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Institute of Terrestrial Ecology

Sand Dune Machair 2

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The Institute of Terrestrial Ecology (ITE) was established in 1973, from the former Nature Conservancy's research stations and staff, joined later by the Institute of Tree Biology and the Culture Centre of Algae and Protozoa. ITE contributes to and draws upon the collective knowledge of the fourteen sister institutes which make up the Natural Environment Research Council, spanning all the environmental sciences.

The Institute studies the factors determining the structure, composition and processes of land and freshwater systems, and of individual plant and animal species. It is developing a sounder scientific basis for predicting and modelling environmental trends arising from natural or man-made change. The results of this research are available to those responsible for the protection, management and wise use of our natural resources.

Nearly half of ITE's work is research commissioned by customers, such as the Nature Conservancy Council who require information for wildlife conservation, the Forestry Commission and the Department of the Environment. The remainder is fundamental research supported by NERC.

ITE's expertise is widely used by international organisations in overseas projects and programmes of research.

Contents

Introduction

Machair is a localised landscape term applied to a type of dune pasture (often calcareous), subject to local cultivation, and developed in humid and windy conditions in north and north west Scotland. It can form extensive undulating swards to 300 ft. or more above sea level, overlying glacial till or blanket bog.

The idea of a seminar on machair arose out of correspondence with Dr. W. Ritchie and Professor C. H. Gimingham of Aberdeen University. A first meeting was held in November 1973 at the Coastal Ecology Research Station (now The Institute of Terrestrial Ecology, Colney Research Station) Norwich, and the first report was published in 1974. At the meeting, it was decided to set up a small Machair Working Group to improve communications between workers in the field of machair studies, to encourage complementary research studies and research in areas where it is most needed. The Group's secretary, Dr. Roland Randall, produced a first newsletter in Spring 1975.

It is entirely appropriate that a second meeting should have been held on 24th September 1975 at Aberdeen University where so much work has been done on machair by members of the Departments of Botany and Geography. This report brings together the contributions given at that meeting, which also included a field trip to Forvie National Nature Reserve on the morning of September 25th. Plans for a machair bibliography were also discussed at the meeting.

Any opinions expressed in the following papers are solely attributable to the authors concerned.

D. S. RANWELL

ACKNOWLEDGEMENTS

Thanks are due to all contributors for their participation. The Machair Working Group is grateful to Dr. R. Randall for helping to organise the meeting and to Professor C. H. Gimingham, Dr. A. Mather, and Dr. W. Ritchie for providing such excellent facilities for the meeting at Aberdeen University and to Professor Gimingham for leading the field trip to Forvie N.N.R. Miss L. P. Harrison gave much help in the editing of this report. Thanks are due to Mr. P. G. Ainsworth for help with the illustrations. The cover illustration was designed by Mr. S. V. N. Lewis.

Man and Machair Soil Ecosystems

G. Dickinson

The object of this paper is to offer for discussion some general ideas relating to the nature of, and management of machair soils. Machair soils form part of an overall machair ecosystem, and the ecosystem approach may be valuable in independently studying the soils component. Using information largely drawn from field studies in the Uists and Harris, some areas for further analysis and possible lines of inquiry, together with some management strategies are put forward.

Several important machair soil characteristics can be noted at the outset. The nature of the parent material and its continuous variation within machair areas leads to very complex spatial patterns. Within a particular locality, it is possible to establish a catena based on a number of environmental gradients including hydrology and nature of parent material. Interactive response to machair vegetation is always a critical factor in machair soil development. Machair soils are characterised by high $CaCO_3$ content (though in the Uists this varies between 20–90% of total mineral composition), by low organic matter content (usually less than 10% and frequently, particularly in the seawards and less stable areas, below 2% content), and by nutrient deficiences. These deficiencies occur particularly in phosphates, nitrates, and potash, and in some areas in copper and manganese. Soil moisture and air conditions vary profoundly both in time and space. All of the above combine to produce a distinctive soil ecosystem which has regional agricultural significance yet presents considerable difficulties in utilisation and conservation.

There are many areas of study which are important to our understanding of machair soils. The nature, paths and routes of nutrient cycling, energy flows within the soils and the role and nature of the distinctive soil fauna are among these. Presently, much valuable work relating to agricultural management has been carried out by the North of Scotland College of Agriculture, and this work would be enhanced by further regional surveys and by detailed studies in selected localities.

Most machair soils have experienced a long history of agricultural use (Photos 1 and 2), which should be seen within its relevant regional and socio-economic contexts. There are considerable technical and social problems in managing and conserving the ecological and agricultural values of these soils, and in reconciling these two interests. Whilst it is widely recognised that in the past there have been serious problems in soil utilisation, it is now increasingly clear that although the problems are soluble, developing solutions in practical terms may be much more difficult.

Suggestions for the future are based on an assessment of what seems practicable in scientific, technical, economic and social terms. In management of machair soils, conservation is presented with a challenge and an opportunity perhaps unique in Britain, for in this habitat man and nature have been so inextricably linked for literally thousands of years that solutions to present problems will only be found by co-operative effort and by application of the concepts of conservation in the fullest sense of that term.

Photo 1 Cattle on the machair, a common herd belonging to the Township. Loch a'Mhacair in the distance looking across to Grogarry, South Uist. (Photo: Copyright Tom Weir, Gartocharn.)

