Pollen analysis and the vegetational history of Barra and South Uist in the Outer Hebrides, Scotland

Volume 2

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Holocene Vegetation History at Loch Hellisdale, South Uist.

Holocene vegetation history at Loch Hellisdale ; South Uist.

Site description

Loch Hellisdale (NF828310) is an upland loch situated in a remote glacial trough, Glen Hellisdale, on the mountainous east coast of South Uist (Figure 25). The loch represents the eastern most pollen site sampled on the South Uist transect.

The loch has an inflow stream which is draining into the loch from the slopes of Beinn Mhor (620m O.D) and Cas fo Dheos (1723m O.D.) which rises steeply from the north shore of the loch. An outflow stream flows into the lower valley. The loch was selected for analysis because of its low organic productivity, long sediment sequence (extending potentially into the Devensian Late-glacial), its relative protection from strong winds which could disturb lake sedimentation and its potential as a trap for the airfall recruitment of pollen and tephra. This relatively shallow loch is typically 1-5m deep and lies at approximately 75m O.D. in the eastern end of Glen Hellisdale, itself an isolated, short, glacially-eroded, steep sided trough-like valley which opens eastward from its head at the flanks of Beinn Mhor towards the Sea of the Minches (Figure 26).

Geology and soils

The solid geology of the valley is predominantly Lewisian granitic gneiss, with hornblende lenses. The impact of the Outer Hebrides thrust zone is thought to have produced the myolinites and crushed gneisses found along this eastern coast of the Outer Hebrides. (Figure 15). Drift deposits consist of a thin covering of till which is provisionally attributed to the Devensian (Peacock 1984). Hudson et al. (1982) have recognised three soil mapping units of the Lochinvar Association in Glen Hellisdale. (Figure 18)

Mapping Unit 398 is located on the broad mountain flanks and is classed as an alpine/sub alpine lithosol. Characteristic contemporary vegetation associated with this soil type consists of

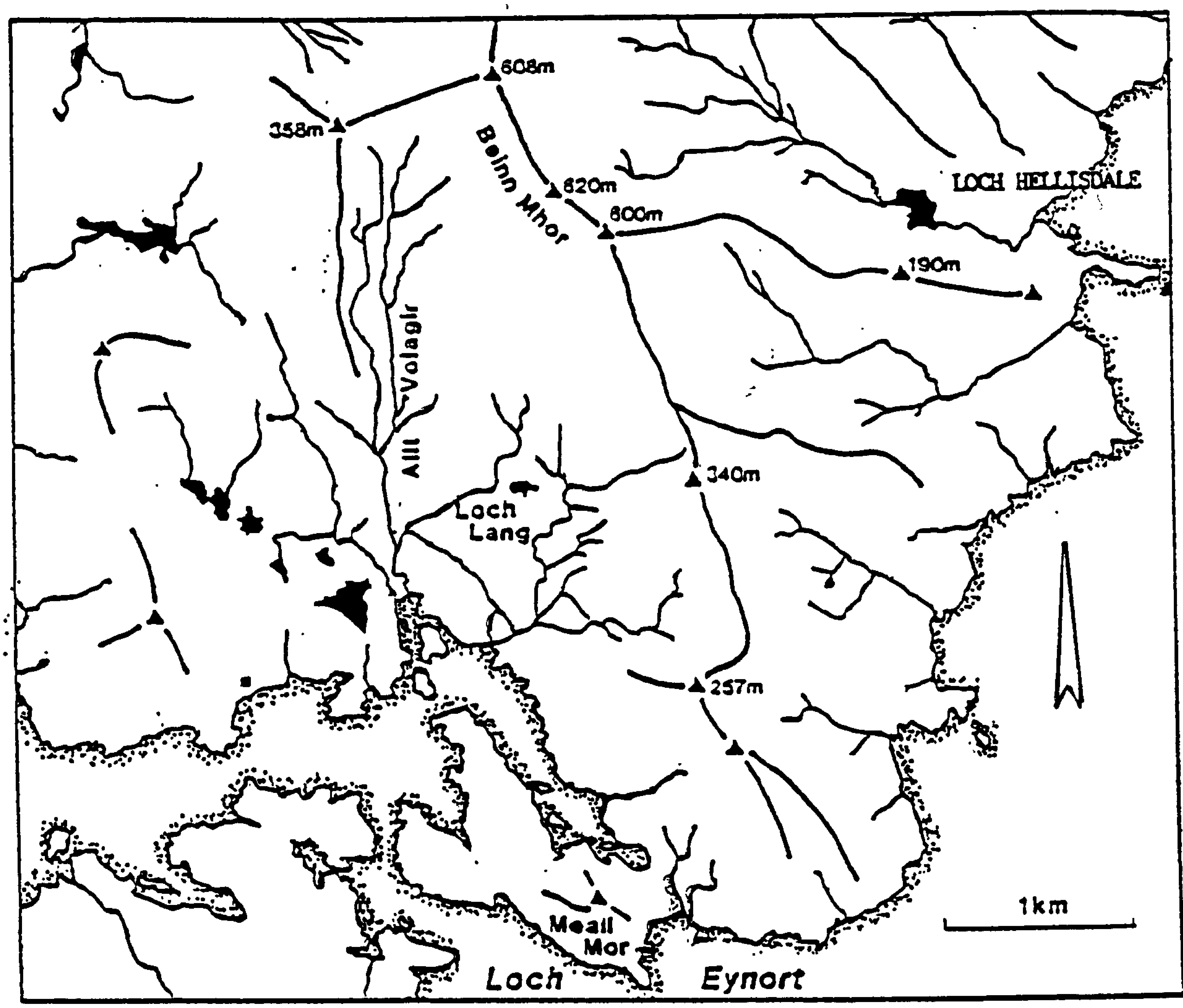

Figure 25. Location of Loch Hellisdale in relation to local topography.

mountain heath communities including Juniperus communis, Empetrum nigrum and Huperzia selago.

Mapping Unit 395 is located in the upper valley and abutting the western shores of the loch and is classed as peaty gleys, peaty podzols and rankers which support various bog communities, acid grassland, Salix aurita scrub and one individual of Sorbus aucuparia.

Mapping unit 394 dominates the lower glen and eastern loch shores and is classed as peaty gleys, peat, peaty podzols and rankers. Contemporary vegetation associated with this soil type is predominantly Calluna vulgaris dominated blanket bog.

The contemporary vegetation of the valley is dominated by acid grassland communities in the better drained upper valley and extensive mature Calluna vulgaris heath in the lower valley. The steep slopes of Cas fo Dheos have large areas of bare rock and scree with little plant cover. Higher up on north facing craggs Empetrum nigrum, Huperzia selago, Juniperus communis and Thalictrum alpinum are present. The only woodland in the valley consists of a few scattered Salix aurita with an individual Sorbus aucuparia in the upper valley.

Contemporary land use in Glen Hellisdale is limited to sheep and deer grazing; however abandoned crofts, 'lazy beds' and peat covered field boundary walls in the lower valley indicate more intensive land use and settlement in the past. Hellisdale was apparently abandoned when the east coast was cleared of crofts in the early 19th century (M.Elliot pers.com). The presence of archaeological sites in Glen Hellisdale associated with evidence of past cultivation practice provides an opportunity to examine the impact of cultivation on the palaeoenvironmental record contained in the loch sediments.

Figure 26. Glen Hellisdale.

Methods

The core was retrieved from the loch basin using a standard Russian Peat Corer from a sponson-stabilised boat, after attempts with a Livingstone piston corer (Wright,1967) failed. The sampling site is located in the north-eastern corner of the loch where there was minimum disturbance to the sediments from the inflow stream (figure 25). A 4.98m core was retrieved from the loch (the core did not reach the base of the loch's infill deposits). The core was stored in plastic tubing, wrapped in clingfilm and black, heavy plastic and stored at 4°C prior to laboratory analysis.

The sediment lithology was as follows;

Youngest	Depth	Description
Unit 1 :	0 - 20 cms.	Organic clay with orange mottles.
Unit 2 :	20 - 90 cms.	Blue/grey silt/clay + charcoal at 90cms.
Unit 3 :	90 - 400 cms.	Organic lake mud + 0.5 cms charcoal band at 390 cms.
Unit 4 :	400 - 425 cms.	Brown organic mud increasingly clay rich with depth.
Unit 5 :	425 - 460 cms.	Blue/grey silt/clay.
Unit 6 :	460 - 498 cms.	Grey/brown organic silty clay.
Oldest		

Pollen analysis

The samples were prepared for counting using standard acetolysis procedures (Faegri and Iversen 1975) with additional micro sieving and swirling for samples with high minerogenic content (see chapter 4 this study). Lycopodium clavatum spores were added to the pollen preparation to facilitate the calculation of pollen concentration values (Stockmarr, 1971). Pollen was counted using an Olympus BH microscope operating at X400, X600 magnification and X1,000 oil immersion for difficult identifications. A minimum of 200 land pollen types were counted from samples with low pollen concentrations (475-400cms. & 90-20cms). Otherwise a minimum of

600 land pollen types were counted at a sampling interval of 4cms throughout the core with some closer 1cms. sampling at critical horizons. All cores have been stored in a refrigerated cold room at 4°C.

The results of the pollen analysis are presented here as summary pollen percentage and pollen concentration diagrams (Figures 27 and 28). Local pollen assemblage zones (LPAZ) defined by numerical zonation procedures are described below prefixed by the site designation LHD (Loch Hellisdale).

Oldest LPAZ

LHD1A ; Empetrum, Juniperus, Pinus, Huperzio ; 498cms-455cms

The basal LPAZ is characterised here by high pollen frequencies for *Juniperus*,(5-30% tlp) and *Empetrum*,(5-63% tlp).
Pinus frequencies increase from 2-30% tlp and *Betula* and *Salix* are present but do not achieve values greater than 20% tlp.
Gramineae pollen frequencies vary between 4-25% tlp. Herbaceous pollen types, principally *Rumex acetosa*, Compositae Liguliflorae and Caryophyllaceae are an important component in the pollen spectra in this zone, together with the spores *Huperzia selago*(12-30% tlp) and Polypodium type(4-50% tlp).
Scarcer pollen and spore types recorded include *Artemisia*, *Thalictrum*, species of Chenopodiaceae, Onagraceae, and *Diphasiastrum alpina* and *Botrychium lunaria*.

LHD1B ; Huperzia, Polypodium, Empetrum, Artemisia, Juniperus ; 455-425cms.

The start of this zone is marked by reductions in *Pinus* and increasing proportions of *Empetrum*, *Artemisia* (22% tlp), *Thalictrum* (5% tlp). *Huperzia selago* and *Polypodium* are also present. Non-tree/shrub pollen may reach up to 80% of the total pollen assemblage.

FIGURE 27

Pollen percentage diagram from
Loch Hellisdale, South Uist.

see Appendix

LHD2 ; Betula, Juniperus, Gramineae : 425-400cms

This zone is characterised by relative increases in Betula, Juniperus, Cyperaceae (up to 30% tlp) and Empetrum falls to 10% tlp. Total tree pollen is 18 - 23% total pollen; whereas the proportions of Huperzia selago, Polypodium, and Artemisia all decline.

LHD3A ; Corylus/Myrica, Betula : 400-355cms.

Coryloid pollen frequencies increase from minimal proportions to over 40% tlp in mid zone. Lesser increases occur in Betula,(5-20% tlp). Juniperus declines to a trace within the zone. There are few rare grains of Populus, and Quercus and Ulmus occur in low but consistent frequencies (<2% tlp). The proportion of tree pollen increases to over 50% of total pollen present. There are also increased frequencies of Cyperaceae, Gramineae and Calluna vulgaris is present from 400cms at 2-10% tlp. Artemisia, Thalictrum, Huperzia selago and Polypodium all become scarce. Large grass "cereal- type" pollen together with Plantago media / major, Plantago lanceolata and Rumex acetosa are recorded between 395-390cms, coincident with a peak in Isoetes lacustris. The aquatic component of the samples includes Isoetes lacustris and a small number of grains of Myriophyllum alterniflorum.

LHD 3B ; Betula : 355-320cms.

Corylus/Myrica frequencies start at <2% tlp, and increase to >25%, and Betula increases to between 30-40% tlp. Other woodland taxa are poorly represented in a tree pollen assemblage that now represents nearly 60% total pollen. In contrast there is a peak in Gramineae pollen (30-40% tlp). Herbaceous types include Rumex (acetosa), Compositae Liguliflorae, Plantago media /major, Succisa and Viola. Spores of Isoetes lacustris are reduced to <5% tlp) but Isoetes echinospora frequencies increased to 5% tlp.

LHD 4: Corylus/Myrica, Betula, Pinus, Quercus, Ulmus : 320-170cms.

Characterised by Coryloid frequencies of approximately 40% tlp and Betula 12-22% tlp. Other woodland types including Quercus and Ulmus also increase to between 5-10% tlp and there is a peak in Pinus pollen frequencies (12-22% tlp) just before the upper zone boundary. Scarcer woodland types recorded include Fraxinus, Sorbus and Salix. Gramineae frequencies remain at around (10-15% tlp) throughout the zone. Calluna vulgaris frequencies begin to increase to 10%·tlp. Osmunda, Filicales and Pteridium aquilinum are present in this zone. High frequencies for Isoetes lacustris are a feature of this zone.

LHD 5 ; Alnus, Salix, Gramineae, Cyperaceae, Calluna ; 170-90cms.

This zone is defined by lower pollen frequencies for Betula which falls to approximately 2% tlp at the upper zone boundary. Pinus frequencies remain between 10-26% tlp and Alnus and Salix are recorded at low but consistent levels (<2% tlp). Gramineae, Cyperaceae and Calluna vulgaris values all increase. There is a small peak in Cannabis / Humulus type pollen at 135cms. and a few grains of "cereal- type" pollen at 110 cms. Microscopic particles of charcoal also increase dramatically in abundance in this zone (see figure 28).

LHD6 ; Huperzia, Polypodium, Artemisia ; 90-20cms.

A marked reduction in the representation of the woodland species that dominated the pollen spectra in the previous zones defines this zone. Pollen preservation is very poor and this biostratigraphic zone is co-incident with a lithological change from organic lake mud to clay (sediment unit 2).

The pollen and spore signature for this sediment unit is dominated by spores, principally Huperzia selago and Polypodium with Artemisia, Juniperus and Empetrum.

FIGURE 28

Pollen concentration diagram from
Loch Hellisdale, South Uist : selected taxa.

see Appendix

LHD7 ; 20-0cms.

The lithological change from clay to mottled orange organic lake mud also signifies a change in the pollen and spore assemblage. Calluna vulgaris, Gramineae, Cyperaceae and Sphagnum characterise the zone as woodland types decline in representation to below 2% tlp.

Pollen Concentration Zones.

Six pollen concentration zones are defined on the basis of major fluctuations in the total pollen and spore concentration values (Figure 49) and are used to describe the pollen concentration diagram.

Pollen Concentration Zone ; PCZ-LHD1 ; 498 - 390cms.

Total pollen and spore concentration values are generally low with values averaging < 100k grains / per cm^3. in the basal sediments.The major contributors to the pollen spectra are Empetrum, Juniperus communis, Huperzia selago, Artemisia and Rumex acetosa type.

Pollen Concentration Zone ; PCZ-LHD2 : 390 - 305cms.

This zone is marked by a significant increase in total pollen and spore concentration with values remaining consistently at c.400k grains / per cm^3 throughout the zone. This increase in pollen concentration corresponds with the expansion of arboreal pollen taxa together with Calluna vulgaris and aquatic taxa (Myriophyllum, Isoetes).

Pollen Concentration Zone ; PCZ-LHD3 : 305 - 210 cms

Total pollen and spore concentrations decline further to c.100k grains per cm^3. The decline in pollen concentration appears to affect all the major pollen taxa including all arboreal types together with Gramineae and Cyperaceae.

Pollen Concentration Zone ; PCZ-LHD4 ; 210 - 80cms.

Total pollen and spore concentration values begin to increase again in this zone to consistent levels of c.200k grains per cm^3. Major pollen contributors are Calluna, Cyperaceae, Gramineae and Sphagnum. There is a peak in particulate charcoal concentrations in the centre of the zone and near the top of the zone.

Pollen Concentration Zone ; PCZ-LHD5 : 80 - 20 cms.

Total pollen and spore concentration values decline again in this zone to <100k grains per cm^3. This decline in pollen concentration values affects all pollen types and is associated with a lithological change from organic lake mud to clay.

Pollen Concentration Zone PCZ-LHD6 : 20 - 0 cms.

Total pollen concentration values begin to increase again but remain low (50-200k grains per cm^3). Interestingly all tree pollen concentration are reduced considerably from those recorded in PCZ LHD4. Gramineae and Calluna are the most abundant taxa.

Vegetation history.

The vegetation history recorded in the Loch Hellisdale pollen data indicates a number of distinct ecological groupings which have changed considerably through time. These can be summarised in a series of main phases which correlate with the major local pollen assemblage zones.

1) The Devensian Lateglacial.

The pollen spectra of LH-1A indicates a very open vegetation mosaic which includes typically Empetrum heathland, Juniperus-Salix scrub, with herb-rich grassland represented in the pollen record by Gramineae, Cyperaceae and herbs such as' Rumex acetosa' type, the Compositae, Caryophyllaceae, Chenopodiaceae, Umbelliferae and Onagraceae. Artemisia and Thalictrum may have grown on disturbed open ground and Huperzia selago and Saxifraga possibly on the bare rock substrates above the lake. Elements of these vegetation types occur today on the highest north-facing slopes of Beinn Mhor.

Pollen taphonomic studies (see Tyldesley 1973, Birks 1980) suggest that the high values (10-32% tlp) for Pinus in this zone may be the result of long distance transport of Pinus pollen from off island sources which are over represented in the pollen record as a result of the low pollen productivity of the local vegetation at the time.

A number of potentially important changes occur within this general picture. The upper part of LHD1A is marked by a decline in the representation of Juniperus / Empetrum and their partial replacement by a vegetation dominated by more tundra-like communities with Rumex acetosa, Artemisia, and Huperzia selago and a sedimentary regime characterised by minerogenic as opposed to more biogenic deposits.

Pollen concentration values decline LHD1A to LHD1B, indicating either a decline in pollen productivity and/or an increasing rate of sedimentation. LHD-1A correlates well with LLp-1 at Loch Lang (Bennett et al. 1990) which predates 10,145 B.P.

There are also strong similarities with LHD1A / LHD1B and the Late-glacial profiles from Skye where Walker et al. (1988) describe a generalised sequence of vegetation history following deglaciation. This includes a pioneer phase with Gramineae, Cyperaceae, Compositae, Rumex and Salix (represented in the Hellisdale pollen record by the basal pollen sample) which was succeeded by the expansion of Empetrum and Juniperus heath. The climatic deterioration during the Loch Lomond Stadial led to the demise of these heathland communities and the expansion of tundra type vegetation characterised by Artemisia, Rumex and Huperzia selago. The Loch Hellisdale sequence correlates well with this generalised picture from the end of the Late-Glacial interstadial on Skye. In LHD1A the Juniperus/Empetrum heath declines as the minerogenic content of the sediment increases, leading to an erosional episode represented by LHD 1B (450-425cms) where there is a decline in the frequencies of shrub and heathland taxa and an increase in Artemisia and Huperzia selago. Zone LHD1B at Hellisdale is therefore correlated here with the Loch Lomond Stadial and LHD1A with a period preceeding its coldest period.

LHD2-4 Early to mid Holocene Woodland.

The arrival and rapid spread of Betula and Juniperus at the relative expense of open ground indicators, highlighted in the pollen concentration diagram of Figure 28, and the change in sedimentary regime from mineral rich to more organic sediments in the lake basin, clearly marked the onset of the Holocene and have exact parallels at Loch Lang (Bennett et al. 1990) and on nearby Skye (Walker et al. 1988). The date of approximately 10,145 B.P. was obtained at Loch Lang (Bennett et al. 1990) is therefore adopted here at nearby Loch Hellisdale (Figure 25) for the LHD1B-LHD2 boundary. Several critical radio-carbon dated biostratigraphic features from the Loch Lang data set have parallels in the Hellisdale sequence which provide an initial chronology for the early and mid-Holocene. Importantly there is an ordered arrival of tree pollen types Betula, Corylus, Ulmus, Quercus and Calluna vulgaris at both sites accompanied by a rapid decline in Juniperus and Empetrum. This group of events suggests a precise correlation of Loch Lang LLp-2a with Hellisdale LHD2. At Loch Lang the Corylus rise is dated to 9,400 B.P. and Calluna vulgaris appears in the record from 9,500 B.P. Maximum values for Quercus and Ulmus are achieved at approximately 7,800 B.P. This parallelism continues through LLp-2b and LLp-2c at Loch Lang in the arboreal pollen data and is evident in the behaviour of the Gramineae, Cyperaceae, Calluna vulgaris values and the aquatic Isoetes lacustris. The pollen evidence suggests that the landscape of Hellisdale was vegetated in the early Holocene with a mosaic of Betula- Corylus dominant woodland with some Populus (Aspen), similar to the Betula pubescens - Molinia caerulea community found at Allt Volagir National Nature Reserve today (see Pankhurst and Mullin 1990). By 9,000 B.P. this woodland was diversifying with small numbers of Populus, Quercus, and Ulmus. Lonicera periclymenum, Hedera helix and pteridophytes Dryopteris and Polypodium were present most properly as understory components in the woodland. Alnus is recorded in low frequencies in Hellisdale from 7,800 B.P.

The non wooded elements in the vegetation were principally grassland and wet sedge communities with Filipendula, Umbelliferae, species of the Compositae, Potentilla and Equisetum with Calluna vulgaris growing on stable soils. The open ground communities of the basal sub-zones LHD1A and LHD1B perhaps being restricted to the more exposed areas on the nearby mountain of Beinn Mhor (Figure 25).

Whilst there appears to have been comparatively little disturbance of the vegetation cover in Glen Hellisdale during LPAZ : LHD2-4 there are a number of events which may have an anthropogenic cause and which may also be represented elsewhere in the pollen record from the Outer Hebrides. For example at 390-395 cms. in LHD3A there are apparently simultaneous fluctuations in the relative proportions of Corylus and Betula, together with a 0.5cms. thick band of charcoal in the core, all of which suggest vegetation disturbance and the influx of debris from fires. " Cereal pollen type" grains together with Plantago lanceolata occur in the pollen record together with a peak in the abundance of spores of Isoetes lacustris. Vuorela (1980) noted similar peaks in Isoetes in Swedish lake basins and recognised their association with increasing inputs of minerogenic sediments as a result of the onset of vegetation clearance in the catchment. These changes are not isolated phenomena, similar events are recorded elsewhere in the Outer Hebrides at Callanish (Bohncke 1988), North Loch Eyenort

(Edwards 1990), and to a lesser extent at Loch Lang (Bennett et al. 1990). All these authors suspect that the changes might be attributable to the activities of mesolithic people.

Following these early disturbances in the pollen record the Hellisdale pollen data suggests that open woodland seems to have persisted undisturbed in Glen Hellisdale throughout much of the early to mid-Holocene. The high Corylus frequencies suggest that the plant was flowering freely, forming an extensive Corylus scrub: pollen production was not inhibited by a dense tree canopy.

LHD5-7 ; Mid-Holocene to the present.

The pollen analytical evidence from Hellisdale corresponds fairly precisely with that from Loch Lang during this period in that both indicate a progressive decrease in the representation of woodland and scrub with most tree genera undergoing reduction to the minima associated with the contemporary open landscape. The most distinctive shared features between LHD5 and LLp-3a are the major reductions in the overall abundance of tree taxa. At the start of LHD5 Corylus/Myrica declines from 40% tlp to 11% tlp and Ulmus declines from 12% tlp to 6% tlp. These features are dated to approximately 4,125 B.P. at Loch Lang (Bennett et al. 1990). The reduction in woodland cover is associated at both sites with the expansion of Gramineae and Isoetes lacustris. At Hellisdale these changes are accompanied by deposition in the lake of an increasing number of degraded pollen and spores. It is interesting to note that Calluna vulgaris values do not increase notably, suggesting that the vegetation changes were associated with some degree of soil destabilisation and loss rather than being the consequence of the spread of blanket bog. However Calluna frequencies are high enough to indicate that large areas of Calluna heath and perhaps blanket bog were widespread in the valley. Once again these changes are recorded at Loch Lang, furthur justifying a general correlation between LPAZ LHD5 and LLp-3a, dated to between c.4,125 and c.1,425 B.P.

More precise evidence of past cultivation, albeit of uncertain antiquity, is given by a small peak in Cannabis type pollen at 135 cms. This pollen type is also recorded from Callanish in North Uist in the Outer Hebrides by Bohncke (1988) where it was associated with agriculture predating the introduction of the potato. The Hellisdale peak appears to be notably older than this date.

However the dating correlation of the upper section of the Hellisdale core is insecure. Changes of biostratigraphic importance do not occur in this part of the sequence. A further complication is the thick band of mottled clay at 90-20 cms., which is just above a notable increase in charcoal at 110-95 cms- a feature not recorded in Loch Lang. This sedimentary change indicates an episode of soil erosion and mineral sediment generation in the catchment - perhaps associated with the lazy beds and more recent field boundaries evident in the valley. The pollen yield of these clays is low, and pollen is poorly preserved. The pollen spectra are dominated by Huperzia selago, Polypodium and Artemisia, at least some of which may have been incorporated into the lake sediments with eroded soils from the catchment. Clearance may have altered local hydrological patterns in the upper valley, where the inflow stream has formed a new stream channel, cutting through and exposing Holocene soil and peat deposits at its banks. The corroded pollen curves (Figure 27) support this hypothesis in that they mirror the development of Holocene vegetation in the valley. It seems possible that these pollen types were recruited into the loch sediments from the upper valley, transported by the stream as it cut through ancient sediments. The poverty of pollen types typical of the previous LPAZ such as Calluna vulgaris which was abundant in the valley prior to the deposition of the clay, suggests that either a rapid change in vegetation or pollen productivity had taken place. This is possibly a result of the burning intimated by the high charcoal counts at c.110-95 cms., or the sediment has accumulated so rapidly that very little pollen from the local vegetation has been incorporated into it. There is no clear historical or archaeological evidence of the inferred episode of soil erosion. Caird (1979) reported that the area had been cleared of its occupants by AD 1850.

The uppermost pollen spectra LHD7 essentially reflects the same suite of plant communities as those noted at Loch Lang and are fairly representative of the contemporary vegetation of the valley, which is a mosaic of Calluna dominated blanket peat and acid grassland communities. The spread of blanket peat in Glen Hellisdale seems to be strongly correlated with the demise of scrub woodland.

Discussion

There is a clear and precise parallelism between the Hellisdale pollen record and that of nearby Loch Lang which encourages the extrapolation of the Loch Lang radio-carbon dating sequence to the Hellisdale deposits. These correlations need to be supported by further radiocarbon dating studies.

Woodland appears to have been more abundant and diverse than was the case further north at Little Loch Roag, Isle of Lewis (Birks and Madsen 1979) and Callinish also on Lewis (Bohncke 1988). The pattern is seen to be essentially similar to that observed on nutrient-poor soils, rather than exposed sites on Skye, as well as other nearby sites in South Uist described by Edwards (1990), Bennett et al. (1990), Heslop Harrison and Blackburn (1946), and on Barra, Blackburn (1946) and at Lochan na Cartach (this study).

In Glen Hellisdale itself, the tundra-like plant communities of the Late Devensian were associated with soil instability and the deposition of minerogenic sediments in the loch basin. Once the early Holocene vegetation mosaic of mixed woodland and scrub, acid grasslands, bog and montane communities had become widespread, the vegetation appears to have remained relatively stable until its long term decline started at approximately 4,300 B.P., when

Figure 29. Abandoned croft ; Glen Hellisdale

noticeable reductions in Corylus, Betula and Ulmus occurred. Biostratigraphic correlations become less convincing after 4,300 B.P. as the spread of bog and perhaps human activity had their impacts.

