each location are broadly comparable in that at LDPBII it is from about 1 - 80, rising to 120 at LDPBI; at LDIII it is from <0.5 - >140, although at LDIV the figures are 0 to around 40. For the post-Elm Decline portions, higher values occur at LDPBII than at LDIV, but the former has records of <3, as at LDIV. Since the shape of the curves are partly dependent on the input of pollen to each site the ratio is suppressed if local pollen is highly represented. This has likely happened during early Fl II at the site of Loch Doon IV. From the foregoing discussions (Sects. 2.3.1 and 2.3.3) on the difficulties of interpreting fire history from charcoal stratigraphies of peat deposits in particular, the emphasis placed in interpretation has been as a general indicator of burning over centuries, accepting that neither the numbers and/or positions of fires, nor their purpose be known if considered as a regional record; individual more local fires may be unrecorded due to the sampling interval. The general consistency of results where the sampling interval is closest, which appears to show trends over a number of levels, may allow the curves to be interpreted as exhibiting at least an

pattern. Some 'peaks' may indeed signal local events (e.g. at the base the LDPBI profile). The smoothing that occurs by using the ratio rather than absolute values may be the best way to represent the charcoal record for peat deposits of local catchment. Later enlargement of the catchment by clearance, for instance, causes a discrepancy in the representation compared to that of periods of local woodland.

Concerning the hypothesis that fire may have caused disturbances in the early to mid-Flandrian forests that gave opportunities to incoming trees, or perhaps in the case of pine their destruction, there is to some extent an incompatibility in the nature of the evidence. If the charcoal curves are to be treated firstly as a regional record, the pollen diagrams from the sites by Loch Doon, Loch Dee and at Palnure are mostly representing local pollen. However, there would seem to be a distinction between the earliest records at the first two areas. The Coryloid rise at Loch Dee (409 cm; LDPBII) succeeds some evidence for the disturbance of local birch woodland. It is immediately followed by an increase in the charcoal curve. This rise is dated to c.8700 b.p. By Loch Doon there is no evidence for an increase in charcoal around the rise (395 cm) dated to c.9300 b.p. When Coryloid rapidly expands at Loch Dee (c.8400 b.p.) there is no further increase in charcoal; at Loch Doon the expansion of Coryloid (383 cm) cannot confidently be dated (6.3.2) and is not matched with any rise in charcoal.

The Alnus rise occurs at Loch Dee whilst there is a significant amount of charcoal being recorded; its date is 7450±70 b.p. There is no conspicuous peak of charcoal at its inception, but the values do increase thereafter for a period. The curves of the Alnus rise from the sites within the basin by Loch Doon all have microscopic charcoal in the sediment at this time. There is no particular pattern discernible by inspection of the curves alongside the rises; at LDIII and LDIV there is

clearly charcoal in the stratigraphy before the rise, having increased at some stage after the Corylus rise, though the problems of the radiocarbon dating for the profile at LDIV precludes an adequate estimate as to when the quantities of charcoal became generally greater than in the earliest postglacial. The estimate of c.6600 b.p. for the Alnus rise at Loch Doon is tentative, being extrapolated from the date of 6500±90 b.p., only 3.5 cm higher in the profile, but in a deposit showing some possible variation in deposition rate as inferred from the pollen concentrations. Its earlier appearance at LDIV was noted (see also Appendix 1) and so Alnus may have been more regionally present or occurring as limited growth locally for some considerable time (again it cannot here be estimated) prior to the rise. At both Loch Dee and Loch Doon some signs of possible disturbance (from the pollen evidence) at the rise have been noted; the inference seems best supported at the former site.

It is probably unwise to attribute great significance to these dates for the Corylus rise and Alnus rise to make deductions about the variation in rates of migration of these trees in the Flandrian of south-west Scotland. They are from sites of local catchment and effects due to grazing, clearance or natural regeneration cycles (cf. Smith and Cloutman 1988, 168f.) may well not be characteristic of a more regional landscape history. Birks (1989, in press) gives a critical evaluation of the criteria for choosing the limits of pollen curves for the dating of phytogeographic change in the Flandrian forest and for a local catchment the limit is likely to be more difficult to define because of the potential overrepresentation of local taxa. By comparison with other determinations of the Corylus rise (Table 3.7 and Sect. 3.7), the rise at Loch Dee is late (by perhaps 500 years for mainland sites), but there may be a higher than usual degree of contamination by later humic acids since the deposition rate is so slow (Sect. 7.5, LDPII-2). Smith and Cloutman (1988) found a

discrepancy of c.1300 years between the large expansion of Corylus in the uplands of south Wales at two sites some 320m apart (in the same basin today, though separated by dry land then). The younger of the dates was considered to be perhaps an underestimate of the age. The expansion of Corylus discussed by Smith and Cloutman (1988) compares to that occurring after the rise as defined here. For the Alnus rise, the two Welsh sites had dates that differed by c.1100 years; the younger was c.6600 b.p. for a site close to the edge of the basin; the other was near to the centre. Inspection of the dates in Table 3.7 shows that those from Lochs Dee and Doon are within the range of those for south-west Scotland. The date from the loch core from Loch Doon indicates that Alnus was important before c.7200 b.p. in its very large potential catchment. The apparently very rapid rise of Alnus from the threshold value of 2% AP at LDIV implies that the value of 2% AP+S for the local presence of the tree (Huntley and Birks 1983) is an appropriate one.

There is ample previous evidence for at least local stands of Pinus in the early part of the postglacial in south-west Scotland (see Sect. 3.7), but in this study it was seen to have been of importance only at Loch Dee, although well-represented in the core from Loch Doon itself. Its decline at Loch Dee shows no correlation with increased charcoal values and whilst potentially flammable, the occurrence of fire may be beneficial to its continuance (Sect. 7.5 and cf. Carlisle 1977, 74 and O'Connell et al. 1988).

In common with other sites in south-west Scotland there is little separation beween the registration of Ulmus and Quercus. Quercus is recorded before Ulmus at both Loch Doon and Loch Dee, but their rise to consistently higher values is coincident at Loch Dee and virtually so at the Loch Doon sites. Oak achieved local dominance at Loch Dee, but was never as well established at Loch Doon. There is a sizeable representation of charcoal as Ulmus and Quercus expand at the southern location, but the

charcoal curve had not yet risen by the rational limits of these trees at Loch Doon. The slow immigration of oak in the uplands of the Central Pennines was believed to have been the result of grazing, without management by fire, within hazel woodland (Williams 1985). However, whilst this remains a possibility at Loch Doon, where oak is especially low at LDIV, it probably had to compete with abundant birch as well as hazel locally. Even accepting Williams's argument, which depended on increased herbs being represented (Potentilla is characteristic) and lowered values of Corylus, like features are not significantly in evidence here.

The approximate correlation between the first higher values of charcoal and the earliest records of Pteridium at both localities is of interest (cf. the coincidence of rises in Pteridium and carbonised plant remains at Cooran Lane [Birks 1975]). Some of the fluctuations in the representation of trees at Loch Dee, with which Pteridium is associated, are marked, whereas at Loch Doon Pteridium is much less prominent. The suggestion that the spread of bracken may well be partly due to man's disturbance of early woodland (Rackham 1980, 85; cf. Rymer 1976, 154f.) is borne out.

If the charcoal curves of the sites at each end of the Loch Doon-Loch Dee basin are some measure of regional burning there is probably no support for the notion that natural (or man-made) fire was more prevalent in the drier climate of the Boreal period since by Loch Doon, for much of the profile after the Corylus rise there is little charcoal recorded, though this section is not well dated. The sediment collected from the loch has microscopic charcoal from its base at some time after the Alnus rise, but no inferences can be made as to the timing of increased charcoal in the Boreal or the earliest postglacial in its catchment.

At the Ulmus Decline the behaviour of the charcoal curve differs: showing no decline at Loch Dee and declining before the start of Fl III at

Loch Doon (cf. the Cooran Lane stratigraphy [Birks 1975]). At neither site, at this level of counting, were cereal-type grains recorded until Bronze Age times, except for a single record in the later part of the Neolithic at Loch Doon, which is its first occurrence there and it is not accompanied by other possible indicators of cultivation. The Palnure record has its highest values in Fl II with a reduction shortly before the Elm Decline. On the Isle of Arran, at Machrie Moor, the fall in charcoal at the Decline (Robinson and Dickson 1988, Edwards and McIntosh 1988) was accompanied by the increased incidence of cereal-type pollen (Edwards and McIntosh 1988). The Moss Raploch charcoal profile presented by Edwards (1989) can now almost certainly be placed within Fl III.

9.2.3 Land-use history during Fl III

In concluding the later land-use histories of the catchments around the sites by Lochs Doon and Dee comparison was made with the pre-Elm Decline evidence of disturbance, in terms of the likely dry-land communities. This provided some measure of the degree of open canopy, but the type of land use i.e. for local encampments or increasing browse in the field layer of woodland (or both) could not be resolved. Considering the later evidence for land use, the increased representation of Plantago lanceolata is conspicuous (it was not recorded at all by Loch Doon during Fl I and II), so some difference in kind is suggested. Behre (1981) stresses the complexity of using this as an indicator of human disturbance, but reiterates Iversen's (1973) observation that it will not grow in grazed woodland since there is insufficient light. For most of the early to mid-Flandrian sequence at Loch Dee either the woodland disturbance was not great enough, or the heath communities that must have spread on mor or sandy soils were unsuitable for it (cf. Behre 1981). However, records were made at the Alnus rise and in late Fl II (LDPBII).

The appearance of Plantago lanceolata at the Elm Decline is almost doctrine (exceptions to an immediate registration at sites in south-west Scotland are cited in Sect. 3.8.2) and the pollen stratigraphy at the sites investigated in this study follow the general rule. The death of elms allowed sufficient open ground for the ribwort plantain to colonise from its previously restricted habitats. Unless the openings were maintained by an adequately high level of grazing or other activity, whether managed or not, the areas would revert to woodland. The Regeneration Phase discussed by Göransson (1987) with respect to elm was interpreted not as necessarily due to the abandonment of opened areas, but the effect of coppicing woodland as a crop. Such growth was envisaged as shading out weed species; nevertheless, cereal grains from other cultivated areas might be detected. At Loch Dee, it was elm itself that eventually regenerated, at Loch Doon this is less certain, but nonetheless apparently the case. Ash and hazel became more common (cf. Birks 1986a, 50) and in the absence of a notable and sustained increase of herb types associated with human activity and in particular cereal-type grains, anthropogenic involvement either by taking advantage of naturally cleared (e.g. by disease) areas or creating or enlarging such, need not be invoked. Equally, Smith's (1961, 46) observation on the nature of pollen evidence at the Elm Decline that 'absence of evidence is not a strong argument for absence of human activity' applies and is equivalent to the dictum that cautions similar inferences based on a lack of archaeological evidence. The site at Palnure lies within the lowland distribution of Earlier Neolithic burials (Fig. 3.11a) and regional activity may be represented here. There are also Earlier Neolithic cairns in the upper reaches of the Glenkens, the adjacent valley to the east of the Loch Doon-Loch Dee basin and to the south and west of the basin, in the valley of the River Cree and its tributary, the Water of Minnoch (Fig. 3.11a). Even if human occupation was not directly

responsible for any of the changes, 'secondary woodland' resulted and it was on this that more definite impacts were made.

These impacts on secondary woodland occurred in the Bronze Age as recorded at Loch Dee. Fluctuations in the curves of elm, hazel, grasses, ribwort plantain and bracken in particular show times of increased clearance, with some regeneration in between, until relatively recently. The picture is not as clear at Loch Doon, the curves for ribwort plantain and bracken expand some time before c.3600 b.p., the summary curve not displaying the same sections of increased and reduced dry-land tree percentages. Local birch, though not in the calculation sum, may be affecting the representation of hazel at times, with which it may have grown in some nearby stands. Tinsley (1981) saw the failure of woodland regeneration after Bronze Age clearance at other upland sites in Britain and Ireland as a result of climatic deterioration. Occurrences of cereal-type pollen are few and sporadic before the extensive deforestation witnessed at both sites towards the top of the profiles. This is in keeping with the limited documentary evidence for clearance in the Middle Ages (Sect. 3.8.1); Turner's (1965) criterion (Gramineae about 100% AP; here applied, as by Birks [1972], to refer to the sum of dry-land herbs and dry-land trees less Corylus) for 'extensive clearance' (at c.400 a.d. at Bloak Moss) is first fulfilled in the Bronze Age stratigraphy at Loch Dee, though not until later at Loch Doon. The fairly recent deforestation is evidenced in other diagrams in south-west Scotland, the closest sites being Snibe Bog and Clatteringshaws Loch (Birks 1972, 1975).

From the investigations to date (from north to south: at the Tauchers [Moar 1969, 459], Cooran Lane [Birks 1975], Snibe Bog [Birks 1972], Craigeazle Bog [Ratcliffe and Walker 1958, 427], Clatteringshaws [Birks 1975]), it would appear that many areas of the valley floor between Lochs Doon and Dee and along the course of the Blackwater of Dee to

Clatteringshaws Loch would have been filling with peaty deposits by the start of Fl III. The sequence from Round Loch of Glenhead (Jones et al. 1986 and 1989) also suggests that peat was spreading in the uplands by this time. The factor of peat development and the often steep-sided slopes along the edges of the Loch Doon-Loch Dee basin would make the Glenkens and the valleys reaching the southern part of the study area the most favourable for settlement during this time. The most obvious indications of later prehistoric forest clearance phases in the Loch Dee profile are likely to be a reflection of this. From this study there is some indication of the range of dates for the initiation of peat development i.e. in 'confined' (Hulme 1980) foci it began in the 10th millennium b.p. by Loch Doon and perhaps the earliest 9th millennium by Loch Dee. The spread of blanket peat is indicated by 2900 b.p. at the Starr Cottage sites and in the intervening period Carter's (1986) site LDI has an extrapolated basal date of 5290 b.p. The hillock to the south of LDIV has a well-developed mor under Calluna and the accelerator date from a fragment of oak wood in underlying soil (OxA-1597, 3150±70 b.p.) suggests that this mor began to build up relatively recently. By Loch Dee, the profile of LDRI has a date, from near to the base, of 5340±40 b.p. (fine fraction); the peninsula-sequence LDP84 has a basal date of 5190±80 b.p. At Moss Raploch peat growth probably began after the Elm Decline (Sect. 5.2.4).

The influence of Mesolithic occupation may have been a factor in local peat development at Loch Dee from the 9th millennium, given the possibility of disturbance from this time. The later initiation at LDPBI coincided with distinct indications of disturbance. Elsewhere, at Palnure and by Loch Doon (LDIII and LDIV), the local hydrology was probably most influential at the start of peat growth.

9.3 The methodology used and suggestions for further work

9.3.1 Aspects of the methodology

Loch Doon

The basis for any reconstruction of past vegetation is dependent on a knowledge of the palaeogeography of the area under investigation at a scale that is appropriate to that reconstruction. In the case of relatively local reconstruction, the need to have a fairly precise idea of the ancient topography is especially important. This has emerged from the investigation of a number of cores from a basin by Loch Doon that is scarcely perceptible today now that blanket peat mantles almost all the mineral soil. The distances between the cores and from their supposed areas of dry terrain in the past are such that if expressed in terms of basin diameters in the generalised model of Jacobson and Bradshaw (1981), they occur within the range 0 - about 125m, where the model is at its weakest for the purpose of estimating the relative contributions of local and extralocal components. The curve separating these components is changing most. The use of a number of profiles enables some idea of the range of variabilty to be evaluated.

A wider survey in this area would have been preferable, to define the topography of the north, west and south more clearly and additional pollen analyses of basal samples would have contributed to an estimate of the area of dry land around the 'basin', which in the earliest postglacial may not have been the coherent unit that was reconstructed at the Alnus rise (Fig. 6.2). A determination of the sediment stratigraphy on a grid or selected transects might also have assisted in interpreting how far from the edge of the basin woodland may have grown at various times and the identification of fossil wood (detrital or otherwise) would provide an indication of the species locally present. In these respects the descriptions of Smith and Cloutman (1988) and Cloutman (1988a) are good

examples. The description of peaty sediment in the laboratory is hampered by its rapid oxidation. Streaks of charcoal in particular might be missed.