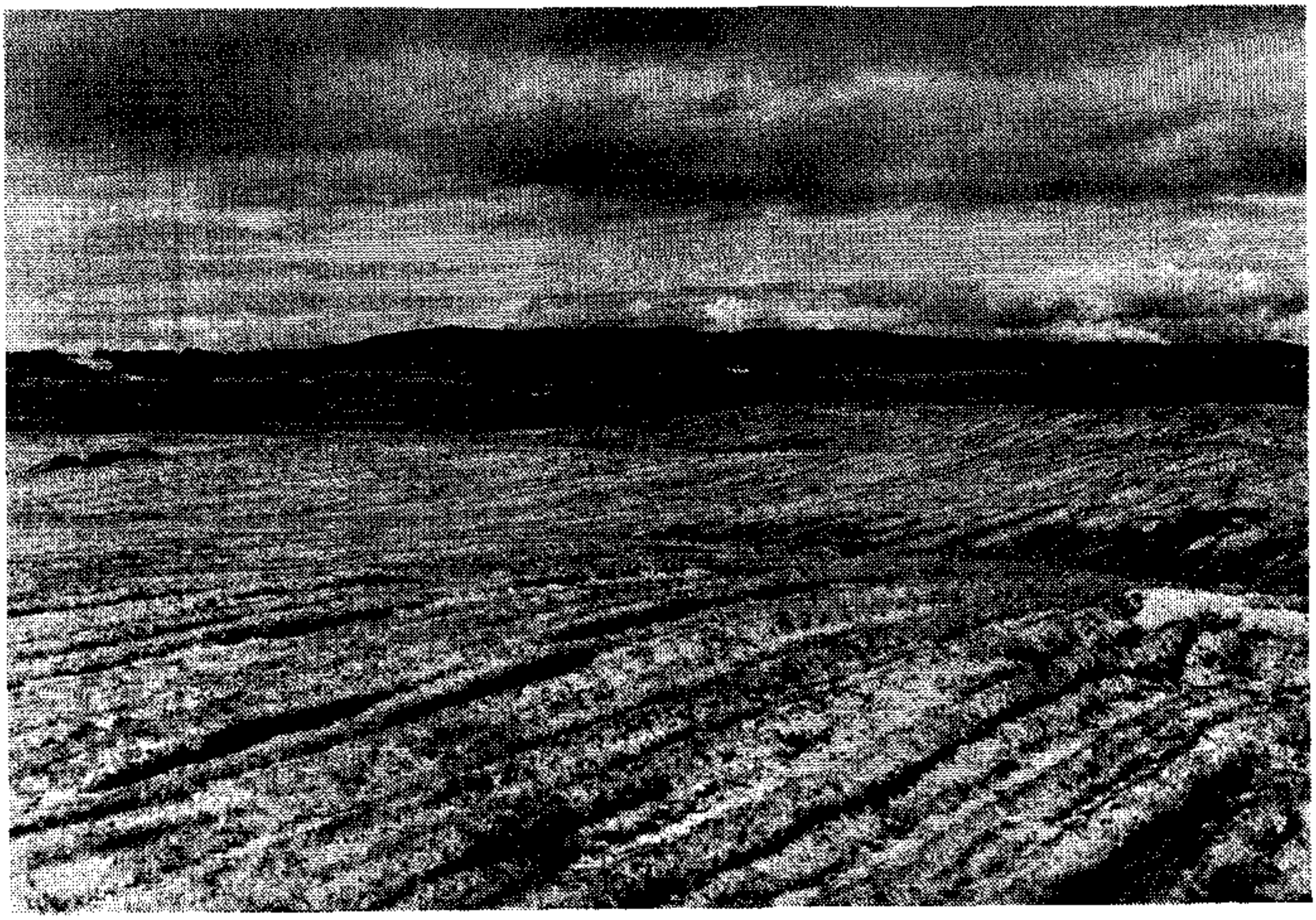

Photo 2 Machair cultivation, Sollas, North Uist. (Photo: R. E. Randall.)

The Evaluation of Machair sites in the Shetlands

P. Sargeant

The discovery and development of oil fields in the northern North Sea could pose serious threats to the continued existence of the scientific interests found in Shetland. Accordingly, the Nature Conservancy Council's Geology and Physiography Section evaluated the sites of geological and geomorphological importance of the area.

The beach-dune-machair complexes are an integral part of the scientific interest of the archipelago and it is important to protect the most important areas. Mather & Smith (1974) have identified the main characteristics of the Shetland beaches and noted that the deep water and high energy conditions have resulted in small dune machair areas with few accreting beaches. All of the machair sites were evaluated in terms of their uniqueness, size, controlling processes, variety or absence of typical machair features, conservability and threats. The seven areas given below were considered to warrant Sites of Special Scientific Importance (S.S.S.I.) status on purely geomorphological grounds. It is important to protect such a range of different machair complexes both as type examples and for research to be carried out into their mode of formation and the contemporary controlling processes.

Quendale	the largest sand 'reservoir' in Shetland with a well-developed dune ridge and complex machair.
Scousburgh	an area containing a wide variety of different machair forms related to deflation, redeposition and revegetation.

St. Ninians	a small machair system associated with a classic tombolo.
Breckin (Yell)	an extensive system with unusual deflated hill machair.
Sandwick (Yell)	a severely deflated dune-machair complex representing a late stage in machair evolution.
Balta Island (Unst)	the best example of a 'true' machair in Shetland.
Burrafirth (Unst)	a machair area with no dune system controlled by aeolian marine and fluvial processes.

The proposed oil and gas developments will have no direct effect on the machair sites, and the most serious threat is sand extraction. The sand-machair areas are inadequate to meet the demands of a developing industry, but the Shetland Islands Council have stated that "major developers will be required to satisfy the planning authority that they will obtain their supplies of sand and aggregate without affecting Shetland's environment". Small-scale extraction will still continue at Quendale, St. Ninians and Sandwick to supply local demands.

The influx of workers associated with the Sullom Voe development site, together with the improved ferry system and the expanding tourist industry, will increase recreational pressures, particularly on the more accessible beaches at Scousburgh and St. Ninians. The more fragile areas need to be identified and management guidelines formulated to ensure that the most important beach-dune-machair complexes (see Mather & Smith 1974) are not irretrievably destroyed.

The findings of the Shetland survey have been published in a report (Anon 1976).

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Rosinish 1974: A Summary

I. A. G. Shepherd

Wind erosion is severely affecting a large machair hillock, some 15m high, which is unique on the rocky east coast of Benbecula. Many ancient land surfaces preserved within the dunes are consequently being exposed and destroyed. In July, with the support of the Society of Antiquaries of Scotland and the Abercromby Fund of the University of Edinburgh, systematic surface collection, surveying, soil sampling and trial excavations were carried out to assess the nature and extent of occupation trades associated with some of these early horizons.

A gridded surface collection over 0.9 hectares recovered some 3,500 sherds, mostly eroded from two middens 0.8m apart near the top of the dune. These were each 0.3m thick; the upper one being of a light brown sandy texture and the lower of a dense humic nature. Both contained many limpets and sherds of a hard ware, with much quartz gritting, ranging in colour from orange to black. This fabric, and the occasional applied fillet, have general wheelhouse (Bronze age to Iron age) affinities. Medieval — 12th Century — Platter Ware was identified from the upper midden. These upper surfaces are exposed in the dunes over a length of *c*. 300m: no structures are at present visible in them.

The earliest features now visible are two areas of beaker midden, the larger of which is completely exposed on the shore (NGR NF 87285371) *c*. 5m due west of the small burial cairn excavated in 1964 (Crawford 1964), and less than 20m from the high tide line. Small scale excavation showed it to be *c*. 200m^2 and 1m thick, consisting of a compact matrix of dirty brown non-calcareous sand yielding some charcoal fragments, animal bones and shellfish. Pottery from this midden comprises many sherds of beakers on which groups of horizontal lines, chevrons, and short obliques made by both incisions and tooth comb impressions were common. This pottery seems closest to Clarke's (Clarke 1970) early to mid-Northern series, steps 4 and 5 in the scheme of Lanting and van der Waals 1972. Of interest among the pottery of this area were a large rim-to-shoulder fragment of an All Over Toothcomb decorated beaker, one piece of ***Cardium*** impressed beaker, both from the surface collection, and from the bottom level in the midden, several sherds of thick (0.015m) black ware with a heavy rolled rim and internal decoration of short vertical slashes. Quartz flakes, some of them struck, and a piece of pumice were also found in this midden.

A possible structure represented by a U-shaped arrangement of loose boulders 7.5m by 4m in maximum extent, *c.* 1.5m across its 'wall', open on the landward side and resting on the surface of part of the beaker midden, clearly post-dates the midden but by what interval must await further investigation.