At various times in the Holocene the landscape of Glen Hellisdale has been disturbed by relatively minor fluctuations in the vegetation that may have been the consequence of human activity in the catchment. These inferred events may have parallels elsewhere in the Outer Hebrides. The widespread encroachment of blanket bog described by Bennett et al. (1990) also occurs in Hellisdale. The deposition of organic muds occurred throughout the Holocene, coincident with stable vegetation cover in the catchment until the deposition of mineral sediments became dominant at a time tentatively related to post-late medieval farming which employed spade cultivation to produce 'lazy-beds'. This is followed by a return to organic sedimentation, possibly concurrent with the abandonment of the valley at the turn of this century. The pollen record from Hellisdale emphasises that many of the taxa in the present plant communities have been present in the vegetation of this area for most of the Holocene.

Chapter 9.

Holocene Vegetation History at Kildonan Glen, South Uist.

Holocene vegetation at Kildonan Glen.

Introduction

Kildonan Glen, South Uist is a bleak, west facing valley, fully exposed to the full force of Atlantic storms, located mid-way across the South Uist transect on the 'blacklands' transition from machair grassland to blanket bog (Figure 30 and 31).

The S.E.A.R.C.H. archaeological survey of the area, extending from the west coast machair into Kildonan Glen, indicated that the area was rich in archaeological sites, the earliest dating from the late Neolithic period. Field studies identified three midden sites in the west coast machair c.1km. from the coring site. Subsequent excavation of the largest midden, CDM III revealed large quantities of marine shell, animal and human bones, pottery and carbonised seed remains. The animal bones were primarily sheep /goat, cattle and pig and Hordeum-type cereal grains dominated the plant macrofossil assemblage. The abundance of edible marine fauna, ranging from shellfish to whale, indicate an economy in which a wide variety of marine resources were utilised, together with pastoral and arable agriculture represented by the fossil bone and seed assemblages. Pottery from the midden dates the site to the Iron Age.

In Kildonan Glen itself two cairns not recorded in the HMR (Historic Monuments Record) were discovered on the north-west valley side (Figure 30) and may represent chambered tombs of late Neolithic date. (S.E.A.R.C.H. 1989 unpublished report). Also a potsherd and pieces of worked flint were found in situ below c.20cms. of peat (S.E.A.R.C.H., 1988). The archaeological field survey also records the remains of rectangular stone buildings, enclosures and field walls to the east and south-west of Upper Loch Kildonan. A major archaeological monument in the area is the church at Upper Loch Cill Donain which is thought to have been constructed on the remains of a Neolithic cairn or a dun.

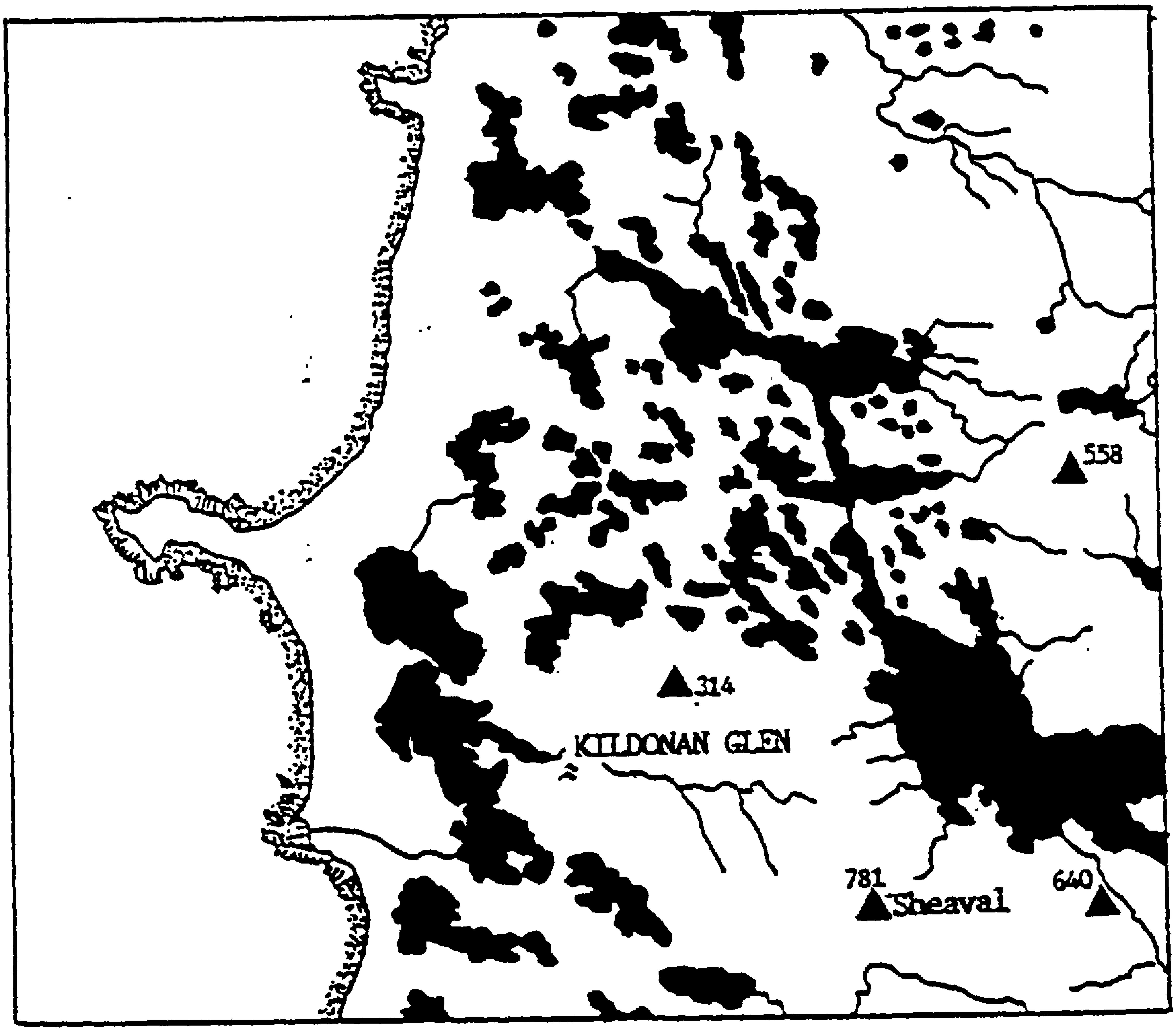

Figure 30. Location of Kildonan Glen in relation to local topography, lakes and streams.

Figure 31. Kildonan Glen.

The site.

Stratigraphic studies described later have shown that Kildonan Glen consists of a series of shallow rock basins in which mid-late Holocene peat sediments are interbedded with lacustrine sequences formed in lochs that have been impounded behind the machair.

The contemporary vegetation of the valley sides is characteristic of the *Agrostis capillaris*-*Festuca ovina* grasslands (Group E) cf. in chapter 6, this study and Kent *et al*. (in press) with *Agrostis capillaris*, *Festuca ovina*, *Potentilla erecta* as diagnostic species and with *Viola riviniana*, *Rhytidiadelphus squarrosus*, *Nardus stricta*, *Trifolium repens* and *Galium saxatile* as common associates. On lower valley slopes, *Calluna vulgaris* wet heath (Group C in chapter 6 this study, Kent *et al*. in press) predominates. Patches of *Pteridium aquilinum* - *Potentilla erecta* - *Anthoxanthum odoratum* (Group F in chapter 6 this study and Kent *et al. in press*) and *Salix aurita* scrub occur on the valley sides and around small inflow streams. The valley bottom vegetation comprised *Carex paniculata* sedge swamp community of the NVC (Rodwell 1991) on the surface of the infilled loch basins and *Molinia caerulea* - *Scirpus cespitosus* - *Erica tetralix* - *Calluna vulgaris* wet heath (Group C, Kent *et al*. in press). Contemporary land use in the valley is restricted to sheep grazing and peat cutting which is confined by the wetness of the valley bottom to the better drained areas of the valley sides.

The coring survey was carried out in order to identify the environmental history of the valley and if possible to establish the stratigraphic relationships between peat growth and the history of the machair and machair lochs in the western part of the Glen. Local historians on South Uist emphasise that the existing water levels in the present Loch Kildonan are about 1m lower than the "natural" water level of the loch, the lowering being caused by artificial drainage. If this were the case it is possible that buried machair lake deposits could extend into Glen

Kildonan. It is also possible that machair shell sands themselves could extend beneath peat into the Glen. It is impossible to hand - core into the machair sands to establish if lakes or marsh once extended seawards because of the looseness and impenetrability of the shell sand once the water table is encountered, usually found 1m below the machair surfaces.

This pollen investigation was undertaken to ascertain the stratigraphy and history of Holocene vegetation in an exposed, west facing valley which contrasts with the relatively sheltered east coast Loch Hellisdale and Lochan na Cartach on Barra. This site is similarly exposed but more elevated than that at Port Caol, Barra (chapter 11 this study). The archaeological evidence suggests that the Kildonan area was utilised by people, possibly from the late neolithic period. The pollen record contained in the small infilled loch basin selected for the study should in theory represent more local vegetation (Jacobson and Bradshaw 1981). These site characteristics, coupled with the richness of the archaeological record in the area, provided an opportunity to examine vegetation history and possible human impact in the 'Blacklands' zone of the transect, in the boundary zone between the shell sands of the machair and the true mountain and moorlands, which is currently the principal zone of human settlement and activity in the Outer Hebrides.

Methods

The site was chosen because it appears to offer the clearest and least disturbed site location which had a history of being continuously wet, but which was close to the drier hillslopes with their important archaeological land-use history. A series of boreholes were made along the valley floor, the stratigraphy was recorded and the boreholes "levelled" in. The extensive treacherous swamps left by peat cutting limited the number of locations that could be studied. The stratigraphic picture is therefore somewhat skeletal but a number of important features emerged from the study. First two infilled loch basins were located in Glen Kildonan, itself separated in mid valley by a rock bar and from Upper Loch Kildonan by a similar rock bar on which the contemporary road is constructed. The survey also revealed that Upper Loch Kildonan was once more extensive and extended landwards from its contemporary shoreline to the road. Also of interest was the presence of "woody" peat layers in the cores and Betula macrofossils exposed by peat cutting at the edge of Upper Loch Kildonan.

A 2.6m. core was retrieved from the deepest part of the lower basin in Kildonan Glen (Figure 30) using a 10cm. bore Russian peat corer, transfered to plastic guttering, wrapped in heavy gauge plastic and stored at 4°C prior to analysis.

Stratigraphy.

The sediment stratigraphy of the core was examined and nine sediment units (S.U.), described below, were recorded.

S.U.1	0 - 70 cms	Coarse sedge peat.
S.U.2	70 - 80 cms	Organic - silty layer.
S.U.3	80 - 150 cms	Woody peat with Betula wood fragments.
S.U.4	150 - 170 cms	Sedge peat.
S.U.5	170 - 190 cms	Sphagnum peat.
S.U.6	190 - 210 cms	Organic gytta.
S.U.7	210 - 220 cms	Blue - grey / silt / clay.
S.U.8	220 - 250 cms	Organic gytta with clay / silt.
S.U.9	250 - 260 cms	Coarse minerogenic layer with grit inclusions.

The samples were prepared for counting using standard acetolysis procedures (Faegri and Iversen 1975) with additional micro-sieving and swirling for samples with high minerogenic content. Lycopodium clavatum spores were added to the pollen preparation to facilitate the calculation of pollen concentration values (Stockmarr 1971). Pollen was counted using an Olympus BH microscope operating at x400, x600 magnification and x1000 oil immersion for difficult identifications. A minimum of 600 land pollen types were counted from each sub-sample, using a sampling interval of 4cms. throughout the core.

The results of the pollen analysis are presented here as summary pollen percentage and pollen concentration diagrams (Figures 32 and 33). Local pollen assemblage zones (LPAZ) defined by numerical zonation procedures are described below prefixed by the site designation code KDG (Kildonan Glen).

The pollen diagrams.

Oldest LPAZ KDG1a ; 260-245cms.

This basal LPAZ is characterised by high frequencies of Empetrum (50% tlp,total land pollen), Gramineae (10-22% tlp), Cyperaceae (16-18% tlp). In contrast arboreal pollen frequencies are low with Betula, Juniperus, Coryloid less than 2% tlp. respectivley and Salix (4-5% tlp). Herbaceous pollen types included Filipendula, Rumex acetosa, Artemisia, Caryophyllaceae and Onograceae-type. Spores present include Polypodium (29% tlp + spores), Huperzia selago (9% tlp + spores) and Sphagnum frequencies are <2% tlp + Sphagnum. The aquatic component comprises Myriophyllum alterniflorum (30% tlp + aquatics).

LPAZ KDG2a 245-190cms.

Empetrum declines from the high levels recorded in KDG1 and percentage values fluctuate between 10% tlp in the lower part of the sub-zone to 5-3% tlp in the middle of the zone, rising to 10-12% tlp near the upper sub-zone boundary. Increasing proportions of arboreal-type pollen, particularly Betula (8-14% tlp) and Coryloid (5-8% tlp) characterise this sub-zone, together with Calluna vulgaris, Gramineae c.25% tlp and Cyperaceae (c.25% tlp). Two small peaks in Juniperus are recorded at 240 cms. and 200 cms. Herbaceous pollen types include Potentilla, Succisa, Compositae Liguliflorae, Filipendula, Valeriana-type and Ranunculus. The proportions of Huperzia selago, Empetrum, Artemisia and Polypodium

FIGURE 32

Pollen percentage diagram from
Kildonan Glen, South Uist.

see Appendix

all decline, whereas Filicales increase to c.10% tlp and Sphagnum to 0% tlp.

LPAZ KDG2b : 190-150 cms.

An increase in Calluna vulgaris frequencies are the main feature of this sub-zone. Betula is c.8-10% tlp, Coryloid c.5% tlp and Salix 2-4% tlp. Ulmus <2% tlp is recorded for the first time in the diagram at the lower sub-zone boundary. Gramineae and Cyperaceae percentages rise and Sphagnum increases dramatically to between 60-80% tlp + Sphagnum. Herbaceous type pollen recorded include Potentilla, Ranunculus, Plantago media / major, Valeriana (cf. V. officinale) and a peak in Filipendula in the upper part of zone.

LPAZ KDG3 : 150-80 cms.

Betula pollen frequencies increase to over 40% tlp and there is a lesser increase in Corylus / Myrica from 12% tlp in the lower part of the zone to over 20% tlp. in upper LPAZ KDG3. Salix frequencies also vary between 10-18% tlp in the opening part of the zone. The lower part of the zone shows decline in Calluna vulgaris (<10% tlp), and Sphagnum (<10% tlp + Sphagnum). Other arboreal types recorded include Sambucus, Quercus and Alnus. Betula and Corylus / Myrica frequencies decline briefly in the middle of the zone. Occasional cereal-type grains are recorded. Filicales and Osmunda spores are well represented and Plantago lanceolata is present for the first time from 140 cms. Other herbaceous types include Filipendula, Potentilla, Trifolium repens, Ranunculus-type, Rumex acetosa, and Succisa. Myriophyllum alterniflorum and Littorella are absent.

LPAZ KDG4a 80-20cms.

A dramatic decline in arboreal pollen frequencies and an increase in Gramineae and Cyperaceae characterise LPAZ KDG4.
Calluna vulgaris frequencies remain below 5-10% tlp. Potentilla type and Filipendula dominate the herbaceous pollen spectra with Plantago lanceolata, Plantago media / major, Scrophulariaceae-

type, Ranunculus-type, Menyanthes trifoliata, Succisa and Cereal-type present in low frequencies. Spores are poorly represented and Sphagnum percentages fall below 5% tlp. Charcoal concentrations are low throughout the zone.

LPAZ KDG4b : 20-0cms.

Increasing Calluna vulgaris percentages (c.20% tlp) characterise this subzone and Narthecium ossifragum is present for the first time in the diagram. Gramineae (30-40% tlp) and Cyperaceae (20-40% tlp) dominate the pollen spectra throughout the sub-zone.

Pollen Concentration Zones.

Six pollen concentration zones are defined on the basis of major fluctuations in the total pollen and spore concentration values (Figure 33) and are used to describe the pollen concentration diagram.

Pollen Concentration Zone PCZ-KDG1 ; 260 - 222cms.

Total pollen and spore concentration values in this basal zone are generally low with values averaging < 100k grains / per cm^3. The major contributors to the pollen spectra are Empetrum, Juniperus communis, Huperzia selago, Artemisia and Rumex acetosa type.

Pollen Concentration Zone PCZ-KDG2 : 222 - 142cms.

This zone is marked by an increase in total pollen and spore concentration with values remaining consistently at c. 50-100k grains / per cm^3 throughout the zone. This increase in pollen concentration corresponds with the expansion of Juniperus and Empetrum together with aquatic types such as Myriophyllum.

Pollen Concentration Zone PCZ-KDG3 : 142 - 107 cms.

Total pollen and spore concentration values increase again in this zone occasionally reaching over c.100k grains per cm^3. This increase in pollen concentration values reflects the increased representation of arboreal taxa, particularly *Betula*, *Corylus*, *Alnus*, and *Fraxinus*. *Polypodium* and Filicales spore frequencies also increase in this zone together with herbaceous taxa associated with an infilled loch edge (e.g. *Filipendula*)

Pollen Concentration Zone KDG4 : 107 - 90 cms

Total pollen and spore concentrations decline throughout this zone to <50k grains per cm^3. The decline in pollen concentration appears to affect all the major pollen taxa including all arboreal types together with *Calluna*, Gramineae and Cyperaceae. Significantly, immediately below the lower zone boundary there is a marked peak in the concentration values of *Pinus*, Filicales, *Polypodium*, *Pteridium* and charcoal particle frequency.

Pollen Concentration Zone ; PCZ-KDG5 ; 90 - 20cms.

Total pollen and spore concentration values decline further in this zone to consistent levels of c.<50k grains per cm^3. All contributing pollen taxa appear to be affected.

Pollen Concentration Zone PCZ-KDG6 : 20 - 0 cms.

Total pollen concentration values begin to increase again but remain low (50k grains per cm^3). Arboreal pollen concentration values are particularly low, although there is a slight increase in *Alnus*, *Sorbus*, *Calluna vulgaris*, *Narthecium ossifragrum* and *Potentilla* representation.

FIGURE 33

Pollen concentration diagram from Kildonan Glen, South Uist.

see Appendix

Local environment and regional correlation.

Devensian late-glacial.

The basal pollen assemblage recorded in Kildonan Glen indicates a brief phase in which species of open herb-rich grassland, sedge communities and Empetrum heath were dominant in the vegetation. Scattered Juniperus and Salix scrub were present. Herbaceous taxa are particularly well represented, notably species of Compositae, with Filipendula, Umbelliferae, Rumex acetosa and Caryophyllaceae type. Artemisia, Onagraceae-type and Huperzia selago suggest the presence of bare rock and soil substrates. Sediment recruitment into the basin at this time also suggests the presence of unstable and eroding soils in the catchment. The high percentage frequencies of Polypodium recorded in the basal pollen spectra may represent the erosion of terrestrial soils and the relatively resistant recycled Polypodium spores in the catchment rather than abundance its in the vegetation. Myriophyllum alterniflorum and Littorella indicate open water conditions in the loch. In the absence of radiocarbon dating evidence for the Kildonan core biostratigraphic correlation with the radiocarbon chronology at Loch Lang, South Uist (Bennett et al. 1990) provides some provisional dates for the Kildonan pollen record. However such correlations are made tentatively given a number of differences in the pollen diagrams from both sites. Comparison between the basal pollen assemblage recorded at Kildonan Glen and Loch Lang where a similar basal pollen assemblage (LL-p1) is dated to 10,700 - 10,200 B.P. is adopted as a provisional age determination for KDG1.

Early to Mid - Holocene

The pollen spectra in KDG2a suggest a change from the open landscapes of the basal LPAZ KDG1 to one in which small areas of Betula, Juniperus, Salix and Corylus / Myrica scrub were present, possibly on the better drained valley slopes above the loch. However the Betula rise at 240-235 cms Kildonan Glen is more moderate (<20% tlp) than the 20-30% tlp rise recorded at Loch Hellisdale, South Uist (this study) and at Loch Lang, South Uist

(Bennett et al. 1990) where Betula frequencies expand rapidly to c.30% tlp in L1-p2a. Possibly Betula expansion was inhibited in Kildonan Glen at this time by the wetness of the valley bottom, suggested by the high Sphagnum percentages in KDG2a and KDG2b. Corylus / Myrica frequencies are also lower than those recorded at Loch Lang (Bennett et al. 1990), Glen Hellisdale (this study) and Lochan na Cartach, Barra (this study). Calluna vulgaris appears to have expanded gradually in KDG2a at the expense of Empetrum and Juniperus heath. Grassland and tall herb communities with Filipendula, Umbelliferae (Angelica type), species of Onagraceae, Ranunculaceae and Compositae flourished properly in more fertile areas of the valley bottom. An increase in organic sediment deposition (S.U.2) suggests that organic productivity was increasing in the loch basin and vegetation cover was more complete, stabilising soils in the catchment. The abundance of Calluna vulgaris and Sphagnum spp. in KDG2 reflects the influence of acid substrates and possibly podsolisation on soil forming processes from the early Holocene.

At Loch Lang (Bennett et al. 1990), Loch Hellisdale (this study) and Lochan na Cartach (this study), the open grassland and Empetrum heath communities of the Devensian Late-Glacial and early Holocene are succeeded by a distinctive sequence of woodland and scrub development which is typical, not only of early Holocene vegetation history on South Uist, but in much of north-west Scotland (Birks 1989). At Loch Lang this sequence begins with the expansion of Betula and Juniperus at c.10,200 B.P., followed by Corylus / Myrica at 9,400 B.P. and Calluna vulgaris from c.9,500 B.P. (Bennett et al. 1990). These vegetation changes are accompanied by a sequence of sedimentary changes which display a classic tri-partite Late Devensian - early Holocene lithological sequence. At Kildonan Glen, Betula, Juniperus, Corylus / Myrica and Calluna vulgaris are present together at the KDG2a boundary before the sedimentary change to clays and silts in S.U.3 which indicates a change to an erosional sedimentary environment in the catchment. The double Juniperus peaks in KDG2a are also characteristic of the climatic ameliorations of the late Devensian and early Holocene, which are separated by the clay / silt layer which typically correlates with the Loch Lomond cold phase in north west Scotland (Walker *et al.* 1979). The *Betula* rise and second *Juniperus* peak provide a biostratigraphic marker for the start of the Holocene. The pollen spectra in KDG2a are typical of Holocene vegetation rather than that of the Devensian Late Glacial. Therefore the return to minerogenic sedimentation in S.U.3 suggests a change in local hydrological conditions or the erosion and leaching of local soils, possibly as a result of climatic fluctuations during the early Holocene.

Correlation is further complicated by comparison of the Kildonan Glen and Loch Lang pollen data with the radiocarbon dated early Holocene pollen record from the exposed west coast site at Little Loch Roag, Isle of Lewis (Birks and Madsen 1979). Such comparisons demonstrate the non-synchroneity of radiocarbon dates for similar vegetation 'events' during the early Holocene in the Outer Hebrides. For example the *Corylus* / *Myrica* / *Betula* rise is dated at 7,900 B.P. at Little Loch Roag, *c.*2,000 years later than Loch Lang, South Uist (Bennett *et al.* 1991) and Loch Airigh na n-Aon Oidhche, South Uist (Edwards 1990), both sheltered east coast locations. It may be that in west facing valleys such as Kildonan Glen and Little Loch Roag vegetation succession was different from that found in the more sheltered east coast sites - perhaps due to the impact of their different climates and topographies on the course of succession. Similarly at Kildonan Glen, local site conditions rather than any regional effect may have inhibited the spread of *Betula* then *Corylus* woodland. Alternatively the early Holocene sequence noted at Loch Lang and Glen Hellisdale may be absent from the Kildonan pollen record as a result of a break in sedimentation at the KDG1 - KDG2a boundary caused by the erosion of sediments or an hiatus of deposition. In the absence of a break in the sedimentary record it is possible that *Betula*, *Corylus* / *Myrica*, *Juniperus* and *Calluna vulgaris* were present together in the landscape of Kildonan Glen from the earliest

Holocene (c.10,200 B.P.)

Maximum values for Sphagnum (80% tlp + Sphagnum) in KDG2b coincide with a change in the sedimentary environment where lacustrine deposition is replaced by Sphagnum peat. This feature of the Kildonan diagram is of particular interest because the change from lacustrine to terrestrial sedimentation in the loch suggests the initiation of a hydrosere as terrestrial vegetation encroached onto the loch sediment surface. A second, brief stage of hydroseral succession follows in which the pollen representation of species associated with swamp and tall herb fen increases possibly as these species colonised the infilled loch margins, for example, Menyanthes trifoliata, Filipendula ulmaria and Valineria officinalis. The presence of small numbers of Ulmus and Quercus in KDG2b provide a possible date for this period as radiocarbon dates from other Outer Hebridean pollen diagrams date the arrival of Quercus and Ulmus pollen on the island to c.7,800 B.P. (Bennett et al. 1990)

A third stage in the hydrosere is indicated by the rapid expansion of Betula, Sambucus, Salix and Corylus / Myrica at the lower KDG3 boundary at the expense of Gramineae, Cyperaceae and Calluna vulgaris. An increase in Filicales, Osmunda regalis and Pteridium aquilinum suggest that ferns flourished in the woodland understory. Elsewhere in the valley open herb-rich communities were present with Succisa pratensis, Rumex acetosa, Viola palustre, Trifolium repens and Plantago lanceolata. These vegetation changes are accompanied by sedimentary change to woody peat in which small fragments of Betula wood were preserved. Such vegetation and sedimentary change reflects a classic hydroseral succession as shrubs colonised the loch margins as the infilling process continued.

The pollen of Ulmus, Quercus and later Alnus first appear in KDG2b. Pollen of all these trees is found in such low quantities that it is probably derived from Quercus, Ulmus and Alnus trees which were growing in the sheltered valleys and gorges of the east coast, such as Glen Hellisdale, sheltered by the Beinn Mhor massive. Betula and Corylus / Myrica decline briefly in the middle of KDG3. There is a slight increase in Gramineae, Calluna vulgaris and charcoal concentration values are present in notable quantities, and Alnus and Plantago lanceolata are present for the first time in the diagram. Alnus was recorded at Loch Lang, South Uist (Bennett et al. 1990) from 7,200-6,000 B.P. and c.6,000 B.P. at Callanish, Isle of Lewis (Bohncke 1988), 6,100 B.P. at Little Loch Roag, Isle of Lewis (Birks and Madsen 1979) c.7,280 BP, North Loch Eyenort, 7,030 ± 230 B.P. and 7,030 ± 230 B.P. at Loch Airigh na n-Aon Oidhche (Edwards 1990). The South Uist dates suggest a provisional date for the Alnus entrance at Kildonan Glen of c.7,000 B.P. There are no indications in the pollen spectra which can be interpreted as significant indicators of climatic or anthropogenic impacts on the vegetation during this period. However Edwards (1990) reports an increase in charcoal representation and a decline in Corylus around the time of the alder rise at North Loch Eyenort, South Uist which has been suggested (above) as the nearest biostratigraphic correlative to these events at Kildonan Glen. If this interpolated date is correct it is rather too late for the regional decline in Betula woodland at c.7,900 BP. suggested by Wilkins (1984) which he suggests was caused by a wetter climate.

Woodland regenerates briefly before decline in LPAZ KDG4a, and again at LPAZ KD4b. An increase in minerogenic deposition in the basin coincident with the decline in Betula and Corylus / Myrica woodland suggests a return to unstable and eroding soils in the catchment. There is a corresponding increase in charcoal concentrations, Gramineae and Potentilla together with Cereal-type, Onagraceae-type and Plantago lanceolata. These effects could result from the clearance of Birch and Hazel scrub and local agricultural activity which would lead to the expansion of pasture land evidenced in the pollen record, and the in-washing of mineral material into the loch basin from the valley sides. There are some indications of increased wetness in the valley floor as the

Cyperaceae and Sambucus values increase across the KDG3-KDG4 zone boundary, possibly as a result of an increase in overland flow caused by the reduction of woodland. Again without radiocarbon dating evidence the final demise of woodland at Kildonan Glen is difficult to date. The Plantago lanceolata curve becomes continuous from 90 cms. as Betula declines rapidly. Plantago lanceolata is continuously present at Loch Lang (Bennett et al. 1990) and Callanish, Isle of Lewis (Bohncke 1988) from c.5,000 B.P. which is thus suggested as a provisional date for the onset of woodland decline at Kildonan Glen. The palynological record from other sites in the Outer Hebrides suggest that anthropogenic impact on the vegetation was in effect during the Neolithic period. Similar pollen spectra recorded at Callanish, Isle of Lewis, (Bohncke 1988) are interpreted as clearance phases in which scrub woodland was reduced to provide land for pasture and some arable cultivation. Several such clearances are recorded at Callanish, with the earliest evidence of cultivation occurring between 5,320-4,580 B.P. In Loch Lang, Bennett et al. (1990) reported woodland decline accompanied by the spread of blanket peat from 4,300 B.P. and similarly at Lochan na Cartach, Barra, woodland disappears from the landscape from c.4,000 B.P. At both sites these changes were interpreted as part of a regional change brought about by the stress of grazing and possibly a worsening of climatic conditions. At Kildonan Glen the spread of Calluna vulgaris, Narthecium ossifragum and Drosera, taxa typical of blanket bog vegetation, are not recorded until KDG4b and these spectra correlate much more strongly with the c.4,000 B.P. spectra at the other sites, suggesting that the Betula / Corylus decline at Kildonan Glen predates the spread of blanket peat on South Uist by c.1,000 years.