In the selection of sites for the most detailed pollen-analytical work using 'basin' or 'confined' peat, a steep-sided part of the basin may be best in that there is less likely to be very local successional changes amongst the tree or shrub populations. These can take place where the shallower slope of a substrate close to the water table or under incipient peat or mor allow a more extensive bog-side woodland development (cf. Andersen 1984, 82). A suitable distance would have to be chosen where either slumping of deposits or considerable inwash of pollen and other sediment was unlikely. The core of LDIV whilst away from the steepest sides of the basin to the east, was clearly affected by local Alnus growth on the possibly less steep margin to the south where the time of peat initiation in the southerly basin was not accurately determined, but may have supported damp woodland for at least a part of F1 II.

The use of the 'rapid' preparation method was found to be beneficial in establishing preliminary pollen profiles within an area and may enhance the likelihoood of finding clumps of pollen suggestive of local sources.

Loch Dee

These conclusions concerning the need for pollen analysis from more than one site and a good knowledge of the palaeogeography of the study area can be extended to the investigations at Loch Dee. The peninsula was possibly visited early in the ninth millennium b.p. when the site of LDPBII may have been little more than a damp hollow within birchwood at a level below the present-day surface almost equal to the greatest height of the morainic ridge to the east above today's surface. Until perhaps the second half of the Flandrian when peat formation may have become more widespread on the peninsula, the contrast between the morainic ridges and lower

ground would have been more pronounced. The pollen analysis of two cores (LDPBI and II) showed considerable parallelism (and it was demonstrated that the sites shared a proportion of their extralocal catchments (cf. Jacobsen and Bradshaw 1981)), but also distinct differences in their records.

General conclusions

At all the sites investigated the determination of pollen concentrations has meant that the inferences on the direction of vegetational change can be strenghtened by inspecting the curves of the taxa involved and comparing their trends against those of other curves. Sometimes the concentrations may have more bearing on the rate of sediment accumulation. For many sites the use of concentrations for peat deposits is probably preferable to influx data because there are fluctuations in the accumulation rate over periods that are much shorter than the interval of radiocarbon determinations. Cloutman (1983) concluded that concentrations may be a better expression of abundance than influx, having calculated the latter.

The estimate of microscopic charcoal abundance in terms of numbers of fragments per total pollen may give a useful indication of the frequency or proximity of burning; the more levels analysed in this way, the greater the confidence in establishing pattern. The beginnings of increased amounts following low representation in the earliest postglacial may prove to be of significance for the timing of early impact on the vegetation.

9.3.2 Possible future work

At each of the principal areas of investigation, by Loch Doon and Loch Dee an extension of the surveys to determine the sub-peat topography and collection of further basal (and perhaps later) cores would permit more

detailed reconstructions. It is evident from work in south Wales (Cloutman 1983, Smith and Cloutman 1988), the North York Moors (Innes 1981, Simmons and Innes 1988a,b,c) and the Vale of Pickering (Cloutman 1988b, Cloutman and Smith 1988) that the best situation in which to detect small-scale effects on the vegetation is near the base of accumulating peat at sites of lithics, where the woodland was most certainly local and not to be inferred from deposits which might be separated by a fringe of basin-edge wet woodland from the actual site of disturbance (cf. Edwards 1982, Caseldine 1984). However, it is only possible to use sufficiently old deposits and these may not be to order.

An extension to the survey at Loch Doon might reveal other suitable sediments from which a more detailed understanding of the mosaic of woodland vegetation, any cleared areas and the incidence of mire deposits might be gained. At Loch Dee, the peninsula survey indicates that the oldest peat may have been found, but there is probably scope for three-dimensional reconstructions of the vegetation in the later parts of Fl II at least. Further dating of basal peats in particular could give the opportunity to map the development of mor or blanket peat and assess the possible role of man in this process at a local scale in each area (cf. Smith and Cloutman 1988). At LDPBII the curve of the time-depth graph shows the increasing rate of peat growth; nevertheless, the actual timing of its ombrotrophic development has only been conjectured as occurring some time in Fl II and further, more comprehensive, study of the peat stratigraphy and dating would be needed to refine this. Comparison with studies of the peat stratigraghy at Ellergower Knowe (Prof. Clymo, pers. comm.), to the northeast, would be of interest in view of the above inferences of disturbance in the Mesolithic and in respect of the validity of mathematical models for peat growth (e.g. Clymo 1978, 1984), as well as assessing the influence of past climate.

The site of LDPBII may prove to be unique in providing a pollen stratigraphy from the 9th millennium on the peninsula at Loch Dee. It is unfortunate that the Fl I section of the profile is so short making additional analyses at a sampling thickness of 1cm too coarse to add much detail to the significant changes already plotted. The nature of the sediment, however, a slowly-formed peat or mor, may be amenable to high-resolution sampling using a freezing microtome (cf. Bradshaw 1988, Simmons et al. 1989).

The dating of the start of the Pteridium curve at Loch Doon is unresolved and radiocarbon dating of this point in the profile at LDIV and perhaps also at LDIII would provide an estimate of the date of this event and additional dates at LDIV in the Fl I portion of the profile would help to answer the question of the peat deposition rate at this site. In order to assess whether the beginning of an increased charcoal input and the earliest incidence of Pteridium were related in a wider context, sediment from the deepest part of Loch Doon might contain pollen from the earliest Flandrian, even if focused into this part of the basin. The ratio of charcoal to pollen might still circumvent this potential difficulty in expressing the amount of charcoal present (cf. Swain 1973) because of the differential input of sediment through time. The incomplete record from the core described here is possibly a consequence of this process. The low LOI value at the base (5.7%, Diag. 6.5.1) suggests that the core contains all the most organic part of the sequence at this point in the loch. It was retrieved from a depth of an order at which resuspension can be expected to have occurred and the loch has a considerably deeper profundal area into which suitably organic earlier sediment has perhaps been winnowed (e.g. Davis et al. 1984). The very wide catchment of the loch has been noted; another factor affecting the possible representation of open-ground indicators, is the sources from above or near the tree-

line.

In addition to increasing the understanding of the spatial pattern of vegetation and the dynamics of change in time by investigating more sites, the data so far gathered could be treated statistically as has been done for sequences elsewhere. Although Birks et al. (1988) outline theoretical difficulties that exist in the application of Principal Components Analysis and recommend Correspondence Analysis as an alternative, PCA of the pollen stratigraphy of a variety of sediments that had collected in a valley bottom at the Dod proved to be discriminating enough to detect a single level where Mesolithic disturbance could be inferred and generally the clusters of levels were found to correspond closely to the zones drawn up using the Zonation program (Shennan and Innes 1986). Simmons and Innes (1988b) found that PCA vindicated the pollen zones chosen by inspection of the North Gill profiles. It also allowed the association of types to be made, giving insights into the communities that were together subject to change. As part of this deduction it was possible to confirm the phases of disturbance. For an index of diversity Birks et al. (1988) propose that Rarefaction Analysis is appropriate for pollen stratigraphical studies and such might prove to be more discerning than visual inspection of the curves of the number of herb types adopted here.

No statistical analysis is a substitute for basing inferences on the likeliest ecological niches (cf. Birks 1986b), but since it can help in the process of discovering the taxa that may belong together in communities and point to the important changes in pollen stratigraphy (Simmons and Innes 1988b), it would perhaps give confidence in accepting the choice of zones and attribution of disturbance presented here. Correlation of the pollen (groups of taxa or single types), and charcoal stratigraphies might be seen using appropriate techniques

(cf. Carter 1986).

An additional technique that might give extra evidence for disturbance is the analysis of the inorganic component of the sediment by loss on ignition. Used elsewhere as an indicator of broken ground (Vuorela 1983), only small increases may suggest disturbance, though all possible influences of the natural local hydrology would have to be taken into account. To be rigorous, contiguous sampling would be carried out using a sample thickness appropriate to the level of the resolution of the pollen analysis (i.e. probably 1 or 2cm slices).

Further fieldwork would probably increase the number of archaeological sites near deposits suitable for pollen analysis. Only with more sites can any pattern of increased charcoal occurring in the earliest postglacial come to light. To suspect, if not more certainly demonstrate, disturbance events, a temporal resolution within 100 years for initial sampling may be required (cf. Simmons et al. 1989). Concerning the effect of impact in allowing the establishment of the postglacial woodland flora, in particular of Alnus, only a greater number of detailed investigations and datings will enable its complexity to viewed and mechanisms (e.g. climate [cf. West 1980] and/or man [cf. Smith 1984]) decided upon. It is the amount of detail required that epitomises the application of pollen analysis to Mesolithic vegetational studies generally. There can be no shortage of potential projects.

APPENDIX 1

Correlation of the basal cores of Loch Doon IV

The two deepest cores from the site of Loch Doon IV as they were taken in the field overlapped by 25cm. The cores were measured from the original coring datum as being between the depths 350-400cm and 375-425cm. Subsequent analysis showed that the pollen stratigraphy of each core exhibited a rise in Coryloid percentages, which if plotted as occurring at the depths originally defined would give two separate rises. Since the two cores came from different locations at the site (about 50cm apart), it is clearly possible for there to be some discrepancy of pollen stratigraphy between the cores as labelled. In order to correlate the pollen spectra of the two cores, the point at which Coryloid began to rise to higher values was taken as a common horizon and the depths of the lower core modified accordingly. This is marked on each of the diagrams (Fig. A1) and results in a mean discrepancy of 17cm. The limits of the correlation are determined by the sampling interval of each core and are ±2cm.

This seems rather a large difference, but makes sense in terms of the radiocarbon date of 9280±140 b.p. from the lowest core and 9200±110 b.p. from the penultimate core, given the errors of the dates (see Fig. 6.6, where the modified depths of the deepest core are plotted and the dates for this core [9610 b.p. and 9280 b.p.] are used to indicate the sedimentation rate because they are from the same core).

Due to the overlap of pollen stratigraphy some levels (they are annotated on Fig. A1) have been omitted from the full diagrams of Loch Doon IV (e.g. Diag. 6.3.1). It is of interest to note, however, the occurrence of Alnus pollen (3.1% AP) at the corrected depth of 360cm (377cm on profile 375-425cm of Fig. A1), since it is also apparent at the same depth on the other core, although at a lower value (0.5%; profile 350-400cm on Fig. A1, and Diag. 6.3.1).

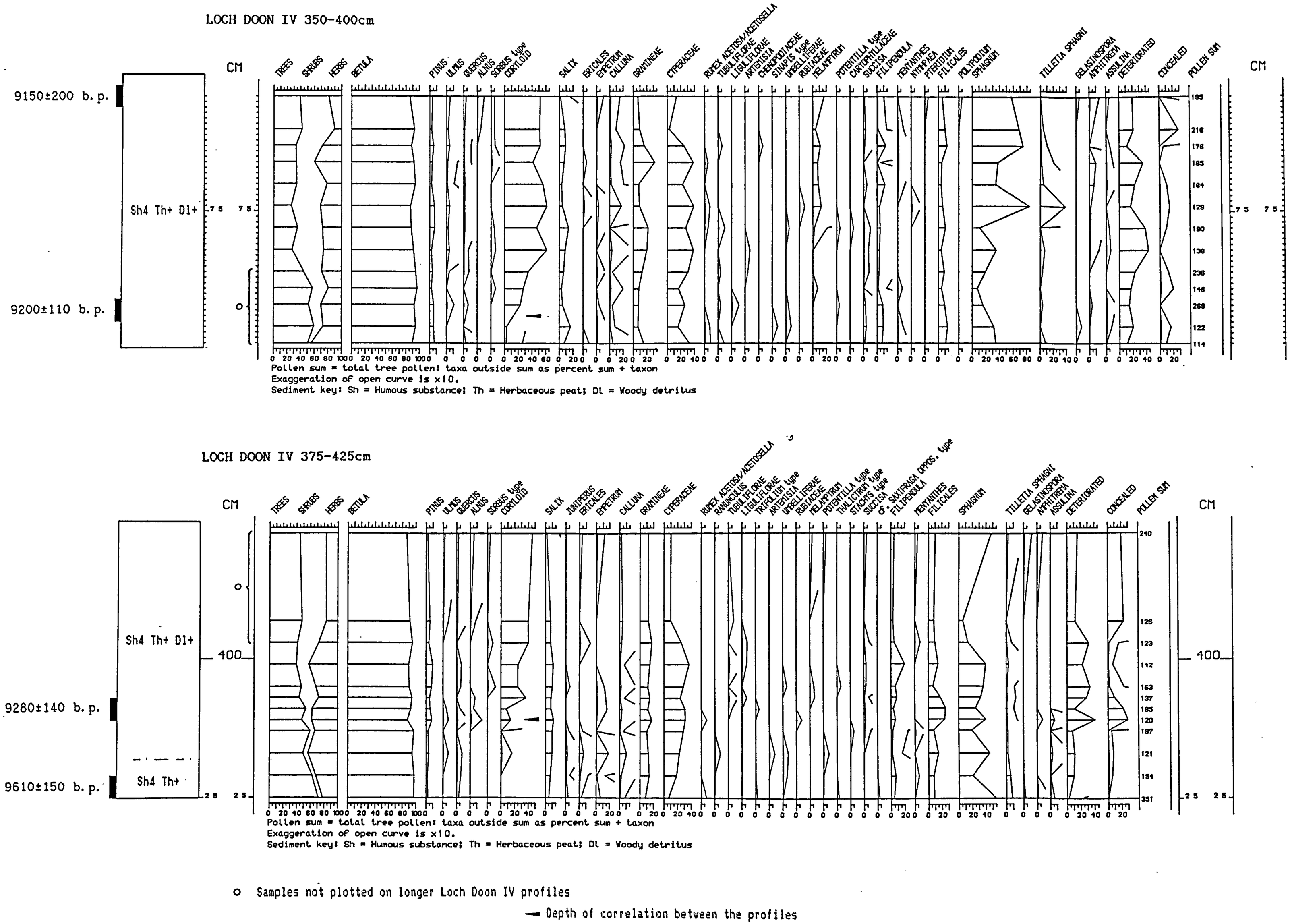


Fig. A1. Pollen stratigraphies of cores 350-400 cm and 375-425 cm (as originally labelled) from site Loch Doon IV (LDIV).

APPENDIX 2

Pollen analysis of core LDI, Loch Doon, by B.A.Carter

In order to provide a comparison with diagrams from by Loch Doon, the relative diagram of site LDI (Fig. 6.2; Photo. IX) from Carter (1986) is reproduced here as Fig. A2.