A second much smaller trace of beaker occupation is represented by a stump of midden *c.* 1.5m protruding from a small dune some 50m SW of the cairn. Trial excavation revealed a hearth 0.7m by 0.6m and three post holes 0.13m both in diameter and depth. The midden was only 0.25m thick in this area, but further traces of a structure may lie within the dune. Finds from this hearth site included: a fine base sherd decorated with panels of tooth comb impressed chervons, vertical lines, and a basal fringe of short verticals; a rim sherd from a beaker with a short, sharply flaring neck, and a sherd of an extremely fine beaker only 0.005m thick, decorated with very small punctulations and incised lines. A neat thumbnail scraper of blue-grey flint 0.015m in diameter, quartz flakes and a small pebble knife were also found here. While only a thin deposit of beaker date is visible in this area at present, the possibility of other, earlier deposits existing at lower levels in the immediate vicinity of the hearth should not be ruled out as the latter is situated on a shelf of sand some 4.58m higher than the large beaker midden on the shore.

In summary, the large machair knoll at Rosinish is suffering from considerable wind erosion, with the result that patterns of land formations and human settlement built up there over the last four thousand years are fast being destroyed.

The Iron Age and Medieval occupation, represented by two upper midden levels, appears to have been extensive; although no structures are at present visible in any of the dune sections.

Of prime importance are the two areas of beaker midden; one the vestige of a house site, and the other a large and accessible exposure of a thick deposit on the shore. Finds from exploratory excavation of only 0.5% of these areas largely comprise sherds characteristic of a mature, but not particularly late phase of British beaker development. Especially interesting is the great range of pot sizes, and consequently an inferred variety of functions, represented by the beaker sherds so far recovered. The fineness and delicacy of a few sherds and the size and weight of others suggest that the whole spectrum of domestic, and hitherto extremely exclusive beaker pottery, may be present at Rosinish.

Furthermore, the potential for recovering much useful environmental information from the main beaker midden is high. Samples for land snail analysis by Dr. John Evans which will provide most interesting comparisons with the Northton diagrams were taken from all middens and many buried land surfaces this year. The midden matrix is ideally suited to processing by sieving and/or flotation to recover macro-faunal and plant remains.

A rare opportunity to reconstruct the economic basis of beaker settlement in Scotland, previously denied to prehistorians, presents itself in the rapidly disintegrating landscape of Rosinish.

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Machair Lochs

R. N. Campbell

In the Hebrides, terrestrial ecologists (whether they all knew they were "ecologists" or not!) have long been impressed by the juxtaposition of base-rich and base-poor habitats and a fair amount of recorded scientific investigation has taken place as a result (Ritchie 1967 and Waterston 1968). The same cannot really be said for freshwater aquatic habitats, although a similar degree of contrast in trophic status exists between adjacent open-water bodies. This paper is a plea for increased interest in Hebridean limnology.

Base-rich ("eutrophic") lochs with their rich and varied associations of flora and fauna are rare in northern Scotland. Those that exist are found only on the Old Red Sandstones of the narrow east coastal plain and in part of Caithness, on the sporadically occurring Durness and Dalradian magnesium-limestones, and on the machairs of the west coast and Western Isles (Campbell 1971).

However, machair lochs differ markedly from those other base-rich lochs due to their particularly recent, brackish origin and to strong marine influence. In Table 1, figures for some chemical constituents of machair lochs are shown along with those of other fundamentally different lochs for comparison, including two central mainland lochs.

Some of the best examples of machair lochs occur along the South Uist west coastal strip (Photo 3). Here there is a classic example of transition of open water habitats – from spray zone pools and lochans impounded by storm beaches (such as Loch Ardvule on the Rudha Ardvule peninsula), through machair lochs and a little further inland "mesotrophic" lochs lying on "acid" gneiss but influenced by calcareous machair sands and improved grazing land, to the oligotrophic and dystrophic lochs lying on gneiss surrounded by peat moorland. All of these habitats can occur along a transect of only 3 to 4 km.

Considerable floral and faunal diversity occurs in the machair lochs where the expected, rich, "eutrophic" invertebrate fauna is augmented by forms associated with the recent origin of these lakes and the continued marine influence. Such forms are the "freshwater shrimp" ***Gammarus duebeni*** (which does not apparently occur on the mainland of Scotland), the opossum shrimp ***Neomysis integer*** and the small mollusc ***Potamopyrgus jenkensi***. Along with these brackish elements is a wide range of other invertebrates associated with the base–rich environment, normally absent from the great majority of northern Scottish lochs. For instance, 13 species of snail are present in and around Lochs Stilligarry and a'Mhachair in contrast to the oligotrophic lochs Druidbeg and Hamasclett 0.2 and 3.2 km further inland respectively where only 2 species are present along with a much sparser flora and fauna. ***Neomysis integer*** appears to be absent from Loch Hamasclett and local only in Loch Druidbeg (A. R. Waterson et al, unpublished). It is interesting to speculate how these forms, far from their present centres of concentration, colonised the machair lochs of the Western Isles within what must have been a relatively short period.

Floristically, too, the machair lochs are rich, with dense banks of submerged and emergent macrophytes in contrast to the relatively bare littoral zones of the peatland lochs. At least 13 species of ***Potamogeton*** have been recorded in South Uist machair and mesotrophic lochs.

TABLE 1. Chemical constituents (ppm) of 4 machair lochs and 2 mainland lochs for comparison.

	Loch Ardvule, spray zone South Uist	**Loch Stilligarry, machair South Uist**	**Loch a'Duin Mhurchaid, mesotrophic Benbecula**	**Loch Druidibeg moorland South Uist**	**Eutrophic loch mainland**	**Oligotrophic loch mainland**
pH	8.2	7.6	6.8	6.1	8.3	6.2
Alk (as $CaCO_3$)	47.2	90.4	22.6	3.4	50.0	3.3
Ca	30.8	49.7	9.9	2.9	21.5	2.3
Mg	28.0	6.4	4.9	2.7	8.0	2.2
Na	214.0	32.4	28.6	22.8	7.0	2.7
K	9.7	3.6	2.3	0.9	2.0	0.8
Cl	452.0	66.3	57.8	42.8	13.5	*
SO_4	8.8	40.1	5.8	5.6	25.0	*

* No figures available. However in the case of Cl the concentration (in relation to that of Na) would have probably been in the order of 6.0 ppm.

Photo 3 General view over Grogarry Lodge to South Uist machairs with machair lochs. (Photo: R. E. Randall.)

The permanent and temporary fish populations of machair lochs, where there is a clear access to the sea, may be salmon, sea trout, brown trout, flounder, grey mullet, eel, saith, coalfish and three- and ten-spined sticklebacks, while in lochs without clear access brown trout, eel and sticklebacks only occur.

Although the rate of growth of brown trout and the ultimate size of individuals is not directly correlated with the trophic status of the loch, their biomass is (Campbell 1971). In machair lochs, where inflowing streams run through machair land (e.g. at Loch a'Mhachair), the physically poor spawning facilities lead to a low level of recruitment and, consequently, to the higher growth rate of individual trout. In contrast, Loch Kildonan, another machair loch, has a large population of relatively slow growing and small trout due to the extensive spawning grounds provided by the Kildonan burn which flows in from the east across 2 km of peat moorland. Machair loch trout are fast growing but short-lived (Campbell 1971).

Another unusual feature of machair lochs is the strong effect of wind action on bottom sediments, constantly augmented by wind blown sand, due to the strength, frequency and duration of Hebridean winds and the characteristic shallowness of these lochs. A clear example of this effect is shown by Campbell 1971, (Plate III).