An important factor complicating the interpretation of woodland decline in Kildonan Glen is the effects of sand ingress onto the west coast of South Uist which Ritchie (1985) considers to have taken place before 4,500 B.P. The primary deposition of sand inland on the coast could have lead to palaeohydrological changes

in the Kildonan loch complex of which the pollen sampling site was a part. Sand ingress may have indirectly favoured Sambucus and impeded drainage caused by sand ingress could have raised the water table in the valley causing woodland decline and favouring the expansion of taxa such as Potentilla palustris and Carex spp. Changes on the western coast resulting from sea level change may have led to the transfer of settlement, or some form of agricultural activity inland from the coast to the inland valleys slopes such as Kildonan Glen. Independent dating evidence from Kildonan Glen would help to resolve some of these complexities by linking the palynological record to sand deposition on the coast and the archaeological monuments in the valley.
Higher charcoal concentrations in KDG4b suggest a greater human presence in the area, possibly Calluna heath was being burned to provide grazing for animals or the charcoal may originate from domestic fires, an idea previously discussed by Edwards (1990).

Synthesis

The pollen record from Kildonan Glen differs in some respects from Holocene pollen sequences described from more sheltered east coast valley sites such as Glen Hellisdale (this study) and Loch Lang (Bennett et al. 1990). The lower arboreal pollen frequencies recorded in the more exposed Kildonan Glen during the early Holocene possibly reflects the effects of the strength of westerly "on shore" winds and gales on the developing vegetation. An interesting feature of the pollen diagram is the abundance of Calluna vulgaris prior to the expansion of Birch / Hazel woodland in KDG3a which suggests that Calluna heath was abundant in areas of the landscape which were perhaps inhospitable to tree growth during the early Holocene.

Infilling of the loch during the Holocene led to a hydroseral succession which culminated in the expansion of Birch / Hazel dominated woodland which appears to have differed slightly in species composition from the woodlands in Glen Hellisdale and Loch Lang. Quercus, Ulmus and Alnus are poorly represented in the pollen record at Kildonan Glen whereas Salix and Sambucus are more abundant, probably reflecting the wetter environment of the valley bottom. Grasses, sedges and tall herb communities flourished in the valley together with Calluna heath on its drier parts. An early phase of inferred agricultural activity evidenced by increased charcoal concentrations, reduced Betula and Corylus / Myrica pollen frequencies, and an increase in grassland and heath indicators may be associated with early Neolithic presence in the area. The subsequent rapid demise of woody scrub vegetation in Kildonan Glen contrasts with the more gradual reduction of woodland in Glen Hellisdale and Loch Lang from c.4,300 B.P. There are some indications of increased human activity associated with the reduction in woodland, specifically increased charcoal representation and cereal type pollen grains. These may be linked to a later Neolithic occupation of the valley evidenced by the burial chamber. Such a rapid decline in woodland may however be linked to the wider environmental repercussions of sand ingress onto the western coastline from around 4,500 B.P. The contemporary vegetation of the valley appears to have become established after the decline in woodland and scrub vegetation which may have failed to regenerate as a result of increasing land use pressure, evidenced by the palynological and archaeological record, combined with worsening climatic conditions and a change in the local hydrological regime as sea level rose sometime after 5,000 B.P.

Chapter 10.

The Historical Ecology of Loch Druidibeg, Lake Island Woodland.

The historical ecology of loch island woodland ; Loch Druidibeg National Nature Reserve ; South Uist.

Introduction.

Pollen analytical studies of Holocene lake and peat sediments (Bennett et al.1990, Edwards 1990, Loch Hellisdale this study) suggest that woodland was once more widespread and diverse on South Uist than the species poor communities that occur in the contemporary landscape. Today many South Uist lake islands support dense shrubby woodlands (described by Spence 1960) in contrast to the surrounding lake shores which are covered in blanket peat. Such island woodland fragments are of interest since they might represent remnants of primary, ancient woodland which has survived due to protection from past and present land-use pressures - such as over-grazing - by their isolation on the lake islands. These sites are potentially important for the study of recent vegetation dynamics and are of conservation interest because of their restricted distribution in the Outer Hebrides. However the nature of any possible relationship between the lake island woodlands and those of earlier, and early to mid-Holocene vegetation is at present unknown.

The primary status of woodland (as defined by Peterkin (1981), in terms of areas that have supported woody plants throughout the historic period), is difficult to demonstrate from studies of the contemporary vegetation in the absence of historical or palaeoecological information. Conventional palynological studies have contributed relatively little to woodland successional theory because many published pollen diagrams record vegetational change at too wide a spatial and temporal scale to track the history of individual woodlands (see Webb III et al. 1978, Jacobson and Bradshaw 1981).

However palynological studies from mor humus deposits under closed woodland and shrub canopies have successfully revealed the history of individual woodlands, past disturbance, regeneration phases and successional relationships as shown by Aaby (1983), Andersen (1984), Bradshaw (1987), Mitchell (1988), Bradshaw and Hannon (1986), Hannon and Bradshaw (1989). Moreover recent palynological studies from mor humus profiles beneath woodland on similar lake islands in Connemara, western Ireland have revealed the recent history of individual woodland stands in landscapes similar to those found in South Uist (Flannelly 1988, Hannon 1985).

Many of the South Uist loch islands have a thin covering of mor humus which provides a good matrix for pollen preservation. The humus is acid and previous studies indicate that there is little evidence of sediment mixing due to soil fauna or downwashing in the sediment profile (Bradshaw 1988). The present palynological study of a mor humus profile from a loch island at Loch Druidibeg National Nature Reserve provided an opportunity to investigate the historical ecology of this woodland and its relationship with the Holocene record, and so would provide an important link between the present and past vegetation and land-use in this region. In addition the closed canopy woodland also provided an opportunity to quantify the pollen representation of woody plants within existing woodland on South Uist, a study which could assist in the interpretation of woodland pollen floras in the Holocene pollen record from the islands.

Pollen analysis of a mor humus profile is used here to establish the history of this woody scrub vegetation, woodland dynamics and plant succession at the site. The impact of people is likely to be important in this context as many of the islands in the South Uist lochs contain the remains of archaeological sites, including brochs and duns (Barber 1987). The presence of an abandoned stone structure and causeway to the island in Loch Druidibeg thus raised the possibility also of investigating human influence on the vegetation.

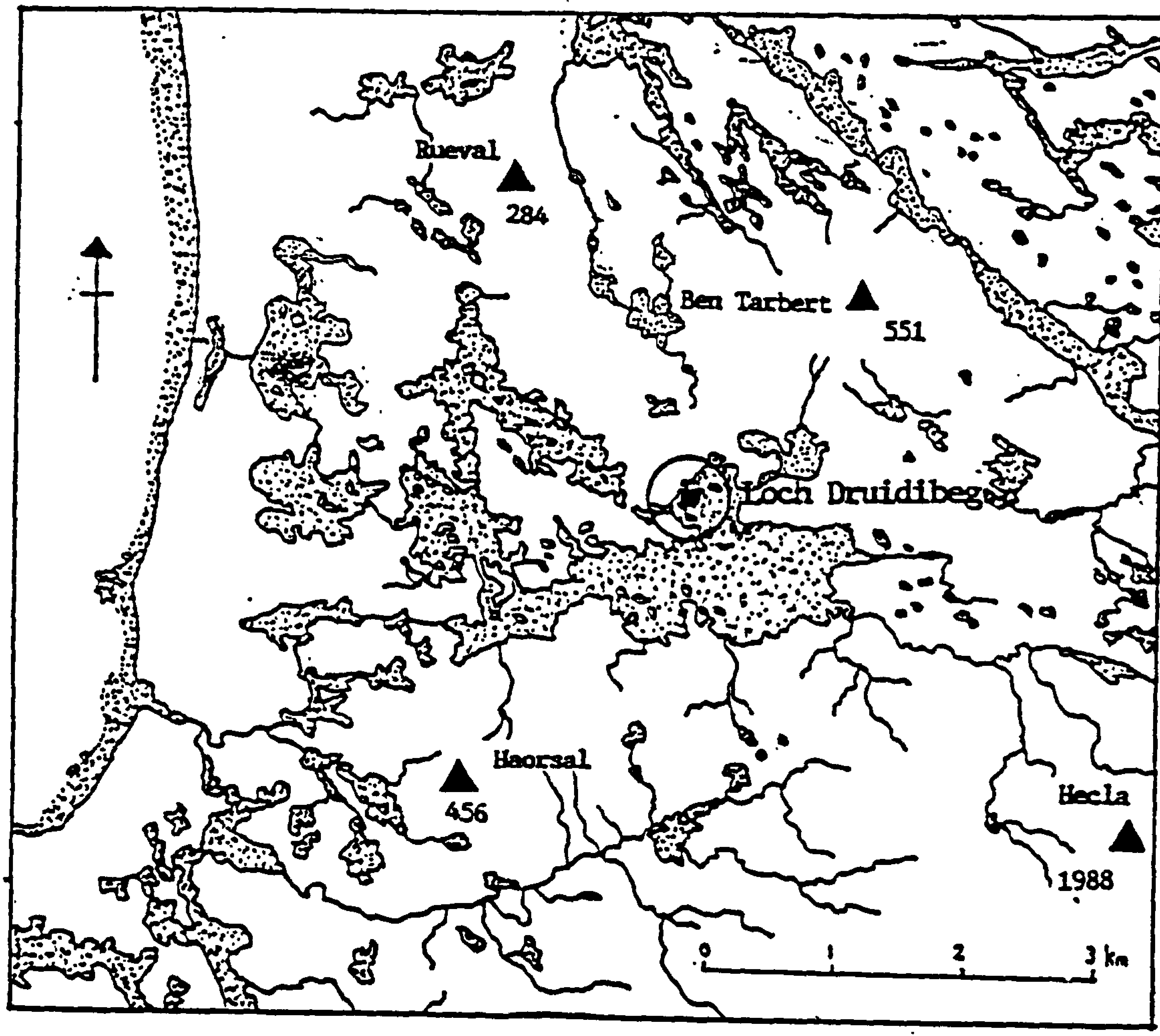

Figure 34. Location of Loch Druidibeg Island, South Uist.

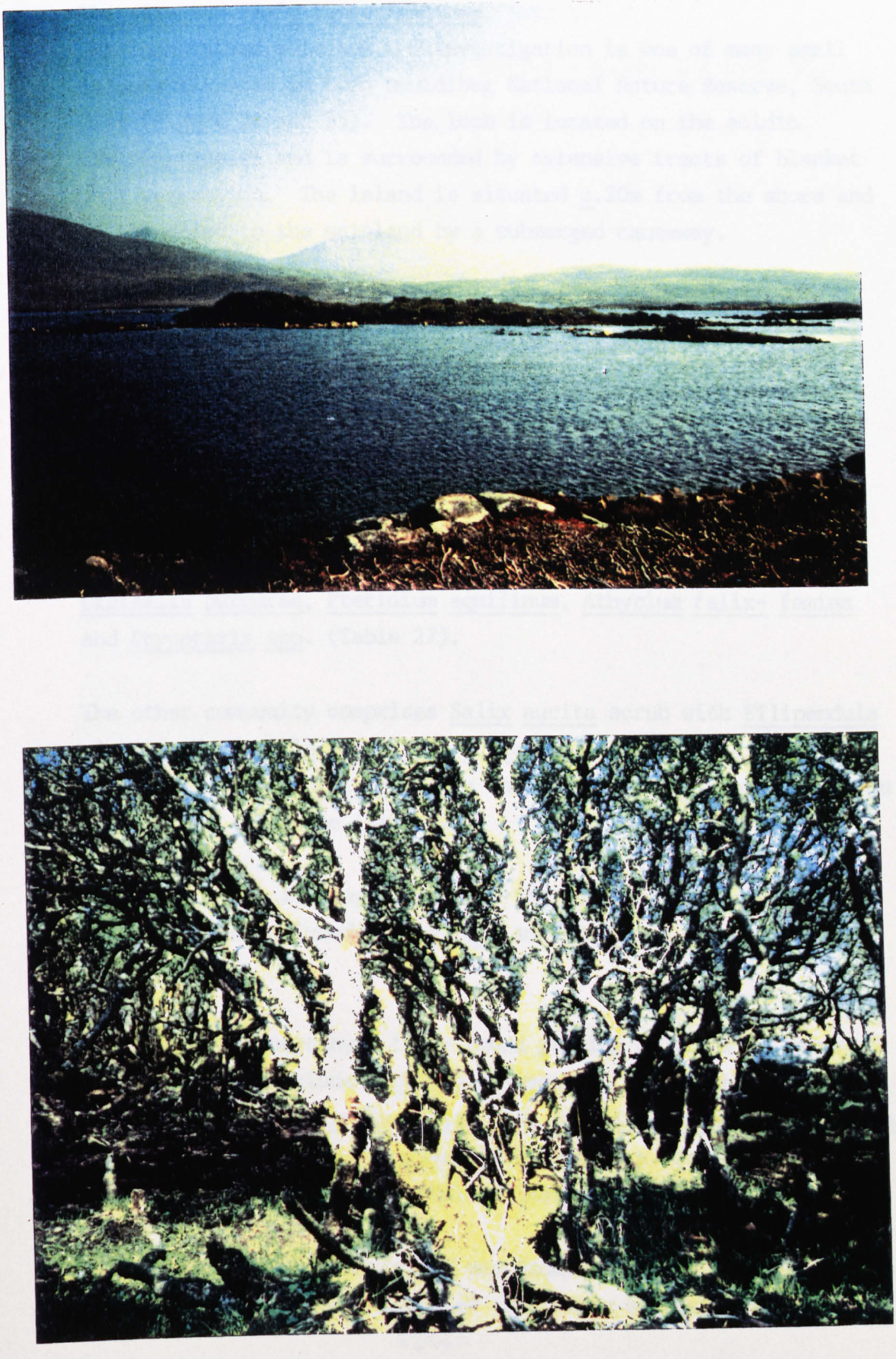

Figure 35. Woody-scrub vegetation ; Loch Druidibeg, South Uist.

The site and field investigations.

The loch island selected for investigation is one of many small islands situated in Loch Druidibeg National Nature Reserve, South Uist (Figure 34 and 35). The loch is located on the acidic Lewisian gneiss and is surrounded by extensive tracts of blanket peat vegetation. The island is situated c.20m from the shore and is connected to the mainland by a submerged causeway.

The vegetation of the island was surveyed using a series of releves, and the results are presented in tables 26 - 30. Two woody stands of vegetation form the dominant vegetation conmmumities on the island. At the eastern end of the island Taxus baccata, Sorbus aurita and Betula pendula form a low dense canopy (Figure 35). The diverse shrub and ground flora included Rosa canina, Lonicera periclymenum, Rubus fruticosus, Hyacinthoides non-scriptus, Stellaria media, Rumex acetosa, Digitalis purpurea, Pteridium aquilinum, Athyrium felix- femina and Dryopteris spp. (Table 27).

The other community comprises Salix aurita scrub with Filipendula ulmaria, Potentilla palustris, P. erecta, Ranunculus ficaria, R. flamula, Hydrocotyle vulgaris and Osmunda regalis and occurs on the eastern shoreline (Table 26).

Other woody species represented at the western, more exposed end of the island included Myrica gale and Juniperus communis (tables 28 and 29).

The lichen and bryophyte flora found growing on trees in releve 2 is diverse and includes Lobaria pulmonaria, Usnea subfloridana, Parmelia parlta, Parmelia glabratula, Evernia prunastre, Metzgaria furcata and Frullania tamarisci (P.Watham pers. com.) and may be characteristic of ancient woodland (Rose 1976).

The assumption that the island was inaccessible to grazing animals was dismissed when on the day of the survey a grazing sheep was

Table 26

Loch Druidibeg Island Vegetation Survey : Releve 1 : east-end.

Species	Domin No.
Salix aurita	2
Osmunda regalis	4
Filipendula ulmaria	3
Ranunculus repens	2
Ranunculus ficaria	1
Ranunculus flammula	1
Hydrocotyle vulgaris	2
Montia fontana	1
Potentilla palustris	1
Potentilla erecta	1
Senecio jacobea	1
Hyracium spp.	1
Viola riviniana	1
Rumex acetosa	1
Juncus effusus	1
Carex nigra	2
Agrostis stolonifera	1
Littorella littorina	2
Pellia epiphylla	4
Plagiomnium undulatum	2
Bare rock	5
Open water	5

Table 27

Loch Druidibeg Island Vegetation Survey : Releve 2 : east end.

Species	Domin No.
Salix aurita	2
Sorbus aucuparia	3
Taxus baccata	1
Betula pendula	3
Lonicera periclymenum	1
Rosa canina	1
Rubus fruticosus agg.	2
Digitalis purpurea	2
Geranium robertianum	2
Hyacinthoides nonscriptus	2
Rumex acetosa	4
Stellaria media	1
Poa trivialis	1
Athyrium felix-femina	1
Dryopteris spp.	1
Pteridium aquilinum	1
Isothecium myurum	1
Ulota crispa	1
Metzgaria furcata	1
Frullania tamarisci	2
Lobaria pulmoneria	2
Usnea subfloridana	1
Parmelia parlata	2
Usnea subfloridana	1
Ramalina farinacea	1
Parmelia glabrata	1
Evernia prunastre	1
Eurhynchium striatum	3
Plagiomnium undulatum	1

Table 28

Loch Druidibeg Island Vegetation Survey : Releve 3 : West end

Species	Domin No.
Myrica gale	3
Potentilla palustris	2
Potentilla erecta	1
Hydrocotyle vulgaris	1
Prunella vulgaris	1
Viola riviniana	1
Galium palustris	1
Molinia caerulea	3
Agrostis stolonifera	1
Nardus stricta	1
Juncus effusus	1
Carex echinata	1
Osmunda regalis	1

Table 29

Loch Druidibeg Island Vegetation Survey : Releve 4 : West end

Species	Domin No.
Myrica gale	1
Potamogeton polygonifolius	4
Carex nigra	3
Eleocharis palustris	3
Potentilla palustris	1
Bare peat	1
Litter	2

Table 30

Loch Druidibeg Island Vegetation Survey : Releve 5 : West end

Species	Domin No.
Juniperus communis	3
Myrica gale	4
Rosa canina	1
Salix aurita	1
Sorbus aucuparia	1
Lonicera periclymenum	1
Rubus fruticosus agg.	1
Calluna vulgaris	3
Erica cinerea	1
Potentilla erecta	1
Hieracium spp.	1
Leontodon autumnalis	1
Plantago lanceolata	1
Hydrocotyle vulgaris	1
Sedum acre	1
Ranunculus flammula	1
Filipendula ulmaria	1
Angelica sylvestris	1
Lotus corniculatus	1
Narthecium ossifragum	1
Drosera rotundifolia	1
Anagallis tenella	1
Nardus stricta	1
Agrostis capillaris	1
Agrostis stolonifera	1
Molinia caerulea	1
Carex dioica	1
Carex nigra	1
Luzula campestris	1
Juncus effusus	1
Osmunda regalis	2

disturbed. Presumably sheep can reach the island at low water via the "submerged causeway" and across the ice at times of extreme cold, as well as with the aid of local people.

Mor humus deposits were located beneath the Taxus - Betula - Salix scrub, where probing revealed variable depths of humus ranging from 10-55 cms. A mor humus monolith was retrieved from beneath the woody scrub canopy in relevé 2 which consisted of c.55cms of mor humus which had accumulated in a shallow depression in the bedrock. A further short core from a waterlogged organic soil beneath Salix scrub in releve 1 was also collected for analysis.

Methods.

The mor humus and peat monoliths were stored in plastic tubing, wrapped in heavy polythene sheeting and stored at 4°C prior to sampling for pollen analysis. In order to facilitate close sampling of the deposits the mor humus profile was frozen and cut into 1cm. slices from which $1cm^3$. sub-samples were taken for pollen analysis following Hannon et al. (1988). The samples were processed using standard KOH digestion and acetolysis (Faegri and Iversen 1979). Lycopodium clavatum tablets were added to each sample to facilitate pollen concentration calculations. A minimum of 600 pollen grains was counted at each level and the results are presented as pollen percentage and pollen concentration diagrams. Local pollen assemblage zones LPAZ were defined using numerical zonation techniques (Padmore 1990) and are described using the site designation LDB1 (mor humus profile) and LDB2 (organic soil profile).

Sediment characteristics.

The mor humus profile consisted of three sediment units;

Unit 1 55 - 54 cms. minerogenic layer.
Unit 2 53 - 24 cms. Dark brown humified organic layer.
Unit 3 24 - 0 cms. Light brown, fibrous organic layer.

Mor humus.

Muller (1879) originally classified forest humus into mull and mor humus types differentiated by processes of accumulation. Mor humus consists of organic litter which accumulates when there is no active mixing between the litter layer and the underlying mineral soil. Consequently mor humus is stratified and almost entirely organic with a dry fibrous texture in the upper layers due to the slow rate of accumulation. It is distinguished from peat by processes of formation - mor is essentially a dry deposit whereas peat is formed in a waterlogged environment (Bradshaw 1988). Andersen (1979, 1984a, 1984b) and Aaby (1983) note that brown fungal hyphae characterise mor humus types. Andersen (1979) in a study of soil profiles and historical data from Eldrup forest, Denmark, found that the original brown earth soil had degraded into a podzol following woodland felling and a period of cattle grazing. Andersen demonstrated that the four profiles had the same vegetational history but had undergone different soil development. This led Andersen (1979) to conclude that the influence of microtopography was an important controlling factor in the accumulation of mor humus. Aaby (1983) also suggested that bedrock topography affected mor humus accumulation in Draved Forest soil profiles. At one site the proximity of the water table to the soil surface had reduced biological activity causing mor humus to accumulate 1,700 years earlier than at the other site.

Stockmarr (1975) produced a model of a pedogenic sequence and compared it to a pollen diagram from a soil profile from Martingerbos, The Netherlands. He showed that some aspects of past vegetation changes at the site were associated with anthropogenic activity. As *Tilia* forest was replaced by *Quercus* and *Fagus*, secondary woodland mull humus degraded to mor as a result of increased soil acidity following disturbance. Davies *et al.* (1964) suggested that reduced phosphate and nitrogen levels were causal factors in mor humus accumulation following disturbance. In a further study from Breen Wood, Co. Antrim, Northern Ireland, Cruickshank *et al.* (1981) suggested that mor humus accumulation, which coincided with blanket peat formation at a pollen site adjacent to the wood, was induced by wetter climatic conditions. These studies suggest that a number of site related and other local factors are infuential in the formation of a mor humus type. In particular the chemical nature of leaf litter (Handley 1964) which influences the phosphate and nitrogen status of the soil (Davies et al. 1964) and which may be related to woodland disturbance, site topography and climate.

The pollen diagrams. (Figures 36-39).

1) Taxus - Sorbus stand (LDB2).

LPAZ LDB2-1 ; 55 cms - 14 cms..

High Calluna vulgaris pollen frequencies characterise the basal pollen spectra (c90% tlp.). Other pollen types are poorly represented and include scarce grains of Gramineae, Potentilla, Osmunda regalis, Filicales and Pteridium. Arboreal pollen frequencies are low (<2% tlp) and comprise occasional grains of Pinus, Betula, Alnus, Salix and Coryloid type.

LPAZ LDB2-2 : 14 - 8cms.

Calluna pollen frequencies vary from 55% tlp to c.72% tlp. Overall there is a small increase in arboreal pollen representation. Coryloid type (15-20% tlp), Betula (5-10% tlp) and Sorbus (5-8% tlp) together with occasional grains of Taxus, Quercus, Ulmus, Alnus, Sorbus and Taxus. Lonicera and Rosaceae (undifferentiated) pollen are present in low frequencies. There is an increasing diversity of herbaceous pollen includes Plantago lanceolata, Rumex acetosa and Succisa. Filicales, and Athyrium spp. spore frequencies are higher.

FIGURE 36

Pollen percentage diagram,
Taxus - Sorbus stand : LDB2
Loch Druidbeg, South Uist.

see Appendix

LPAZ LDB2-3 : 8 - 0 cms.
Characterised by Betula (15-45%), Sorbus (10-20%), Taxus (15% tlp) and Athyrium spp. Calluna representation falls to c.5% tlp. Scarce pollen types include Rumex acetosa, Ranunculus type, Succisa, and Scrophulariaceae (Digitalis type). Lonicera, Rosaceae type and Hedera helix are present.

Discussion
Three phases of vegetation succession are therefore recorded in the LDB2 profile. Following initial clearance of the vegetation (indicated by the high charcoal values in the basal spectra) firstly, Calluna heath, then Corylus / Myrica dominated scrub and finally Taxus -Betula - Sorbus woodland developed.

Pollen Concentration Zones (LDB2).
Four pollen concentration zones are defined on the basis of major fluctuations in the total pollen and spore concentration values (Figure 37) and are used to describe the pollen concentration diagram.

Pollen Concentration Zone ; PCZ-LDB2 -1 ; 50-48cms.

Total pollen and spore concentration values are high with values averaging 2000k grains / per cm^3. in the basal sediments. The major contributor to the pollen spectra is Calluna, with low but significant amounts of Pinus and Salix. Charcoal concentrations are particularly high in this zone.

Pollen Concentration Zone PCZ-LDB2-2 : 48 - 14 cms.

This zone is marked by a decrease in total pollen and spore concentration with values remaining consistently at c.400k grains / per cm^3 throughout the zone. The main constituent of the pollen spectra is Calluna vulgaris .

Pollen Concentration Zone PCZ-LDB2-3 : 14-8cms.

Total pollen and spore concentration values increase very slightly in this zone to c.500k grains per cm^3. However Calluna values decline slightly and there is a corresponding increase in Corylus / Myrica, Taxus, Gramineae and Cyperaceae. Fungal spore concentrations increase across the zone boundary.

Pollen Concentration Zone PCZ-LDB2-4 : 8-0cms

Total pollen and spore concentrations increase further to c.1000k grains per cm^3. This increase in pollen concentration values reflects the decline in Calluna pollen values and a corresponding increase in Betula, Sorbus, Taxus and Athyrium type and Dryopteris spores.

Salix stand : LDB1.

LPAZ : LBB1-1 : 22 - 16cms.

High Calluna frequencies (c.60-65% tlp) characterise the basal pollen spectra together with Gramineae (10-12% tlp) and Cyperaceae (5-10% tlp). Low, but consistent frequencies of Plantago lanceolata, Rumex acetosa and species of Compositae and Umbelliferae occur. Arboreal pollen values are low with Alnus (c.5% tlp), Coryloid (c.10%-12% tlp), Salix (c.5% tlp) and Sorbus (c.3% tlp) most frequent. Betula, Pinus, Quercus and Ulmus are also present with values of <2% tlp respectively. Spores included Filicales, Osmunda regalis, Polypodium, Selaginella selaginoides and Equisetum. Aquatic pollen frequencies, Littorella (10% tlp + aquatics) and Isoetes lacustris and Isoetes echinospora (c. 20% tlp + aquatics) decline towards the upper zone boundary. Sphagnum (4-5% tlp + spores) was recorded.

LPAZ LDB1-2 ; 16-5cms.