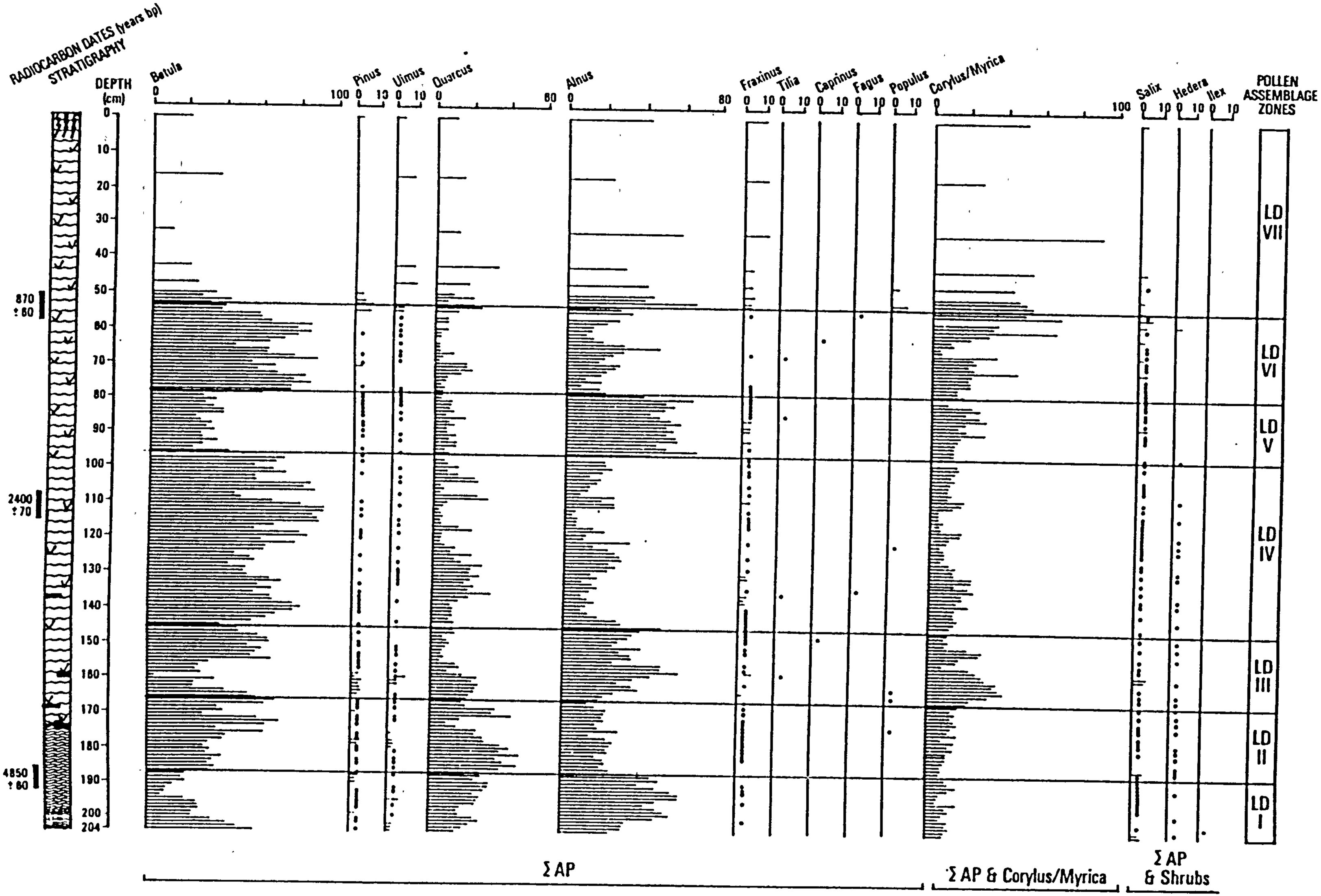


Fig. A2. Relative (percentage) pollen diagram from site Loch Doon I (LDI). (From Carter 1986).

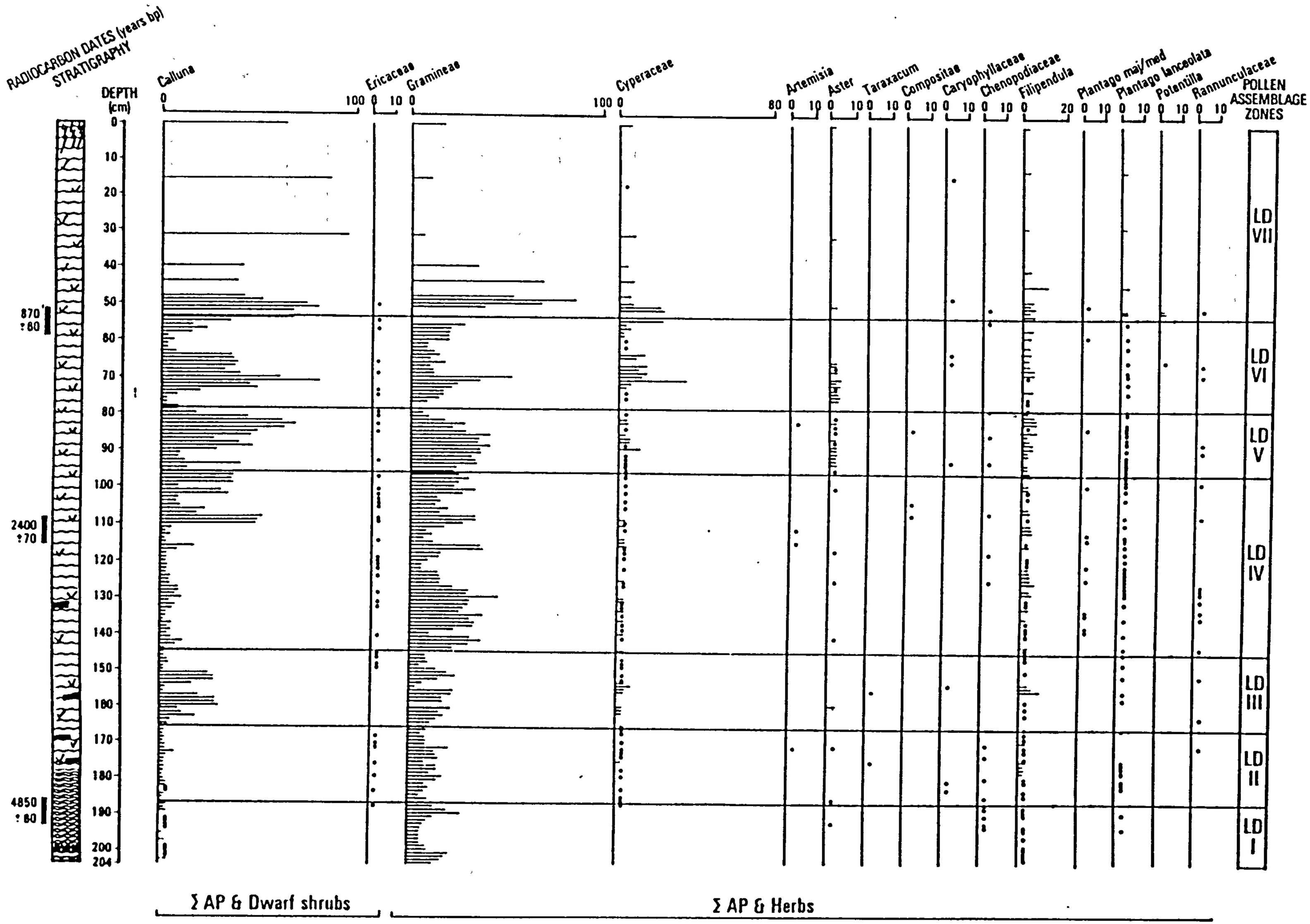


Fig. A2 (continued).

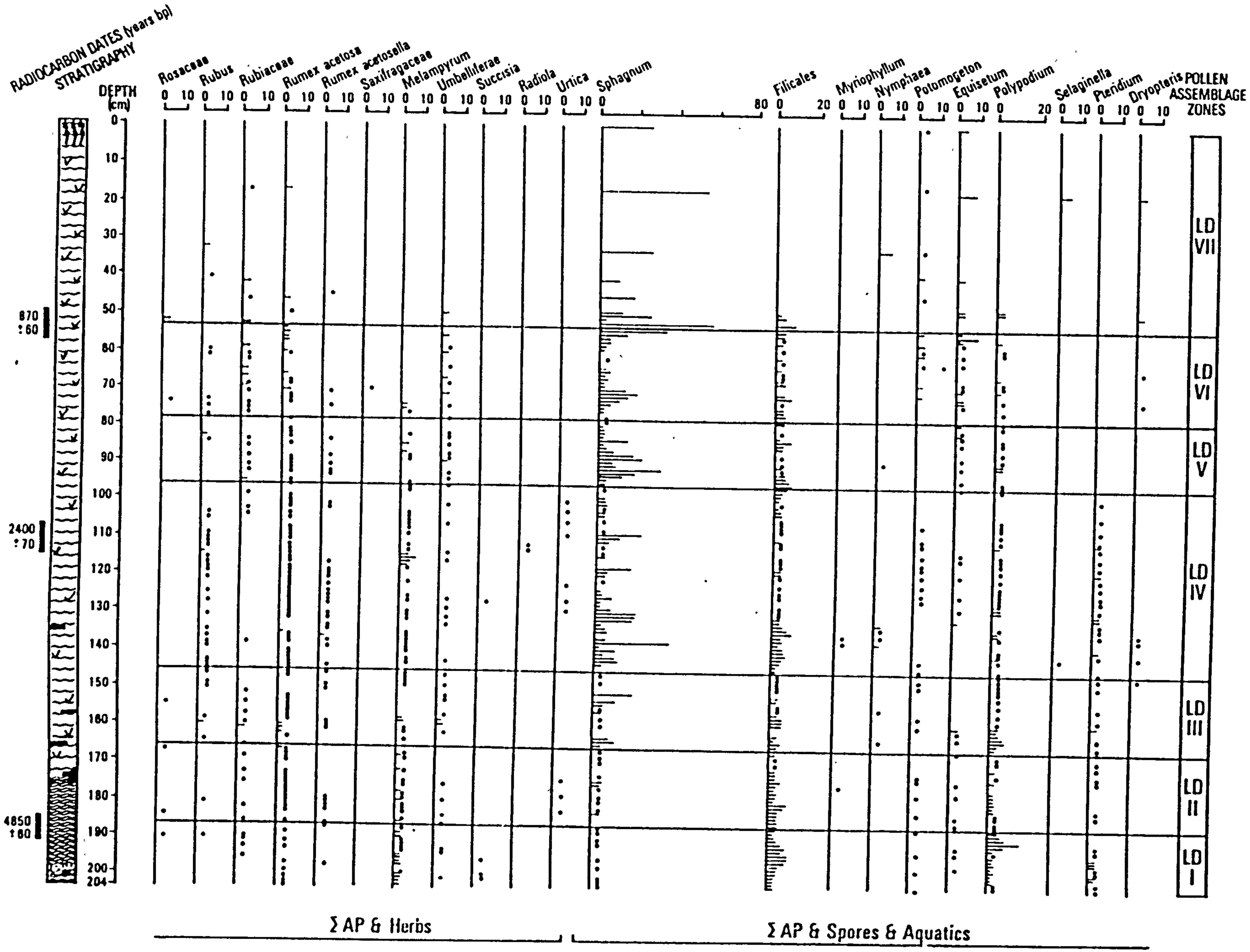


Fig. A2 (continued).

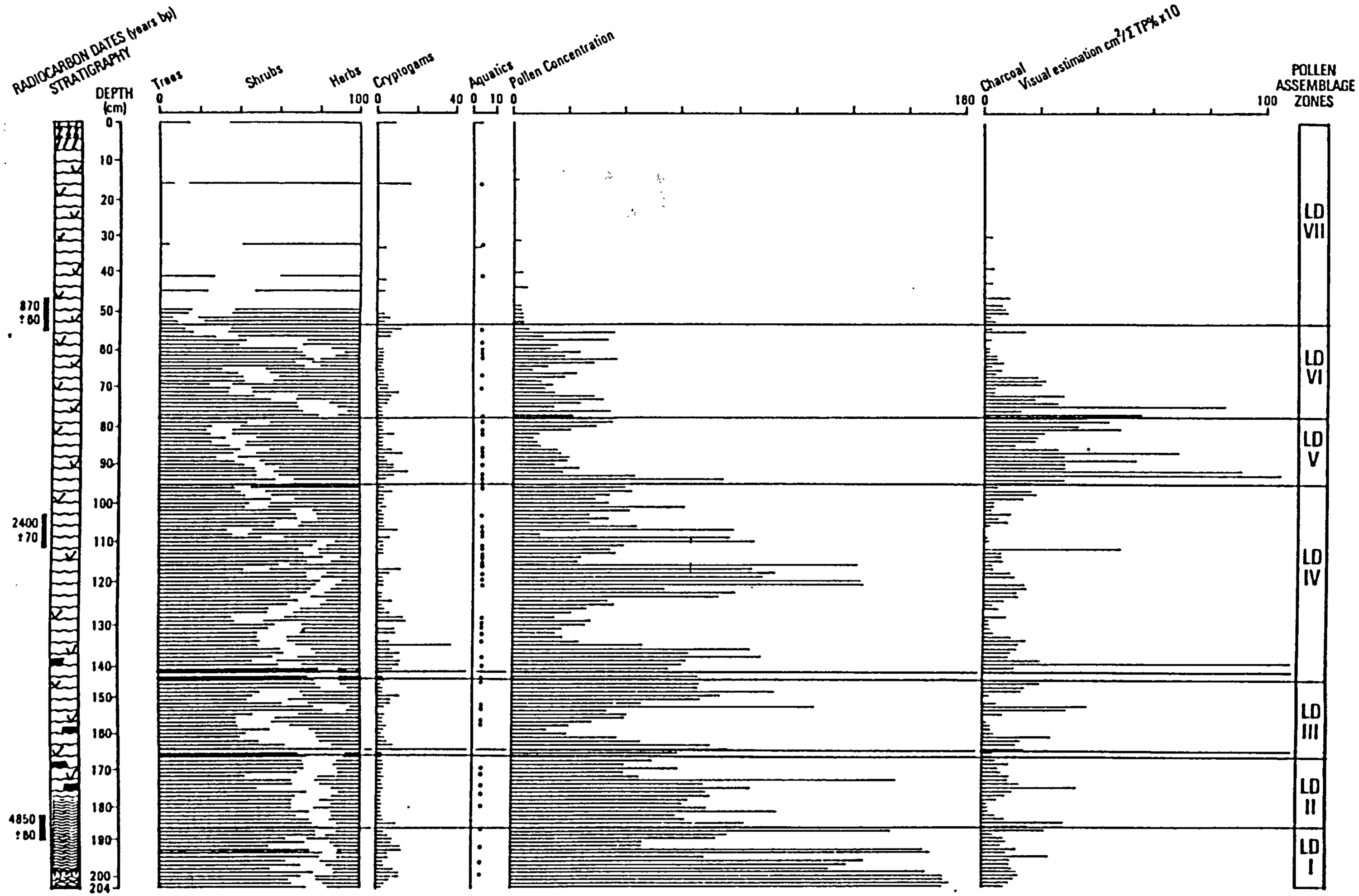


Fig. A2 (continued).

STRATIGRAPHIC SYMBOLS

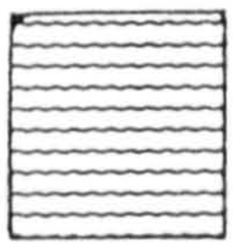
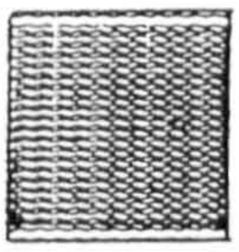
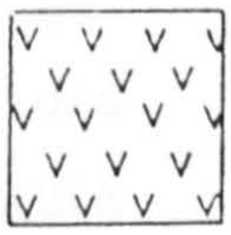
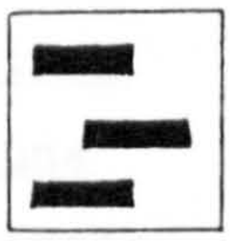
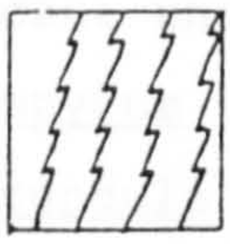
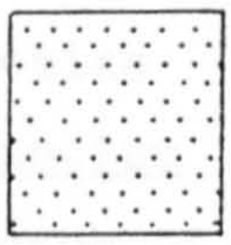
KEY	DESCRIPTION
	Light brown, humified sedge peat.
	Dark brown, completely humified sedge peat.
	Rootlets of sedge
	Wood fragments
	Calluna roots
	Sand

Fig. A2 (continued).