As a consequence of their rich flora and fauna and the relative mildness of the Hebridean winter, machair lochs are important breeding and wintering sites for wildfowl and waders. Possibly the true significance of base-rich Hebridean open waters and fen as a whole, within a British and European context, has not yet been fully realised.

ACKNOWLEDGEMENTS

I am indebted to the Freshwater Fisheries Laboratory, Pitlochry for details of water analyses.

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The Effect of a Porous Fence set Normal to Aeolian Sand Motion On a Flat Surface

B. B. Willetts

Uniform motion of sand by wind was found by Bagnold (1941) to involve a two stage dislodgement mechanism, momentum being transferred, first from the wind to grains in saltation, and then from them to stationary grains in collisions which renew the population of moving grains. The uniform transport rate of sand has been related by several investigators to the tractive stress between the wind and the sand boundary – often using shear velocity to represent tractive stress. (If tractive stress = τ_0 , and air density = ρ, then shear velocity = $(\frac{\tau_0}{\rho})^{\frac{1}{2}}$

A fence set at right angles to the wind disturbs the flow near the surface (fig. 1a), producing local reductions in tractive stress (fig. 1b), and in sand transport rate (fig. 1c). As a result of the local reduction in sand transport rate, sand accumulates at the fence. The variation of boundary shear stress near fences of various porosities has been measured in wind tunnel experiments, and the rate of sand accumulation can be found by elementary calculation from a given pattern of sand transport. Calculations can therefore be made (using empirical results for the boundary shear stress near the fence) of the growth of a dune near the fence. The results of such calculations can be checked experimentally with more reliability than is usual in sediment transport work generally. Such a check is illustrated in fig. 1d.

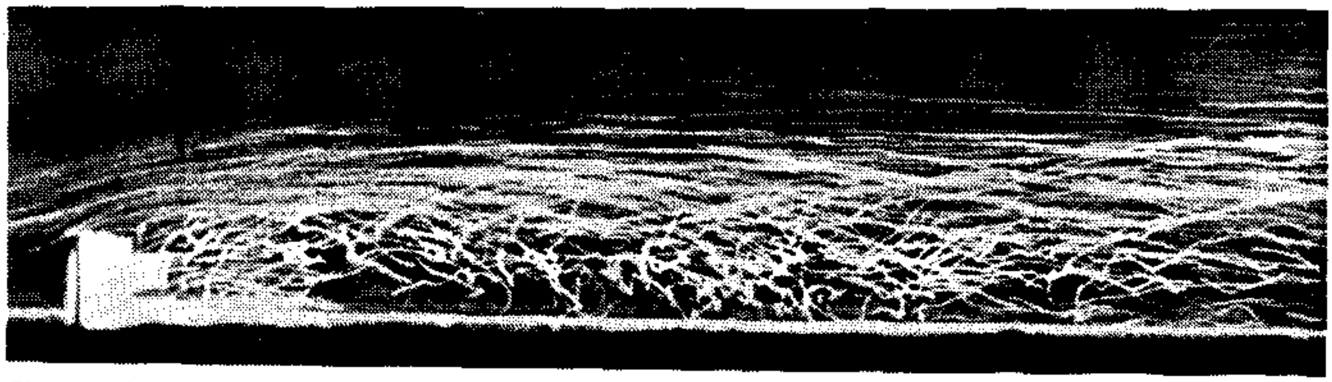

Figure 1 (a) Helium bubble streaks near a fence of 35% porosity

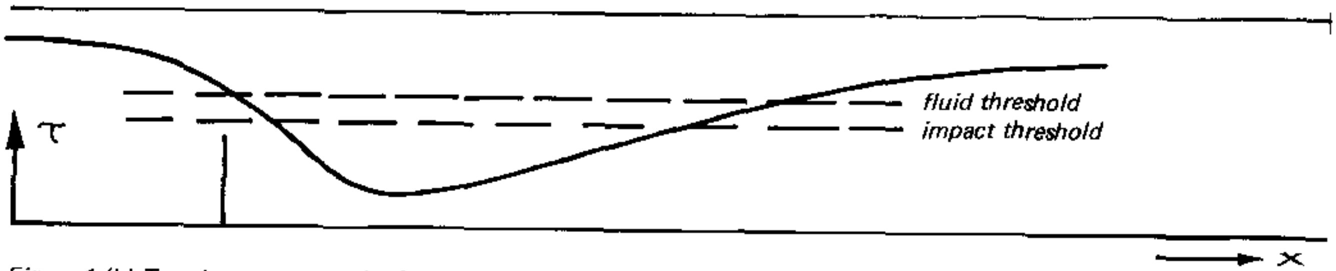

Figure 1 (b) Tractive stress near the fence (Diagramatic only)

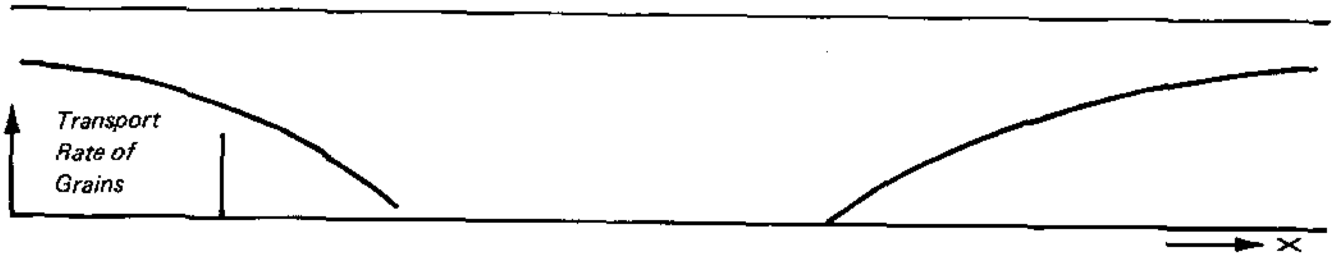

Figure 1 (c) Grain transport rate near the fence (Diagramatic only)

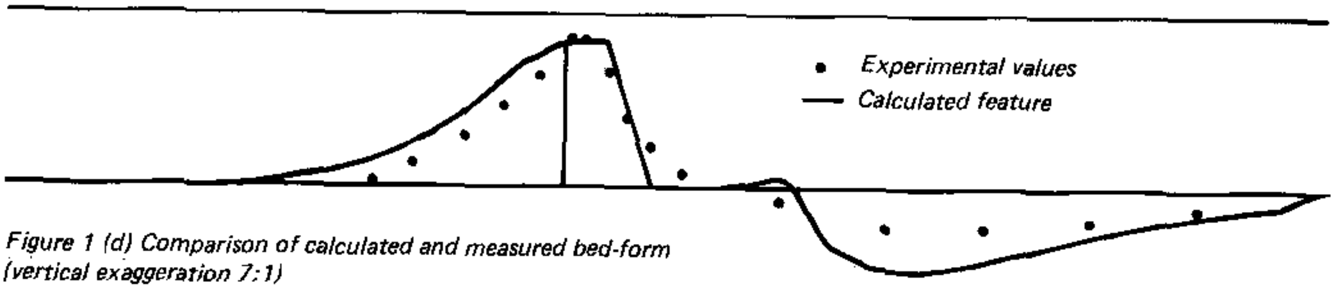

Figure 1 (d) Comparison of calculated and measured bed-form (vertical exaggeration 7:1)

The speculative step in the calculation concerns the relationship between tractive stress and sand transport rate in a zone where both are changing spatially. Uniform flow relationships cannot be relied on in such a zone, since one implication of Bagnold's two-stage model is a dislocated grain transport response to a change of wind condition. An attempt is being made to establish this relationship with sufficient accuracy to make predictions of dune growth reliable.