A marked increase in the representation of Salix and a decline in Calluna from the high frequencies recorded in LDB1-1 characterise this LPAZ. Coryloid (12-15% tlp) and Sorbus (4-7% tlp) increase

FIGURE 37

Pollen percentage diagram,
Taxus - Sorbus stand : LDB2
Loch Druidbeg, South Uist.

see Appendix

gradually then decline from 11 cms. Other arboreal species include Alnus, Pinus, Betula and occasional grains of Ulmus Fraxinus and Taxus. Gramineae, Cyperaceae and a similar suite of herbaceous species are well represented, together with spores of Osmunda, Pteridium and Filicales. Isoetes echinospora declines and Isoetes lacustris increases. A small peak in Sphagnum occurs between 13-10 cms. Charcoal concentrations fall from the high levels of LDB1-1 (Figure 38).

LPAZ LDB1-3a ; 5-2cms.

Calluna frequencies peak again (50-57% tlp) and there is a corresponding decline in Salix from maximum levels of 80% tlp in LDB2b to between 55-30% tlp in LDB2c. Gramineae and Rumex acetosa also increase in abundance and Plantago lanceolata, Rubiaceae type (Polygala) and Polygonum bistorta type were present.

LPAZ LDB1-3b ; 2-0 cms.

Salix dominates the pollen assemblage in the uppermost LPAZ. Gramineae and Calluna vulgaris decline, as does the representation of herbaceous type pollen.

Pollen Concentration Zones.

Four pollen concentration zones are defined on the basis of major fluctuations in the total pollen and spore concentration values (Figure 39) and are used to describe the pollen concentration diagram.

Pollen Concentration Zone PCZ-LDB1-1 : 22-16cms.

Total pollen and spore concentration values average 4-800k grains / per cm^3. in the basal sediments. Calluna is a major contributor to the pollen spectra, together with Gramineae, Cyperaceae, and some woody taxa such as Betula, Taxus and Sorbus.
Sphagnum. Aquatic types such as Isoetes also have relatively high concentration values for the diagram in this zone.

FIGURE 38

Pollen percentage diagram,
Salix stand LDB1
Loch Druidbeg, South Uist.

see Appendix

Pollen Concentration Zone PCZ-LDB1-2 : 16 - 5cms.

This zone is marked by a slight decline in total pollen and spore concentrations with values falling to between 2-400k grains / per cm^3 throughout the zone. This decline in pollen concentration values corresponds with a change from *Calluna* to *Salix* dominated pollen concentrations.

Pollen Concentration Zone PCZ-LDB1-3 : 5 - 2 cms.

Total pollen and spore concentration values fluctuate between 2-400k grains per cm^3, reflecting a brief decline in *Salix* values and increase in *Calluna*.

Pollen Concentration Zone ; PCZ-LDB1-4 : 2 - 0 cms

Total pollen and spore concentrations increase slightly as *Salix* values rise once again.

FIGURE 39

Pollen concentration diagram,
Salix stand : LDB1
Loch Druidbeg, South Uist.

see Appendix

Four phases of vegetation change are recorded in LDB1. The basal pollen assemblage LDB1-1 suggests that the vegetation at this time consisted of open grassland and Calluna vulgaris heath with a small copse of Salix scrub. Waterlogged conditions at the site are indicated by the abundance of Littorella pollen and Isoetes spores, aquatic taxa probably present in the sediments as a result of inundation by lake water. As in LDB2 the open aspect of the vegetation in this part of the diagram means that the source area represented by the pollen spectra reflects not only the vegetation at the site but also that of the surrounding lake island communities and lake shores. The Coryloid pollen curve may represent a separate Coryloid scrub growing either on the island or lake shore rather than a Salix / Coryloid association at the site. In the second phase of vegetational succession Salix scrub appears to have flourished as the waterlogged conditions at the site improved and is accompanied by grasses, herbs and ferns in the understory. In LDB1-3a a brief period of disturbance in which grass and heath communities are re-established at the expense of Salix may be the result of an increase in grazing. In the final phase, Salix scrub regenerates and the upper pollen spectra is a fairly good representation of the modern vegetation at the site.

Discussion.

a) Pollen source area.

Comparison of the contemporary vegetation at LDB1 with the surface sample from the mor humus profile suggests that pollen representation under the dense wood and shrub canopy strongly represents the vegetation within 20 m. of the site. If other "on-island" pollen sources were contributing significantly to the pollen spectra within the woodland higher Salix values than those recorded could be anticipated, having their source in the Salix scrub approximately 30 metres away. If "off-island" sources were contributing to the pollen spectra then much higher values for Calluna and other blanket bog species would occur. Surface samples from within the Salix scrub at LBD1 also display similar taphonomic characteristics, for example, Betula, Sorbus and Taxus are recorded as scarce pollen types in LBD1 surface samples, despite the fact that they are present in the vegetation only c.30m from the site. "Off island" pollen spectra (blanket bog species) are also poorly represented suggesting that at both sites pollen dispersal from within the woodland is concentrated within a few metres of source.

Surface pollen samples from the three other vegetation relevés sampled are more varied and contain a much greater proportion of "off-island" pollen (blanket bog taxa) and "on-island" pollen from LDB1 and LDB2 woodland (Betula, Sorbus, Salix). These data suggest that the physiognomy of the vegetation plays a considerable role in the dispersal of pollen on the island. The low growing communities at the exposed, western end, appear to receive pollen from a wider source area than the closed canopy sites. These taphonomic characteristics are significant in relation to the interpretation of the pollen sequences recorded in the deposits from LDB1 and LDB2 in that they suggest that the open heathland recorded in LDB1-1 and LDB2-1 represents a pollen source area which includes local and extra local sources.

Dating.

Previous studies of mor humus profiles have adopted several methods for dating palynological sequences (see Bradshaw 1988). Radiocarbon dating has been successfully employed at some sites but dating the humus matrix is problematic due to the translocation of humic acids within the profile (Cruickshank and Cruickshank 1981). Alternative methods have been employed based on known historical dates for vegetation characteristics and the constant pollen accumulation rate assumption (Hannon and Bradshaw 1989, Aaby 1983, Middeldorp 1980). Calibration with tree ring data from sites has been used to calibrate the dating curve (Hannon and Bradshaw 1989), although in the case of this Loch Druidibeg island, no suitable taxa or individuals were found.

Radiocarbon dates are not available for the Loch Druidibeg profile and there are no features of the pollen record from the site which provide a useful marker on which to base an age-depth relationship curve by assuming constant pollen and humus accumulation rates. The Sorbus and Taxus trees on the island are mature specimens but tree ring age determinations were not attempted.

In the absence of absolute or relative age-depth time scales consideration of the pollen and archaeological record may provide some clues to the age of the deposits.

Surface sample studies (see above) suggest that the two basal LPAZ's - (LBD1-1 and LDB2-1) are representative of a wider source area than that recorded in the closed canopy woodland higher in the profiles . Mor humus accumulation on Loch Druidibeg island appears to have been initiated during a period in which widespread Calluna heath, similar to that surrounding the loch today, was the dominant vegetation type. Radiocarbon dates from other Outer Hebridean sites suggest that similar open landscapes were present from c.4,300 B.P. at Loch Lang (Bennett et al. 1990), c.4345 B.P. at Rosinish III (Whittington and Ritchie 1988), c. 3,220 B.P. at Callanish (Bhoncke 1988) and c.4,000 B.P. Lochan na Cartach, Barra (this study). Biostratigraphic correlation with the pollen record from these sites is extremely tentative given the very different nature of the pollen preserving deposits and geographical locations of the other sites. However this palynological evidence clearly suggests a post 4,000 B.P. date for the basal Loch Druidibeg island profiles.

Archaeological structures on lake islands dating from the Neolithic period are a feature of the South Uist archaeological record. Iron Age island Duns and Brochs such as Dun Raouvill in Loch Druidibeg, are the most common archaeological structures dating from this period. Possibly the structure and initial clearance phase recorded in LDB2-1 and LDB1-1 on Loch Druidibeg island dates from this period (c.2,000 B.P., Barber 1987). The relationship between the construction of the archaeological site and the onset of mor humus accumulation is unknown, consequently it is very speculative to assume that the mor humus post-dates the structure.

The pollen diagrams.

Analysis of the mor humus profile from Loch Druidibeg island provides no evidence of continuous woodland or scrub vegetation during the present phase of mor humus accumulation. The high frequencies of microscopic charcoal particles in the basal minerogenic layer in LDB PCZ2:1 indicates that the preceeding vegetation of the island may have been cleared by fire and that subsequently the area was colonised by dry Calluna heath. This clearance may be associated with the occupation of the island.

The Coryloid pollen type contains two species, Corylus avellana and Myrica gale, and attempts to separate these types proved unreliable and as a result interpretation of the Coryloid frequencies is difficult. Myrica gale, a characteristic species of blanket peat vegetation is present on the island (Table 29) and it may have flourished briefly in this first phase of scrub development. However the generally dry nature of the Calluna heath recorded in the previous zone would suggest that Corylus avellana, rather than Myrica gale was present. Though the acid soils, or a change to a wetter environment could favour Myrica.

There are other indications of scrub development as Sorbus, Betula, Taxus, Dryopteris spp., Filicales and Athyrium are recorded. Lonicera and scarce grains of Hedera occur, Rosaceae pollen is also present and may be derived from Rubus fruticosa or Rosa canina, species abundant within the present day woodland. Difficulties in the identification of Rosaceae type pollen to species level caused problems in the separation of these types except in the case of Sorbus which was identified using the pollen keys of Eide (1981) and Boyd and Dickson (1987). A small peak in Gramineae together with a more diverse herbaceous pollen flora which includes Plantago lanceolata, Rumex acetosa, Succisa, Ranunculus type and Umbelliferae suggest the presence of acid grassland. An increase in fungal spores in the pollen samples at this vegetation transition corresponds with the change from heathland to scrub vegetation indicating a change in the humus forming matrix.

In the uppermost LPAZ LDB2-4 Betula attains values of c.45% tlp and Sorbus and Taxus values increase to between 10-25% tlp respectively. The dominance of Betula in the pollen spectra may reflect high pollen productivity rather than abundance in the vegetation, Taxus and Sorbus aucuparia are relatively low pollen producers, consequently these low values probably represent a local presence of these taxa. Calluna and Pteridium decline as the woodland canopy develops and Dryopteris and Athyrium increase in abundance.

The pollen record from LDB2 shows that the recent history of vegetation on the island has been dynamic as the heathland flora was invaded by Corylus / Myrica dominated scrub, then Betula, Taxus and Sorbus woodland.

The pollen sequence from LDB1 (Figures 38-39) suggests simpler vegetation dynamics as a small Salix copse, present at the start of the pollen diagram flourishes possibly as a result of a relaxation of anthropogenic disturbance on the island. A brief period disturbance is recorded in LDB1-3 in which the Salix scrub is reduced possibly as a result of coppicing which would reduce pollen production or sheep grazing which would restrict regeneration, temporarily depleting the scrub.

Salix remains the dominant woody species at this site possibly because the shallow soil and wet conditions prevented further succession by other species such as Betula, Sorbus and Taxus. The two pollen sequences may overlap as the basal spectra are similar and the Taxus and Sorbus follow similar trends.

Several characteristics of the Druidibeg island pollen data are remarkably similar to the record from the Connemara lake islands (Hannon and Bradshaw 1989, Flannelly 1988). In both cases there is no orderly arrival of woody plant species on the island, rather they arrive simultaneously with Corylus / Myrica. Hannon and Bradshaw's 1989 model (Figure 40) of recent vegetation change in western Ireland provides a valuable aid to the interpretation of the Loch Druidibeg island pollen data. This model suggests a three stage process in which temporary tree clearance on acid soils created heathland which, in the absence of grazing and disturbance, would develop woodland similar in species composition to the Loch Druidibeg island woods. Comparison of the Loch Druidibeg pollen data with this model suggests that the Calluna heath and grassland communities of the basal LPAZ's were maintained by anthropogenic pressure during a phase in which the island was occupied. The woody succession in which Corylus / Myrica scrub then Betula - Taxus - Sorbus woodland at one site and Salix scrub at the other could have been initiated after the (archaeological) site was abandoned.

The source of the tree seed which colonised the island is difficult to ascertain given the apparently non-wooded nature of the wider landscape. Hannon and Bradshaw (1989) discuss possible dispersal mechanisms in the similar non-wooded landscapes of Connemara and suggest that;

"the observed mixture of species are not purely the result of chance colonisations, but reflect the interaction between the regional seed-pool and available habitats".

Similar arboreal species with predominantly wind-dispersed seeds and bird dispersed berries are recorded in the woodland colonisation of the Connemara and Loch Druidibeg islands. It seems probable that a local source of seed was available in South Uist from other wooded islands and sheltered woodland fragments such as the gorge at Allt Volagir. Most of the species present in the Loch Druidibeg pollen data were present on South Uist earlier during the Holocene and fragments of ancient woodland have persisted, despite the predominance of blanket peat communities from the mid to late Holocene. An exception is Taxus baccata which currently has no history in the Holocene pollen record from the Outer Hebrides. Hannon and Bradshaw (1989) describe the presence of Taxus as an early colonist of post clearance woodland on Connemara lake islands where, as in South Uist, its presence on the acid soils of the lake island contrasts with its current distribution on calcareous base rich soils in the British Isles. This fits in with Tittensor's (1980) inference that;

'Yew is obviously an opportunistic species which can expand rapidly in the context of open areas where there is low grazing pressure' (Tittensor 1980 pp 263).

The status of Taxus as a colonist of post- "elm decline" woodland in Ireland has been noted by O'Connell et al. (1987) who suggest that the role of Taxus in Holocene woodland dynamics has been underestimated largely as a result of difficulties in the identification of this rather indistinct grain. Taxus does not appear to colonise in this manner today, for example, grazing pressure is thought to prevent Taxus colonisation in the forests of Killarney where secondary successions, recorded by pollen analysis, do not include Taxus despite the local availability of seed sources (Mitchell 1987b). Its presence on Loch Druidibeg island may be the result of a chance dispersal and also support the hypothesis that woodland became established on the island as a result of the relaxation of human activity.

Synthesis.

There are a number of limitations to this study which prevent any useful correlation between island vegetation dynamics, the regional Holocene pollen record and the archaeological record. Specifically the lack of reliable dating evidence imposes severe limitations to establishing a chronology for the sequence. The

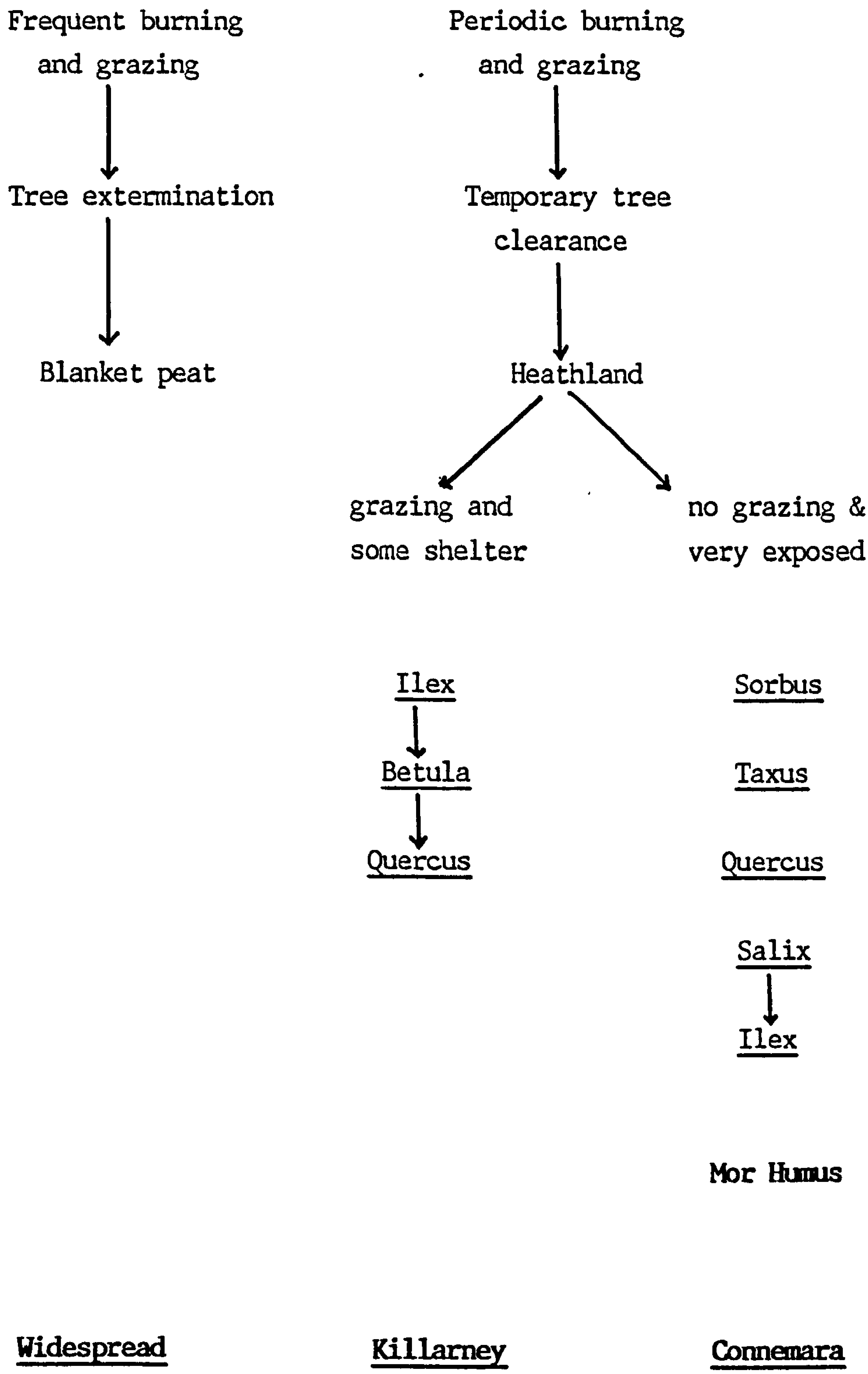

Figure 40. : Model describing recent woodland succession in Western Ireland (source Hannon & Bradshaw, 1989).

duration of vegetation phases recognised in the pollen diagrams cannot be established, thus the antiquity of the pre-woodland phase during which the island may have been occupied, and the woodland itself remains unknown. Equally frustrating is the lack of dating for the archaeological structure on the island as one could provide a provisional timescale for the other. However the study is significant in that it further demonstrates the potential of palynological studies in elucidating the history of individual woodland stands and vegetation dynamics within closed canopy sites which would not normally be expressed in conventional pollen - stratigraphic sequences. Importantly, this study shows that in the absence of anthropogenic disturbance, woodland colonisation can be successful in South Uist and was not just a phenomenon of the early Holocene vegetation history in the Outer Hebrides. This new information has importance for management of such sites in the Loch Druidibeg nature Reserve. Significantly no tree or shrub seedlings were recorded in any of the vegetation releves probably because the island is accessible to grazing sheep which remove the seedlings and are preventing regeneration.

Chapter 11.

Holocene Vegetation History at Port Caol, Barra.

Holocene vegetation history at Port Caol, Borve, Barra.

The intertidal peat deposit (figure 41) at Port Caol (NF 646022) is located on the north facing side of the Borve Headland, Barra (Figure 42). Erosion around the headland has revealed a series of complex interbedded sand and organic deposits which include lacustrine marl, rich in freshwater molluscs (figure 43). The diversity of the sediments reflects the complexity of former coastal processes which represent phases in the origins and development of the machair. The sequence contains sediments which can be classified stratigraphically as pre- machair and machair (above basal sand deposits) in age. The Holocene deposits on the Borve Headland, Barra, illustrated in figure 43 are described below.

Unit Thickness / Description.

Youngest ; 1a and 1 - 2m.
Pale brown / white sand of comminuted shell sand, often well sorted, with occasional quasi-horizontal darker brown / black organic bands (Unit 1b) each 2-3 cms. thick, transitional contact below.

1c 2-5 cms.
Dark brown, black peaty sand, undulating surface, dipping and thickening into Port Caol, sharp upper contact, transitional lower boundary.

Interpretation ; 1a, 1b and 1c.

1a and 1b. Dune sands and machair sands with intermittent soil formation.

1c. A wet swamp or pond deposit accumulating at the back beach or upon the machair.

At south margin of exposure

1i 1-5 cms.
Sand with a peat matrix.

Figure 41. Inter-tidal peat ; Port Caol, Barra.

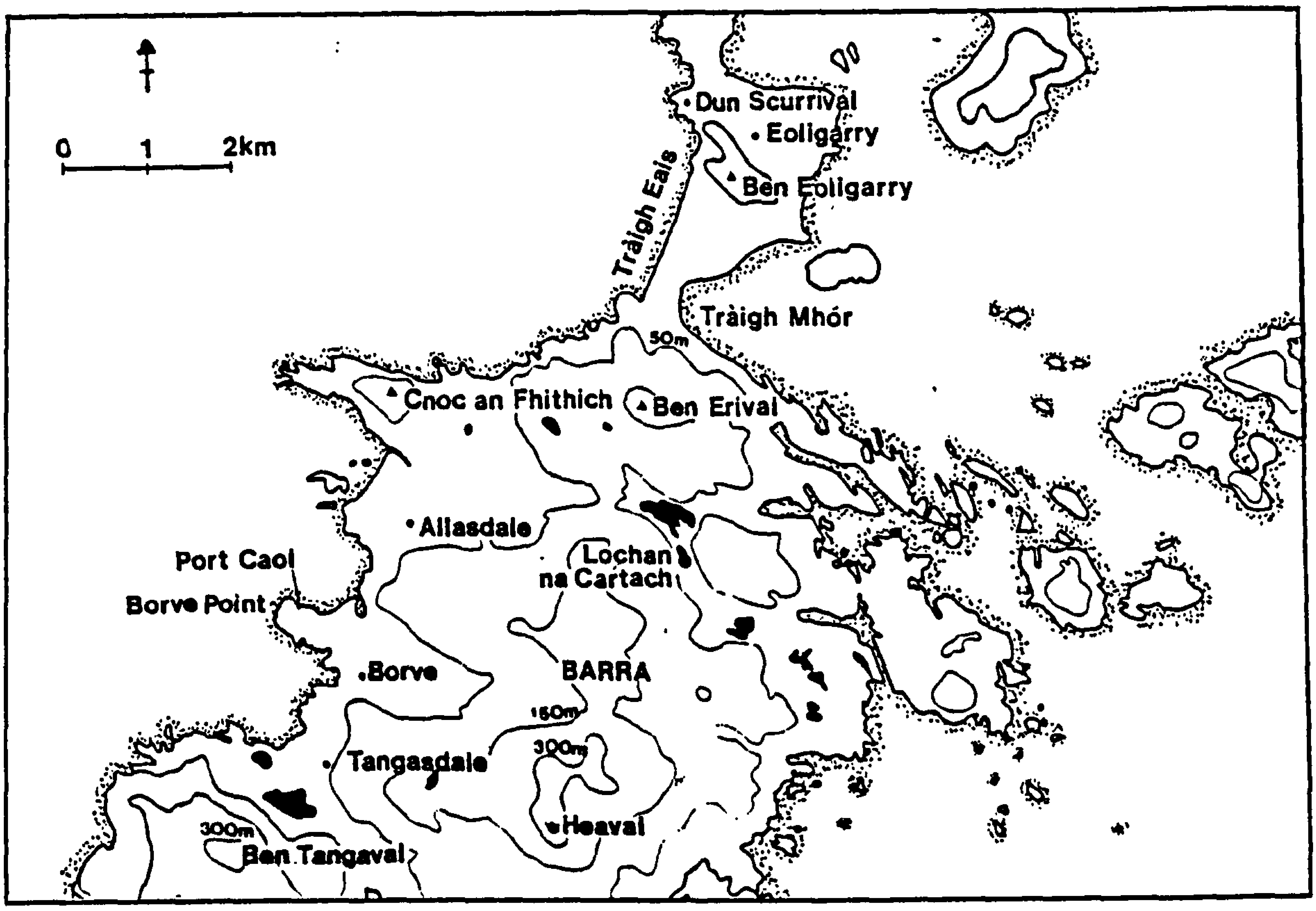

Figure 42. Location map ; Port Caol Barra.
(stipples show shoreline)

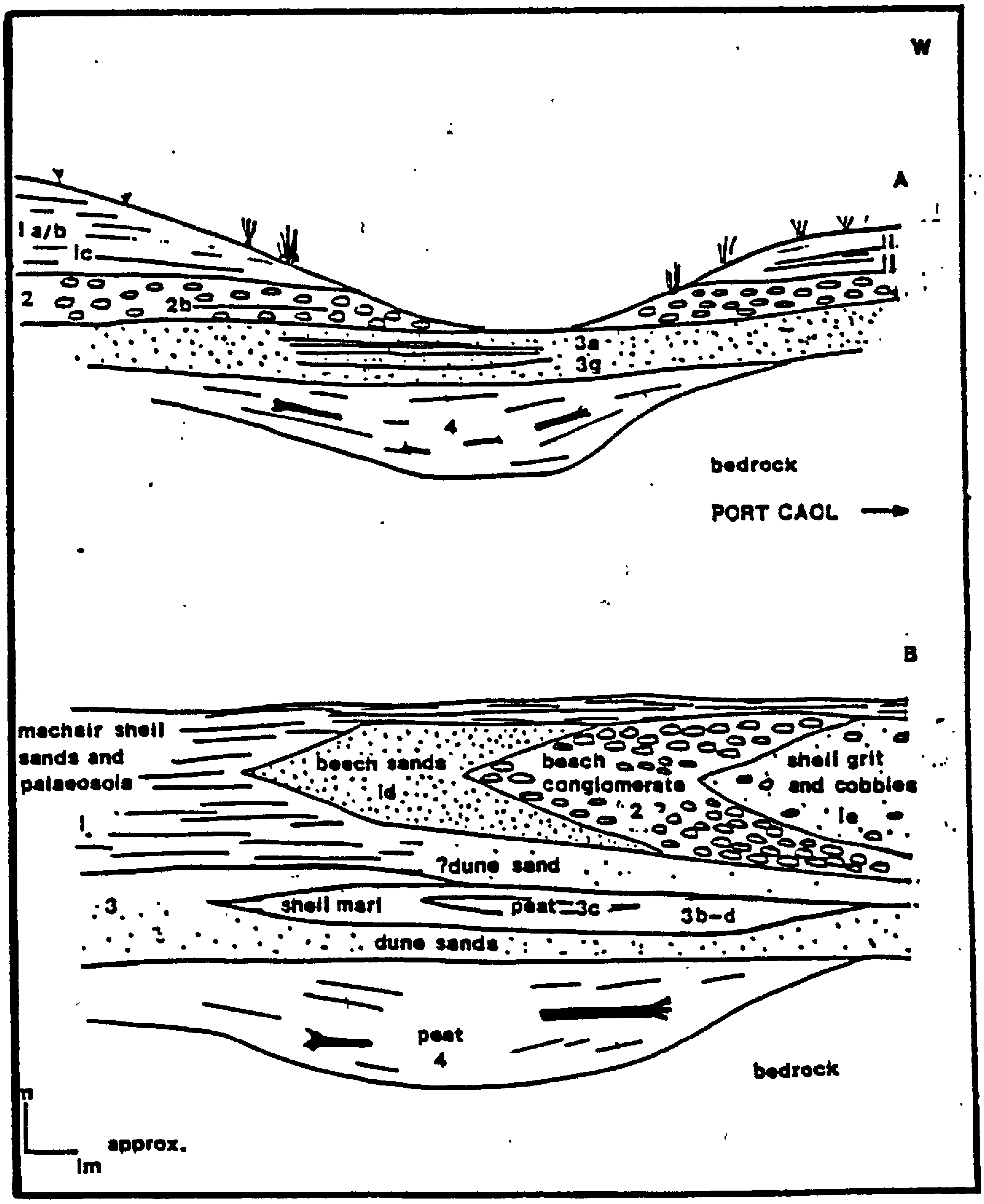

Figure 43. Sediments at Port Caol ; Barra.

1j 10-20 cms.

Buff sand with pebbles and cobbles, poor to good sorting.

1k 1-5 cms.

Sand with a peat matrix.

Interpretation ; 1i-1k.

A back beach depression which has been infilled with storm beach and beach sands.

2a > 40 cms.