APPENDIX 3

Results of pollen analysis of basal samples from Sites LDPBIII and LDPBIV

	LDPBIII	LDPBIV
	305cm	206cm
Betula	50.0	48.4
Pinus	1.3	1.4
Ulmus	6.5	1.8
Quercus	19.1	13.6
Alnus	22.6	33.5
Tilia cordata	--	0.5
Sorbus type	0.4	0.9
∑ Trees	230	221
Coryloid	27.7	26.6
Frangula	--	0.5
∑ Shrubs	88	81
Ericales	--	1.8
Empetrum	0.4	--
Calluna	4.5	44.1
Gramineae	8.2	8.3
Tubuliflorae	--	0.9
Rosaceae undiff.	--	0.5
Melampyrum	1.7	6.8
Filipendula	--	0.5
∑ Herbs	37	218
Pteridium	3.0	16.9
Filicales	5.7	0.9
Polypodium	0.9	1.3
Sphagnum	0.4	1.8
Indeterminable (deteriorated)	9.4	15.6
Concealed	--	1.8
Total Pollen	355	519
% Trees	64.8	42.5
% Shrubs	24.8	15.6
% Herbs	10.4	41.9

ABBREVIATIONS

Pollen analysis

AP	Arboreal Pollen
AP+S	Tree Pollen + Shrub Pollen
DLP	Sum of selected Dry-Land Pollen
TLP	Total Land Pollen
LPAZ	Local Pollen Assemblage Zone
LPAS	Local Pollen Assemblage Subzone
RPAZ	Regional Pollen Assemblage Zone
B.A.T.	Boreal/Atlantic Transition

Other

b.p./b.c./a.d.	Uncalibrated radiocarbon dates before present (1950 A.D.)/before 1950 b.p./after 1950 b.p.
A.O.D.	Above Ordnance Datum
LOI	Loss On Ignition
NGR	National Grid Reference

Also

E	Sum of (on pollen diagrams)

REFERENCES

Affleck, T.L. 1983-85. Notes. In: *Discovery and Excavation in Scotland.* Council for British Archaeology. Scotland.

Affleck, T.L. 1986. Excavation at Starr, Loch Doon 1985. *Glasgow Archaeol. Soc. Bulletin.* No. 22, 10-21.

Alway, F.J. and McMiller, P.R. 1933. Interrelationships of soil and forest cover on Star Island, Minnesota. *Soil Sci.*, 36, 281-295.

Andersen, S.T. 1960. Silicone oil as a mounting medium for pollen grains. *Damn. Geol. Unders. IV. Ser.*, 4, 1-24.

Andersen, S.T. 1970. The relative pollen productivity and pollen representation of north European trees, and correction factors of tree pollen spectra. *Damn. Geol. Unders. II. Ser.*, 96, 1-99.

Andersen, S.T. 1973. Differential pollen productivity of trees and its significance for the interpretation of a pollen diagram from a forested region. In: Birks, H.J.B. and West, R.G. (eds). *Quaternary plant ecology.* 14th Symposium of the British Ecological Society. Oxford: Blackwell Scientific Publications. pp. 109-129.

Andersen, S.T. 1979. Identification of wild grasses and cereal pollen. *Damn. Geol. Unders. Årbog 1978.* København. pp.69-92.

Andersen, S.T. 1984. Forests at Løvenholm, Djursland, Denmark, at present and in the past. *Det Konelige Danske Videnskabernes Selskab Biologiske Skrifter*, 24. København. 208 pp.

Andrew, R. 1984. *A practical pollen guide to the British flora.* Technical Guide 1. Cambridge: Quaternary Research Association.

Andrews, J. 1986. *Modern pollen studies in Scords Wood, Brasted, Kent.* Unpub. Ph.D. thesis. King's College, Univ. of London.

Atkinson, T.C., Briffa, K.R. and Coope, G.R. 1987. Seasonal temperatures in Britain during the past 22,000 years, reconstructed using beetle remains. *Nature*, 325, 587-592.

Balmer, D.A. 1987. *Studies of fossil pollen and charcoal at Snibe Bog (Silver Flowe National Nature Reserve) south-west Scotland.* Unpub. Dissertation. Dept. of Geography, Univ. of Birmingham.

Barber, K.E. 1982. Peat-bog stratigraphy as a proxy record. In: Harding, A.F. (ed). *Climatic change in later prehistory.* Edinburgh: Edinburgh University Press. pp. 103-113.

Barker, G. 1985. *Prehistoric farming in Europe.* Cambridge: Cambridge University Press.

Barton, R.N.E. 1987. Vertical distribution of artefacts and some post-depositional factors affecting site formation. In: Rowley-Conwy, P., Zvelebil, M. and Blankholm, H.P. (eds). *Mesolithic northwest Europe: recent trends series.* 2. Sheffield: Univ. of Sheffield. pp. 55-62.

Battarbee, R.W. and Flower, R.J. 1985. *Palaeoecological evidence for the timing and causes of lake acidfication in Galloway, southwest Scotland.* Working Paper No. 8. London: Palaeoecological Research Unit, Univ. College.

Beckett, S.C. 1979. Pollen influx in peat deposits: values from raised bogs in the Somerset Levels, south-western England. *New Phytol.*, 83, 839-847.

Beckett, S.C. and Hibbert, F.A. 1979. Vegetational change and the influence of prehistoric man in the Somerset Levels. *New Phytol.*, 833, 577-600.

Behre, K.-E. 1981. The interpretation of anthropogenic indicators in pollen diagrams. *Pollen et Spores*, 23, 225-245.

Behre, K.-E. 1986. Preface. In: Behre, K.-E. (ed). *Anthropogenic indicators in pollen diagrams.* Rotterdam: Balkema.

Bennett, K.D. 1983. Devensian late-glacial and Flandrian vegetational history at Hockham Mere, Norfolk, England. I. Pollen percentages and concentrations. *New Phytol.*, 95, 457-487.

Bennett, K.D. 1984. The post-glacial history of *Pinus sylvestris* in the British Isles. *Quat. Sci. Rev.*, 3, 133-155.

Bennett, K.D. 1986a. Competitive interactions among forest tree populations in Norfolk, England, during the last 10 000 years. *New Phytol.*, 103, 603-620.

Bennett, K.D. 1986b. The rate of spread and population increase of forest trees during the postglacial. *Philos. Trans. R. Soc. Lond. Ser. B*, 314, 523-531.

Bennett, K.D. 1988a. Holocene pollen stratigraphy of central East Anglia, and comparison of pollen zones across the British Isles. *New Phytol.*, 109, 237-253.

Bennett, K.D. 1988b. Holocene geographic spread and population expansion of *Fagus grandiflora* in Ontario, Canada. *J. Ecol.*, 76, 547-557.

Bennett, K.D., Fossitt, J.A., Sharp, M.J. and Switsur, V.R. 1990. Holocene vegetational and environmental history at Loch Lang, South Uist, Western Isles, Scotland. *New Phytol.*, 114, 281-298.

Berglund, B.E. 1966. Late-Quaternary vegetation in eastern Blekinge south-eastern Sweden. A pollen-analytical study. II. Post-glacial time. *Op. Bot. A Soc. Bot. Lund.*, 12. 190 pp.

Birks, H.H. 1969. *Studies in the vegetational history of Scotland.* Vol. 2. Figures and tables. Unpub. Ph.D. thesis. Univ. of Cambridge.

Birks, H.H. 1972. Studies in the vegetational history of Scotland. II. Two pollen diagrams from the Galloway Hills, Kirkudbrightshire. *J. Ecol.*, 60, 183-217.

Birks, H.H 1975. Studies in the vegetational history of Scotland. IV. Pine stumps in Scottish blanket peats. *Philos. Trans. R. Soc. Lond., Ser. B*, 270, 181-226.

Birks, H.J.B. 1973. *Past and present vegetation of the Isle of Skye: a palaeoecological study.* London: Cambridge University Press.

Birks, H.J.B. 1977. The Flandrian vegetational history of Scotland: a preliminary synthesis. In: Shotton, F.W. (ed). *British Quaternary studies. Recent advances.* Oxford: Clarendon Press. pp. 119-135.

Birks, H.J.B. 1980. *Quaternary vegetation history of west Scotland.* 5th Int. Palynol. Conf. Excursion C8 Guide. Cambridge.

Birks, H.J.B. 1982. Mid-Flandrian forest history of Roudsea Wood National Nature Reserve. *New Phytol.*, 90, 339-354.

Birks, H.J.B. 1986a. Late-Quaternary biotic changes in terrestrial and lacustrine environments, with particular reference to north-west Europe. In: Berglund, B.E. (ed). *Handbook of Holocene palaeoecology and palaeohydrology.* Chichester: Wiley and Sons. pp. 3-65.

Birks, H.J.B. 1986b. Numerical zonation, comparison and correlation of Quaternary pollen-stratigraphical data. In: Berglund, B.E. (ed). *op. cit.* (Birks 1986a). pp. 743-774.

Birks, H.J.B. 1987. The past and present vegetation of Oronsay and Colonsay. In: Mellars, P.A. *Excavations on Oronsay. Prehistoric ecology on a small island.* Edinburgh: Edinburgh University Press. pp. 52-77.

Birks, H.J.B. 1988a. Long-term ecological change in the British uplands. In: Usher, M.B. and Thompson, D.B.A. (eds). *Ecological change in the uplands.* Special Publication No.7 of the British Ecological Society. Oxford: Blackwell Scientific Publications. pp. 37-56.

Birks, H.J.B. 1988b. Introduction. In: Birks, H.H., Birks, H.J.B., Kaland, P.E. and Moe, D. (eds). *The cultural landscape - past, present and future.* Cambridge: Cambridge University Press. pp. 179-187.

Birks, H.J.B. In press. Holocene isochrone maps and patterns of tree spreading in the British Isles.

Birks, H.J.B. and Birks, H.H. 1980. *Quaternary palaeoecology.* London: Edward Arnold.

Birks, H.J.B., Deacon, J. and Peglar, S. 1975. Pollen maps for the British Isles 5000 years ago. *Proc. R. Soc. Lond., Ser. B*, 189, 87-105.

Birks, H.J.B. and Gordon, A.D. 1985. *Numerical methods in Quaternary pollen analysis.* London: Academic Press.

Birks, H.J.B., Line, J.M. and Persson, T. 1988. Quantitative estimation of human impact on cultural landscape. In: Birks, H.H. *et al.* (eds). *op. cit.* (Birks 1988b). pp. 229-240.

Birse, E.L. and Robertson, J.S. 1976. *Plant communities and soils of the lowland and southern upland regions of Scotland.* Aberdeen: The Macaulay Institute for Soil Research.

Bishop, W.W. and Coope, G.R. 1977. Stratigraphical and faunal evidence for lateglacial and early Flandrian environments in south-west Scotland. In: Gray, J.M. and Lowe, J.J. (eds). *Studies in the Scottish lateglacial environment.* London: Pergamon. pp. 61-88.

Boatman, D.J. 1983. The Silver FLowe National Nature Reserve, Galloway, Scotland. *J. Biogeogr.*, 10, 163-274.

Boncke, S.J.P. 1988. Vegetation and habitation history of the Callanish area, Isle of Lewis, Scotland. In: Birks, H.H, Birks, H.J.B., Kaland, P.E. and Moe, D. (eds). *The cultural landscape - past, present and future.* Cambridge: Cambridge Univ. Press. pp. 445-461.

Bonny, A.P. 1972. A method for determining absolute pollen frequencies in lake sediments. *New Phytol.*, 71, 393-405.

Bonny, A.P. 1978. The effect of pollen recruitment processes on pollen distribution over the sediment surface of a small lake in Cumbria. *J. Ecol.*, 66, 385-416.

Bonsall, C. 1981. The coastal factor in the Mesolithic settlement of north-west England. In: Gramsch, B. (ed). *Mesolithikum in Europa.* Veröffentlichungen des Museums für Ur- und Frühgeschicte Potsdam, 14-15. Berlin: Deutscher Verlag der Wissenschaften. pp. 451-472.

Bown, C.J. 1973. *The soils of Carrick and the country around Girvan (Sheets 7 and 8).* Memoirs of the Soil Survey Great Britain. Scotland. Edinburgh: HMSO.

Bown, C.J. and Heslop, R.E.F. 1979. *The soils of the country around Stranraer and Wigtown (Sheets 1, 2, 3, 4 and part 7).* Memoirs of the Soil Survey of Great Britain. Scotland. Aberdeen: The Macaulay Institute for Soil Research.

Bown, C.J., Shipley, B.M. and Bibby, J.S. 1982. *South-west Scotland. Soil and land capability for agriculture.* Soil Survey for Scotland. Aberdeen: The Macaulay Institute for Soil Research.

Boyd, W.E. 1982. Archaeological implications of a new palaeoenvironmental model for part of the Ayrshire coast. *Glasgow Archaeol. J.*, 9, 15-17.

Boyd, W.E. 1986. Vegetation history at Linwwod Moss, Renfrewshire, Central Scotland. *J. Biogeogr.*, 13, 207-223.

Boyd, W.E. 1988. Early Flandrian vegetational development on the coastal plain of north Ayrshire, Scotland: evidence from multiple pollen profiles. *J. Biogr.*, 15, 325-337.

Boyd, W.E. and Dickson, J.H. 1986. Patterns in the geographical distribution of the early Flandrian *Corylus* rise in southwest Scotland. *New Phytol.*, 102, 615-623.

Boyd, W.E. and Dickson, J.H. 1987. A post-glacial pollen sequence from Loch a'Mhuillinn, North Arran: a record of vegetation history with special reference to the history of endemic *Sorbus* species. *New Phytol.*, 107, 221-244.

Bradley, R. 1984. Regional systems in Neolithic Britain. In: Bradley, R. and Gardiner, J. (eds). *Neolithic studies. A review of some current research.* Oxford: British Archaeological Reports, Br. Ser., 133. pp. 5-14.

Bradshaw, R.H.W. 1981. Modern pollen-representation factors for woods in south-east England. *J. Ecol.*. 69, 45-70.

Bradshaw, R.H.W. 1988. Spatially-precise studies of forest dynamics. In: Huntley, B. and Webb, T., III. (eds). *Vegetation history.* Dordrecht: Dr. W. Junk. Kluwer Academic Publishers. pp. 727-753.

Bradshaw, R.H.W. and Browne, P. 1987. Changing patterns in the post-glacial distribution of *Pinus sylvestris* in Ireland. *J. Biogeogr.*, 14, 237-248.

Breeze, D.J. and Ritchie, J.N.G. 1980. A Roman burial at High Torrs, Luce Sands, Wigtownshire. *Trans. Dumfries. Galloway Nat. Hist. Antiq. Soc.*, 55, 77-85.

Brookes, D. and Thomas, K.W. 1967. The distribution of pollen grains on microscope slides. I. The non-randomness of the distribution. *Pollen et Spores*, 9, 621-629.

Brown, A.G. 1988. The palaeoecology of *Alnus* (alder) and the Postglacial history of floodplain vegetation. Pollen percentage and influx data from the West Midlands, United Kingdom. *New Phytol.*, 110, 425-436.

Buckland, P.C. and Edwards, K.J. 1984. The longevity of pastoral episodes of clearance activity in pollen diagrams: the role of post-occupation grazing. *J. Biogeogr.*, 11, 243-249.

Burzynski, M.P. 1982. *Prehistoric fires and forest development as recorded in peat from New Brunswick.* M.Sci. Thesis. Dept. of Biology, Univ. of New Brunswick, Fredericton, Canada.

Bush, M.B. 1988. Early Mesolithic disturbance: a force on the landscape. *J. Archaeol. Sci.*, 15, 453-462.

Bush, M.B. and Hall, A.R. 1987. Flandrian *Alnus*: expansion or immigration? *J. Biogeogr.*, 14, 479-481.

Carlisle, A. 1977. The impact of man on the native pinewoods of Scotland. In: Bunce, R.G.H. and Jeffers, J.N.R. (eds). *Native pinewoods of Scotland.* Cambridge: Institute of Terrestrial Ecology. pp. 70-77.

Carter, B.A. 1986. *Pollen and microscopic charcoal studies in south west Scotland.* Unpub. M.Phil. thesis. Univ. of Birmingham.

Case, H. 1969. Neolithic explanations. *Antiquity*, 43, 176-186.