Were the attempt to be successful, there would be several useful consequences in terms of machair. Most obviously, the predictive capacity developed would help in deployment of fences used to control sand drifting. Perhaps this would be less useful, however, than the consequent ability to predict sand behaviour in areas where tractive stress varies for unintentional reasons in no way connected with fences. Such circumstances occur, for instance, on any topographical feature, wherever patches of bare sand occur in a generally vegetated area, or where there are dry areas in a generally wet sand surface.

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Extensive Survey of Dune Vegetation in Scotland

D. S. Ranwell

Over the past ten years, regular visits have been made to Scotland to improve botanical knowledge of coastal sites in anticipation of inevitable changes. These reconnaissance visits provided lists of vascular plant species, information on the range of habitat and vegetation types, and on human impacts on the environment, for the Nature Conservancy.

Within the past five years, with more assistance available, a more quantative approach was developed to sample the range of habitats in representative examples of our bigger dune systems such as St. Ouens Bay, Jersey, Channel Islands (Ranwell 1975, 1976), Strathbeg, Aberdeenshire and Dunnet Links, Caithness. Data have been subjected to reciprocal averaging analysis (Hill, 1973) and indicator species analysis (Hill, Bunce & Shaw, 1975), but results of these exploratory analyses have not been published.

Recently, these studies have been transformed by the needs of the Nature Conservancy Council for objective information on a large scale urgently in relation to oil and other developments on the Scottish coast. The Institute of Terrestrial Ecology has been asked to take responsibility for biological survey of 94 sites (mainly sand dune) all round the coast of Scotland, covering a total area of some 32,500 ha. The study was started in April 1975 and is expected to run for 3 years.

The objectives are to determine the nature and extent of habitats and composition of vegetation so that objective comparisons can be made between sites. Also the survey aims to record the vascular plants, terrestrial bryophytes and lichens on each site, and to estimate so far as possible, population sizes and distributions of rare species. Estimates of the effects of human activities on the site are also to be given.

The method for objective botanical and habitat survey has been adapted from Bunce and Shaw (1973). Sampling points were pre-located objectively on 6 inch to the mile maps and located in the field by direction and distance from fixed features on the map. Each sampling point was the centre of a uniformly orientated nest of six quadrats increasing in size from 1m^2 to 200m^2. The nest of quadrats gives information on habitat variability around the sampling point. Vascular plants are recorded in an additive way so that only new species are recorded in quadrats successively larger than the 25m^2 quadrat. Cover and height measurements of the vegetation are made for the 25m^2 quadrat, and a collection of bryophytes and lichens from this size also made. Environmental data and a sketch map are recorded on the 200m^2 quadrat. Soil and water table data are collected from a small pit and augur borings to 2m at the sampling point, the centre of the nest of quadrats.

In 1975, 1,117 sampling points were recorded at 28 sites by 4 teams of two people working from May to September. Data are coded, punched onto tape and stored in a computer. Analyses will provide objective site to site comparisons and explore correlations between a wide range of environmental factors and vegetation.

Further information on the progress of the survey is given in Institute of Terrestrial Ecology: Annual Reports for 1975 and 1976.

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Birds and Machair

I. R. Hepburn

INTRODUCTION

Sand dunes and machair systems have attracted a large number of workers from a variety of disciplines within the general field of 'environmental sciences'. These include plant and animal ecologists, geomorphologists and palaeoecologists. It appears, however, that little attention has been paid to the bird-life of these systems. A search of the more recent ornithological literature uncovered only one paper on the "bird populations of a Welsh sand dune system", and nothing at all relating to machair birds.

This dearth of information is particularly apparent when considering breeding birds. Many sand dune systems (such as Blakeney Point, Norfolk and Minsmere, Suffolk) are very well known to ornithologists for their regular attraction of passerine migrants. Such birds are normally not associated with the dune systems, but with the scrub or tree cover which is invading the dunes either through natural succession or with aid from man. Less is known (or at least little is published) about the breeding birds of these same systems.

This paper, while not pretending to rectify the present situation, may be regarded as an initial statement summarizing the ornithological status and significance of one particular sand dune and machair area in the Outer Hebrides — the Monach Isles.

The work reported here was carried out during the summer of 1973, and concentrates on the distribution of breeding bird populations within different habitats.

HABITATS

The plant communities of the Monach Isles (Photos 4 and 5) were described by Dr. Randall during the first meeting of the Machair Working Group. As a brief summary, the 5 islands situated 10 km south-west of North Uist are comprised of 8 basic vegetation habitats:

1. Unstable dunes, dominated by ***Ammophila arenaria***
2. Flat dunes, dominated by ***Ammophila*** and ***Bellis perennis***
3. Stable dunes, dominated by ***Ammophila*** and ***Carex arenaria***
4. Machair pasture, dominated by ***Bellis perennis***
5. ***Carex arenaria*** pasture
6. Maritime cliffs and coastlands, dominated by ***Armeria maritima***
7. Peatlands, dominated by ***Carex nigra***
8. A 'residue' of strandline and cobble-beach habitats

The habitats relevant to the following discussion are firstly, stable dunes (which includes flat dunes), and secondly, machair pasture. These two habitats cover about 75% of Ceann Ear, the island on which most of the bird distribution survey work was carried out.

BREEDING BIRDS

Nine species were recorded as breeding in either or both of the stable sand dune and machair habitats. This record accounted for 25% of the total number of species found breeding on the Monachs. Two species were found nesting on stable sand dunes but not machair: eiders, which require the extra cover provided by marram compared with the shorter, grazed machair turf, and starlings which used deserted rabbit burrows in the dunes. Three species nested in both machair and stable dunes: fulmars, skylarks and meadow pipits. The last two are commonly associated with dune and grazed pasture habitats, but the fulmar's use of sand dune and machair habitats is of particular interest. The nest site distribution of this species was the subject of a detailed investigation, and it was found that 57% of the total fulmar population of 176 nests on four islands was using sand dune/machair nest sites. Most of these nests were located in stable sand dune areas adjacent to the sea. Others were inland on the machair, often where rabbit burrowing had led to localised erosion and the formation of very small "cliffs" in the otherwise fairly level surface. Such habitats are quite atypical fór fulmars which are generally associated with precipitous maritime cliffs. This apparent extension of the habitat niche, probably brought about by the species' "population explosion" resulting in a shortage of conventional nest sites, is almost certainly only possible on the Monachs because of the lack of terrestrial predators and minimal interference by man since the species first nested there.

It is thought that fulmars nesting in sand dune and machair sites could well lead to further localised erosion of the vegetated surfaces, possibly resulting in extensive blowouts.