Boulders and cobbles in point-contact with a sand matrix, well to poorly sorted, clasts sometimes up to 30cms. long, eliptical, well rounded, sometimes horizontally bedded, sometimes imbricated. In places this deposit changes laterally into a shelly-grit matrix, sometimes cemented in a carbonate cement. Elsewhere the deposit appears to change laterally into the beach and dune sands of Units 1a and 1j; the lower boundary is not exposed.

Interpretation

A cobble beach with an infiltration deposit of beach sand, which collected adjacent to a beach sand and machair zone into which the cobble beach appears to merge.

2b 1-5 cms.

Undulating patchy layers of buff sand and shell marl, deposit appears to taper to the east, precise nature of contacts with the enclosing boulder rich deposits of Unit 2a is unclear.

Interpretation.

A small fresh / brackish pool trapped behind a cobble beach which was subsequently overwhelmed by further ingress of the boulder beach.

3a 20-30 cms.

Pale buff/grey sand often well sorted, with thin (1-2cms.) thick undulating layers of dark sands.

Interpretation

Dune /machair sands with thin soils.

3b 2-3cms.

Pale grey/buff shell marl, including the marsh snail Succinea putris

3c 2-5cms.

Dark brown peaty sand/peat, thickens towards the centre of Port Caol.

3d 2-3cms.

Shell grit of freshwater shell debris.

3e 2-3cms.

Pale grey silt, sometimes with shell grit and decomposing freshwater shell debris, undulating, iron stained at base.

3f 1cm.

Shell marl, freshwater shells, undulating surfaces.

3g 1-15 cms.

Pale buff sands, often well sorted.

Interpretation.

3a-3g represents a small fresh/brackish calcareous pool or lake on or adjacent to machair probably within the rock hollow of Port Caol, often in receipt of windblown sand.

4 0.1-0.9m.

Brown slightly humified peat, fibrous, many leaves and horizontally bedded tree trunks of Betula and Pinus(?), the peat layer dips towards the centre of the basin which is in the centre of the present Port Caol. The peat is confined to an oval shaped basin which opens under the present machair in the rock gulley of Port Caol and closes to the seaward; (throw direction appears to be towards the north). The basin was extensively sampled for plant and beetle remains.

Interpretation.

A rock basin which infilled with peat as a result of impeded drainage caused perhaps by any of the following;

1) The rock basin has not been drained and has been collecting peat throughout the Holocene,

2) and/or the drainage impedence was caused by rising sea level; and/or the ingress of the machair.

The deposits have collected in an eroded fault zone in the underlying bedrock of gneiss. Elsewhere on the headland there is a thin (<1m. thick) covering of till, the surface of which is weathered. There are however, no clear exposures.

Overall the sequence indicates the collection of organic mud in a small freshwater lake (95m.+ long and 10-20m. across), around which there were abundant trees. The lake existed (locally at least) before the ingress of the local machair, and the arrival of the beach. The cessation of accumulation of organic mud was associated with the ingress of blown sand. Subsequently small freshwater pools with calcareous water collected in the infilling basin and more aeolian sand blew in. Locally soils developed on the machair sands, before the basin was overwhelmed by more sand. More feeble episodes of soil development occurred. The shoreline then reached the area of the inlet. Storm beach and back-beach deposits moved across the area, and machair sands collected further inland. Small pools of fresh to brackish water deposits accumulated temporarily as the sea was briefly unable to reach the site, before further movements of the coastline caused further storm conglomerates, beach sand, and machair sand deposits to collect in the area. The sequence may then be summarised as a substantial early period characterised by the formation of organic mud in a "wet", freshwater, tree fringed basin, and a later period in which there was a very complex interaction between the ingress of blown sand - the machair, soil development, the formation of small freshwater ponds or slacks, and erosion and over-topping by the sea.

This study focuses on the 'intertidal peat' deposit, (Unit 4 above). Sequences exposed in the modern inter-tidal and sub-tidal zone are described from a number of sites in the Uists (Ritchie 1985) and outline pollen diagrams from radiocarbon dated deposits of mid to late Holocene age indicate that typically the intertidal sites were freshwater lochs which became marshy grassland (Ritchie 1985). The stratigraphic studies from these sites suggested that prior to a major period of sand deposition before about 4,500 B.P. there was a complex history involving minor episodes of sand ingress, interspersed with periods of sand surface stability during which wet and marshy conditions returned. Ritchie (1985) suggests that sea level was some 3-5 m. lower than at present between 8,800-5,165 B.P. and that primary deposition of sand took place sometime around 4,366 B.P.. Importantly Ritchie (1985) demonstrates that from the mid Holocene coastal retreat and sea-level rise have produced considerable changes in the position and shape of the coastline. The "intertidal- peat" sites suggest that freshwater lochs were once present in areas of the landscape which are now covered by the sea. The Port Caol intertidal peat deposit provided an opportunity to investigate such a site and provides information on the pre-machair vegetation of Barra in an area totally exposed to the full force of Atlantic weather conditions.

The site

The inter-tidal peat deposit extends beneath a storm beach at the back shore and beneath sand and pebbles at low water mark. The surface peat contains numerous wood remains comprising of branches and rooted trunks identified as *Betula* spp. (figure 41).

Methods

Due to compaction of the sediments, coring at the site was accomplished by retrieving a series of overlapping cores with a Dutch Gouge corer. Subsequently a pit was excavated for studies of insects and tephra in the peats. The sediment sections were then transferred to plastic guttering, wrapped in heavy plastic sheeting and stored at 4 degrees Celsius prior to analysis.

The details of the sediment sequence in the core was recorded as follows,

Stratigraphy

S.U.1   0 - 4 cms. Dark brown organic layer.
S.U.2   4 - 5 cms. White / grey marl.

S.U.3	5 - 9	cms.	Sand layer.
S.U.4	9 - 10	cms.	White / grey marl.
S.U.5	10 - 15	cms.	Brown organic layer.
S.U.6	15 - 16	cms.	Sand layer.
S.U.7	16 - 23	cms.	Brown Organic layer.
S.U.8	23 - 24	cms.	Sand layer.
S.U.9	24 - 40	cms.	Organic layer with sand inclusions.
S.U.10	40 - 44	cms.	Sand layer.
S.U.11	44 - 86	cms.	Organic layer with wood remains.
S.U.12	86 - 94	cms.	Sphagnum peat.
S.U.13	94 - 98	cms.	Organic sedge peat with fine sand layers.
S.U.14	98 - 116	cms.	Lake mud with silt / clay.
S.U.15	116 - 120	cms.	Blue / grey / silt / clay.
S.U.16	120 - 158	cms.	Minerogenic lake mud.

Sub-samples for pollen analysis were prepared using the procedures outlined in chapter 4 (this study) with additional sieving through micro-sieves of the more minerogenic samples. 1 cm^3. pollen sub-samples were taken at 4 cm. intervals (where possible) or from organic bands between sand bands in the upper core sections.

The Pollen Diagrams (Figures 44 and 45).

Oldest LPAZ PC1a 158 - 120 cms.

The basal pollen assemblage is characterised by high and increasing frequencies of Empetrum, Gramineae and Cyperaceae. Arboreal pollen frequencies are low with Salix, Betula, Juniperus and Pinus <2% tlp respectively. Herbaceous taxa present include Rumex acetosa, Artemisia, Caryophyllaceae, Onagraceae type, Ranunculus type, Plantago media /major and Compositae Liguliflorea. Spores include Polypodium, Huperzia selago and scarce grains of Equisetum. The aquatic component comprises Myriophyllum alterniflorum, Littorella, Lemna type, and Pediastrum type algae.

FIGURE 44

Pollen percentage diagram from
Port Caol, Barra.

see Appendix

PAZ PC1b 120 - 115 cms.

Empetrum pollen frequencies decline rapidly from 75% to 11% tlp in this sub-zone. Cyperaceae percentages increase to <60% tlp and there is a small peak in Huperzia selago.

LPAZ PC2 115 - 96 cms.

Empetrum values are very low or zero. Cyperaceae reaches 70% in some samples. Arboreal pollen representation remains low (<15% total tree pollen). The diversity of herbaceous pollen types declines as Rumex acetosa, Artemisia and Caryophyllaceae become scarce. However Menyanthes trifoliata and Filipendula are present. Occasional Polypodium, Huperzia selago and Equisetum spores are present.

LPAZ PC3a 96-90cms.

High Calluna vulgaris percentages (c.65% tlp) characterise this sub-zone together with high Sphagnum. Arboreal pollen representation remains low and includes scarce grains of Betula, Corylus, Salix and Juniperus. The herbaceous pollen flora includes Menyanthes trifoliata, Filipendula, Rumex acetosa, Ranunculus type and Plantago media / major. Menyanthes trifoliata and Littorella occur as scarce grains.

LPAZ PC3b 90 - 80 cms.

An increase in tree and shrub pollen representation characterises this sub-zone. Corylus / Myrica (c.45% tlp), Betula (up to 55% tlp)and Salix (5-7% tlp) occur together with scarce grains of Ulmus, Quercus, Hedera helix and Lonicera periclymenum. There is a corresponding decline in Calluna vulgaris, Gramineae and Cyperaceae frequencies. However Sphagnum increases to c.70% tlp + Sphagnum. Menyanthes trifoliata and Filipendula are the most common herbaceous types.

LPAZ PC3c 80 - 55 cms.

A rapid increase in Betula to 80-85% tlp at maximum characterises this sub-zone. Corylus / Myrica percentages decline to c.6% tlp.

Ulmus and Quercus frequencies remain below 2% tlp and scarce grains of Hedera helix and Lonicera periclymenum are present. Gramineae and Cyperaceae percentages fall to <5% tlp and 15% tlp respectively. Alnus occurs at 65 cms.

LPAZ PC3d 55 - 35 cms.

Low Betula and increasing Cyperaceae percentages characterise this subzone. Herbs include Umbelliferae, Potentilla, Ranunculus type, Plantago lanceolata, Mentha type, Menyanthes trifoliata and Filipendula.

LPAZ PC4 35 - 0 cms.

High Cyperaceae percentages characterise this zone together with a diversity of herbs particularly Compositae Liguliflorae, Umbelliferae (Crithmum maritimum type), Plantago maritima, Carophyllaceae, Viccia cracca, Lotus type and Potentilla.

Pollen Concentration Zones.

Three pollen concentration zones are defined on the basis of major fluctuations in the total pollen and spore concentration values (Figure 45) and are used to describe the pollen concentration diagram.

Pollen Concentration ; PCZ-PC1 ; 158 - 90 cms.

Total pollen and spore concentration values are generally low with values averaging 200k grains / per cm^3. in the basal sediments to c.4500k grains / per cm^3. at the upper zone boundary. The major contributors to the basal pollen spectra are Empetrum, Juniperus, Huperzia selago and Rumex type. The small peak in total pollen concentration values at 122 cms reflects the abundance of Myriophyllum pollen found in the sediments at this level.

Pollen Concentration : PCZ-PC2 : 90 - 60 cms.

This zone is marked by a significant increase in total pollen and spore concentration with values reaching a maximum of c.800k grains / per cm^3. The dominant elements in the pollen spectra are peaks in the abundance of individual taxa notably Calluna, Corylus / Myrica, Betula and Cyperaceae. Potentilla (P. palustris?) and Filipendula are also well represented.

Pollen Concentration ; PCZ-PC3 : 60 - 0 cms.

Total pollen and spore concentration values decline again in this zone to <100k grains per cm^3. This decline in pollen concentration values reflects not only the decrease in arboreal pollen representation, most notably in Betula and Corylus / Myrica, but affects all the pollen and spore types - with the exception of Plantago maritima.

Interpretation.

The basal pollen assemblage in the Port Caol profile differs markedly from the rest of the diagram principally in respect of the high pollen frequencies for Empetrum recorded in PC1 but also in the presence of relatively high frequencies of Rumex acetosa and in the consistent occurrence of Caryophyllaceae, Artemisia and Onagraceae type. Gramineae and Cyperaceae frequencies are also relatively high for the diagram indicating the wide spread occurrence of grass and sedge communities around the loch. Huperzia selago and scarce grains of Saxifraga suggest the availability of rock - crevice habitats in the vicinity. Pollen of woodland and scrub vegetation is virtually absent with the exception of scarce grains of Salix, Betula and Juniperus. Increasingly organic sediment deposition and high pollen percentage values for Myriophyllum alterniflorum and Littorella spp. indicate an increase in organic productivity in the loch basin and a freshwater lacustrine environment. Correlation with similar radiocarbon dated pollen spectra at Loch Lang, South Uist

FIGURE 45

Pollen concentration diagram from
Port Caol, Barra.

see Appendix

(Bennett et al. 1990) suggest that the basal deposits at Port Caol are of a late Devensian Late-Glacial age.

A peak in *Empetrum* pollen and *Huperzia selago* spores in LPAZ PC1b, coinicident with a return to highly minerogenic sedimentation in S.U.15 are thought to be indicative of a change in sediment recruitment processes, possibly as skeletal soils which had previously supported *Empetrum* heath were eroded and deposited in the loch. A similar peak in Empetrum pollen and minerogenic sedimentation of presumed Loch Lomond Stadial age are reported at Lochan na Cartach, Barra (this study) and from Mull (Lowe and Walker 1986). Importantly the lower three LPAZ's at Port Caol predate the *Betula* / *Corylus* / *Myrica* rise in PC3a further supporting the suggested pre-Holocene date for these deposits.

The rapid decline in *Empetrum* heath which is accompanied by a sharp rise in the pollen representation of Cyperaceae and a return to more organic sedimentation in the loch are evident in LPAZ PC2. The notable reduction in aquatic pollen representation is significant at this point as it indicates a second phase of hydroseral succession in the loch, presumably as terrestrial vegetation encroached onto the infilled loch margins. Other plant species associated with lake margin, swamp and tall herb fen communities in South Uist (see Kent et al. in press, Pankhurst and Mullin 1991) are present in the pollen spectra, for example, *Filipendula*, *Equisetum* (cf. *E.fluvatile*, *Menyanthes trifoliata* and *Valeriana officinalis* type. The pollen from these plants, probably derived from plants growing in or around the loch, dominates the pollen spectra. However the vegetation in the wider landscape around the loch appears to consist of a mosaic of herb rich grassland and sedge communities. Arboreal pollen percentage and concentration values remain low and the *Empetrum* heaths of the previous zone are declining in the vegetation mosaic round the loch.

The transition from the open grasslands and heaths of the Late Devensian (Late-glacial) and early Holocene appears to involve a complex sequence of vegetation dynamics. Infilling of the loch basin is indicated by the decline in aquatic species such as Myriophyllum and Littorella and an increase in Nymphaea. Calluna vulgaris and Sphagnum spp. then expand together in PC3a at the expense of the grass, sedge and tall herb communities described in LPAZ PC2. There is a change in sediment deposition as lacustrine deposits are replaced by Sphagnum peat. These changes indicate acidifying soil conditions and vegetation response to increased waterlogging. Peat formation appears to have begun in a freshwater-marsh environment.

Calluna vulgaris and Sphagnum dominated pollen spectra are replaced firstly by Corylus / Myrica and Betula, then Betula / Salix dominated assemblages. Scarce grains of Quercus and Ulmus are also noted from the LPAZ PC3c. The expansion of Calluna vulgaris, Sphagnum, Corylus / Myrica, and Betula clearly suggest Holocene vegetation and this transition has much in common with that recorded at Kildonan Glen, South Uist (this study) where these species are recorded simultaneously at the LPAZ KDG3 boundary. These changes are interpreted as signifying a further stage in the development of a hydrosere at the site, possibly initiated by a climatic shift towards dryer conditions. Comparison of the Betula and Coryloid rise at Port Coal with early Holocene pollen diagrams from Lochan na Cartach, Barra (this study), Loch Hellisdale, South Uist (this study) and Loch Lang South Uist (Bennett et al. 1990) suggests that the woodland succession described at these sites differed from that recorded at Port Coal. At Port Caol Coryloid is the first type to increase rather than Betula. At Loch Lang, South Uist (Bennett et al. 1990) the arrival of Betula at 10,145 B.P. is followed by the arrival of Calluna vulgaris at 9,500 B.P. and the rapid spread of Corylus / Myrica at 9,400 B.P. This sequence is paralleled at Lochan na Cartach, Barra. However at Port Caol the early Holocene vegetation succession is different in that the sequence begins with the expansion of Calluna vulgaris followed by Corylus / Myrica and then Betula. As at Kildonan Glen, South Uist, a hiatus in sediment deposition during the early Holocene could account for the absence of the pollen record of woodland succession similar to that recorded at the more sheltered inland and east coast sites described above. However it is interesting to consider that the pattern of plant colonisation may have been different along the western margins of the islands. Betula may not have spread westwards from the east coast valleys until Corylus / Myrica had reached the islands, or alternativley Corylus / Myrica may have reached Barra at the same time as Betula and spread from the west coast to the eastern valleys. Further palynological and radiocarbon dated studies are required to test these hypotheses.

Woodland begins to decline as Betula and Salix are replaced by a return to the marshy conditions in which Cyperaceae, Equisetum, Filipendula and Umbelliferae flourished. Armeria maritima and Plantago maritima and Plantago coronopus are also present indicating the presence of maritime grassland similar to the Festuca rubra - Armeria maritima - Plantago coronopus community, Group A (Kent et al. in press).

Alnus is first recorded at the LPAZ PC3d lower boundary. The Alnus entrance at the lower LPAZ PC3d boundary provides a biostratigraphic marker which when correlated with the Alnus entrance in the radiocarbon dated Holocene record from Lochan na Cartach, Barra (this study) provides a provisional date for the LPAZ PC3d boundary. Alnus is present in low freqencies, at Lochan na Cartach, Barra (this study) from c.7,500 B.P. and the Alnus rise occurs at c.6,000 B.P. suggesting that the Alnus entrance and the onset of woodland decline at Port Caol occurred during this period. (This biostratigraphic correlation of course needs to be confirmed by radiocarbon dating to establish if colonisation on this very exposed area was earlier, later or the same age as the sheltered Lochan na Cartach site).

In LPAZ PC4 pollen of marsh and swamp communities dominates the pollen spectra and Compositae Liguliflorae contributes significantly to the herbaceous pollen flora which includes a diversity of taxa associated with grassland and lake margin communities. The replacement of woody - scrub vegetation by sedge communities is interesting as it suggests that the acidification noted in LPAZ PC3a is no longer influencing the vegetation to the same degree. Increasing proportions of sand and distinctive sand layers characterise the sediment matrix and pollen preservation becomes increasingly poor. The pollen analysis of the upper organic bands suggests that periods of sand influx represented by the sand layers were interspersed with more stable periods in which marshy grassland vegetation developed at the site. The occurrence of lacustrine marl deposits together with abundant freshwater mollusc shells suggests that shell sand ingress was increasingly influencing sediment deposition. The site at this time may have resembled wetland areas in the modern machair in which water table levels fluctuate in response to seasonal rainfall and the erosion of surface sand layers. Organic sediment accumulation is truncated at Port Caol by storm beach and aeolian sand deposits.

Without independent radiocarbon dating evidence it is difficult to correlate with reliability the pollen diagram from Port Caol with the other Hebridean sites, and especially the peat deposits exposed in the intertidal zone and described by Ritchie (1985). A submerged organic peat layer at Forvath Reef, Pabbay which is dominated by Cyperaceae, Sphagnum and Ericoid (undifferentiated) pollen together with low Corylus / Myrica, Betula and Alnus is radiocarbon dated to c.8,330 B.P. A similar date of 8,802 ± 70 B.P.(SRR-396) was reported from Holme, near Stornaway, Isle of Lewis for submerged organic deposits beneath a thin sand layer. Pollen analysis from The Jetty, Pabbay shows a transition from sedge and grassland vegetation to Ericaceous heath and Betula, Corylus / Myrica woodland. The basal organic clay layer is radiocarbon dated to 7,703 ± 60 B.P. and Durno, in Ritchie (1985), suggests that the top of the profile could be c.5,000 B.P.. The basal pollen assemblage at the Jetty is similar to the LPAZ PC3a lower boundary but the date of c.7,730 B.P. appears too late in comparison with the suggested early Holocene date for the Calluna vulgaris, Corylus / Myrica, Betula rise at Port Caol.

Unfortunately without radiocarbon dates it is not possible to know if the sediment sequence is continuous and there are no breaks in sediment accumulation. So it is possible that the early Holocene colonisation of Betula then Corylus woodland on Barra, which is recorded in the Lochan na Cartach pollen diagram, may be absent from Port Caol.

The movement of sand onshore appears to have altered the vegetation at Port Caol from the LPAZ PC4 lower boundary, that is from c.7,000 B.P. which is the time of the Alnus entrance. However the rapid rise in sea level after 5,100 B.P. suggested by Ritchie (1985) may provide a provisional date for the primary ingress of sand and storm beach deposits which appear to have buried the Port Caol site. Present coastal erosion is reworking these deposits and exposing the remains of the buried loch basin. Importantly this study shows that woodland and scrub vegetation was established in exposed western locations in Barra in areas which were subsequently buried by the ingress of sand as sea levels rose in the mid Holocene.

Discussion.

The studies reported here suggest that Port Caol is an unusually important site. The pollen analytical studies indicate with reasonable confidence that lacustrine sedimentation began in the late Devensian and continued into the early-mid Holocene. Typically sites of this time range have only been detected in deep cores such as Loch Hellisdale, Lochan na Cartach and Kildonan Glen where the sequence could not be examined in open section, neither was it possible in these locations to observe the presence of significant macrofossils. At Port Coal, the formerly contentious taphonomic issues concerning the actual presence or absence of woodland with trees in the Outer Hebrides has been definitly settled. Log sized macrofossils of tree birch and perhaps Pinus sylvestris (Dr.F.B.Pyatt pers. com.) have been recovered in abundance, and in abundance from a site which at all times in its Pleistocene history, must have been totally exposed to Atlantic gales. It is therefore interesting to examine the pollen content of the sediment matrix in which the tree birch macro-fossils were embedded. It is worth recalling that an apparently "natural" stand of birch woodland survives in an exposed location immediately south-east of the Allt Volagir National Nature Reserve (Chapter 6 this study, Bennett and Fossit 1989). In combination with the other finds of Holocene tree stumps recorded along the foreshore of North Uist, South Uist, Pabbay and Benbecula by Elton (1938) and Ritchie (1966, 1985), it now appears incontrovertible that tree species forming woodland (perhaps rather open) clothed at least the lower slopes of the western Atlantic seaboard of the Outer Hebrides.

The Holocene Port Caol lacustrine basin has been shown (in part) to be of different origin to sites noted previously in the inter-tidal area in the study region. The Holocene lake existed because of the topographic control of the rocky basin, only much later did the rising sea level, coastal retreat and the ingress of machair produce the type of calcareous, machair dammed lakes that characterise the modern western margins of the Outer Hebrides, especially South Uist.

Interestingly the late Devensian pollen sequence at Port Caol, when compared with the other sites studied in the area, reveals a broadly similar suite of plant communities during this period. Pollen analytical studies such as those from Loch Hellisdale (this study), Loch Lang (Bennett et al. 1990), Lochan na Cartach (this study) and Kildonan Glen (this study) suggest that a mosaic of open grassland, widespread Empetrum heath and sedge communities characterised the sheltered eastern and exposed western areas of

South Uist and Barra. However the early Holocene sequence of tree colonisation differs from that observed elsewhere with Corylus / Myrica preceding Betula. In many ways the site at Port Caol is likely to have been a more characteristic location than the others of this period previously studied. Port Caol lies in what must have been a wide and long "plain" sloping westwards along most of the western shoreline of the Outer Hebrides, whereas the other sites are in somewhat isolated mountain basins. It is possible to speculate that the sequence of tree colonisation at Port Caol (and Kildonan Glen) is likely to be the more typical of the greater part of the Western Isles land mass during the early Holocene than the more frequently investigated mountain sites. The stratigraphic evidence and topographic situation of the small rock bounded Port Caol site can never have been the equivalent of the wet peat covered moorland which provides a habitat for Myrica gale in the present landscape of the Outer Hebrides. This evidence suggests that Myrica gale is unlikely to have been a dominant coloniser in the region during the early Holocene and suggests that the Coryloid pollen recovered in the core derived from Corylus rather than Myrica gale. Even if this suggestion is not regarded as particularly reliable it remains the case that the present Port Caol study suggests caution in the use of biostratigraphically based correlation of cores, involving Betula - Corylus / Myrica in this island region.

The upper part of the Port Caol sequence demonstrates the complexity of the soils, peat, machair sand and storm beach sequences produced by the ingress of the machair and coastal retreat during the more recent Holocene. At present there is no clear evidence of the exact antiquity of these events recorded in the stratigraphy. A fuller treatment of this site awaits the completion of studies of the fossil insects, tephra and possible tidal wave incursions (A.Dugmore pers. com.) by G.R.Coope and A.Dugmore.

Conclusion.

The present Port Caol study provides new and interesting information on the character of the vegetation of the western fringes of Barra during the early to mid Holocene. The small rock basin infilled from the late Devensian to mid Holocene by lacustrine deposits records the increasing magnitude of sand moving on-shore as sea-levels rose during the early to mid Holocene. Importantly the palynological data suggest that on the western margins of Barra the Late Devensian vegetation was similar in species composition to that recorded at Lochan na Cartach, Barra (this study) and sites from the "blacklands" interior of South Uist such as Kildonan Glen, and from sheltered east coast valleys such as Loch Hellisdale (this study), Loch Lang (Bennett et al. 1990). The early Holocene transition to open woodland at Port Caol is similar to that recorded only from one other site in the study, at Kildonan Glen, South Uist, in that Corylus and Betula are co-dominant in the earliest stages of woodland succession. However pollen percentage and concentration values for Corylus and Betula pollen are comparable with those from other sites which record the local presence of birch and hazel woodland, and exceed contemporary pollen spectra from within existing woodland on South Uist (Chapter 7 this study). At Port Caol Betula and Corylus pollen frequencies are much greater than those recorded at Little Loch Roag, Isle of Lewis (Birks and Madsen 1979). This suggests that Betula and Corylus were successful colonisers of the southern, western margins of the island chain but may have been under more stress in the north west (at Little Loch Roag, Lewis for example). Commenting on the direction and rate of spread of these species is speculative due to a lack of radiocarbon dating control and the paucity of studies from other similarly located sites.

Woodland diversification in the mid-Holocene also appears to have been different at Port Caol to east coast sites. Quercus, Ulmus, Pinus and Alnus are poorly represented in the woodland pollen flora suggesting that these species were not locally present on the west coast of Barra, whereas their much higher pollen frequencies at sheltered inland sites indicates the local presence of these species. Possibly these species were only able to establish in less exposed locations.

The cause of woodland decline at Port Caol is difficult to pinpoint. The rising sea-level obviously played a critical role in impeding drainage, the site may have been temporarily "dammed" by encroaching sand dune and machair systems before being finally overwhelmed by the sea. Equally a sudden more catastrophic event such as massive sand-blowing onto the coast suggested by Ritchie (1985) may have adversely affected woodland regeneration.

The primary interest of the site lies in its location which must have been initially on the landward margins of the early Holocene coastline, sensitive to the effects of sea-level change. The presence of wood macrofossils and polleniferous deposits rich in the representation of arboreal pollen confirms the existence of natural woodland on the west coast of Barra during the early Holocene.

Chapter 12.

Holocene Vegetation History at Lochan na Cartach, Barra.

Holocene vegetation history at Lochan na Cartach : Barra.

The island of Barra, one of the most southerly islands in the Outer Hebridean island chain is separated from the Scottish mainland by the Sea of the Hebrides by a distance of 95 miles: and from South Uist, Barra's nearest island neighbour by the Sound of Barra, a distance of 5 miles. Barra is a small island, 8 miles long and 4 miles wide yet presents a landscape which is of considerable ecological and archaeological interest.

The physical background.

The solid geology of Barra as described by the British Geological survey (B.G.S.) in 1981 consists of Pre-cambrian basement rocks which are predominantly acidic gneisses. The bedrock is overlain by deposits of Quaternary age which provide a range of substrates for plant growth. The distribution of drift deposits on the island is indicated in the 1:50 000 Provisional Soil Map Sheet 31 (Hudson et al. 1982). Thin locally derived tills occur widely on lower hill slopes and valley bottoms and correspond with the soils of the Lochinver Association. Peat deposits are extensive on the island either as deep pockets formed in rock basins or as thin blanket peats extending to altitudes of 200-300 metres O.D.