Caseldine, A.E. 1984. Palaeobotanical investigations at the Sweet Track. In: Coles, J.M., Orme, B.J. and Roulliard, S.E. (eds). *Somerset Levels Papers No. 10.* pp. 65-114.

Caseldine, C.J. 1983. Problems of relating site and environment in pollen-analytical research in south west England. In: Proudfoot, B. (ed). *Site, environment and economy.* Oxford: British Archaeolgical Reports, Int. Ser., 173. pp. 61-74.

Caseldine, C.J. and Maguire, D.J. 1986. Lateglacial/early Flandrian vegetation change on northern Dartmoor, south-west England. *J. Biogeogr.*, 13, 255-264.

Chambers, F.M. 1983a. The palaeoecological setting of the Cefn Gwernffrwd - a prehistoric complex in mid-Wales. *Proc. Prehist. Soc.*, 49, 303-316.

Chambers, F.M. 1983b. Three radiocarbon-dated pollen diagrams from upland peats north-west of Merthyr Tydfil, South Wales. *J. Ecol.*, 71, 475-487.

Chambers, F.M. 1984. *Studies on the initiation, growth-rate and humification of 'blanket peats' in south Wales.* Keele: Dept. of Geography, Univ. of Keele, Occas. Paper No.9.

Chambers, F.M., Kelly, R.S. and Price, S.-M. 1988. Development of the late-prehistoric cultural landscape in upland Ardudwy, north-west Wales. In: Birks, H.H., Birks, H.J.B., Kaland, P.E. and Moe, D. (eds). *The cultural landscape - past, present and future.* Cambridge: Cambridge University Press. pp. 333-348.

Chambers, F.M. and Price, S.-M. 1985. Palaeoecology of *Alnus* (alder): early post-glacial rise in a valley mire, north-west Wales. *New Phytol.*, 101, 333-344.

Charlesworth, J.K. 1926. The glacial geology of the Southern Uplands of Scotland, west of Annandale and Upper Clydesdale. I. *Trans. R. Soc. Edinb.*, 55, 1-24.

Childe, V.G. 1931. The forest cultures of northern Europe: a study in evolution and diffusion. *J. R. Anthropol. Inst. Gr. Brit. Ireland*, 61, 325-348.

Clapham, A.R., Tutin, W.G. and Warburg, E.F. 1981. *Excursion flora of the British Isles.* 3rd ed. Cambridge: Cambridge University Press.

Clark, J.G.D. 1932. *The Mesolithic age in Britain.* Cambridge: Cambridge Univ. Press.

Clark, J.G.D. 1936. *The Mesolithic settlement of northern Europe.* Cambridge Univ. Press.

Clark, J.G.D. 1952. *Prehistoric Europe: the economic basis.* Reprinted 1974. London: Methuen.

Clark, J.G.D. 1954. *Excavations at Star Carr.* London: Cambridge Univ. Press.

Clark, J.G.D. 1955. A microlithic industry from the Cambridgeshire Fenland and other industries of Sauveterrian affinities from Britain. *Proc. Prehist. Soc.*, 21, 3-20.

Clark, J.G.D. 1966. The invasion hypothesis in prehistory. *Antiquity*, 40, 172-189.

Clark, J.G.D. 1972. *Star Carr: a case study in bioarchaeology.* An Addison-Wesley Module in Anthropology. No. 10. Reading, Massachusetts.

Clark. J.G.D. 1980. *Mesolithic prelude.* Edinburgh: Edinburgh Univ. Press.

Clark, R.L. 1982. Point count estimation of ccharcoal in pollen preparations and thin sections of sediments. *Pollen et Spores*, 23, 523-538.

Clark, J.S. 1988. Particle motion and the theory of charcoal analysis: source area, transport, deposition, and sampling. *Quat. Res.*, 30, 67-80.

Clarke, D. 1976. Mesolithic Europe: the economic basis. In: Sieveking, G. de G., Longworth, I.H. and Wilson, K.E. (eds). *Problems in economic and social archaeology.* London: Duckworth. pp. 449-481. Reprint 1978. 37pp.

Cloutman, E.W. 1983. *Studies in the vegetational history of the Black Mountain range South Wales.* Unpub. Ph.D. thesis. Univ. of Wales.

Cloutman, E.W. 1987. A mini-monolith cutter for absolute pollen analysis and fine sectioning of peats and sediments. *New Phytol.*, 107, 245-248.

Cloutman, E.W. 1988a. Palaeoenvironments in the Vale of Pickering. Part 1: stratigraphy and palaeogeography of Seamer Carr, Star Carr and Flixton Carr. *Proc. Prehist. Soc.*, 54, 1-19.

Cloutman, E.W. 1988b. Palaeoenvironments in the Vale of Pickering. Part 2: environmental history at Seamer Carr. *Proc. Prehist. Soc.*, 54, 21-36.

Cloutman, E.W. and Smith, A.G. 1988. Palaeoenvironments in the Vale of Pickering. Part 3: environmental history at Star Carr. *Proc. Prehist. Soc.*, 54, 37-58.

Clymo, R.S. 1978. A model of peat bog growth. In: Heal, O.W. and Perkins, D.F. (eds). *Production ecology of British moors and grasslands.* Berlin: Springer-Verlag. pp. 188-223.

Clymo, R.S. 1984. The limits to peat bog growth. *Philos. Trans. R. Soc. Lond., Ser. B*, 303, 605-654.

Cohen, M.N. 1977. *The food crisis in prehistory.* New Haven: Yale Univ. Press.

Coles, J.M. 1964. New aspects of the Mesolithic settlement of south-west Scotland. *Trans. Dumfries. Galloway Nat. Hist. Antiq. Soc.*, 41, 67-98.

Coles, J.M. 1971. The early settlement of Scotland: excavations at Morton, Fife. *Proc. Prehist. Soc.*, 37, 284-366.

Coles, J.M. 1976. Forest farmers: some archaeological, historical and experimental evidence relating to the prehistory of Europe. *Dissertationes Archaeol. Gandenses*, 16. From: De Laet, S.J. (ed). *Acculturation and continuity in Atlantic Europe.* Brugge: De Tempel. pp. 59-66.

Coles, J.M. 1979. *Experimental archaeology.* London: Academic Press.

Coles, J.M. and Orme, B.J. 1983. *Homo sapiens* or *Castor fiber*? *Antiquity*, 57, 95-102.

Condry, J. and Ansell, M. 1977-78. The excavation of a hut-circle at Moss Raploch, Clatteringshaws. *Trans. Dumfries. Galloway Nat. Hist. Antiq. Soc.*, 53, 105-113.

Corlett, R.T. 1984. Human impact on the subalpine vegetation of Mt Wilhelm, Papua New Guinea. *J. Ecol.*, 72, 841-854.

Cormack, W.F. 1970. A Mesolithic site at Barsalloch, Wigtownshire. *Trans. Dumfries. Galloway Nat. Hist. Antiq. Soc.*, 45, 47-72.

Cormack, W.F. and Coles, J.M. 1968. A Mesolithic site at Low Clone, Wigtownshire. *Trans. Dumfries. Galloway Nat. Hist. Antiq. Soc.*, 45, 44-72.

Cornish, R. 1979. *Glacial geomorphology of the west-central Southern Uplands of Scotland, with particular reference to 'Rogen' moraines.* Unpub. Ph.D. thesis. Univ. of Edinburgh.

Cornish, R. 1981. Glaciers of the Loch Lomond Stadial in the western Southern Uplands of Scotland. *Proc. Geol. Ass.*, 92, 105-114.

Cornish, R. 1982. Glacier flow at a former ice-divide in SW Scotland. *Trans. R. Soc. Edinb.: Earth Sci.*, 73, 31-41.

Cornish, R. 1983. Glacial erosion in an ice-divide zone. *Nature*, 301, 413-415.

Cousens, J. 1974. *An introduction to woodland ecology.* Edinburgh: Oliver and Boyd.

Cwynar, L.C., Burden, E. and McAndrews, J.H. 1979. An inexpensive sieving method for concentrating pollen and spores from fine-grained sediments. *Can. J. Earth Sci.*, 16, 1115-1120.

Darby, H.C. 1956. The clearing of the woodland in Europe. In: Thomas, W.L. (ed). *Man's role in changing the face of the earth.* Chicago: Univ. Chicago Press. pp. 183-216.

Davis, M.B., Moeller, R.E. and Ford, J. 1984. Sediment focusing and pollen influx. In: Haworth, E.Y. and Lund, W.G. (eds). *Lake sediments and environmental history.* Leicester: Leicester Univ. Press. pp. 261-293.

Dennell, R. 1983. *European economic prehistory: a new approach.* London: Academic Press.

D.E.S. 1984-1986. *Discovery and excavation in Scotland.* Council for British Archaeology. Scotland.

Dickson, C.A. 1988. Distinguishing cereal from wild grass pollen: some limitations. *Circaea*, 5, 67-71.

Dickson, J.H. 1980. Carstairs area. In: *Quat. Res. Ass. field guide. Glasgow region.* pp. 64-65.

Dickson, J.H. 1984. Pleistocene history of *Betula* with special reference to the British Isles. *Proc. R. Soc. Edinb.*, 85B, 1-11.

Dimbleby, G.W. 1962. *The development of British heathlands and their soils.* Oxford Forestry Memoirs 23. Oxford: Clarendon Press.

Dimbleby, G.W. 1976. A review of pollen analysis of archaeological deposits. In: Davidson, D.A. and Shackley, M.L. (eds). *Geoarchaeology: earth science and the past.* London: Duckworth. pp. 347-354.

Dimbleby, G.W. 1981. The Mesolithic. In: Simmons, I.G. and Tooley, M.J. (eds). *The environment in British prehistory.* London: Duckworth. pp. 82-124.

Dimbleby, G.W. 1984. Anthropogenic changes from Neolithic through Mediaeval times. *New Phytol.*, 98, 57-72.

Dimbleby, G.W. 1985. *The palynology of archaeological sites.* London: Academic Press.

Dresser, P.Q. 1970. *A study of sampling and pretreatments of materials for radiocarbon dating.* Unpub. Ph.D. thesis. Queen's Univ. of Belfast.

Durno, S.E. 1956. Pollen analysis of peat deposits in Scotland. *Scott. geogr. Mag.*, 72, 177-187.

Durno, S.E. 1976. Post-glacial change in vegetation. In: Birse, E.L. and Robertson, J.S. (eds). *Plant communities of the lowland and Southern Upland regions of Scotland.* Aberdeen: The Macaulay Institute for Soil Research. pp. 20-36.

Durno, S.E. 1979. Vegetational history. In: Bown, C.J. and Heslop, R.E.F. (eds). *The soils of the country around Stranraer and Wigtown (sheets 1, 2, 3, 4 and part 7).* Memoirs of the Soil Survey of Great Britain. Scotland. Aberdeen: The Macaulay Institute for Soil Research. pp. 190-194.

Durno, S.E. and McVean, D.N. 1959. Forest history of the Beinn Eighe nature reserve. *New Phytol.*, 58, 228-236.

Edlin, H.L. 1974. History and tradition. In: Edlin, H.L. (ed). *Galloway Forest Park.* Forestry Commission guide. Edinburgh: HMSO. pp. 8-15.

Edwards, K.J. 1981. The separation of *Corylus* and *Myrica* pollen in modern and fossil samples. *Pollen et Spores*, 23, 205-218.

Edwards, K.J. 1982. Man, space and the woodland edge - speculations on the detection and interpretation of human impact in pollen profiles. In: Bell, M. and Limbrey, S. (eds). *Archaeological aspects of woodland ecology.* Oxford: British Archaeological Reports, Int. Ser., 146. pp. 5-22.

Edwards, K.J. 1985. Radiocarbon dating. In: Edwards, K.J. and Warren, W. (eds). *Quaternary history of Ireland.* London: Academic Press. pp. 280-293.

Edwards, K.J. 1988. The hunter gatherer/agricultural transition and the pollen record in the British Isles. In: Birks, H.H., Birks, H.J.B., Kaland, P.E. and Moe, D. (eds). *The cultural landscape - past, present and future.* Cambridge: Cambridge University Press. pp. 255-266.

Edwards, K.J. 1989. Meso-Neolithic vegetational impacts in Scotland and beyond: palynological considerations. In: Bonsall, C. (ed). *The Mesolithic in Europe. Papers presented at the 3rd Int. Sympos., Edinb. 1985.* Edinburgh: Donald. pp. 143-155.

Edwards, K.J., Ansell, M. and Carter, B.A. 1983. New Mesolithic sites in Galloway, and their importance as indicators of inland penetration. *Trans., Dumfries. Galloway Nat. Hist. Antiq. Soc.*, 58, 9-15.

Edwards, K.J. and Hirons, K.R. 1984. Cereal pollen grains in pre-elm decline deposits: implications for the earliest agriculture in Britain and Ireland. *J. Archaeol. Sci.*, 11, 71-80.

Edwards, K.J. and McIntosh, C.J. 1988. Improving the detection rate of cereal-type pollen grains from *Ulmus* decline and earlier deposits from Scotland. *Pollen et Spores*, 30, 179-188.

Edwards, K.J., McIntosh, C.J. and Robinson, D.E. 1986. Optimising the detection of cereal-type pollen grains in pre-elm decline deposits. *Circaea*, 4, 11-13.

Edwards, K.J. and Ralston, I. 1984. Postglacial hunter-gatherers and vegetational history in Scotland. *Proc. Soc. Antiq. Scot.*, 114, 15-34.

Erdtman, G. 1928. Studies in the postarctic history of the forests of north-western Europe. I. Investigations in the British Isles. *Geol. Fören. Stockh. Förh.*, 50, 123-192.

Erdtman, G., Berglund, B. and Praglowski, J. 1961. *An introduction to a Scandinavian pollen flora.* Stockholm: Almqvist and Wiksell.

Evans, A.T. and Moore, P.D. 1985. Surface pollen studies of *Calluna vulgaris* (L.) Hull and their relevance to the interpretation of bog and moorland pollen diagrams. *Circaea*, 3, 173-178.

Evans, J.G. 1975. *The environment of early man in the British Isles.* London: Elek.

Faegri, K. 1988. Preface. In: Birks, H.H., Birks, H.J.B., Kaland, P.E. and Moe, D. (eds). *The cultural landscape - past, present and future.* Cambridge: Cambridge University Press. pp. 1-4.

Faegri, K. and Iversen, J. 1975. *Textbook of pollen analysis.* 3rd ed. Oxford: Blackwell Scientific Publications.

Fairburn, A. 1937. Excavation of a medieval site on Donald's Isle Loch Doon, Ayrshire. *Proc. Soc. Antiq. Scot.*, 71, 323-333.

Florin, M.-B. 1958. Pollen analytical evidence of prehistoric agriculture at Mogetorp Neolithic settlement. In: Florin, S. *Vråkulturen.* Stockholm: Almqvist and Wiksell.

Flower, R.J. and Battarbee, R.W. 1983. Diatom evidence for recent acidification of two Scottish lochs. *Nature*, 305, 130-133.

Forman, R.T.T. and Godron, M. 1986. *Landscape ecology.* New York: Wiley and Sons.

Forni, G. 1984. From pyrophytic to domesticated plants: the palaeontological-linguistic evidence for a unitary theory on the origin of plant and animal domestication. In: van Zeist, W. and Casparie, W.A. (eds). *Plants and ancient man. Studies in palaeoethnobotany.* Rotterdam: Balkema. pp. 131-139.

Fraser, G.K. and Godwin, H. 1955. Two Scottish pollen diagrams: Carnwath Moss, Lanarkshire, and Strichen Moss, Aberdeenshire. Data for the study of post-glacial history. XVII. *New Phytol.*, 54, 216-221.

Garbett, G.G. 1981. The elm decline: the depletion of a resource. *New Phytol.*, 88, 573-585.

Gardiner, C.I. and Reynolds, S.H. 1932. The Loch Doon 'granite' area, Galloway. *Q. J. Geol. Soc. Lond.*, 88, 1-34.