The four species recorded as nesting in machair, but not in sand dune habitats, were lapwing, ringed plover, little tern and wheatear. The last species nests in holes and was found in disused rabbit burrows in the machair. Lapwings are commonly associated with heavily grazed grassland habitats, and on the Monachs they nest successfully on the machair sward. The ringed plover and little tern are normally coastal nesting species, using shingle and sandy foreshore habitats. Within the machair of Ceann Ear, both species take advantage of the sparsely vegetated, sandy hollows which appear as a result of localised erosion, initiated through overgrazing or excessive trampling by the rabbits and sheep. About one third of the total ringed plover population on Ceann Ear and all the little terns nest inland within the machair. These two species are known to be very vulnerable to disturbance, and the increase in visitor-pressure on sandy beaches throughout Britain has had detrimental effects on their populations. This is of particular importance in the case of the little tern which has a small total U.K. population (about 1,800 breeding pairs), and more specific

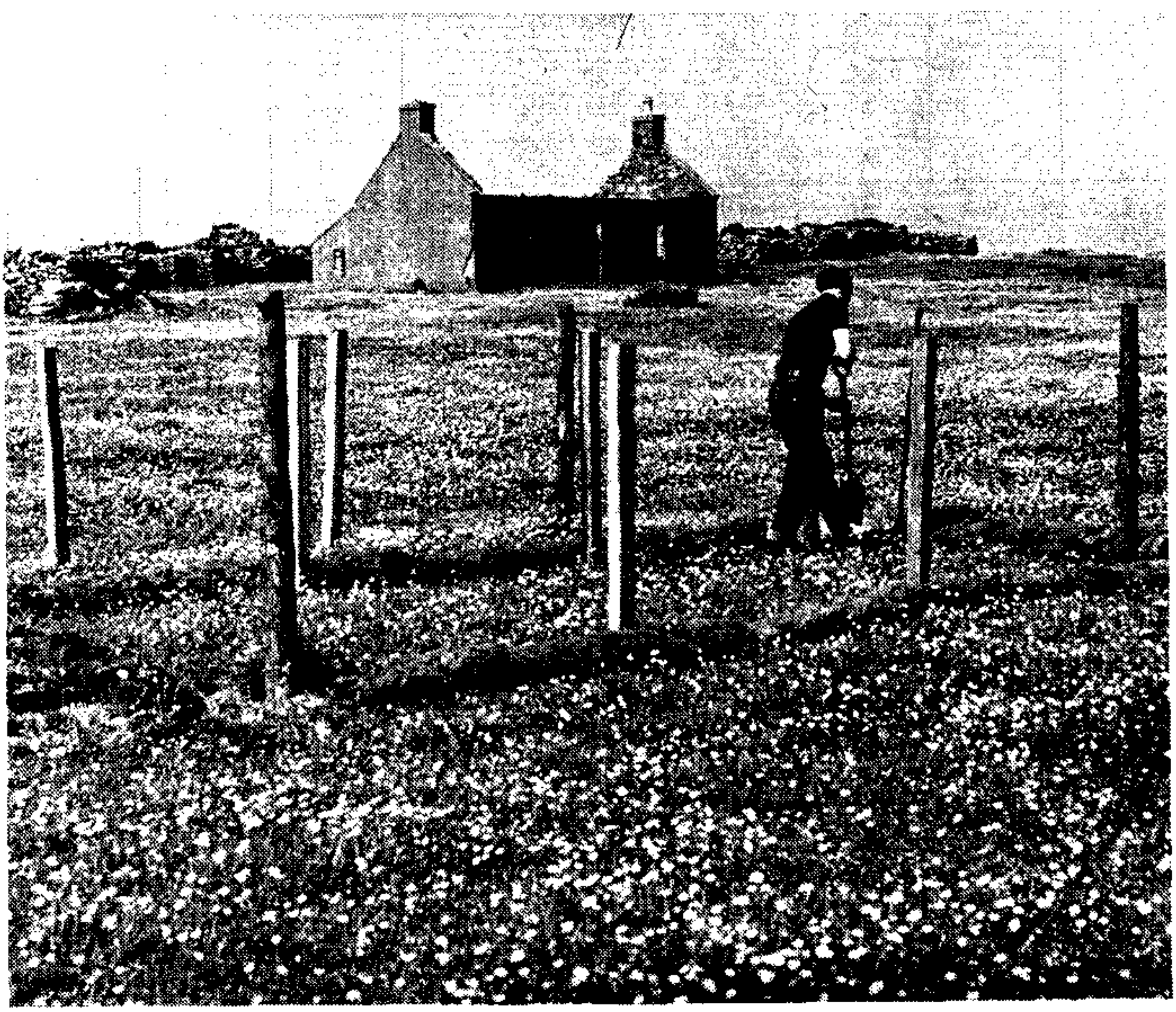

Photo 4 Experimental grazing exclosure being set up on machair pasture, Monach Isles. (Photo: R. E. Randall.)

habitat requirements than the ringed plover.

Thus of the seven species which nest in the machair habitat of the Monachs, three may be regarded as being important either in terms of breeding bird conservation or on a scientific interest basis.

PASSAGE AND WINTER BIRDS

Less is known about the use of machair and sand dune habitats by birds outside the breeding season. During the early period of wader passage, flocks of lapwings, oystercatchers and golden plovers were observed feeding on the machair. Exactly what these three species (or the starlings, meadow pipits, skylarks and wheatears which feed in the machair during the breeding season), actually feed on is not known.

Large flocks of barnacle geese, totalling up to about 1,000 birds, graze the machair during the winter, but other information on birds during the period from October to April is very scant. The Monach Isles present an unusual type of machair and sand dune habitat in that they are virtually free from disturbance by man. They are not subject to the intense recreational pressures that affect many of the machair and dune habitats along the adjacent west coast of Scotland and the Hebrides, and probably have a more "natural" faunal complement than similar habitats elsewhere. If this is true, then the information on breeding birds presented in this paper may be taken as a base-line to indicate the potential ornithological status which might be attained by other machair systems in this region. This is likely to be a too general statement in reality, but it should be taken as an indication that the machair habitat could be potentially richer in bird-life than it is at present in situations where there is heavy recreational use or other forms of disturbance and interference with the machair.