The extent of the machair plain which is well developed on the western coast is defined by the soils of the Fraserburgh Association. These calcareous sands of the machair plain provide a habitat for floristically rich calcareous grassland communities and the area is widely exploited by the islanders for pasture and arable crop cultivation.

A number of major trough like valley systems radiate away from the mountainous centre of the island towards the coast. The contemporary landscape is bleak and windswept, the vegetation characterised by a mosaic of acid grassland - blanket peat - wetland and machair - grassland communities. A few isolated stands of mixed plantation woodland occur, confined to sheltered localities on the eastern side of the island. Species noted by this author included: Populus tremula, Betula pubescens, Corylus avellana, Fraxinus excelsior and Sorbus aucuparia (possibly natural) as well as Acer pseudoplatanus, Salix caprea, Picea abies, Pinus sylvestris and Larix decidua. Lonicera periclymenum and Luzula sylvatica are present in the understory of these woodlands. A few scattered, possibly native Salix shrubs were also noted on loch islands in Loch nic Rhuide. Salix repens is common in acid heaths above the Borve valley and on Ben Tangaval.

Barra contains a rich diversity of archaeological sites which attest to a long history of occupation possibly from neolithic times. The R.C.H.M. volume of 1928 records 28 sites on the island, including 7 duns, 9 cairns and two standing stones. The Sheffield Archaeology survey has substantially extended this inventory and also included ancient buried wall systems and coastal midden sites.

The Pollen Site.

Lochan na Cartach, the site from which cores were obtained for pollen analysis, is a small lake situated in a valley on the north-eastern side of Barra (figure 46, GR. NF695027). The loch lies at an altitude of c.30m. O.D. and is one of a series of lochs in the valley which include Loch Duin, Loch nic Rhuaidhe and Loch nam Faolian (the location of Blackburn's 1948 site) which are sheltered by the surrounding hills. Lochan na Cartach lies in the valley known locally as "The Dark Glen", sheltered by Cora Bhienn, Benn Gunary and Ben Obe. There is little evidence of past or present occupation in the valley. A dun on a small island in Loch nic Rhuaidhe is the only major archaeological monument in the valley, and there are no visible signs of past cultivation such as 'lazy bedding'. In contrast, the Borve Valley, just over the ridge of Cora-Bhienn from Lochan na Cartach has two major neolithic cairns, Dun Bharpa and Tigh Talamanta, together with hut circles, standing stones and field boundaries (Branigan 1989a, 1989b) which testify to a long history of occupation in the Borve Valley. Lochan na Cartach (figure 46) was selected for study

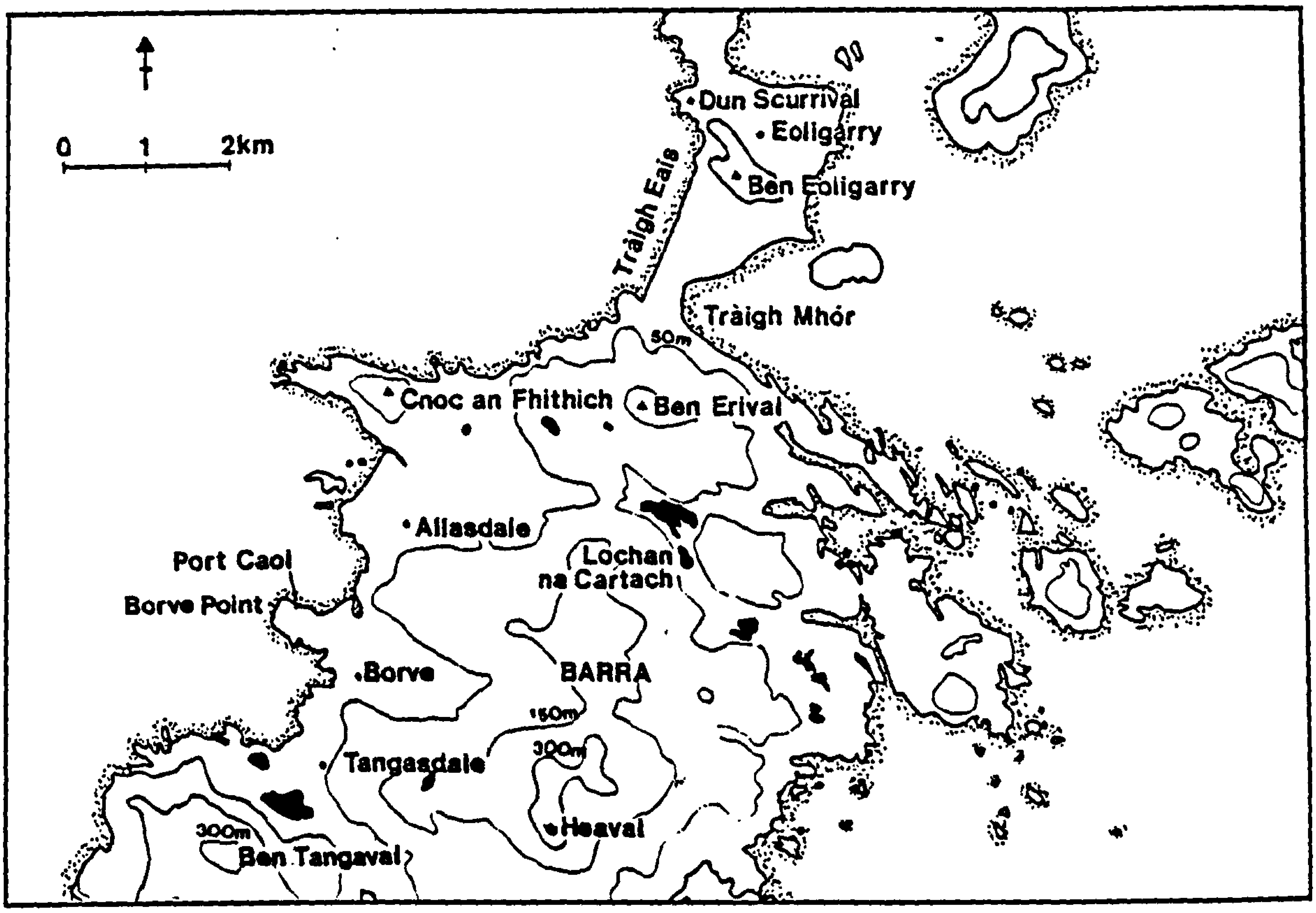

Figure 46. Location map ; Locan na Cartach ; Barra.
(stipple shows shoreline)

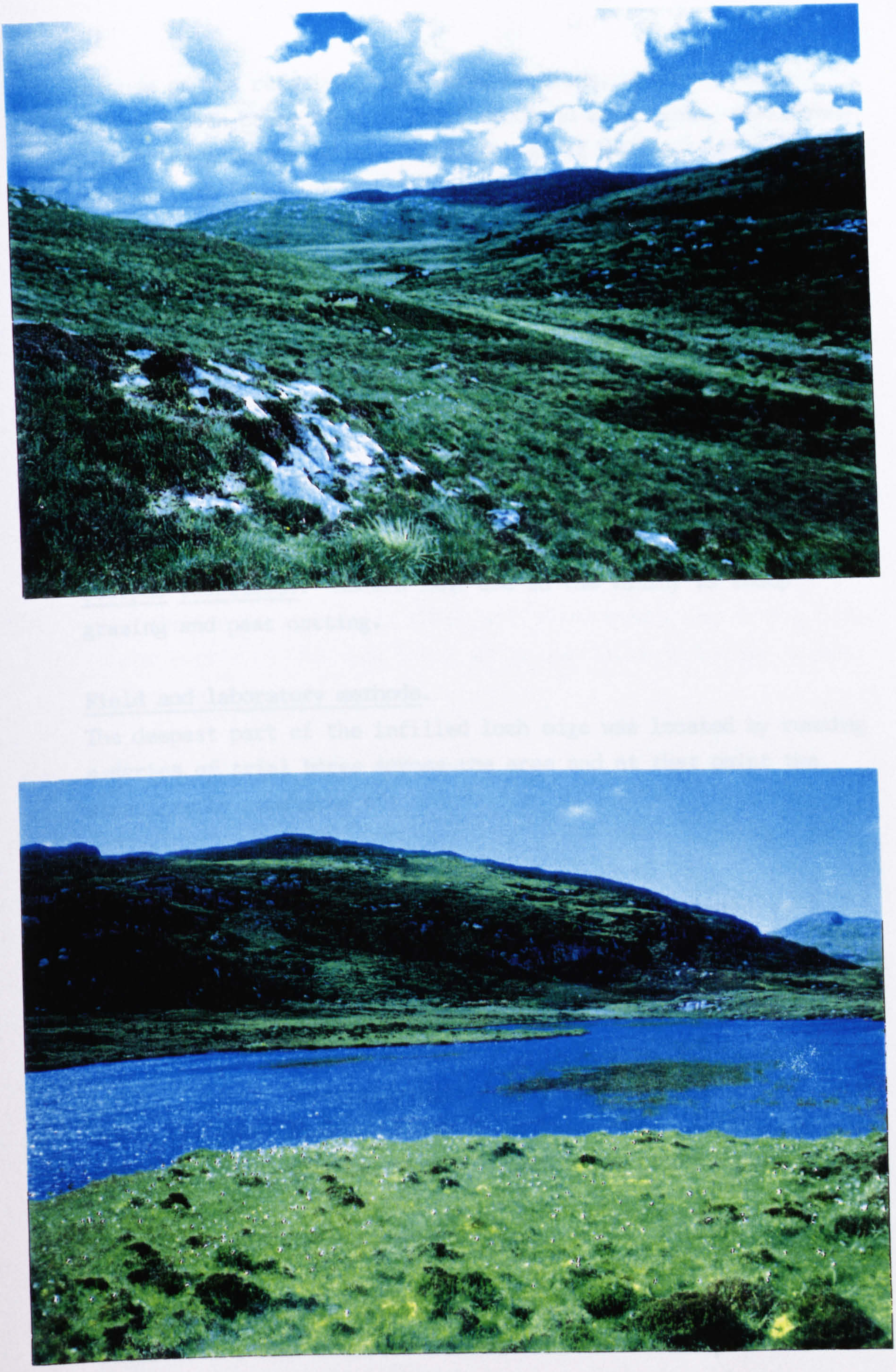

Figure 47. Lochan na Cartach ; Barra

because of its relatively sheltered location, which may have afforded both protection to local woodland from winds, diminished (slightly) problems of aeolian dispersal of pollen, and its proximity to Blackburn's (1948) site.

The contemporary vegetation in the valley is characterised by Molinia caerulea - Scirpus cespitosus - Erica tetralix wet heath with Narthecium ossifragum and Drosera intermedia (Chapter 6 this study, Kent et al. in press). Better drained areas above the loch support Calluna vulgaris dry heath (Group D in chapter 6 this study, Kent et al in press). The infilled loch edge supports an Eriophorum angustifolium bog pool community (Group B, in chapter 6 this study, Kent et al. in press) with Menyanthes trifoliata, Potamogeton polygonifolius, Sphagnum papillosum, S. recurvum and Scirpus cespitosus. Modern land use in the valley is sheep grazing and peat cutting.

Field and laboratory methods.

The deepest part of the infilled loch edge was located by running a series of trial bores across the area and at that point the stratigraphy consisted of:

0 - 50 cms.	Fibrous sedge peat.
50 - 51 cms.	Gritty, coarse, minerogenic inclusions.
51 - 350 cms.	Organic detrital lake mud.
351 - 399 cms.	Organic detrital mud with abundant diatoms.
400 - 500 cms.	Organic detrital lake mud.
501 - 508 cms.	Diffuse boundary / organic lake mud with increasing silt / clay fraction with depth.
509 - 511 cms.	Blue-grey clay.
512 - 517 cms.	Diffuse boundary organic fraction increasing with depth.
518 - 525 cms.	Fibrous organic peat.

Cores for pollen analysis were retrieved using a Russian peat corer with a 5cm. diameter chamber. All cores were placed in clean plastic guttering and sealed in airtight, waterproof film and stored at 4°C. prior to laboratory preparation. Sub-samples were extracted from the cores for pollen analysis at 4cm. intervals for the first 500cms. and at 1cm intervals from 500cms. - 524cms. All samples were prepared for pollen analysis using the methods outlined in chapter 4 this study.

Sedimentation at Lochan na Cartach.

The core from Lochan na Cartach has been divided into a number of lithostratigraphic units for the purposes of description.

Sediment unit 1 ; 525 - 518 cms.

The basal sediment unit consists of an accumulation of fibrous organic remains in a silty matrix. It seems probable that this unit represents a phase in which soil development was taking place in the bottom of the rock basin which was later to become Lochan na Cartach.

Sediment unit 2 ; 517 - 501 cms.

At 517 cms. there is a gradual change in sedimentation from the highly organic material in unit 1 to the organic silts and clays of unit 2. This suggests a change in the depositional environment of the basin. The mobilisation and deposition of clays and silts can result from intense weathering breaking down soils, for example, in periglacial conditions, or as a result of increased precipitation causing leaching of minerals from the soils in the catchment. The unit is increasingly minerogenic as indicated by the transition to blue / grey clay between 509 and 511 cms. and typical of a water lain deposit in terms of the uniformly fine clays forming this unit. The high levels of *Empetrum* pollen found in this unit may indicate the movement of soils into the basin which previously supported *Empetrum* heath. This sedimentary change also represents the begining of open water conditions in the basin. The radiocarbon dates for this section of the core are unhelpful in providing a chronology for the sedimentary sequence (discussed later). However such anomalies in the sequence of radiocarbon dates are not unusual in Late-Glacial and early Holocene sediments (see Walker and Lowe 1980, Edwards et al. 1980) but they do further support the notion of an erosional regime in the catchment, in which older sediments were washed into the catchment contaminating sediments with older carbon. The gradual increase in organic content between 512 - 500 cms. suggests an decrease in erosional processes and an increase in organic productivity.

Sediment Unit 3 ; 500 - 150 cms.

A change to organic detrital lake mud with high diatom concentrations between 399 - 350 cms. defines this sedimentary unit and indicates open water conditions in the basin. A peak in the pollen representation of *Myriophyllum* and *Ranunculus* at the lower boundary indicates an increase aquatic plant productivity in the loch basin consistent with the change from minerogenic to organic sediment accumulation. The pollen representation of these types declines throughout the unit and *Nymphaea* is subsequently recorded indicating shallow open water conditions.

Sediment Unit 4 ; 50 - 0 cms.

The change from fine organic lake sediments to gradually coarsening sedge peat indicates the infilling of the loch basin and the encroachment of terrestrial vegetation into the loch basin.

Synthesis.

The sediments at Lochan na Cartach represent four main depositional environments;

1) Pre-loch soils forming in the base of a shallow rock basin with only limited input of water into the catchment.
2) Deposition of minerogenic clay either in a stream or shallow loch.
3) Open water shallow loch.

4) Loch infilling and the spread of terrestrial vegetation into the loch basin.

The Pollen Diagrams.

The pollen analytical data from Lochan na Cartach are presented as pollen percentage curves (Figure 48) and pollen concentration curves (Figure 49). The local pollen assemblage zones (LPAZ) described below have been defined with the aid of the numerical zonation programs of Padmore (1988, 1990) and are prefixed by the site designation LnC (Lochan na Cartach).

Basal LPAZ LnC - 1a ; Empetrum - Salix - Huperzia selago - Rumex ; 525 - 518 cms.

The basal pollen assemblage is characterised by high frequencies for Empetrum (c. 40-50% tlp), Salix (c. 10-15% tlp), Rumex acetosa (c. 20% tlp) and Huperzia selago. Juniperus and Betula are recorded in low but consistent frequencies. Scarce pollen types include Thalictrum, Saxifraga, Filipendula, Vaccinium and species of Compositae Liguliflorea, Chenopodiaceae, Umbelliferae, Caryophyllaceae.

LnC1b : Empetrum - Huperzia selago ; 518-508 cms.

This subzone is marked by the abrupt increase in Empetrum (70-80% tlp) together with Huperzia selago, Polypodium and Filicales. The pollen representation of all other species declines.

LnC -1c ; Betula - Juniperus - Empetrum 508 - 455 cms.

This sub-zone is characterised by increasing frequencies of Betula up to 20%+tlp and Juniperus (5% tlp). Gramineae and Cyperaceae values rise and herbaceous types also increase in abundance notably Filipendula, species of Umbelliferae and Caryophyllaceae. A peak in Myriophyllum and Ranunculus type are noted at the upper zone boundary. Chenopodiaceae decline together with Huperzia selago and Saxifraga type.

FIGURE 48

Pollen percentage diagram from
Lochan na Cartach, Barra.

see Appendix

Local pollen assemblage zone LnC2 is differentiated from LnC1 by the greatly increased pollen representation of arboreal pollen, particularly Betula and Corylus. Differences in the proportional representation of these two genera form the basis of the sub-division of the zone into two sub-zones.

LnC2a ; Betula - Empetrum - Corylus ; 501 - 455 cms.

Betula frequencies increase to 40% tlp., Corylus/ Myrica gradually increases to c. 15% tlp and Empetrum remains an important element with values of approximately 20-30% tlp. Populus, Ulmus and Quercus are recorded in low but consistent frequencies i.e. <2% tlp, and Salix values increase again to c. 5% tlp. The proportion of arboreal pollen increases to over 50% tlp. Calluna vulgaris and Sphagnum are recorded for the first time in this sub-zone. Gramineae, Cyperaceae, Osmunda regalis and Filicales are also well represented.

LnC2b ; Corylus - Ulmus - Quercus ; 455 - 405 cms.

Corylus / Myrica dominates the pollen spectra in this sub-zone with values exceeding 40% tlp at all levels and maximum values of 70% tlp. Betula is slightly reduced to between 10 - 20% tlp. Ulmus and Quercus increase to c. 5% tlp. Gramineae and Cyperaceae frequencies are lower than in LnC2a, Calluna vulgaris values average 10% tlp and Empetrum, Huperzia selago and Juniperus become scarce.

Local pollen assemblage zone LnC3 is defined by the declining pollen representation of Betula and Corylus / Myrica and a notable increase in Plantago lanceolata, Rumex acetosa, Alnus glutinosa and Sphagnum.

Lnc3a ; Betula - Corylus / Myrica - Quercus : 405 - 245 cms.

Pollen frequencies for Betula and Corylus / Myrica are declining gradually from the high levels recorded in LnC2 and there are corresponding increases in Gramineae and Calluna vulgaris.

Herbaceous pollen types include Filipendula, Potentilla, Plantago lanceolata and Succisa. Pteridophytes include Polypodium, Filicales, Osmunda regalis, as well as Pteridium aquilinum which increases to 5% tlp.

LnC3b ; Alnus - Quercus ; 245 - 165cms.

This sub-zone is characterised by increasing frequencies of Alnus and Quercus in the context of declining values for other woodland genera. Sphagnum, Gramineae and herbaceous types remain important elements in the pollen spectra. Filicales, Polypodium and Osmunda regalis all decline.

LPAZ LnC4

Local pollen assemblage zone LnC4 is defined by strongly declining arboreal pollen values and a corresponding increase in Calluna vulgaris, Gramineae, Cyperaceae and Sphagnum. Two sub-zones are detected.

LnC4a ; Calluna - Gramineae - Cyperaceae - Sphagnum ; 165 - 75 cms.

This zone is characterised by abundant Calluna vulgaris (40 - 60% tlp). Gramineae, Cyperaceae and Sphagnum all increase as arboreal pollen representation declines to below 5% of the total assemblage.

LnC4b ; Calluna - Narthecium - Menyanthes trifoliata ; 70 - 0 cms.

This sub-zone is characterised by an increase in Narthecium ossifragum, Menyanthes trifoliata and Potentilla frequencies together with increasing Calluna vulgaris, Sphagnum, Gramineae and Cyperaceae values.

Pollen Concentration Zones.

Four pollen concentration zones are defined on the basis of major fluctuations in the total pollen and spore concentration values (Figure 49) and are used to describe the pollen concentration diagram.

Pollen Concentration Zone A ; PCZ-LNC1 ; 524 - 455cms.
Total pollen and spore concentration values are generally low with values averaging 400k grains / per cm^3. in the basal sediments to 200k grains / per cm^3. at the upper zone boundary. The major contributors to the pollen spectra are Empetrum, Juniperus communis, Huperzia selago and Rumex type.

Pollen Concentration Zone B ; PCZ-LNC2 : 455 - 355 cms.
This zone is marked by a significant increase in total pollen and spore concentration with values reaching a maximum of c.900k grains / per cm^3. The dominant elements in the pollen spectra are Betula and Corylus / Myrica

Pollen Concentration Zone C ; PCZ-LNC3 : 355 - 305 cms.
Total pollen and spore concentration values decline again in this zone to c.200k grains per cm^3. This decline in pollen concentration values reflects a decrease in arboreal pollen representation, most notably in Betula and Corylus / Myrica.

Pollen Concentration Zone D ; PCZ - LNC4 : 305 - 210 cms
Total pollen and spore concentrations decline further to c.100k grains per cm^3. The decline in pollen concentration appears to affect all the major pollen taxa including all arboreal types together with Calluna, Gramineae and Cyperaceae.

Pollen Concentration Zone E ; (PCZ LNC - 5 ; 210 - 0cms).
Total pollen and spore concentration values begin to increase again in this zone to consistent levels of c.200k grains per cm^3. Major pollen contributors are Calluna, Cyperaceae, Gramineae and Sphagnum. There is a gradual increase in particulate charcoal concentrations from the lower zone boundary.

FIGURE 49

Pollen concentration diagram from
Lochan na Cartach, Barra.

see Appendix

Radiocarbon dates.

A series of radiocarbon dates was provided by Dr.D.D.Harkness, The Radiocarbon Laboratory, East Kilbride on a N.E.R.C. sponsored allocation. The selection of samples for radiocarbon analysis was based on significant changes in the pollen percentage, pollen concentration spectra and sedimentary changes, these are described below :

Shef.#	Depth	Character.
LnC9	50 cms.	Sedimentary change from organic detrital lake mud to terrestrial sedge peat.
LnC8	149 cms.	Increased pollen representation of *Calluna*, *Sphagnum*, Cyperaceae and Gramineae.
LnC7	234 cms.	Decreased pollen representation of tree species and increase in Gramineae and herbs.
LnC6	349 cms.	Decrease in pollen concentration values.
LnC5	397 cms.	*Quercus* arrival.
LnC4	439 cms.	*Corylus* rise, *Ulmus* entrance.
LnC3	508 cms.	*Betula* rise, upper minerogenic sediment. boundary.
LnC2	511 cms.	Lower minerogenic boundary.
LnC1	524 cms.	Basal sediments.

The results of radiocarbon analysis are listed below and plotted against sediment depth with sediment accumulation rates between dates in Figure 50.

Code	Shef.#	Depth	Date
SSR-3733	LnC9	50- 53 cms.	1540 ± 45 B.P.
SSR-3734	LnC8	149-151 cms.	3810 ± 55 B.P.
SSR-3735	LnC7	234-236 cms.	6080 ± 80 B.P.
SSR-3736	LnC6	349-351 cms.	7715 ± 120 B.P.
SSR-3737	LnC5	397-399 cms.	7780 ± 75 B.P.
SSR-3738	LnC4	439-441 cms.	6800 ± 65 B.P.
SSR-3739	LnC3	505-508 cms.	11190 ± 130 B.P.
SSR-3740	LnC1	521-524 cms.	7660 ± 90 B.P.

The basal four radiocarbon dates differ significantly from anticipated age / depth relationships suggesting that the apparently stratified sediments indicated by pollen analysis have been subject to contamination by factors which have produced dates 'younger' and 'older' than those anticipated. The basal sediments contained high levels of acid insoluble carbon which could reflect contamination of the sample by rootlet penetration from vegetation growing on a much later depositional surface (D.D.Harkness pers.com.). Sample no. LnC2 contained insufficient acid soluble carbon to allow meaningful radiocarbon measurement (D.D.Harkness pers.com.). Sample No. SSR-3739 may be contaminated by the addition of older carbon residues washed into the lake basin during what was clearly an erosional environment in the catchment during this phase of deposition. The first reliable date is considered to be SSR-3737 (7,780 ± 75 B.P.) after which the dates follow a pattern which correlates well with radiocarbon-dated biostratigraphic features at Loch Lang, South Uist (Bennett et al. 1990) and Loch Airigh na n-Aon Oidhche, South Uist (Edwards 1990). Several of these features are used to construct a provisional chronology for the Lochan na Cartach data set which preceeds the *Quercus* pollen entrance at 7,780 B.P.

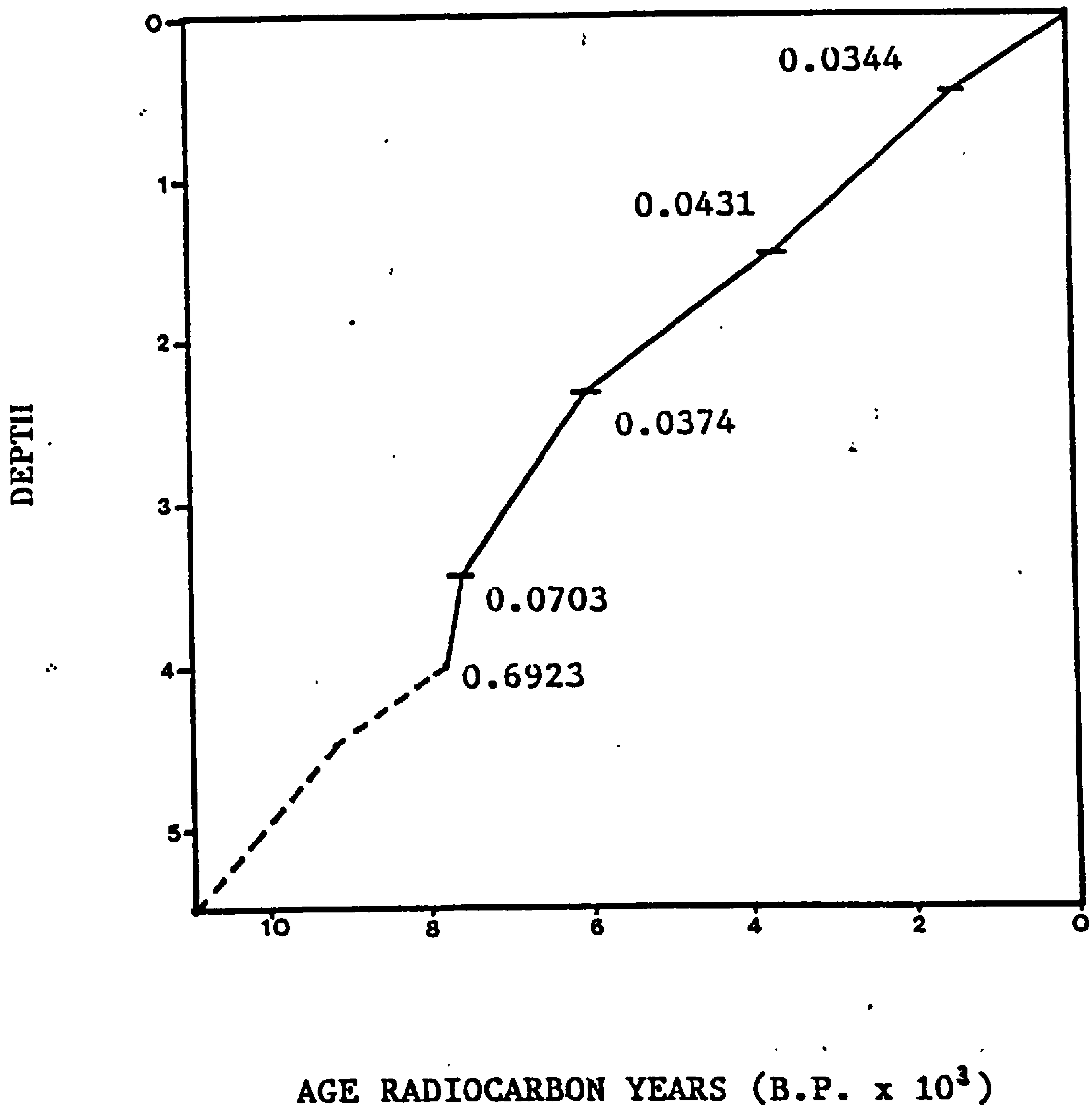

Figure 50. Plot of radiocarbon dates against sediment depth. Accumulation rates (cms yr-2) for the interval between each pair of dates are indicated and calculated assuming constant sediment accumulation.