Gillespie, R., Gowlett, J.A.J., Hall, E.T. Hedges, R.E.M. and Perry, C. 1985. Radiocarbon dates from the Oxford AMS system: archaeometry datelist 2. *Archaeometry*, 27, 237-246.

Gillespie, R. 1986. *Radiocarbon user's handbook.* Oxford: Oxford Univ. Committee for Archaeology. Monograph No. 3.

Gimingham, C.H. 1964. Dwarf shrub heaths. In: Burnett, J.H. (ed). *The vegetation of Scotland.* Edinburgh: Oliver and Boyd. pp. 232-287

Goddard, A. 1971. *Studies of the vegetational changes associated with the initiation of blanket-peat accumulation in north-east Ireland.* Unpub. Ph.D. thesis. Queen's Univ. of Belfast.

Godwin, H. 1933. British Maglemosian harpoon sites. *Antiquity*, 7, 36-48.

Godwin, H. 1965. The beginnings of agriculture in northwest Europe. In: Hutchinson, J. (ed). *Essays in crop evolution.* London: Cambridge Univ. Press. pp. 1-22.

Godwin, H. 1975. *The history of the British flora.* 2nd ed. London: Cambridge Univ. Press.

Godwin, H., Walker, D. and Willis, I.H. 1957. Radiocarbon dating and post-glacial vegetational history. *Proc. R. Soc. Lond. Ser. B*, 147, 352-366.

Göransson, H. 1987. Man and the forests of nemoral broad-leafed trees during the Stone Age. *Striae*, 24, 143-152.

Greig, D.C. 1971. *The south of Scotland.* 3rd ed. British Regional Geology. Edinburgh: HMSO.

Grigson, C. 1981a. The Mesolithic. In: Simmons, I.G. and Tooley, M.J. (eds). *The environment in British prehistory.* London: Duckworth. pp. 82-124.

Grigson, C. 1981b. The Neolithic. In: Simmons, I.G. and Tooley, M.J. (eds). *op. cit.* (Grigson 1981a). pp. 125-209.

Groenman-van Waateringe, W. 1983. The early agricultural utilization of the Irish landscape: the last word on the elm decline? In: Reeves-Smyth, T. and Hamond, F. (eds). *Landscape archaeology in Ireland.* Oxford: British Archaeological Reports, Br. Ser., 116. pp. 217-232.

Grosse-Brauckmann, G. 1972. Über pflanzliche Makrofossilien mitteleuropäischer Torfe. *Telma*, 2, 19-55.

Haggart, B.A. 1988. A review of radiocarbon dates on peat and wood from Holocene coastal sedimentary sequences in Scotland. *Scott. J. Geol.*, 24, 125-144.

Hall, S.A. 1981. Deteriorated pollen grains and the interpretation of Quaternary pollen diagrams. *Rev. Palaeobot. Palynol.*, 32, 193-206.

Havinga, A.J. 1984. A 20-year experimental investigation into the corrosion susceptibility of pollen and spores in various soil types. *Pollen et Spores* , 26, 541-558.

Henshall, A.S. 1974. Scottish chambered tombs and long mounds. In: Renfrew, C. (ed). *British prehistory*. London: Duckworth. pp. 134-164.

Higgs, E.S. and Jarman, M.R. 1969. The origins of agriculture: a reconsideration. *Antiquity*, 43, 31-41.

Hill, G. 1984. *Tunnel and dam - the story of the Galloway hydros*. Glasgow: South of Scotlamd Electricity Board.

Hirons, K.R. and Edwards, K.J. 1986. Events at and around the first and second *Ulmus* declines: palaeoecological investigations in Co. Tyrone, Northern Ireland. *New Phytol.*, 104, 131-153.

Hogg, A.H.A. 1975. *Hillforts of Britain*. London: Hart-Davis, MacGibbon.

Holland, C.H. *et al.* 1978. *a guide to stratigraphic procedure*. Geological Society of London Special Report No. 10.

Hughes, I. 1988. Megaliths: space, time and the landscape - a view from the Clyde. *Scott. Archaeol. Rev.*, 5, 41-56.

Hulme, P.D. 1980. The classification of Scottish peatlands. *Scott. geogr. Mag.*, 96, 46-50.

Hulme, P.D. and Shirriffs, J. 1985. Pollen analysis of a radiocarbon-dated core from North Mains, Strathallan, Perthshire. *Proc. Soc. Antiq. Scot.*, 115, 105-113.

Hunt, D. 1987. *Early farming communities in Scotland. Aspects of economy and settlement 4500-1250 B.C.* Oxford: British Archaeological Reports, Br. Ser., 159 (i and ii).

Huntley, B. and Birks, H.J.B. 1983. *An atlas of past and present pollen maps for Europe: 0-13000 years ago*. Cambridge: Cambridge University Press.

Innes, J.B. 1981. *Environmental alteration by Mesolithic communities in the North York Moors*. Unpub. M.Phil. thesis. Univ. of Durham.

Innes, J.B. and Simmons, I.G. 1988. Disturbance and diversity: floristic changes associated with pre-elm decline woodland recession in north-east Yorkshire. In: Jones, M. (ed). *Archaeology and the flora of the British Isles*. Oxford: Oxford Univ. Committee for Archaeology, Monograph No. 14. pp. 7-20.

Iversen, J. 1941. Landnam i Danmarks Stenalder. Land occupation in Denmark's Stone Age. *Danm. Geol. Unders. II. Ser. No. 66*. 68pp.

Iversen, J. 1949. The influence of prehistoric man on vegetation. *Danm. Geol. Unders. IV. Ser.*, 3(6). 25pp.

Iversen, J. 1956. Forest clearance in the Stone Age. *Sci. Am.*, 194, 36-41.

Iversen, J. 1960. Problems of the early post-glacial forest development in Denmark. *Danm. Geol. Unders. IV. Ser.*, 4(3). 32pp.

Iversen, J. 1973. The development of Denmark's nature since the last glacial. Trans. M. Robson. *Danm. Geol. Unders. V. Ser. No. 7-C.* 126pp.

Jacobi, R.M. 1978. Population and landscape in Mesolithic lowland Britain. In: Limbrey, S. and Evans, J.G. (eds). *The effect of man on the landscape: the Lowland Zone.* London: Council for British Archaeology, Res. Rep. 21. pp. 75-85.

Jacobi, R.M. 1982. When did man come to Scotland? *Mesolithic Miscellany*, 3, 8.

Jacobi, R.M., Tallis, J.H. and Mellars, P.A. 1976. The southern Pennine Mesolithic and the ecological record. *J. Archaeol. Sci.*, 3, 307-320.

Jacobson, G.L. and Bradshaw, R.H.W. 1981. The selection of sites for palaeovegetational studies. *Quat. Res.*, 16, 80-96.

Janssen, C.R. 1966. Recent pollen spectra from the deciduous and coniferous forests of northeastern Minnesota: a study of pollen dispersal. *Ecology*, 44, 804-825.

Janssen, C.R. 1973. Local and regional pollen deposition. In: Birks, H.J.B. and West, R.G. (eds). *Quaternary plant ecology.* 14th Symposium of the British Ecological Society. Oxford: Blackwell Scientific Publications. pp. 31-42.

Janssen, C.R. 1986. The use of local pollen indicators and of the contrast between regional and local pollen values in the assessment of human impact on vegetation. In: Behre, K.-D. (ed). *Anthropogenic indicators in pollen diagrams.* Rotterdam: Balkema. pp. 203-208.

Jardine, W.G. 1959. River development in Galloway. *Scott. geog. Mag.*, 75, 65-74.

Jardine, W.G. 1966. Landscape evolution in Galloway. *Trans. Dumfries. Galloway Nat. Hist. Antiq. Soc.*, 43, 1-13.

Jardine, W.G. 1975a. Chronology of Holocene marine transgression and regression in south-western Scotland. *Boreas*, 4, 173-196.

Jardine, W.G. 1975b. The determination of former sea levels in areas of large tidal range. In: Suggate, R.P. and Creswell, M.M. (eds). *Quaternary studies.* Wellington: R. Soc. New Zealand. Bull. 13. pp. 163-168.

Jardine, W.G. 1980. Holocene raised coastal sediments and former shorelines of Dumfriesshire and eastern Galloway. *Trans. Dumfries. Galloway Nat. Hist. Antiq. Soc.*, 55, 1-59.

Jardine, W.G. and Morrison, A. 1976. The archaeological significance of Holocene coastal deposits in south-western Scotland. In: Davidson, D.A. and Shackley, M.L. (eds). *Geoarchaeology: earth science and the past.* London: Duckworth. pp. 175-195.

Jones, M. 1986. *England before Domesday.* London: Batsford.

Jones, R.L. 1976a. The activities of Mesolithic man: further palaeobotanical evidence from north-east Yorkshire. In: Davidson, D.A. and Shackley, M.A. (eds). *Geoarchaeology: earth science and the past.* London: Duckworth. pp. 355-366.

Jones, R.L. 1976b. Late Quaternary vegetational history of the North York Moors. IV. Seamer Carrs. *J. Biogeogr.*, 3, 397-406.

Jones, R.L. 1988. The impact of early man on coastal plant communities in the British Isles. In: Jones, M. (ed). Archaeology and the flora of the British Isles. Oxford: Oxford Univ. Committee for Archaeology, Monograph No.14. pp. 96-106.

Jones, R.L., Cundill, P.R. and Simmons, I.G. 1979. Archaeology and palaeobotany on the North York Moors and their environs. *Yorks. Archaeol. J.*, 51, 15-22.

Jones, V.J., Stevenson, A.C. and Battarbee, R.W. 1986. Lake acidification and the land-use hypothesis: a mid-post-glacial analogue. *Nature*, 322, 157-158.

Jones, V.J., Stevenson, A.C. and Battarbee, R.W. 1989. Acidification in Galloway, south west Scotland: A diatom and pollen study of the post-glacial history of the Round Loch of Glenhead. *J. Ecol.*, 77, 1-23.

Keef, P.A.M., Wymer, J.J. and Dimbleby, G.W. 1965. A Mesolithic site on Iping Common, Sussex, England. *Proc. Prehist. Soc.*, 31, 85-92.

Kinnes, I. 1985. Circumstance not context: the Neolithic of Scotland as seen from outside. *Proc. Soc. Antiq. Scot.*, 115, 15-57.

Klein, J., Leman, J.C. Damon, P.E. and Ralph, E.K. 1982. Calibration of radiocarbon dates: tables based on the consensus data of the Workshop on calibrating the radiocarbon timescale. *Radiocarbon*, 24, 103-150.

Knox, E.M. 1954. Pollen analysis of a peat at Kingsteps Quarry, Nairn. *Trans. Bot. Soc. Edinb.*, 36, 224-229.

Lacaille, A.D. 1954. *The Stone Age in Scotland.* London: Oxford Univ. Press.

Lawson, T. and Bonsall, C. 1986. Early settlement in Scotland: the evidence from Reindeer Cave, Assynt. *Quat. Newsletter*, 49, 1-7.

Limbrey, S. 1975. *Soil science and archaeology.* London: Academic Press.

MacArthur, W. 1952. *The River Doon.* London: Cassell.

Mackie, E.W. 1964. New excavations on the Monamore Neolithic chambered cairn, Lamlash, Isle of Arran in 1961. *Proc. Soc. Antiq. Scot.*, 97, 1-34.

Mackie, E.W. 1984. Note. A late single-piece canoe from Loch Doon, Ayrshire. *Glasgow Archaeol. J.*, 11, 132-133.

Macky, J. 1722. *A journey through Scotland.* London: Pemberton and Hooke.

Macphail, R.I. and Scaife, R.G. 1987. The geographical and environmental background. In: Bird, J. and Bird, D.G. (eds). *The archaeology of Surrey to 1540.* Guildford: Surrey Archaeol. Soc. pp. 31-51.

Maguire, D.J. 1987. Past and present local variability in environmental phenomena. In: Balaam, N.D., Levitan, B. and Straker, V. (eds). *Studies in palaeoeconomy and environment in south west England.* Oxford: British Archaeological Reports, Br. Ser., 181. pp.89-101.

Maguire, D.J. and Caseldine, C.J. 1985. The former distribution of forest and moorland on northern Dartmoor. *Area*, 17, 193-203.

Maher, L.J. 1981. Statistics for microfossil concentration measurements employing samples spiked with marker grains. *Rev. Palaeobot. Palynol.*, 32, 153-191.

Mallik, A.U., Gimingham, C.H. and Rahman, A.A. 1984. Ecological effects of heather burning. I. Water infiltration, moisture retention and porosity of surface soil. *J. Ecol.*, 72, 767-776.

Mamakowa, K. 1968. Lille Bukken and Lerøy - two pollen diagrams from western Norway. *Årbok for Universitetet i Bergen. Mat.-Naturv. Ser.* No.4. 42pp.

Masters, L.J. 1973. The Lochill long cairn. *Antiquity*, 47, 96-100.

Masters, L.J. 1981. A Mesolithic hearth at Redkirk Point, Gretna. *Trans. Dumfries. Galloway Nat. Hist. Antiq. Soc.*, 56, 111-114.

McCormick, A. 1974. An appreciation of the Galloway Forest Park. In: Edlin, H.L. (ed). *The Galloway Forest Park.* Forestry Commission guide. Edinburgh: HMSO. pp. 1-7.

McIntosh, C.J. 1986. *Palaeoecological investigations of early agriculture on the Isle of Arran and the Kintyre peninsula.* Unpub. M.Sc. thesis. Univ. of Birmingham.

McVean, D.N. 1955a. Ecology of *Alnus glutinosa* (L.) Gaertn. II. Seed distribution and germination. *J. Ecol.*, 43, 61-71.

McVean, D.N. 1955b. Ecology of *Alnus glutinosa* (L.) Gaertn. I. Fruit formation. *J. Ecol.*, 43, 46-60.

McVean, D.N. 1956a. Ecology of *Alnus glutinosa* (L.) Gaertn. VI. Post-glacial history. *J. Ecol.*, 44, 331-333.

McVean, D.N. 1956b. Ecology of *Alnus glutinosa* (L.) Gaertn. V. Notes on some British alder populations. *J. Ecol.*, 44, 321-330.

McVean, D.N. 1964. Woodland and scrub. In: Burnett, J.H. (ed). *The vegetation of Scotland.* Edinburgh: Oliver and Boyd. pp. 144-167.

McVean, D.N. and Ratcliffe, D.A. 1962. *Plant communities of the Scottish Highlands.* Monograph of the Nature Conservancy No. 1. London: HMSO.

Mellars, P.A. 1974. The Palaeolithic and Mesolithic. In: Renfrew, C. (ed). *British prehistory.* London: Duckworth. pp. 41-99.

Mellars, P.A. 1975. Ungulate populations, economic patterns, and the Mesolithic landscape. In: Evans, J.G., Limbrey, S. and Cleere, H. (eds). *The effect of man on the landscape: the Highland Zone.* London: Council for British Archaeology, Res. Rep. 11. pp. 49-56.

Mellars, P.A. 1976a. Fire ecology, animal populations and man: a study of some ecological relationships in prehistory. *Proc. Prehist. Soc.*, 42, 15-45.

Mellars, P.A. 1976b. Settlement patterns and industrial variability in the British Mesolithic. In: Sieveking, G. de G., Longworth, I. and Wilson, K.E. (eds). *Problems in economic and social archaeology.* London: Duckworth. pp. 375-399.

Mellars, P.A. and Reinhardt, S.C. 1978. Patterns of Mesolithic land-use: a geological perspective. In: Mellars, P.A. (ed). *The early postglacial settlement of Europe.* London: Duckworth. pp. 243-293.

Mercer, J. 1972. Mesolithic and Bronze Age camps, 75-26 ft OD, N Carn, Isle of Jura. *Proc. Soc. Antiq. Scot.*, 104, 1-22.

Mercer, J. 1974. New C14 dates from the Isle of Jura, Argyll. *Antiquity*, 48, 65-66.