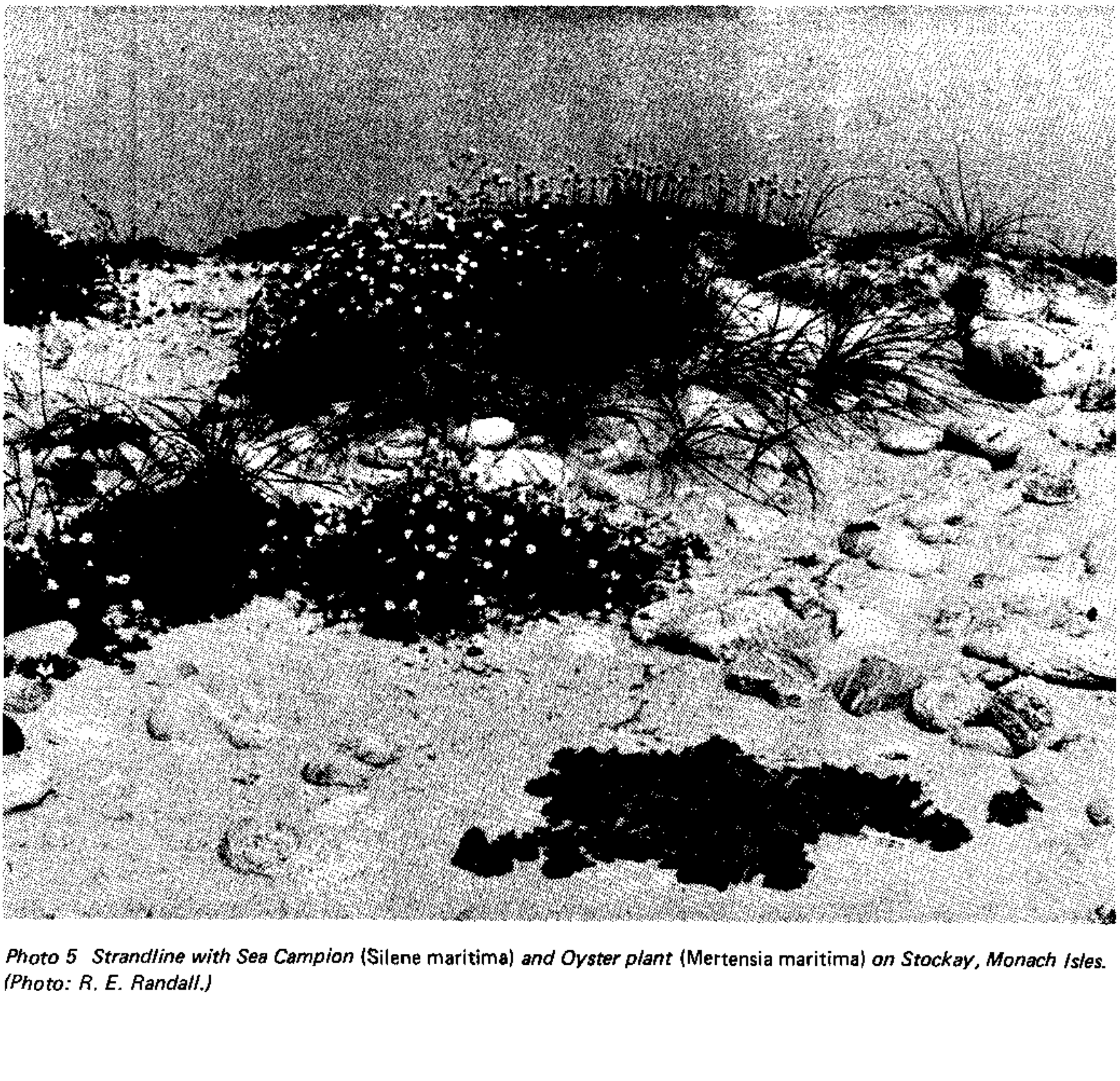

Photo 5 Strandline with Sea Campion (Silene maritima) ***and Oyster plant*** (Mertensia maritima) ***on Stockay, Monach Isles. (Photo: R. E. Randall.)***

Pollen Catchment in Relation to Local Vegetation: Ceann Ear, Monach Isles N.N.R., Outer Hebrides

R. E. Randall

A phytosociological investigation of the vegetation of Ceann Ear was carried out during 1968-71. Detailed results of this investigation are in Ranwell (1974). The following vegetation communities were distinguished:—

1) *Eleocharis palustris* fen.
2) Mixed fen (*Hippuris, Eleocharis, Carex* spp., *Eriophorum* etc.)
3) *Cares nigra* sedgeland (very rich flora)
4) *Calluna vulgaris* heath (incl. *Salix repens, Succisa pratensis* etc.)
5) Maritime grassland (*Armeria, Plantago maritima, Festuca, Glaux*).
6) Vegetated cobble (*Galium aparine* dominant).
7) Disturbed machair (around site of Port Roy village — includes considerable amounts of *Lolium perenne*).
8) Mature machair (*Festucetum rubrae* but with high proportion of *Trifolium pratense*).
9) Machair (*Festucetum rubrae* with *Bellis perennis, P. lanceolata, Achillea millefolium* etc.)
10) Stable dune (closed community with *Ammophila*).
11) Unstable dune (open community with *Ammophila*).
12) Salt marsh (*Spergularia marina, Triglochin palustris, Puccinellia maritima*).
13) Dune slack (*Carex* spp., *Juncus articulatus, Potentilla anserina* etc.)
14) Lochs (*Potamogeton* spp., *Ranunculus* spp., *Myriophyllum* etc.)
15) Unvegetated strand and rock.

Pollen samples were collected from moss polsters within stable dunes, dune slack, machair, maritime grassland, *Carex nigra* sedgeland, *Calluna* heath, Loch mud and fen, and salt marsh. Pollen was identified to recognizable pollen taxa using the Cambridge reference collection. Identification was carried further by reference to the local floristic list (Perring and Randall 1972), which often narrowed the possibilities of identification within pollen taxa to particular genera or species.

Tables 1 to 3 (see Appendix) have been produced relating the pollen content of the samples to the floristic composition of the vegetation. The tables reproduced here are examples and the full set will be published shortly (Randall, Andrew and West, in preparation). It is interesting to relate off-island pollen to physiography and physiognomy of the vegetation and to compare the phytosociological analysis with pollen frequencies. Dispersal distances of various pollens are particularly significant in such a windy site as the Monach Isles since a vast proportion of the pollen shows a very local rain. This may have great significance for the interpretation of fossil herbaceous spectra.

REFERENCES

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Appendix

Each of the following tables is divided into two parts, the first (A) including those pollen taxa related to plants growing on the island, and the second (B) those pollen taxa related to plants not growing on the island, i.e. those known to be of more distant origin.

Each table lists the pollen taxa in the sample, the floristic list from the locality, frequency of existing species (%F), the pollen frequency of the taxon concerned, and the percentage of the taxon's pollen based on total pollen in the sample. Comments are also given for particular taxa, mostly noting the distance of particular species from the pollen sampling sites. Details of species in the communities with under 10% frequency and not related to pollen taxa can be found in Perring and Randall (1972). In these tables a single underline is given for species with over 60% frequency or pollen over 10% of the total, and a double underline for species with over 90% frequency or pollen over 20% of total.