Local environmental and regional correlation.

Examination of the vegetation record shown in figures 48 and 49 suggests an environmental and land use history described below.

LnC1a - 1c ; Pre-woodland phase.

The pollen spectra in these LPAZ on the Lochan na Cartach profile differ considerably from the rest of the diagram particularly with respect to the low values recorded for the pollen of trees and shrubs. Salix and Betula are the main woody types recorded together with low counts for Pinus. Salix which reaches maximum values for the diagram in the basal pollen spectra (c.15% tlp) possibly represents dwarf Salix scrub. Salix repens is common in heathland in Barra today and Salix herbacea, Salix glauca, Salix reticulata or Salix polaris, types of shrub willow found in northern European tundra landscapes could have been present. A similar peak in Salix pollen is also a feature of pollen diagrams from the region, for example in Late-glacial spectra on St. Kilda, (Walker 1984) and at Little Loch Roag, Isle of Lewis at approximatley 9,140 B.P. (Birks and Madsen 1879). Salix may have flourished as part of the montane communities or in sheltered localities in the valley bottoms. The relative abundance of Empetrum, Juniperus, Huperzia selago, Gramineae and Cyperaceae, and the consistent occurrence of Saxifraga type, Rumex acetosa, Filipendula and Caryophyllaceae suggests an open mosaic of vegetation in which species of open ground and heath were abundant. Empetrum dominated heath with Vaccinium was extensive possibly on freely draining valley sides. Empetrum nigrum is associated with acidic, freely draining substrates, its distribution is limited to areas typically above 600m. O.D. in the Cairngorns in Scotland (Watt and Jones 1948). In the Outer Hebrides it has been recorded in the uplands of South Uist and Barra (Chapter 6 this study, Kent et al. in press). The isopol maps of Huntley and Birks (1984) show extensive Empetrum heaths in north-western Britain during the Late-glacial interstadial. These heaths declined in the early Holocene as forest expanded and climate improved.

The abundance of Empetrum / Vaccinium pollen at Lochan na Cartach in these basal sediments suggests that despite the remoteness of Barra, the taxon's slow migration rates and fairly specific environmental requirements, they had become well established in the vegetation. These data correlate well with similar pollen spectra dated to before 10,200 B.P. on South Uist (Bennett et al. 1990).

The Huperzia selago / Juniperus communis assemblage found in the contemporary vegetation of South Uist in north-facing uplands (Chapter 7 this study, Kent et al. in press) may also have been present and more extensive in its distribution than it is today - indicating colder climatic conditions which lowered the altitudinal limits of this community.

Species rich tall herb communities with Gramineae, Cyperaceae and herbaceous taxa such as Rumex, Filipendula and species of Caryophyllaceae, Chenopodiaceae, Compositae Liguliflorae and Umbelliferae (possibly analogous to those described by Spence 1960) may aso have occurred, possibly in the wetter, nutrient flushed valley bottom.

Local bare rock substrates may have provided a habitat for Huperzia selago and the saxifrages. Scarce grains of Artemisia, Thalictrum and Chenopodiaceae could indicate unstable, eroding soils particularly in LnC1b. Ferns were also present, including Polypodium, probably as a component in the scrub and heathland communities. The lithostratigraphic changes recorded in Sediment Unit 2 are interpreted as an inwash of minerogenic material into the basin. The associated peak in Empetrum pollen values tends to suppress the percentage representation of other pollen types, however the concentration data shows a slight expansion of Gramineae, Cyperaceae and a peak in Compositae Liguliflorae. As these types show no signs of exine deterioration it is presumed that the pollen from these types are locally derived and are therefore broadly representative of the local vegetation. Lowe and Walker (1986) report a similar Empetrum inwash within sediments of Loch Lomond Stadial age at Gribun on Mull. As the Outer Hebrides is thought to have been outside the limit of Loch Lomond ice advance, (Sissons,1976, Peacock,1984) the survival of a complete Late-glacial sequence on Barra is possible. The sediment lithology in Lochan na Cartach exhibits an apparently tri-partite (peat-clay-lake mud) Late-Glacial sequence but correlation between these Hebridean sites on biostratigraphic grounds is difficult because at many sites the Late-Glacial pollen signature is so similar to that of the early Holocene (Walker, 1988). The erosional sediment regime in LnC1b and LnC1b supported by the radiocarbon dating analysis suggest that the change in sediment accumulation might also be the result of a change in local hydrological processes and / or the erosion or leaching of local soils. This could itself be due to a return to colder climatic conditions during the Loch Lomond Stadial, or an increase in precipitation and overland flow in the catchment during the early Holocene, or a chance event. On St. Kilda, Walker (1984) reports an hiatus in sedimentation covering a period of 4,000 years from the Late-Glacial to approximately 6,000 B.P. and at Kildonan Glen and Port Caol (this study) possible early Holocene breaks in sedimentation may occur. How this erosional phase at Lochan na Cartach relates, if at all, to these features is difficult to determine without firmer dating control and more palynological evidence.

Overall the pattern of vegetation cover recorded at Lochan na Cartach is very similar to those found from several late-glacial and Holocene 'spectra' from many diagrams in the region (Walker and Lowe 1977, 1987, Walker 1988, Birks and Madsen 1979, Bennett et al. 1990). The source(s) of the pollen found in this early part of the Lochan na Cartach diagram are difficult to ascertain because of the amount of sediment reworking indicated by the radiocarbon dates. It is therefore suggested that LnC1a-1c input represents elements in the pre / early Holocene vegetation of Barra which can best be viewed as providing a generalised picture of an open non-wooded landscape in which species of open ground and heathland were common. Erosion and redeposition of sediments from these ancient land surfaces, probably occurred during the Loch Lomond Stadial and early Holocene, and incorporated stratified contemporary pollen in the process.

LnC1c-LnC2b early Holocene woodland.

The arrival and rapid spread of Betula, the decline in species of open and disturbed ground, and an increase in biogenic sediments in the loch basin, all clearly relate to the onset of Holocene. Radiocarbon dating analysis of this important feature of the diagram provided a date of 11,190 B.P. which is c. 1,000 years older than anticipated that from the isochrone maps of Birks (1989). The Betula rise observed at Lochan na Cartach has a precise match and presumed correlation at Loch Lang, South Uist (Bennett et al. 1990) at 10,145 B.P. and it is suggested here as providing a 'provisional date' for the Holocene Betula rise at Lochan na Cartach. The Lochan na Cartach sequence also has other parallels with Loch Lang LPAZ Llp2a which provides further provisional dates for this section of the diagram. There is a striking parallelism in the ordered entrance of species at both of these sites. For example the arrival of Calluna vulgaris and Ulmus dated at c. 9,360 B.P. at Loch Lang, and the arrival of Quercus at 7,780 B.P. at Lochan na Cartach. These features correlate well with the Loch Lang diagram and reinforce the suggested dating correlations with other features at both sites.

The peak in Myriophyllum pollen at the LnC1c zone boundary at Lochan na Cartach is typical of many Late-glacial and early Holocene diagrams from northern Europe. Huntley and Birks (1984) suggested that Myriophyllum expanded rapidly as a response to climatic warming, an increase in the amount of water in the catchment, and/or the influx of minerogenic bases into lakes which temporarily increased the nutrient status of the loch (factors already suggested as influential in the sedimentary and pollen interpretations offered above).

Tall herb and grassland communities appear to have persisted within the developing woodland, possibly around the loch margins. The presence of Calluna vulgaris indicates the influence of base-poor local bed-rock and soil substrates on vegetation development from the early Holocene. The pollen of species associated with open and disturbed ground such as Artemisia and Chenopodiaceae disappear from the record, and Huperzia selago and Juniperus also decline possibly as a response to successional change. Populus is recorded in low frequencies as part of the developing woodland. Populus tremula and Betula pubescens are present together in the contemporary woodland described at Allt Volagir (N.N.R.) and Meall Mor (Bennett and Fossitt, 1988) on South Uist. Similar woodland ("Birch forest ; Populus variant") was characteristic of early Holocene woodland in southern Norway c. 9,000 B.P. (Huntley and Birks 1983, pp.619). The expansion of Birch woodland on Barra appears to have reduced the habitats available for grassland and heath communities. It seems possible that this woodland was able to extend through the valley shading out some communities, although Empetrum and Juniperus may have persisted as understorey in the developing woodland as they do in the contemporary Birch woodland in Scotland (McVean and Ratcliffe, 1962).

The Corylus / Myrica curve becomes continuous and expands gradually before the main Corylus / Myrica rise in LnC2b. Unfortunately the pollen of Corylus avellana and Myrica gale are particularly difficult to separate reliably to species level. Myrica gale is a common shrub growing in wet peat bogs whereas Corylus avellana is a woodland shrub / tree. As the pollen representation of peat bog indicators is limited in this part of the diagram, it is assumed that the high frequencies of Coryloid pollen recorded here are Corylus avellana rather than Myrica gale. The Corylus rise is dated at c. 9,400 B.P. at Loch lang, South Uist (Bennett et al. 1990).

The pollen concentration data for Betula and Corylus in LnC2a suggest that the fluctuations in the percentage data which indicates the reduction of Betula woodland by Corylus colonisation is an effect of the percentage calculations rather than vegetation.

Both data sets display similar overall trends in LnC2 and Llp2 as firstly Betula and Populus form early Holocene open woodland stands which are invaded by the arrival and expansion of Corylus scrub. As at Loch Airigh na n-Anon Oidhche, South Uist (Edwards, 1990) there appears to be no evidence for human involvement in the establishment or expansion of Corylus. At Lochan na Cartach the pollen diagram at this point suggests that woodland diversified with the arrival of small numbers of Ulmus at c. 9,200 B.P. and Quercus at about 7,800 B.P. Alnus glutinosa is present from c. 7,500 B.P. The Alnus rise, dated at c. 6,080 B.P. at Lochan na Cartach is consistent with the anticipated date of 6,000-5,500 B.P. suggested by the isopol maps (Birks 1989). These data correspond well with zone VI of the Blackburn (1948) diagram in which high percentage values are recorded for Pinus, Betula, Ulmus, and Calluna. Blackburn (1948) suggested that peat formation began in the early Boreal period (c. 9,000 B.P.) and the Calluna vulgaris values recorded in this part of the Lochan na Cartach diagram with an estimated age of c. 9,500 B.P. are in agreement with this idea.

As the pollen representation of all arboreal pollen types, with the exception of Pinus exceed the threshold levels which are thought indicative of local presence (see Table 31, from Huntley and Birks, 1984) it is suggested that the tree pollen was derived from local components of the woodland on Barra. Pinus may have been present on Barra, but not perhaps in the Lochan na Cartach catchment. Pinus is consistently recorded from c.10,000 B.P. with maximum values of 10-12% tlp between 9,200-7,780 B.P. and 3,000-4,200 B.P. These values are difficult to interpret as Huntley and Birks (1983) suggest a threshold value of 25% tlp as indicative of a local presence of Pinus. Isolated individuals of Pinus sylvestris do occur on Barra today near Bay Hulavagh, but no

Table 31 ; Pollen percentage values indicative of the local presence of tree species.

Ulmus

>2% Indicates local presence.

>10% Indicates the species is a significant component in the vegetation cover.

Pinus

>25% Indicates local presence.

Quercus

>2% Indicates local presence.

>10% Indiates the species is a significant component in the vegetation cover.

Fraxinus

>1% Indicates local presence.

>5% Indicates woodland in which Fraxinus is co-dominant.

Salix.

>1% Indicates local presence.

Source : (Huntley & Birks, 1983).

Pinus macrofossils have been found during our investigations. *Pinus* pollen may be of long distance provenance but other pollen analytical studies do not support this theory. *Pinus* pollen does not appear to increase in representation with proximity to Scottish mainland *Pinus* populations, for example in the Inner Hebridean pollen records.

The pollen evidence suggests that the landscape around Lochan na Cartach in the early to mid-Holocene was a mosaic of *Betula* / *Corylus* woodland with small numbers of *Populus*, then specimens of *Ulmus* and *Quercus*.

A decline in pollen concentration values of all pollen and spore types at 7,715 B.P. which coincides with a phase of rapid sediment accumulation and high diatom concentrations in the sediment lithology requires some dicussion at this point in the text. In principle reduced pollen concentration values can be interpreted as the result of a change in pollen productivity, pollen source area, or the rate of sediment accumulation. That reduction in pollen concentrations affects all pollen types rather than specific taxa suggests that the reduction observed is the result of vegetation changes. A change in pollen source area either as a result of a reduction in overland flow or streamflow into the loch basin would also reduce pollen concentration values. Lochan na Cartach has no inflow streams at present but there may have been one flowing from Loch nic Ruaidhe in the past. Sediment accumulation may have blocked inflow streams and this would reduce the pollen source area to immediately local vegetation and account for the decrease in pollen concentration values. Drier climatic conditions could also have reduced the amount of pollen washed into the basin through overland / streamflow. Sediment accumulation rates are high, possibly as a result of rapid accumulation of the diatomite which may be reflecting a change in the magnitude / frequency of overland / streamflow in the catchment which requires further testing. There appears to be little pollen evidence pointing to anthropogenic disturbance of the vegetation cover around Lochan na Cartach during this period - changes in the pollen data discussed above appear to reflect the migration and expansion of arboreal taxa and the response of the preceeding heath and grassland communities to these migrational impacts and Holocene thermal improvements.

LnC3a-3b ; woodland decline.

The pollen analytical evidence from Lochan na Cartach indicates a change in the abundance and composition of woodland communities after 6,080 B.P. Betula and Corylus values begin a gradual decline and there is a corresponding increase in Quercus, Alnus and Salix. The pollen representations of Gramineae, Filipendula, Osmunda regalis, Rumex acetosa, Plantago lanceolata, Succisa pratensis and of Umbelliferae and Compositae all increase suggesting the expansion of species rich grassland and tall-herb communities and the opening up of the woodland canopy.

Alnus begins to increase at Lochan na Cartach from 6,080 B.P., but reaches a maximum between 4,600-4,000 B.P. These dates compare well with Llp2c at Loch Lang, South Uist (Bennett et al. 1990) where Alnus values reach a maximum between 6,000-4,500 B.P. The rational limit for Alnus is dated at 7,030 B.P. at Loch Airigh na n-Anon Oidhche (Edwards 1990) and such agreement between the dates suggests that the Alnus rise at Lochan na Cartach is consistent with other Southern Outer Hebridean sites. The pollen representations of Calluna vulgaris, Sphagnum and Cyperaceae all remain consistent suggesting that the observed decline in Betula / Corylus woodland should not be explained as the result of environmental conditions which encouraged the spread of blanket bog.

There are no unequivocal indications of human activity influencing the vegetation at this time. The changes described above could be the result of vegetation response to climatic change bringing increased wind frequencies and precipitation as sea-levels rose. Ritchie (1979) suggests that initial pre-machair sand accumulation began as sea level rose off the west coast of South Uist before 5,700 B.P. Changes in the coastal zone would have effects on local hydrology, for example, by raising the water table. Increased wind frequencies could change pollen taphonomic patterns within the tree canopy or cause 'wind throw' creating open ground and habitats for grassland and herbaceous plants. Filipendula and Osmunda which are resistant to salinity effects (Hirons and Edwards, 1990) may have profited from such a change and are relatively abundant at this time.

Increasing charcoal representation at Lochan na Cartach at and around the Alnus maxima at 4,600-4,000 B.P. is interesting in the context of the debate already cited in Chapter 2 regarding the relationship between Alnus and human activity. The pattern of gradual decline shown by Betula and Corylus in LnC3a-LnC3b is not suggestive of any large scale woodland clearances which might facilitate the spread of Alnus. However Sphagnum values which begin a progressive increase from 4,700 B.P. may indicate increased wetness around Lochan na Cartach which could have favoured Alnus (see McVean, 1956 for discussion). There may be a direct causal relationship between the decline in Betula / Corylus scrub, human activity, increased waterlogging in the catchment and the spread of Alnus as part of an Alnus - Salix woodland association, but this is difficult to define with precision.

In LnC3b (5,500 - 4,200 B.P.) some intimation of human impact may be detectable as the pollen representation of Gramineae remains high, tall-herb and fern taxa such as Filipendula, Umbelliferae, Filicales and Polypodium decline, whereas Plantago lanceolata increases as does a fern avoided by grazing animals - Pteridium aquilinum. These changes may result from animal grazing which inhibited woodland regeneration, removed flowering herbs and ferns and increased pasture. Human occupation of the area during the Neolithic period is evidenced in the funerary sites in the adjacent Borve Valley. Importantly similar changes are recorded at Little Loch Roag (Birks and Madsen, 1979) after 5,200 B.P. and at Loch Lang from 4,300 B.P. (Bennett et al. 1990).

LnC4 Late Holocene (4,000 B.P.) to present.

The final phase in the vegetation record from Lochan na Cartach is characterised by the expansion in the pollen of Calluna vulgaris, Sphagnum, Cyperaceae and Potentilla - typical taxa associated with blanket peat communities. Between 4,300 - 1,900 B.P., the expansion of the blanket peat communities which had persisted from the early Holocene begin to dominate the pollen spectra. This blanket-peat type depicted in the pollen diagrams appears to be essentially similar to the Molinia caerulea - Scirpus cespitosus - Erica tetralix - Calluna vulgaris wet heath community observed in the survey of modern vegetation of South Uist (Chapter 6, and Kent et al in press). From 1,900 B.P. Narthecium ossifragum, Drosera and Polygala type are recorded indicating a change in the blanket peat communities with elements of Group C2 (Chapter 6, and Kent et al. in press), which includes class character species plus Narthecium ossifragrum, Schoenus nigricans, Polygala vulgaris and Drosera intermedia. This sub-community is widespread often occurring where Calluna heath has been burnt and in peat cuttings at altitudes of approximately 66m. Increased charcoal frequencies from c.2,000 B.P. could signify muir burn and may be related to the expansion of the C2 type sub-community observed in the pollen diagram. This inferred increase in land use pressure in the valley at this time, may be related to settlement (broadly dated to this period, Branigan pers. com.) which was connected with the 'island dun' in Loch nic Ruaidhe. Elsewhere in the Scottish islands similar changes are recorded in the pollen record. The spread of blanket peat communities and the final demise of woodland at c.4,000 B.P. appears to have dominated the regional vegetation pattern from this time (see Chapter 2 for review). In the Uists there is also further independent evidence of changing environmental conditions. Ritchie (1985) has provided evidence of sand blowing onto the coast of Pabbay at approximatley 4,366 B.P. an event which followed a rapid sea level rise from c. 5,100 B.P.

The increased precipitation, and wind frequencies which are alleged to have accompanied the sea level rise can be inferred to have created a stressful environment for plants and people alike. Presumably more land would have been required for pasture and cultivation, as drainage and soil acidification worsened. *Calluna* heath may have been burned to provide grazing.

Pollen assemblage zones LnC4a and LnC4b essentially reflect the same suite of plant communities which occur in the "Dark Glen" today, a bog and heath covered glen which is heavily grazed by sheep.

Conclusion.

All these events suggest that there are marked similarities between the palynological data from Lochan na Cartach, Loch Hellisdale, South Uist (this study), and Loch Lang, South Uist (Bennett *et al*. 1990) which has facilitated a provisional chronology for the early pollen assemblages zones of LnC1-2, after which reliable new radiocarbon analyses have provided a new chronostratigraphic framework for the rest of the Lochan na cartach sequence. To summarise, around Lochan na Cartach itself, the tundra type communities of the Late Devensian - early Holocene were associated with unstable and eroding substrates and the deposition of minerogenic sediments in the loch. The subsequent establishment of an early Holocene vegetation mosaic of scrub, woodland, acid grasslands and bog communities stabilised the catchment soils and open woodland vegetation remained relatively undisturbed until its long term decline began at *c*.6,000 B.P. Woodland appears to have been more abundant and diverse than at Little Loch Roag, Isle of Lewis (Birks and Madsen, 1979). A later period of reduced *Betula* / *Corylus* woodland occurred in which *Quercus* and *Alnus* flourished and open grassland and tall-herb communities were more widespread. This vegetation may be related to a period of Neolithic settlement in the Borve Valley. The spread of blanket peat after *c*.4,000 B.P. is a feature of the regional vegetation history of the Outer Hebrides connected possibly with climatic fluctuations and increasing land use pressure after 2,000 B.P.

Chapter 13.

Borve Valley, Barra : A Stone Setting and Ancient Cereal Cultivation.

Borve valley, Barra : a sub-peat stone setting and ancient cereal cultivation.

Organic deposits associated with sub-peat field boundaries, clearance cairns and associated field systems have yielded palynological evidence of past land use practise and farming economy. A number of such sites are recorded from Britain and Ireland (eg. Herity 1971, Caulfield 1978, Whittington 1980, 1983, Williams 1982, Stevenson 1985, O'Connell 1990, O'Connell 1986, Pals 1987). Burial beneath blanket peat ensures the preservation of the archaeological features, the pre-peat sediments and can also facilitate the establishment of a chronology. These sediments are also good preserving environments for fossil pollen which can be used to reconstruct land use history at the site.

The taphonomic studies of Hall (1988, 1989) and Vuorella (1973) indicate that the pollen of cereals and associated weed taxa are dispersed only short distances from source and are therefore unlikely to be clearly represented in conventional pollen preserving sites. Consequently the sediments directly associated with an archaeological feature are more likely to contain a higher proportion of in situ pollen from crop cultivation associated with the feature and therefore provide detailed information of land use history.

Derelict field boundaries and abandoned "lazy bedding" are evident in the landscape of Barra indicating past cultivation in areas of the landscape now used almost exclusivley for sheep grazing. Historical accounts from the Outer Hebrides describe crops of barley, oats, rye and potatoes being grown on the machair in South Uist (MacDonald, 1811). Elton (1902) relates a story in which the population of Pabbay, Sound of Harris were removed in 1842 because of "the whisky which they distilled from barley grown there".

Unpublished plant macrofossil studies from machair archaeological sites (Baleshare, Hornish, Cill Donain) indicate cereal cultivation on the machair but to date there are no palynological records which document historic or prehistoric crop cultivation from inland peat sites. Palynological studies from sediments associated with sub-peat archaeological features in the Outer Hebrides (figure 5) are concentrated in the north of the islands, for example, on Lewis (Bohncke 1988, Newall 1989), North Uist (Mills *et al.* in prep) and Benbecula (Whittington and Ritchie 1988). Grassland and heath communities represented in these studies indicate pastoral rather than cultivated landscapes.

The site.

A sub-peat stone wall fragment located on the south facing Borve valley side between the major Neolithic cairns Dun Bharpa and Tigh Talamanta (Figure 51) was reported during an extensive field survey by S.E.A.R.C.H. of the Borve valley, Barra in 1989. This survey recorded seventy eight archaeological sites additional to those recorded in the H.M.R. (1928), indicating a history of settlement in the valley dating from the neolithic period (Branigan 1989). The proximity of the sub-peat stone setting to the large neolithic funerary site, Dun Bharpa, suggested the possibility that there may have been a connection between these features. Samples for pollen analysis were retrieved when the site was first investigated in 1989. Subsequent archaeological excavation of the buried stones suggests that the feature may be part of a clearance cairn rather than a continuous field boundary.

Modern land use in the valley is predominantly sheep grazing, there is no cereal / root crop cultivation. The contemporary vegetation at the site is typical of the *Agrostis capillaris* - *Festuca ovina* grassland (Group E2) (Chapter 6, this study, Kent *et al.* in press) and the *Holcus lanatus* - *Trifolium repens* sub community of the NVC (Rodwell 1991). *Agrostis capillaris*, *Festuca ovina* and *Potentilla erecta* are the main diagnostic species with *Nardus stricta*, *Viola riviniana*, *Galium saxatile* and *Trifolium repens*. *Polytrichum commune* and *Sphagnum* spp were also noted.

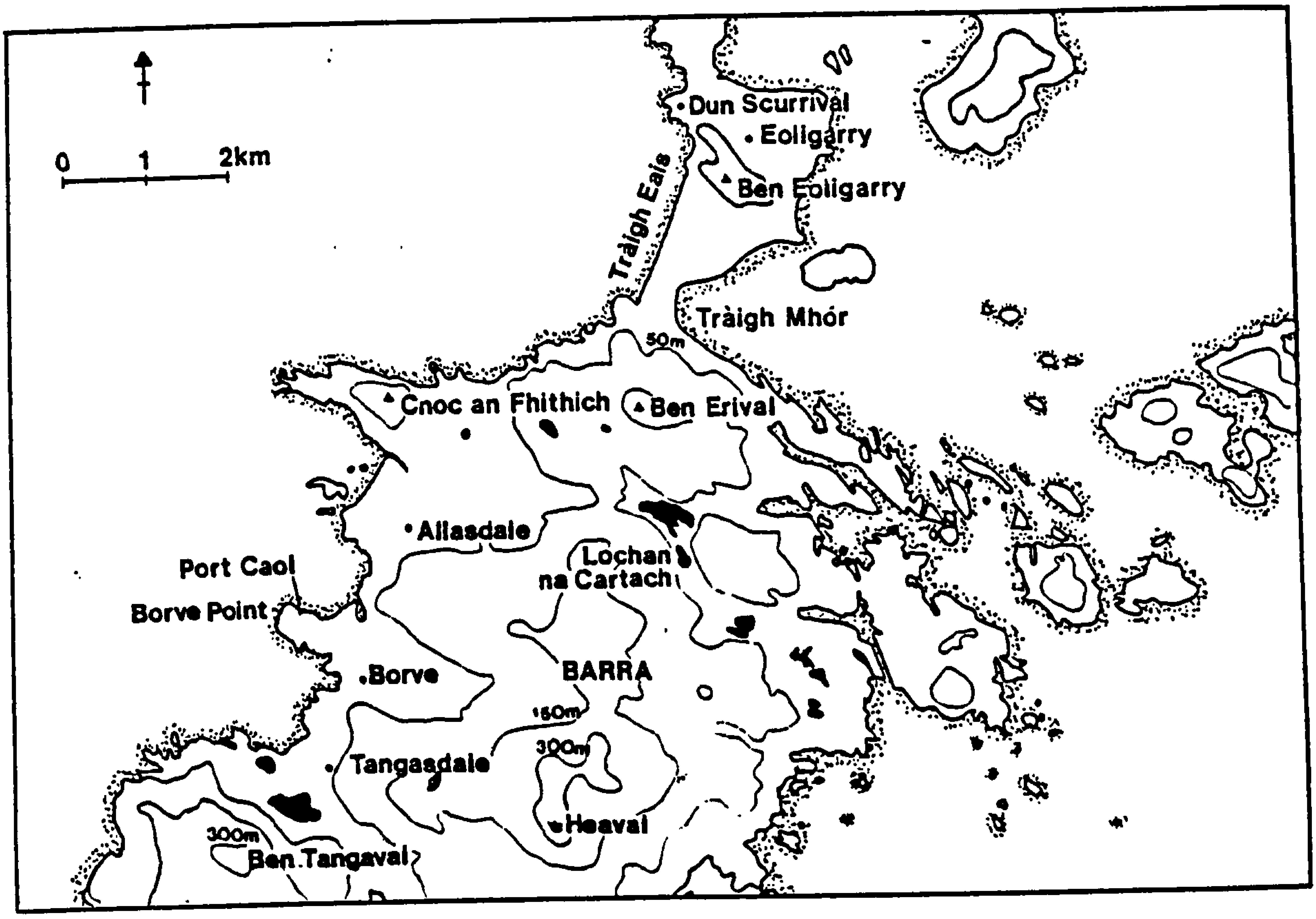

Figure 51. <u>Location map ; Borve valley sub-peat wall</u>
(stipple indicates shoreline)

The context of the samples

The stones which rest on a pre-peat mineral soil were originally exposed by a contemporary agricultural drainage ditch. This analysis consists of a series of samples taken from the excavated ditch section (figure 52) which include mineral soils and immediately overlaying peat. Palynological analysis of the profile, which cuts across the peat-mineral soil interface, investigates sediments directly associated with the field monument. Samples for pollen analysis were retrieved with the specific aims of :

1) Investigating the landuse history of the site.
2) Investigating any relationship which may have existed between the clearance cairn and any cultivation which may have occurred during or after its creation.
3) Provide a provisional date for the feature by correlation with the Lochan na Cartach diagram.