Mercer, J. 1975. Glenbatrick Waterhole, a microlithic site on the Isle of Jura. *Proc. Soc. Antiq. Scot.*, 105, 9-32.

Mercer, J. 1981. Lussa Wood I: the late-glacial and early post-glacial occupation of Jura. *Proc. Soc. Antiq. Scot.*, 110, 1-31.

Merryfield, D.L. and Moore, P.D. 1974. Prehistoric human activity and blanket peat initiation on Exmoor. *Nature*, 250, 439-441.

Middeldorp, A.A. 1986. Functional palaeoecology of the Hahnenmoor raised bog ecosystem - a study of vegetation history, production and decomposition by means of pollen density dating. *Rev. Palaeobot. Palynol.*, 49, 1-73.

Miles, J. 1987. Vegetation succession: past and present perceptions. In: Gray, A.J., Crawley, M.J. and Edwards, P.J. (eds). *Colonisation, succession and stabiltiy.* The 26th Symposium of the British Ecological Society. Oxford: Blackwell Scientific Publications. pp. 1-29.

Mitchell, F.J.G. 1988. The vegetational history of the Killarney oakwoods, S W Ireland: evidence from fine spatial resolution pollen analysis. *J. Ecol.*, 76, 415-436.

M'Myne, D. 1792. Parish of Damelingtoun. In: Sinclair, J. (ed). *The Statistical Account of Scotland.* Vol.VI. Ayrshire. Reissue 1981. Wakefield: EP Publishing. pp. 140-143.

Moar, N.T. 1969. Late Weichselian and Flandrian pollen diagrams from south-west Scotland. *New Phytol.*, 68, 433-467.

Molloy, K. and O'Connell, M. 1987. The nature of the vegetational changes at about 5000 B.P. with particular reference to the elm decline: fresh evidence from Connemara, western Ireland. *New Phytol.*, 106, 203-220.

Mook, W.G. and Waterbolk, H.T. 1985. *Radiocarbon dating.* Handbooks for archaeologists No.3. Strasbourg: European Science Foundation.

Moore, P.D. 1972. The initiation of peat formation and the development of peat deposits in mid-Wales. *Proc. 4th Int. Peat Congress Helsinki, I*, 89-100.

Moore, P.D. 1973. The influence of prehistoric cultures upon the initiation and spread of blanket bog in upland Wales. *Nature*, 241, 350-353.

Moore, P.D. 1975. Origin of blanket mires. *Nature*, 256, 267-269.

Moore, P.D. 1980. Resolution limits of pollen analysis as applied to archaeology. *MASCA J.*, 1(4), 118-120.

Moore, P.D. 1988. The development of moorlands and upland mires. In: Jones, M. (ed). *Archaeology and the flora of the British Isles.* Oxford: Oxford Univ. Committee for Archaeology, Monograph No. 14. pp. 116-122.

Moore, P.D., Evans, A.T. and Chater, M. 1986. Palynological and stratigraphic evidence for hydrological changes in mires associated with human activity. In: Behre, K.-E. (ed). *Anthropogenic indicators in pollen diagrams.* Rotterdam: Balkema. pp. 209-220.

Moore, P.D., Merryfield, D.L. and Price, M.R.D. 1984. The vegetation and development of blanket mires. In: Moore, P.D. (ed). *European mires.* London: Academic Press. pp.203-235.

Moore, P.D. and Webb, D.A. 1978. *An illustrated guide to pollen analysis.* London: Hodder and Stoughton.

Morrison, A. 1982. The Mesolithic period in south-west Scotland: a review of the evidence. *Glasgow Archaeol. J.*, 9, 1-14.

Morrison, I. 1985. *Landscape with lake dwellings. The crannogs of Scotland.* Edinburgh: Edinburgh Univ. Press.

Murray, J. and Pullar, L. 1910. *Bathymetrical survey of the Scottish fresh-water lochs.* Vol.5. Edinburgh: Challenger Office.

Myers, A.M. 1988. Scotland inside and outside of the British mainland Mesolithic. *Scott. Archaeol. Rev.*, 5, 23-33.

Narr, K.J. 1956. Early food-producing populations. In: Thomas, W.L. (ed). *Man's role in changing the face of the earth.* Chicago: Chicago Univ. Press. pp. 134-151.

Nichols, H. 1967. Vegetational change, shoreline displacement and the human factor in the late Quaternary history of south-west Scotland. *Trans. R. Soc. Edinb.*, 67, 145-187.

Núnèz, M.G. and Vuorela, I. 1979. A tentative evaluation of cultural pollen data in early agrarian development. *Suomen Museo 1978*, 5-36.

O'Connell, M. 1987. Early cereal-type pollen records from Connemara, western Ireland and their possible significance. *Pollen et Spores*, 29, 207-224.

O'Connell, M., Molloy, K. and Bowler, M. 1988. Post-glacial landscape evolution in Connemara, western Ireland with particular reference to woodland history. In: Birks, H.H., Birks, H.J.B., Kaland, P.E. and Moe, D. (eds). *The cultural landscape - past, present and future.* Cambridge: Cambridge Univ. Press. pp. 267-287.

Odum, E.P. 1971. *Fundamentals of ecology.* 3rd ed. Philadelphia: Saunders.

Oldfield, F. 1963. Pollen-analysis and man's role in the ecological history of the south-east Lake District. *Geografisker Annaler*, 45, 23-40.

Oldfield, F. 1970. The ecological history of Blelham Bog National Nature Reserve. In: Walker, D. and West, R.G. (eds). *Studies in the vegetational history of the British Isles.* London: Cambridge Univ. Press. pp. 141-157.

Olsson, I.U. 1986. Radiometric dating. In: Berglund, B.E. (ed). *Handbook of Holocene palaeoecology and palaeohydrology.* Chichester: Wiley and Sons. pp. 273-312.

Palmer, S. and Dimbleby, G.W. 1979. A Mesolithic habitation site on Winfrith Heath, Dorset. *Proc. Dorset Nat. Hist. Archaeol. Soc.*, 101, 27-50.

Patterson, W.A., III, Edwards, K.J. and Maguire, D.J. 1987. Microscopic charcoal as a fossil indicator of fire. *Quat. Sci. Rev.*, 6, 3-23.

Peck, R.M. 1973. Pollen budget studies in a small Yorkshire catchment. In: Birks, H.J.B. and West, R.G. (eds). *Quaternary plant ecology.* 14th Symposium of the British Ecological Society. Oxford: Blackwell Scientific Publications. pp. 43-60.

Pennington. W. 1964. Pollen analyses from the deposits of six upland tarns in the Lake District. *Philos. Trans. R. Soc. Lond. Ser. B*, 248, 205-244.

Pennington, W. 1970. Vegetational history in the north-west of England: a regional synthesis. In: Walker, D. and West, R.G. (eds). *Studies in the vegetational history of the British Isles.* London: Cambridge University Press. pp. 41-79.

Pennington, W. 1975. The effect of Neolithic man on the environment in north-west England: the use of absolute pollen diagrams. In: Evans, J.G., Limbrey, S. and Cleere, H. (eds). *The effect of man on the landscape: the Highland Zone.* London: Council for British Archaeology, Res. Rep. 11. pp. 74-86.

Pennington, W. 1986. Lags in the adjustment of vegetation to climate caused by the pace of soil development: evidence from Britain. *Vegetatio*, 67, 105-118.

Perry, I. and Moore, P.D. 1987. Dutch elm disease as an analogue of Neolithic elm decline. *Nature*, 326, 72-73.

Piggott. S. 1972. Excavation of the Dalladies long barrow, Fettercairn, Kincardineshire, *Proc. Soc. Antiq. Scot.*, 106, 23-47.

Pigott, C.D. and Huntley, J.P. 1978. Factors controlling the distribution of *Tilia cordata* at the northern limit of its geographical range. I. Distribution in north-west England. *New Phytol.*, 81, 429-441.

Pigott, C.D. and Walters, S.M. 1954. On the interpretation of the discontinuous distributions shown by certain British species of open habitats. *J. Ecol.*, 42, 95-116.

Pigott, M.E. and Pigott, C.D. 1959. Stratigraphy and pollen analysis of Malham Tarn and Tarn Moss. *Field Studies*, 1, 84-101.

Pilcher, J.R. and Smith, A.G. 1979. Palaeoecological investigations at Ballynagilly, a Neolithic and Bronze Age settlement in County Tyrone, Northern Ireland. *Philos. Trans. R. Soc. Lond. Ser. B*, 286, 345-369.

Preece, R.C., Coxon, P. and Robinson, S.E. 1986. New biostratigraphic evidence of the post-glacial colonization of Ireland and for Mesolithic forest disturbance. *J. Biogeogr.*, 13, 487-509.

Prentice, I.C. 1985. Pollen representation, source area and basin size: towards a unified theory of pollen analysis. *Quat. Res.*, 23, 76-86.

PSAS 1973. Donations to and purchases for the Museum 1969-70. No. 23. *Proc. Soc. Antiq. Scot.*, 102, 296.

Rackham, O. 1980. *Ancient woodland: its history, vegetation and uses in England.* London: Edward Arnold.

Rackham, O. 1986. *The history of the countryside.* London: Dent.

Rackham, O. 1988a. Wildwood. In: Jones, M. (ed). *Archaeology and the flora of the British Isles.* Oxford: Oxford Univ. Committee for Archaeology, Monograph No. 14. pp. 3-6.

Rackham, O. 1988b. Trees and woodland in a crowded landscape - the cultural landscape of the British Isles. In: Birks, H.H., Birks, H.J.B., Kaland, P.E. and Moe, D. (eds). *The cultural landscape - past, present and future.* Cambridge: Cambridge Univ. Press. pp. 53-77.

Radley, J., Tallis, J.H. and Switsur, V.R. 1974. The excavation of three 'narrow blade' Mesolithic sites in the southern Pennines, England. *Proc. Prehist. Soc.*, 40, 1-19.

Rankine, W.F., Rankine, W.M. and Dimbleby, G.W. 1960. Further excavations at a Mesolithic site at Oakhanger, Selborne, Hants. *Proc. Prehist. Soc.*, 26, 246-262.

Ranwell, D.S. 1972. *Ecology of salt marshes and sand dunes.* London: Chapman and Hall.

Ratcliffe, D.A. 1964. Mires and bogs. In: Burnett, J.H. (ed). *The vegetation of Scotland.* Edinburgh: Oliver and Boyd. pp. 426-478.

Ratcliffe, D.A. 1977a. *A Nature Conservation review.* Vol.2. Site accounts. Cambridge: Cambridge Univ. Press.

Ratcliffe, D.A. 1977b. *op. cit.* Vol.1.

Ratcliffe, D.A. and Walker, D. 1958. The Silver Flowe, Galloway, Scotland. *J. Ecol.*, 46, 407-445.

Rawitscher, F. 1945. The hazel period in the post-glacial development of forests. *Nature*, 156, 302-303.

RCHAMS. 1914. Royal Commission on the Ancient and Historical Monuments of Scotland. *Fifth report and inventory of monuments and constructions in Galloway. Vol. II. County of the Stewartry of Kirkudbrightshire.* Edinburgh.

Richardson, N. 1988. Reported in: *Bio News.* No. 23. The newsletter of the Biogeography Study Group. p. 8.

Rivet, A. 1966. *The Iron Age in Britain.* Edinburgh: Edinburgh University Press.

Roberts, B.K., Turner, J. and Ward, P.F. 1973. Recent forest history and land use in Weardale, northern England. In: Birks, H.J.B. and West, R.G. (eds). *Quaternary plant ecology*. 14th Symposium of the British Ecological Society. Oxford: Blackwell Scientific Publications. pp. 207-221.

Robinson, D.E. 1981. *The vegetational and land use history of the west of Arran, Scotland*. Unpub. Ph.D. thesis. Univ. of Glasgow.

Robinson, D.E. 1983a. Prehistoric man and environment on the west of Arran, Scotland. In: Proudfoot, B. (ed). *Site, environment and economy*. Oxford: British Archaeological Reports, Int. Ser., 173. pp. 57-59.

Robinson, D.E. 1983b. Possible Mesolithic activity in the west of Arran: evidence from peat deposits. *Glasgow Archaeol. J.*, 10, 1-10.

Robinson, D.E. 1987. Investigations into the Aukhorn peat mounds, Keiss, Caithness: pollen, plant macrofossil and charcoal analysis. *New Phytol.*, 106, 185-200.

Robinson, D.E. and Dickson, J.H. 1988. Vegetational history and land use: a radiocarbon-dated diagram from Machrie Moor, Arran, Scotland. *New Phytol.*, 109, 223-235.

Rowell, T.K. and Turner, J. 1985. Litho-, humic- and pollen stratigraphy at Quick Moss, Northumberland. *J. Ecol.*, 73, 11-25.

Rowley-Conwy, P. 1982. Forest grazing and clearance in temperate Europe with special reference to Denmark: an archaeological view. In: Bell, M. and Limbrey, S. (eds). *Archaeological aspects of woodland ecology*. Oxford: British Archaeological Reports, Int. Ser., 146. pp. 199-215.

Rull, V. 1987. A note on pollen counting in palaeoecology. *Pollen et Spores*, 29, 471-480.

Rymer, L. 1976. The history and ethnobotany of bracken. *Bot. J. Linnean Soc.*, 73, 151-176.

Scaife, R.G. 1988. The elm decline in the pollen record of south east England and its relationship to early agriculture. In: Jones, M. (ed). *Archaeology and the flora of the British Isles*. Oxford: Oxford Univ. Committee for Archaeology, Monograph No. 14. pp. 21-33.

Schadla-Hall, R.T. 1987. Early man in the eastern vale of Pickering. In: Ellis, S. (ed). *East Yorkshire. Field guide*. Cambridge: Quaternary Research Association. pp. 22-30.

Scott, J.G. 1966. *South-west Scotland*. Regional Archaeologies. London: Cory, Adams and Mackay.

Shennan, I. and Innes, J.B. 1986. Late Devensian and Flandrian environmental changes at the Dod, Borders Region. *Scott. Archaeol. Rev.*, 4, 17-26.

Simmons, I.G. 1969a. Evidence for vegetation changes with Mesolithic men in Britain. In: Ucko, P.J. and Dimbleby, G.W. (eds). *The domestication of plants and animals.* London: Duckworth. pp. 111-119.

Simmons, I.G. 1969b. Pollen diagrams from the North York Moors. *New Phytol.*, 68, 807-827.

Simmons, I.G. 1975a. Towards an ecology of Mesolithic man in the uplands of Great Britain. *J. Archaeol. Sci.*, 2, 1-15.

Simmons, I.G. 1975b. The ecological setting of Mesolithic man in the Highland Zone. In: Evans, J.G., Limbrey, S. and Cleere. H. (eds). *The effect of man on the landscape: the Highland Zone.* London: Council for British Archaeology, Res. Rep. 11. pp. 57-63.

Simmons, I.G. 1979. Late Mesolithic societies and the environment of the uplands of England and Wales. *University of London Institute of Archaeology Bull. 16.* pp. 111-129.

Simmons, I.G. 1983. Mesolithic man and the environment in upland Britain: a historiographic approach. In: Briggs, D.J. and Waters, R.S. (eds). *Studies in Quaternary geomorphology.* Norwich: Geo Books. pp. 215-222.

Simmons, I.G. 1989. *Changing the face of the earth.* Oxford: Blackwell.

Simmons, I.G., Atherden, M.A. and Jones, R.L. 1975. Inorganic layers in soligenous mires of the North Yorkshie Moors. *J. Biogeogr.*, 2, 49-56.

Simmons, I.G. and Innes, J.B. 1981. Tree remains in a North York Moors peat profile. *Nature*, 294, 76-78.

Simmons, I.G. and Innes, J.B. 1985. Late Mesolithic land-use and its impact in the English uplands. In: Smith, R.T. (ed). *The biogeographical impact of land-use change: collected essays.* Leeds: Biogeography Study Group, Biogeogr. Monograph 2. pp. 7-17.