Methods.

A number of critical horizons were identified in the field and a series of spot samples were taken for pollen analysis.
Samples were prepared using the methods detailed in Chapter 4, this study.

The pollen data are presented as a pollen percentage and a pollen concentration diagram (figures 53 and 54).

Pollen identification.

A number of well preserved large Gramineae pollen grains were identified during counting. The separation of cultivated and wild species of Gramineae has been attempted (eg Andersen 1979, Faegri and Iversen 1975, Beug 1961, Dickson 1988). These studies provide a series of morphological criteria for distinguishing wild and

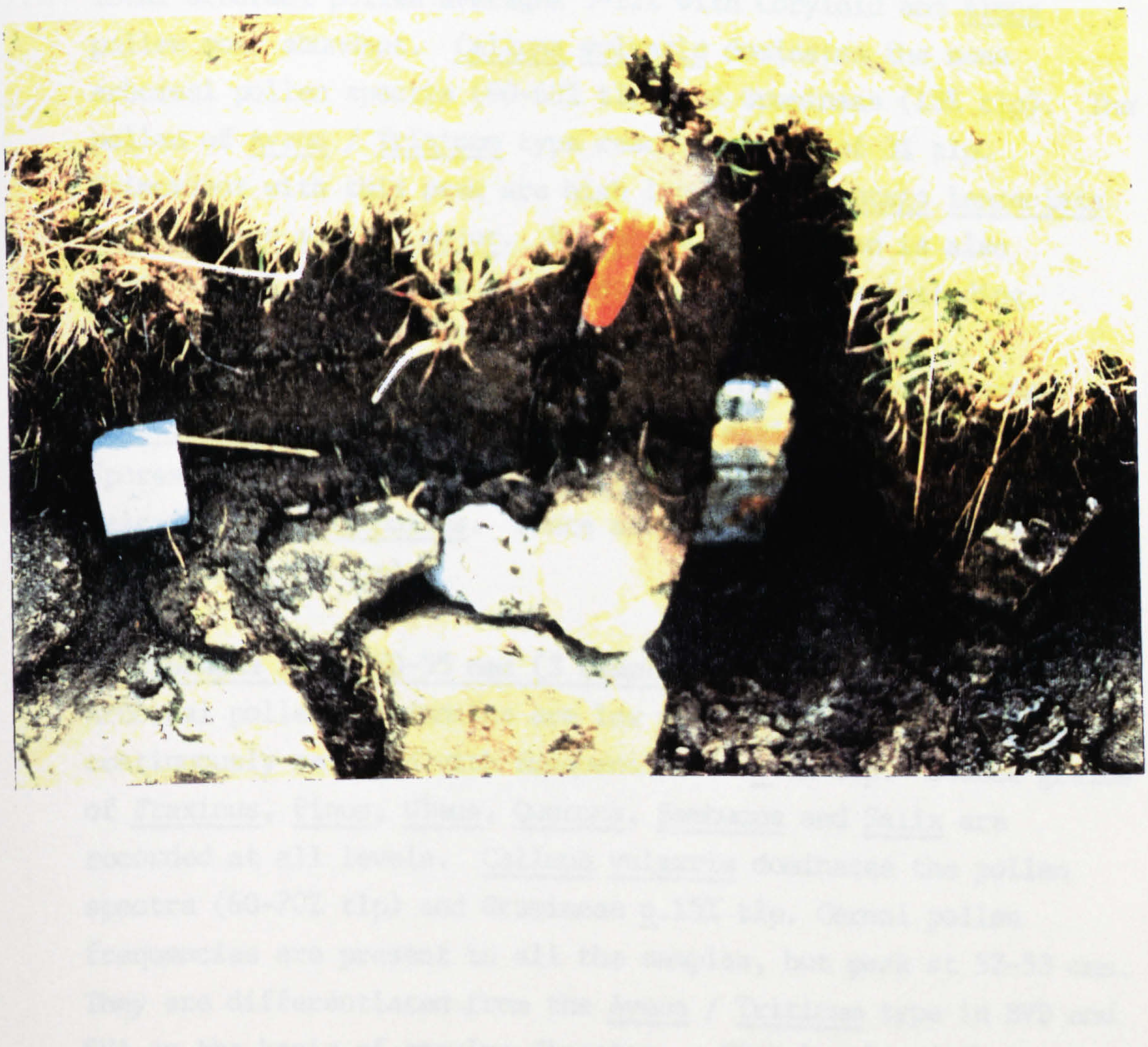

Figure 52: Borve Valley ; ditch section.

cultivated grasses. The criteria described by Andersen (1979) are used in this analysis.

Pollen percentage data.

Peat sample BVD and BVA ; 60-67 cms (6 samples).
Arboreal pollen frequencies are low and include Betula, Pinus, Ulmus, Quercus, Fraxinus, Sorbus, Coryloid, Alnus and Sambucus. Total arboreal pollen averages 5-12% with Coryloid and Alnus pollen most abundant. Calluna vulgaris dominates the none arboreal pollen spectra (60-68% tlp) and Gramineae (15% tlp). The pollen of Avena / Triticum type reaches a peak of 3% tlp. Coincident with this peak are high levels of Plantago lanceolata and Plantago media / major. Epilobium type pollen is also recorded. A diversity of herbaceous pollen types including Succisa, Potentilla, Ranunculaceae, Rubiaceae, Vicia, Umbellifereae, Rumex acetosa, Viola, Urtica, Scrophulariaceae, Pedicularis, Hydrocotyle and Narthecium ossifrag um are recorded. Spores recorded include Polypodium, Pteridium, and the moss Selaginella selaginoides. There are increasing frequencies of microscopic charcoal.

Peat Sample BVB : 50-55 cms (3 samples).
Arboreal pollen frequencies are low with Alnus, Coryloid, Betula, continuously recorded with frequencies of c.2% tlp. Scarce grains of Fraxinus, Pinus, Ulmus, Quercus, Sambucus and Salix are recorded at all levels. Calluna vulgaris dominates the pollen spectra (60-70% tlp) and Gramineae c.15% tlp. Cereal pollen frequencies are present in all the samples, but peak at 52-53 cms. They are differentiated from the Avena / Triticum type in BVD and BVA on the basis of annulus diameter. High levels of Plantago lanceolata (2% tlp), Plantago media/major (7% tlp) together with Epilobium and Spergula arvensis (Corn Spurrey) are also recorded and other herbaceous taxa as in BVA.

FIGURE 53

Pollen percentage diagram (1)
from Borve Valley, Barra.

FIGURE 54

Pollen percentage diagram (2)
from Borve Valley, Barra.

see Appendix

Peat sample BVC ; 40-45cms : (3 samples).

Characterised by Callua vulgaris (70-74% tlp) and low arboreal pollen frequencies (10% tlp). Plantago lanceolata, Plantago media / major frequencies decline and Spergula arvensis, cereal type and Onagraceae are not recorded.

Discussion.

The pollen spectra from the basal samples at 67 cms at the soil /peat interface provide an indication of vegetation at the site at the time of the construction of the stone cairn. The high Calluna vulgaris pollen frequencies and low Cyperaceae and Sphagnum indicate the presence of dry heathland similar to the Calluna vulgaris dry heath community (Group D, chapter 6 this study, Kent et al. in press). Gramineae and herbaceous pollen such as Potentilla, Lotus type, Viola type, Plantago lanceolata, Rubiaceae type (Polygala), Leguminosae and Succisa indicate that grassland communities similar to those found in the locality today were also present. The low pollen frequencies recorded for Sphagnum, Cyperaceae and other blanket bog species such as Drosera and Narthecium ossifragum suggest that conditions were dryer than at present. It would seem that the cairn was constructed in an open landscape supporting dry Calluna heath with neutral soils on the well drained valley slopes supporting grassland communities.
The herbaceous pollen flora in the profile is of particular interest. Plantago lanceolata, Potentilla (cf. erecta), Succisa, Viola type (cf. riviniana) are characteristic of pastoral grassland in Barra today. O'Connell (1991, p267) suggests that some of these species are classic indicators of pastoral farming but they may also colonise fallow land. A change in the vegetation following the construction of the cairn is indicated by the occurrence of large grass pollen >37μ of Avena / Triticum type pollen in small peaks. These pollen types are also recorded as scarce grains in many levels at this site. These types are not recorded in the uppermost samples. The groups defined by Andersen (1979) contain both cultivated and wild species and consequently cannot be taken as unequivocal evidence of cereal cultivation.

However the presence of Plantago media / major, Spergula arvensis and Epilobium type, coincident with the peaks in Cereal type pollen suggest that some type of cultivation or disturbance may have been locally present in the vicinity of the stone cairn.

Spergula arvensis is listed in Pankhurst and Mullin (1991) as a weed of arable fields and gardens in the Outer Hebrides. Pollen spectra similar to that recorded at Borve (0.6%-1.7% tlp) are described by O'Connell (1991) from a prehistoric field enclosure at Carrownaglogh, Co Mayo, Eire, where fossil samples yielded much higher pollen frequencies of Spergula arvensis than a modern oat crop heavily infested with the weed. O'Connell (1991) cites several instances where S. arvensis pollen and seeds have been recorded from prehistoric and medieval contexts in European sites (Willerding 1986, Behre 1986, Pals 1987, Odgaard 1985) and Shetland where Renfrew (1973) reports the use of Spergula arvensis as a food crop.

If land was cultivated at Borve, Spergula arvensis may have grown either as a weed of cultivation or it may have been grown part of a cultivation system with Oats or Barley.
Cereal-type pollen grains become scarce in the upper samples of the profile and arable weed type pollen is poorly represented, whereas the rest of the pollen spectra remains essentially similar to the rest of the profile. Possibly cultivation or disturbance which provided a niche for these taxa had ceased or was taking place elsewhere.

Microscopic charcoal particles are recorded at all levels in the analysis but there is no unequivocal evidence that fire was being used to modify the vegetation.

Comparison with other palynological studies from archaeological sites in the Outer Hebrides such as Callanish, Isle of Lewis (Bohncke 1988) Rosinish, Benbecula (Whittington and Ritchie 1988) Sheshader, Isle of Lewis (Newall 1989) and Loch Portain (Mills et al. in prep.) is difficult because of the disparate locations of the sites. However some interesting details emerge from these studies which may be of relevance to the Borve study. Radiocarbon dates from these sites show that open, non-wooded landscapes similar to that recorded at Borve were present from c.4,990 B.P. at Loch Portain (Mills et al. in prep) and 4,345 B.P. at Rosinish III (Whittington and Ritchie 1988).

Pollen analysis from sediments associated with sub-peat field walls at Callanish, Lewis (Bohncke 1988) dated to c.3,200 B.P. suggests that local woodland was cleared and the corresponding increase in grassland pollen taxa indicates the presence of pasture. Newall (1989) also found that a sub-peat wall at Sheshader, Isle of Lewis was constructed at c. 3,000 B.P. and that the palynological record from an adjacent peat profile indicates pasture. Cereal pollen is also recorded from the site and peaks in fossil charcoal particles recorded at 3,300 B.P. may indicate some anthropogenic influence on the vegetation. A sub-peat wall at Loch Portain, North Uist is thought to have been constructed at 2,600 B.P. (Mills et al. in prep). It is not possible without radiocarbon dating evidence to see how the Borve site compares with the cluster of radiocarbon dates (c. 3,200 - 2,600 B.P.) from the other Outer Hebrides sub-peat field boundary sites which suggest enclosure during this period. However the acid heath and grassland depicted in the pollen spectra, together with the low arboreal pollen frequencies recorded at all levels, correlate most strongly with LPAZ LNC4 from Lochan na Cartach, which is located in an adjacent valley. In the absence of radiocarbon dating this biostratigraphic correlation (post 4,000 B.P.) provides a provisional dating framework for the sequence, suggesting that the sub-peat cairn at Borve may have been constructed during the period of enclosure represented by the other sites. However the presence of cereal-type pollen and relatively high frequencies of taxa associated with cultivated or disturbed ground at the soil-peat interface at Borve are unusual in relation to the observed pattern of pastoral activity at the other sites.

Synthesis.

Pollen analysis from sediments associated with a sub-peat stone clearance cairn in the Borve valley indicates that the feature was constructed during a period in which *Calluna* heath and grassland were widespread in the valley. The palynological evidence provides some indication of two phases of cereal crop cultivation. Large Gramineae pollen grains at the soil peat interface were assigned to the *Avena* / *Triticum* group (Andersen 1979) and may represent the cultivation of Oats. A second phase in which cereal type pollen is assigned to the *Hordeum* type group of Andersen (1979) may indicate a phase of barley (or bere) cultivation. These cultivation or disturbance episodes are interspersed with phases of grassland and heath vegetation which may represent grazing or fallow periods as part of a crop rotation system or "outfield" as described by Dodgson (1988).

Biostratigraphic correlation with the Holocene palynological record from Lochan na Cartach, Barra suggests that the construction of the cairn and subsequent agricultural activity occurred after 4,000 B.P. and may be part of a more widespread pattern of land clearance and enclosure which is beginning to emerge from studies of other sub-peat sites in the Outer Hebrides. Any relationship between the construction of the clearance cairn and the neolithic funerary monuments is difficult to ascertain because of the lack of radiocarbon dating control. However it seems likely that the cairn post-dates the burial chamber.

Chapter 14.

Conclusion.

Conclusion.

This dissertation was started with an interest in the status and history of the vegetation in a most fascinating, remote, bleak part of the British Isles, at the far western margins of the European mainland. A place nowadays characterised by a bleak climate and open, peat covered moorland, lacking trees and also characterised by a profusion of archaeological remains which suggest that both environmental factors such as climatic fluctuations, pedological change and past human activity may have played critical roles in producing the present situation.

Critical examination of the literature showed that there were a whole series of inter-related issues and questions which had to be addressed before a simple but potentially naive application of palynology to the numerous bogs and lakes of the region was made.

For example, an appropriate understanding of the contemporary vegetation in a worthwhile environmental or ecological context was largely absent. Critical species could not be related to environmental gradients of phytosociological situations with the result that the presence or absence of critical species (Quercus, Ulmus, Alnus, Pinus) could not be reliably interpreted.

Not only were familiar issues of pollen taphonomy unknown in this wind dominated region, the biotic situation of these species in the Outer Hebrides itself was poorly known. The available botanical literature was principally concerned with lists of species from very particular habitats - possibly reflecting the taxonomic interests of biologists with perhaps an inbuilt emphasis on rarity and the biological interest of controlled (e.g. Sites of Special Scientific Interest and National Nature Reserves) or otherwise rare and unusual sites. The nature and distribution of the 'ordinary', the human influenced and perhaps the typical were largely unknown.

Closely related in this historical / palynological survey of the research location was seen to be the understanding of pollen taphonomy in the region. Essentially contradictory conclusions had been reached by research workers in Lewis with no consensus on the role, and indeed the significance, of long distance dispersal / inter-regional dispersal or the scales and mechanisms of very local pollen deposition. The implication of Birnie's (1983) studies in Shetland, which indicated background levels of tree pollen in the region, together with Birks and Madsens (1979) findings of minimal palynological evidence of tree presence, where the wood macro-fossil evidence (Wilkins 1984) clearly placed one in a wood, suggested that the situation was more complicated. Here woodland can now be seen to have produced only very modest numbers of tree pollen. This taphonomic discussion curiously appeared to ignore the clear arguments and conclusions drawn by Blackburn (1948) in her pioneering studies of Barra and South Uist. In this situation a research strategy was devised which both resolved the nature and significance of controls upon the modern vegetation and identified the pollen rain accumulating in the vegetation units identified in the east-west transects. The transects were designed to encompass all aspects of the modern environment with maximum efficiency and at the same time to emphasise variability with evidence on the ground. This reading of the existing state of research and study design appears on reflection to have been reasonably successful - although if started again with the acquired knowledge and hindsight the questions, methods and the analyses would have been slightly different.

In the pollen taphonomy study the pollen depositional characteristics of sixteen plant communities are described. Pollen deposition was found to reflect the distribution of major vegetation types on the islands. Patterns of "in-community" and "out-community" pollen deposition reflected the major vegetation units on the transect and revealed a general harmony between the contemporary pollen rain and vegetation, demonstrating the local nature of pollen deposition. These conclusions do appear to have importance for the interpretation of palynological data from the area. In practice the vegetation is seen to be related to environmental gradients and situations which are capable of being investigated and interpreted in palynological studies. The critical roles of pollen taphonomic issues have been clearly identified, for example it is clear that where there is wood or scrubland, for example at Allt Volagir N.N.R. and Loch Druidibeg loch islands, there is clear evidence of reasonably high tree / shrub pollen. There are also clear indications that away from woodland situations the frequencies of tree / shrub pollen are minimal. The meteorological and entrapment processes responsible probably conform to those essentially set out by Tauber (1965) except that once outside the micro-climatic situation produced by the trees and shrubs themselves - a feature itself reinforced by the particular topography and highly sheltered situations of these remnants - wind velocities are sufficiently high at the appropriate times of the year (indeed most times of the year) that tree / shrub pollen is largely removed from depositional environments beyond these present habitats.

Other topographically controlled aspects of variability have also been highlighted. Perhaps not suprisingly Juniperus and Empetrum communities, and in general more arctic and alpine communities, have been shown to predominate in the more remote and high mountainous areas where there are north and east facing crags and cliffs naturally protected from grazing. Pollen catchments in the north and east facing area of the transect such as at Loch Hellisdale are therefore likely to have more substantial and better records of these arctic and alpine heath and shrub communities (even though Loch Hellisdale is some 300' lower in altitude) than much higher and closer sites on the exposed, bleak, grazed and better illuminated sites on the adjacent western flank of the Beinn Mhor massif.

The relationship between past and present plant communities requires further detailed statistical analysis to clarify the degree of similarity between past and present pollen spectra. However the results of the present study suggest a number of correlations which link together the contemporary vegetation / pollen taphonomy and palaeo-vegetation data. The pollen diagrams from Loch Lang (Bennett et al. 1990), Loch Hellisdale, Lochan na Cartach, Kildonan Glen, Port Caol and Loch Druidibeg (this study) provide an indication of vegetation change through the Holocene from c. 10,000 B.P. These studies all indicate that in the Late Glacial arctic-alpine scrub prevailed with Juniperus, Salix, Empetrum, Vaccinium, Huperzia selago and herbaceous taxa such as Rumex, Artemisia and Saxifraga. A similar community (in the vegetation and pollen taphonomy classification it is described as a sub-set of Group E1) is still found above 500m on the north and east facing slopes of Beinn Mhor.

The arctic-alpine communities were then progressively replaced by trees. First Betula then Corylus and Populus arrived on the island forming woodland which had a similar pollen spectra to that recorded in samples of the subset of Group F (bracken-infested grassland) from Allt Volagir N.N.R.. The diversification of woodland which followed with the arrival of Ulmus, Quercus, Alnus and later Fraxinus and Sorbus appears to have no modern equivalent on the islands. However isolated individuals of Fraxinus, Alnus and Sorbus survive in scattered locations and in loch-island scrub

Group F (bracken-infested grassland) outside of the woodland may have been present on the island from 9,000 - 8,700 B.P. when Pteridium first occurs in the pollen spectra; increasing in abundance after c,4,000 B.P. when the record for Pteridium becomes almost continuous.

Blanket bog plants such as Eriophorum and Carex nigra possibly components of the Cyperaceae in the pollen diagrams) have an almost continuous Holocene record. These types together with the Ericaceous species, correspond to groups B and C of the present-day classification. Calluna, Ericales and Cyperaceae are all present in the pollen record from c. 9,200 B.P. and may indicate the presence of blanket bog type communities similar to those found in Group B (Eriophorum angustifolium bog-pool community). and Group C1 (Molinia caerulea - Scirpus cespitosus - Erica tetralix - Calluna vulgaris wet heath during the early Holocene. Group C2 which includes Narthecium ossifragum and Drosera spp. is possibly discernible in the pollen data from c. 4000 B.P. when Narthecium is first recorded in the pollen spectra. Dry heathland, dominated by Calluna (Group D) may also have been present from the early Holocene, evidenced by increasing Calluna pollen frequencies from c.9,200 B.P. with rapid expansion after 4,000 B.P.

A further aspect of the work has been to emphasise the "invisibility" to palynologists (unfortunately) of too many critical plant and "landuse" communities, such as the machair, which plays such a dominant role in the biological and human interest of these islands. There are too many insect-pollinated species and species which cannot be identified to the appropriate taxonomic levels to resolve with confidence the history and development of machair communities. Similarly the availability and location of study sites, and pollen preservation-conditions within them, have been shown to be critical problems in the western areas of these islands and even such immediately down-wind sites as Kildonan Glen have not yielded particularly important information on machair communities. However research at the Borve headland and more generally in the western area has identified with success the nature and changing status of 'pre-machair' vegetation in these presently machair-covered or machair-influenced landscapes.

Even so the palynological studies chosen to address these basic issues of between site variability in these diverse landscapes have been successful. The vegetation studies showed that vegetation development followed a pattern typical for the region at similar latitudes. The early post-glacial vegetation mosaic of

Empetrum heath, herb-rich grassland and dwarf shrub communities was replaced in the early Holocene by woodland. The pollen diagrams record an ordered sequence of tree migration to the islands in which Betula then Corylus were the first colonists, followed later by Ulmus, Quercus, Alnus, Pinus and Fraxinus. An exception to this pattern is noted at Kildonan Glen, South Uist where the Corylus rise briefly precedes the expansion of Betula in the early Holocene. Woodlands appear to have persisted in sheltered localities until c.5,000 B.P., together with species of rich grassland and blanket bog communities which were also present on the islands from the early Holocene.

The gradual decline of woodland from c.5,000 B.P. was accompanied by the expansion of herb-rich grassland and blanket bog communities. After 4,000 B.P. woodland and herb-rich grassland declined further and blanket peat communities spread. Human presence on the islands is indicated from the early Holocene. A brief episode of woodland disturbance, charcoal and cereal type pollen is noted at one east coast site, Loch Hellisdale, during the early Holocene adding to an increasing body of information which suggests some mesolithic presence on the eastern coast of South Uist.

However the causes of vegetation change are attributed to a combination of environmental conditions resulting from rising sea-levels and the corresponding shift towards an oceanic climate, which led to pedological deterioration, as much as to anthropogenic impacts.

Investigations into the historical ecology of existing woodland stands on a previously inhabited island in Loch Druidibeg National Nature Reserve indicated that woodland became established following abandonment, suggesting that factors other than climate have inhibited woodland continuity on such islands - and by inference in the wider Hebridean landscape.

Archaeological Issues.

This palynological and phytosociological research has inevitably been directed towards identifying the nature and significance of human activity with two strategies at two spatial scales. The pollen taphonomy and vegetation study, focussing on the many semi-natural or anthropogenically influenced plant communities in the area, emphasised that the presence of pollen of 'anthropogenic' weeds cannot neccessarily be interpreted in terms of anthropogenic origins in these remote and bleak areas, where significant numbers of these taxa, (*Plantago lanceolata*, *Urtica*, Chenopodiaceae) have niches in natural habitats where bleakness, poor soil conditions or local combinations of base rich soil conditions and bleakness permit the survival of these taxa.

The impact of people appears to be characterised at an island wide scale by the presence and growing abundance of grasslands, moorlands, deforestation, agricultural weeds and in general terms the progressive opening up of the landscape. *However* proof and assessment of this type of information are actually very difficult to obtain. The well known arguments about the respective roles and importance of podzolisation and the spread of blanket bog, and shifts towards wetter climates, singly or in combination, or when associated with human activities as triggers (one burning episode too many in a threshold situation, too many sheep in a threshold situation) cannot be addressed with any independant evidence at the moment. Such indications of the extent of burning, grazing, cultivation on the one hand, or environmental fluctuations on the other, have not emerged as yet with any precision from other current research into the archaeology and geology of the islands.

There is therefore a consensus in this thesis that the progressive loss of trees and the apparent episodes of widespread but relatively sudden spread of bog and raised bog, deduced from parallel *Calluna* curves from so many of the diagrams, are directly or indirectly the result of past human activity. Nevertheless it is clear that *Calluna*, (an indicator of one of the most 'managed'

contemporary plant communities) was a very early Holocene immigrant into these islands and was spreading slowly in a situation where at best only relatively few people might have been present, (bearing in mind that to date there is no archaeological evidence for mesolithic occupation on these islands). The extent to which charcoal curves produced in this study, from Loch Hellisdale, for example, and from Edwards' (1990) sites in the Holocene from South Uist correspond to the debris of fires or small scale burning is far from clear. It could be said that natural fires might be producing these charcoal curves and indeed the emphasis in this study on investigating local variation has highlighted how some basins have charcoal in their early to mid-Holocene sediments, whereas others lack them. It would be wrong therefore to assume that charcoal frequencies in peat cores are a reliable surrogate for the presence of early human communities in the landscape. At best this might be so some of the time.
This study has therefore investigated locations where past human activity is clearly evidenced on the ground, either by archaeological monuments, such as the Borve sub-peat cairn, or by geographical and historical situations, such as the Loch Druidibeg islands. The detailed study of the sediments associated with a sub-peat stone clearance cairn in the Borve valley indicates that the feature was constructed during a period in which Calluna heath and grassland were widespread in the valley. The palynological evidence provides some indication of two phases of cereal crop cultivation. Large Gramineae pollen grains at the soil-peat interface were assigned to the Avena / Triticum group (Andersen 1979) and may represent the cultivation of oats. A second phase in which cereal type pollen is assigned to the Hordeum type group of Andersen (1979) may indicate a phase of barley or bere cultivation. These cultivation or disturbance episodes are interspersed with phases of grassland and heath vegetation which may represent grazing or fallow periods as part of a crop rotation system or "outfield", as described by Dodgson (1988).
Biostratigraphic correlation with the Holocene palynological record from Lochan na Cartach, Barra (this study) suggests that

the construction of the cairn and subsequent agricultural activity occurred after 4,000 B.P and may be part of a more widespread pattern of land clearance and enclosure which is beginning to emerge from studies of other sub-peat sites in the Outer Hebrides. Any relationship between the construction of the clearance cairn and the Neolithic funerary monuments is difficult to ascertain because of the lack of radiocarbon dating control. However it seems likely that the cairn post-dates the burial chamber.

This study appears to have been successful in identifying human activity in an "archaeologically-densely populated" landscape in which blanket bog was already developing. In a sense the identification of this past farming activity was made possible by two things:

1. The chance find of archaeological features in a ditch.
2. The closely spaced sampling intervals which were appropriate to the investigation of a 'used' landscape surface within a blanket bog.

The Loch Druidibeg woodland, all be it apparently unusual, is perhaps more important and representative than it might seem at first sight. It repeats the situation of a landscape in which grazing intensity is reduced (sheep can walk to the islands in summer over partially-submerged causeways, and on the ice in winter). Trees and shrubs of stature can grow in environmental conditions that are very exposed to salt laden winds which blow unimpeded across the machair and surface of the loch. The Loch Druidibeg wooded islands, like the situation of the trees at Allt Volagir and Ben Obe, Barra, all emphasise the critical importance of grazing animals, particularly sheep, in generating the present bleak, treeless landscape.

This study has been able to illuminate the microclimatic and environmental situation and indeed the resource potential of these islands for past people, especially before 4,000 B.P., for which time these data have shown the existence of relatively dense woodland or shrub with canopies, probably above "head-height" much of the time. The particular value of the Druidibeg study has been that the identification and tracing in the pollen and historic record of known alien tree taxa, such as Taxus and Abies, have shown the extreme rapidity with which woody species have established themselves in the past c.200 years. In this sense these studies have also emphasised the technical advantages of working with mor humus and palynology to address issues of conservation management as well as using it to identify the nature of human impact on a landscape and the speed at which biological changes can occur.

Many of the basic problems identified in the opening chapters of this study have been advanced in this thesis with a considerable degree of success. New issues have also arisen. Perhaps the most intractable of these issues has been shown (ironically) to be that associated directly with the application of the theories of island biogeography. The nature and scales of change demonstrated in these particular islands are such that there is still a long way to go before it is clear that in this "theory" we have an appropriate concept with which to understand the present or past vegetation of these Hebridean islands.

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