Simmons, I.G. and Innes, J.B. 1987. Mid-Holocene adaptations and later Mesolithic forest disturbance in northern England. *J. Archaeol. Sci.*, 14, 383-403.

Simmons, I.G. and Innes, J.B. 1988a. Late Quaternary vegetational history of the North York Moors. VIII. Correlation of Flandrian II litho- and pollen stratigraphy at North Gill, Glaisdale Moor. *J. Biogeogr.*, 15, 249-272.

Simmons, I.G. and Innes, J.B. 1988b. Late Quaternary vegetational history of the North York Moors. IX. Numerical analysis and pollen concentration analysis of Flandrian II peat profiles from North Gill, Glaisdale Moor. *J. Biogeogr.*, 15, 273-297.

Simmons, I.G. and Innes, J.B. 1988c. Late Quaternary vegetational history of the North York Moors. X. Investigations on East Bilsdale Moor. *J. Biogeogr.*, 15, 299-324.

Simmons, I.G., Rand, I.J. and Crabtree, K. 1983. A further pollen analytical study of the Blacklane peat section on Dartmoor, England. *New Phytol.*, 94, 655-667.

Simmmons, I.G., Rand, I.J. and Crabtree, K. 1987. Dozmary Pool, Bodmin Moor, Cornwall: a new radiocarbon dated pollen profile. In: Balaam, N.D., Levitan, B. and Straker, V. (eds). *Studies in palaeoeconomy and environment in south west England.* Oxford: British Archaeological Reports, Br. Ser., 181. pp. 125-133.

Simmons, I.G., Turner, J. and Innes, J.B. 1989. An application of fine-resolution pollen analysis to later Mesolithic peats of an English upland. In: Bonsall, C. (ed). *Proc. IIIrd Conf. of the Mesolithic in Europe, Edinburgh.* Edinburgh: Donald.

Sims, R.E. 1973. The anthropogenic factor in East Anglian vegetational history: an approach using A.P.F. techniques. In: Birks, H.J.B. and West, R.G. (eds). *Quaternary plant ecology.* 14th Symposium of the British Ecological Society. Oxford: Blackwell Scientific Publications. pp. 223-236.

Sims, R.E. 1978. Man and vegetation in Norfolk. In: Limbrey, S. and Evans, J.G. (eds). *The effect of man on the landscape: the Lowland Zone.* London: Council for British Archaeology, Res. Rep. 21. pp. 57-62.

Spence, D.H.N. 1964. The macrophytic vegetation of freshwater lochs, swamps and associated fens. In: Burnett, J.H. (ed). *The vegetation of Scotland.* Edinburgh: Oliver and Boyd. pp. 306-425.

Smith, A.G. 1961. The Atlantic - Sub-boreal transition. *Proc. Linnean Soc. Lond.*, 172, 38-49.

Smith, A.G. 1970. The influence of Mesolithic and Neolithic man on British vegetation. In: Walker, D. and West, R.G. (eds). *Studies in the vegetational hstory of the British Isles.* London: Cambridge Univ. Press.

Smith, A.G. 1981a. The Neolithic. In: Simmons, I.G. and Tooley, M.J. (eds). *The environment of British prehistory.* London: Duckworth. pp. 125-209.

Smith, A.G. 1981b. Palynology of a Mesolithic-Neolithic site in County Antrim, N. Ireland. *Proc. IVth Int. Palynol. Conf. Lucknow (1976-77)*, 3, 248-257.

Smith, A.G. 1984. Newferry and the Boreal-Atlantic Transition. *New Phytol.*, 98, 35-55.

Smith, A.G. and Cloutman. E.W. 1988. Reconstruction of Holocene vegetation history in three dimensions at Waun Fignen-Felen, an upland site in south Wales. *Philos. Trans. R. Soc. Lond. Ser. B*, 322, 159-219.

Smith, A.G. and Pilcher, J.R. 1973. Radiocarbon dates and vegetational history of the British Isles. *New Phytol.*, 72, 903-914.

Smith, I.F. 1974. The Neolithic. In: Renfrew, C. (ed). *British prehistory.* London: Duckworth. pp. 100-136.

Smith, R.T. 1982. *Towards a more holistic view of British vegetation history.* Leeds: School of Geography, Univ. of Leeds, Working Paper 328. 51pp.

Squires, R. 1977-78. The pollen analysis of a short core from Burnswark Hill. In: Jobey, G. Burnswark Hill, Dumfriesshire. pp. 99-104. *Trans. Dumfries. Galloway Nat. Hist. Antiq. Soc.*, 53, 57-104.

Statistical Account of Scotland 1792. See e.g. Sinclair (1981) under M'Myne (1792) *op. cit.*.

Stell, G. 1986. *Exploring Scotland's heritage. Dumfries and Galloway.* Royal Commission on the Ancient and Historical Monuments of Scotland. Edinburgh: HMSO.

Stevenson, J.B. 1975. Survival and discovery. In: Evans, J.G., Limbrey, S. and Cleere, H. (eds). *The effect of man on the landscape: the Highland Zone.* London: Council for British Archaeology, Res. Rep. 11. pp. 104-108.

Stevenson, J.B. 1985. *Exploring Scotland's heritage. The Clyde Estuary and Central Region.* Royal Commission on Ancient and Historical Monuments of Scotland. Edinburgh: HMSO.

Stewart, O.C. 1956. Fire as the first great force employed by man. In: Thomas, W.L. (ed). *Man's role in changing the face of the earth.* Chicago: Chicago Univ. Press.

Stockmarr, J. 1971. Tablets with spores in absolute pollen analysis. *Pollen et Spores*, 13, 615-621.

Stuart, J. 1868. Notices of a group of artificial islands in the loch of Dowalton, Wigtownshire and of other artificial islands or 'crannogs' throughout Scotland. *Proc. Soc. Antiq. Scot.* (1864-1866), 6, 114-178.

Sturludottir, S.A. and Turner, J. 1985. The elm decline at Pawlaw Mire: an anthropogenic interpretation. *New Phytol.*, 99, 323-329.

Swain, A.M. 1973. A history of fire and vegetation in northeastern Minnesota as recorded in lake sediments. *Quat. Res.*, 3, 383-396.

Switsur, V.R. 1981. Cambridge University natural radiocarbon measurements XV. *Radiocarbon*, 23, 81-93.

Tallis, J.H. 1975. Tree remains in southern Pennine peats. *Nature*, 256, 482-484.

Tallis, J.H. and Switsur, V.R. 1983. Forest and moorland in the southern Pennine uplands in the Mid-Flandrian period. I. Macrofossil evidence of the former forest cover. *J. Ecol.*, 71, 585-600.

Tansley, A.G. 1949. *The British Islands and their vegetation.* London: Cambridge Univ. Press.

Tansley, A.G. 1968. *Britain's green mantle: past, present and future.* 2nd ed. (rev. by M.C.F. Proctor). London: George Allen and Unwin.

Tauber, H. 1965. Differential pollen dispersion and the interpretation of pollen diagrams. *Danm. Geol. Unders., Ser. 2,* 89, 1-69.

Tauber, H. 1967. Investigation of the mode of pollen transfer in forested areas. *Rev. Palaeobot. Palynol.*, 3, 277-286.

Tauber, H. 1977. Investigations of aerial pollen tansport in a forested area. *Dansk. Bot. Arkiv.*, 32(1), 5-121.

Taylor, J.A. 1975. The role of climatic factors in environmental and cultural changes in prehistoric times. In: Evans, J.G., Limbrey, S. and Cleere, H. (eds). *The effect of man on the landscape: the Highland Zone.* London: Council for British Archaeology, Res. Rep. 11. pp. 6-19.

Ten Hove, H.A. 1968. The *Ulmus* fall at the transition Atlanticum/Subboreal in pollen diagrams. *Palaeogeogr., Palaeoclimatol., Palaeoecol.*, 5, 359-369.

Thomas, J. 1988. Neolithic explanations revisited: the Mesolithic-Neolithic transition in Britain and south Scandinavia. *Proc. Prehist. Soc.*, 54, 59-66.

Tinsley, H.M. 1975. The former woodland of the Nidderdale Moors (Yorkshire) and the role of early man in its decline. *J. Ecol.*, 63, 310-322.

Tinsley, H.M. 1976. Cultural influences on Pennine vegetation with particular reference to North Yorkshire. *Trans. Inst. Br. Geogr., New Ser.*, 1, 310-322.

Tinsley, H.M. 1981. The Bronze Age. In: Simmons, I.G. and Tooley, M.J. (eds). *The environment in British prehistory.* London: Duckworth. pp. 210-249.

Tinsley, H.M. and Smith, R.T. 1974. Surface pollen studies across a woodland/heath transition and their application to the interpretation of pollen diagrams. *New Phytol.*, 73, 547-565.

Tolonen, M. 1985. Palaeoecolgical record of local fire history from a peat deposit in SW Finland. *Ann. Bot. Fennici*, 22, 15-29.

Tolonen, M. 1986. Charred particle analysis. In: Berglund, B.E. (ed). *Handbook of palaeoecology and palaeohydrology.* Chichester: Wiley and Sons. pp. 485-496.

Tolonen, M. 1987. Primary and secondary forest successions reflected in a late Holocene pollen sequence from an upland mire near the SW coast of Finland. *Ann. Bot. Fennici*, 24, 97-109.

Tooley, M.J., Rackham, D.J. and Simmons, I.G. 1982. A red deer (*Cervus elephus* L.) skeleton and the palaeoecology of the site. *J. Archaeol. Sci.*, 6, 365-376.

Troels-Smith, J. 1955. Karakterisering af løse jordater. Characterisation of unconsolidated sediments. *Danm. Geol. Unders. IV. Ser.*, 3(10), 1-73.

Troels- Smith, J. 1960. Ivy, mistletoe and elm. Climatic indicators - fodder plants. *Damn. Geol. Unders. IV. Ser.*, 4, 1-32.

Turner, J. 1964a. Surface sample analysis from Ayrshire, Scotland. *Pollen et Spores*, 6, 583-592.

Turner, J. 1964b. The anthropogenic factor in vegetational history. I. Tregaron and Whixall Mosses. *New Phytol.*, 63, 73-90.

Turner, J. 1965. A contribution to the history of forest clearance. *Proc. R. Soc. Lond., Ser. B*, 161, 343-353.

Turner, J. 1970. Post-Neolithic disturbance of British vegetation. In: Walker, D. and West, R.G. (eds). *Studies in the vegetational history of the British Isles.* London: Cambridge Univ. Press. pp. 97-116.

Turner, J. 1975. The evidence for land use by prehistoric communities: the use of three-dimensional pollen diagrams. In: Evans, J.G. and Limbrey, S. (eds). *The effect of man on the landscape: the Highland Zone.* London: Council for British Archaeology, Res. Rep. 11. pp. 86-95.

Turner, J. 1981. The Iron Age. In: Simmons, I.G. and Tooley, M.J. (eds). *The environment in British prehistory.* London: Duckworth. pp. 250-281.

Turner, J. and Hodgson, J. 1983. Studies in the vegetational history of the northern Pennines. III. Variations in the composition of the mid-Flandrian forests. *J. Ecol.*, 71, 95-118.

van Geel, B. 1978. A palaeoecolgical study of Holocene peat bog sections in Germany and the Netherlands. *Rev. Palaeobot. Palynol.*, 25, 1-120.

Vita-Finzi, C. and Higgs, E.S. 1970. Prehistoric economy in the Mount Carmel area of Palestine: site catchment analysis. *Proc. Prehist. Soc.*, 36, 1-37.

Vorren, K.-D. 1986. The impact of early agriculture on the vegetation of northern Norway. A discussion of anthropogenic indicators in biostratigraphical data. In: Behre, K.-D. (ed). *Anthropogenic indicators in pollen diagrams.* Rotterdam: Balkema. pp. 1-18.

Vuorela, I. 1980. Microspores of *Isoetes* as indicators of human settlement in pollen diagrams. *Memoranda Soc. Fauna Flora Fennica*, 56, 13-19.

Vuorela, I. 1983. Field erosion by wind as indicated by fluctuations in the ash content of *Sphagnum* peat. *Bull. Geol. Soc. Finland*, 55, 25-33.

Walker, D. 1956. A site at Stump Cross, near Grassington, Yorkshire, and the age of the Pennine microlithic industry. *Proc. Prehist. Soc.*, 22, 23-28.

Walker, D. 1966. The late-Quaternary history of the Cumberland lowland. *Philos. Trans. R. Soc. Lond., Ser. B*, 251, 1-210.

Walker, D. and Godwin, H. 1954. Lake stratigraphy, pollen analysis, and vegetational history. In: Clark, J.G.D. *Excavations at Star Carr*. Cambridge: Cambridge Univ. Press. pp. 25-69.

Walker, M.J.C. 1984. Pollen analysis and Quaternary science in Scotland. *Quat. Sci. Rev.*, 3, 369-404.

Waton, P.V. 1982. Man's impact on the chalklands: some new pollen evidence. In: Bell, M. and Limbrey, S. (eds). *Archaeological aspects of woodland ecology*. Oxford: British Archaeological Reports, Int. Ser. 146. pp.75-91.

Welinder, S. 1978. The concept of 'ecology' in Mesolithic research. In: Mellars, P.A. (ed). *The early postglacial settlement of northern Europe*. London: Duckworth. pp. 11-25.

Welinder, S. 1983a. Ecosystems change at the Neolithic transition. *Norw. Archaeol. Rev.*, 16, 99-105.

Welinder, S. 1983b. Man-made fires in the Mesolithic. *Mesolithic Miscellany*, 4, 9-10.

Welinder, S. 1983c. The ecology of long-term change. *Acta Archaeol. Lundensia Ser. in 8° minore*. No.9. Lund: CWK Gleerup. 115pp.

West, R.G. 1970. Pollen zones in the Pleistocene of Great Britain and their correlation. *New Phytol.*, 69, 1179-1183.

West, R.G. 1980. Pleistocene forest history in East Anglia. *New Phytol.*, 85, 571-622.

West, R.G. 1988. Rates of change of the terrestrial flora. Abstract in: *Quat. Newsletter*, 59, 31.

Whittle, A.W.R. 1978. Resources and population in the British Neolithic. *Antiquity*, 52, 34-42.

Whittow, J.B. 1977. *Geology and scenery in Scotland*. London: Penguin.

Wickham-Jones, C.R. and Collins, G.H. 1980. The sources of flint and chert in northern Britain. *Proc. Soc. Antiq. Scot.*, 109, 7-21.

Wickham-Jones, C.R. and Pollock, D.L. 1987. The early settlement of Scotland: Rhum: the excavations. *Mesolithic Miscellany*, 8, 9-12.

Wilkinson, D.M. and Huntley, B. 1987. Differential pollen preservation in a topogenous mire by High Force, Teesdale, northern England. *Pollen et Spores*, 29, 455-460.

Williams, C.T. 1985. *Mesolithic exploitation patterns in the Central Pennines. A palynological study of Soyland Moor.* Oxford: British Archaeological Reports, Br. Ser. 139.

Williams, E. 1989. Dating the introduction of food production into Britain and Ireland. *Antiquity*, 63, 510-521.

Wilson, J.M. (ed). Undated. *The Imperial Gazeteer of Scotland.* Vol. I. Edinburgh: Fullarton. pp.386-387.

Woodman, P.C. 1978. *The Mesolithic in Ireland.* Oxford: British Archaeological Reports, Br. Ser., 58.

Yates, M.J. 1984. *Bronze Age round cairns in Dumfries and Galloway. An inventory and discussion.* Oxford: British Archaeological Reports, Br. Ser., 132.

Zvelebil, M. 1986a. Introduction: the scope of the present volume. In: Zvelebil, M. (ed). *Mesolithic societies of temperate Eurasia and their transition to farming.* London: Cambridge Univ. Press. pp. 1-4.

Zvelebil, M. 1986b. Mesolithic prelude and Neolithic revolution. In: Zvelebil, M. (ed). *op. cit.* (Zvelebil 1986a). pp. 5-15.