Table 1. Machair (sites 3 and 4)

Pollen taxon	Species over 10%F or with related pollen taxon	%F	Site 3 Domin value	Site 3 Pollen/ spore count	Site 3 % total pollen	Site 4 Domin value	Site 4 Pollen/ spore count	Site 4 % total pollen	Comments and distances to parent taxon
A. On-island pollen taxa									
Ranunculus acris	Ranunculus acris	78	3	105	17	5	280	14	
Cerastium	Cerastium fontanum	43					5	<1	
Sagina	C. diffusum	9		1	<1				S. nodosa in peatland, 80m.
Linum catharticum	Linum catharticum	59	2	2	<1	2			
	Geranium molle	43	2						
	Erodium cicutarium	13							
	Trifolium pratense	31				3			
Trifolium repens	T. repens	67	2				1	<1	
Lotus corniculatus	Lotus corniculatus	76	2				1	<1	
	Potentilla anserina	13							
	Myosotis arvensis	17							
Euphrasia nemorosa	Euphrasia nemorosa	83	1	4	<1	2	14	1	
Odontites verna	Odontites verna	13					2	<1	
	Prunella vulgaris	71	1			1			
Plantago lanceolata	Plantago lanceolata	93	3	132	22	4	744	33	
Galium verum	Galium verum	83		11	2	4	85	4	
Senecio jacobaea	Senecio jacobaea	61	2			3	3	<1	
Bellis perennis	Bellis perennis	100	6	276	46	5	630	32	
Achillea millefolium	Achillea millefolium	91	3			2	18	1	
Liguliflorae compositae	Hypochaeris radicata	22							
Liguliflorae compositae	Leontodon autumnalis	15		1	<1		3	<1	
Liguliflorae compositae	Pilosella offinarum	4							
Carex	Carex flacca	24	2						
Carex	C. arenaria	85	3	65	11	4	24	2	
Carex	C. pulicaris	24	1						
Gramineae (28-30μ)	Sieglingia decumbens	22	2						
Gramineae	Festuca rubra	96	8	7	1	7	30	2	
Gramineae	Lolium perenne	19							
Poa trivialis (18-20μ)	Poa trivialis	41				2	67	3	
Agropyron junceiforme (36μ)	Agropyron junceiforme	2					17	1	In dunes (only record), 50m.
Gramineae (26-30μ)	Holcus lanatus	11				3			

Table 1 continued

Pollen taxon	Species over 10%F or with related pollen taxon	%F	Site 3 Domin value	Site 3 Pollen/ spore count	Site 3 % total pollen	Site 4 Domin value	Site 4 Pollen/ spore count	Site 4 % total pollen	Comments and distances to parent taxon
Gramineae	Aira praecox	9							
Gramineae	Anthoxanthum odoratum	6							
Total pollen				604			1924		
Total taxa		33	16	10		14	16		
B. Off-island pollen taxa									
Pinus				3	<1		7	<1	
Betula				2	<1		3	<1	
Corylus							1	<1	
Sphagnum							1	<1	
Total pollen				5			12		
Total taxa				2			4		
Total A + B pollen				609			1936		

Table 2. Stable dune (site 1)

Pollen taxon	Species over 10%F or with related pollen taxon	%F	Domin value	Pollen/ spore count	% total pollen	Comments and distances to parent taxon
A. On-island pollen taxa						
Ranunculus acris	Ranunculus acris	71	5	40	3	
	Thalictrum minus	21				
	Viola tricolor	40	4			
Cerastium	Cerastium fontanum	42	1	26	2	
	C. diffusum	30				
Atriplex				1	<1	On beach, 50m.
	Linum catharticum	83	3			
	Geranium molle	56	2			
	Trifolium pratense	17	3			
Trifolium repens	T. repens	79	2	36	3	
	Anthyllis vulneraria	30				
Lotus corniculatus	Lotus corniculatus	48		11	1	

Table 2 continued

Pollen taxon	Species over 10%F or with related pollen taxon	%F	Domin value	Pollen/ spore count	% total pollen	Comments and distances to parent taxon
Daucus carota	Daucus carota	48		10	1	
Rumex crispus	Rumex crispus	2		1	<1	
	Veronica arvensis	13				
Euphrasia	Euphrasia nemorosa	77	2	10	1	
	Prunella vulgaris	56	2			
Salix				1	<1	On peaty heath, 200m.
Plantago lanceolata	Plantago lanceolata	87	3	504	41	
P. maritima				5	<1	On coast rocks, 80m.
Galium verum	Galium verum	92	4	73	6	
	Senecio jacobaea	67	2			
Bellis perennis	Bellis perennis	100	4	120	10	
	Achillea millefolium	77	4			
Artemisia vulgaris				1	<1	Around houses at Port Roy (only record), 150m.
	Leontodon autumnalis	17		1	<1	
	Taraxacum spectabile	10	2			
Carex	Carex arenaria	73		5	<1	
Carex	C. pulicaris	6				
Gramineae (28-30μ)	Festuca rubra	94	5	364	30	
	Poa pratensis	10				
Gramineae (28-30μ)	P. subcoerulea	38				
	Koeleria cristata	10				
Ammophila arenaria (40-45μ)	Ammophila arenaria	100	4	20	2	
Total pollen				1229		
Total taxa		30	17	18		
B. Off-island pollen taxa						
Pteridium				2	<1	
Pinus				8	1	
Myrica				2	<1	

Table 2 continued

Pollen taxon	Species over 10%F or with related pollen taxon	%F	Domin value	Pollen/ spore count	% total pollen	Comments and distances to parent taxon
Betula				11	1	
Fraxinus				1	<1	
Total pollen				24		
Total taxa				5		
Total A + B pollen				1253		

Table 3. Calluna vulgaris heath (site 10)

Pollen taxon	Species over 10%F or with related pollen taxon	%F	Domin value	Pollen/ spore count	% total pollen	Comments and distances to parent taxon
A. On-island pollen taxa						
Selaginella	Selaginella selaginoides	48		3	<1	
Ophioglossum	Ophioglossum vulgatum	24		7	1	
Caltha palustris				1	<1	In fen, 25m.
Ranunculus acris	Ranunculus acris	64	4	40	4	
R. flammula				4	<1	In fen, 25m.
	R. ficaria	16				
	Viola riviniana	16	2			
	Polygala vulgaris	16	4			
Cerastium	Cerastium fontanum	72		4	<1	
Linum catharticum	Linum catharticum	24		1	<1	
	Trifolium pratense	32	3			
Trifolium repens	T. repens	48	2	2	<1	
Lotus corniculatus	Lotus corniculatus	43	3	4	<1	
Potentilla	Potentilla erecta	40	3	15	1	
Hippuris vulgaris				2	<1	In fen, 25m.
	Hydrocotyle vulgaris	32	2			
Daucus carota				2	<1	In machair, 50m.
Rumex acetosa	Rumex acetosa	48	2	5	<1	
R. obtusifolius				1	<1	In Port Roy village, 100m.

Table 3 continued

Pollen taxon	Species over 10%F or with related pollen taxon	%F	Domin value	Pollen/ spore count	% total pollen	Comments and distances to parent taxon
Salix	Salix repens	80		11	1	
Calluna	Calluna vulgaris	80	6	180	16	
	Armeria maritima	64				
	Anagallis tenella	32	4			
Gentianella	Gentianella campestris	40	4	2	<1	Only pollen and site record.
	Euphrasia tetraquetra	72	4			
Thymus	Thymus drucei	16	3	4	<1	
	Prunella vulgaris	24	3			
Plantago lanceolata	*Plantago lanceolata*	72	3	129	11	
P. maritima	P. maritima	64		120	11	
	P. coronopus	40		25	3	
	Galium verum	40		1	<1	
Succisa pratensis	Succisa pratensis	72		11	1	Only pollen and site record.
Bellis perennis	Bellis perennis	64	3	18	2	
	Achillea millefolium	40	3			
Cirsium				1	<1	Only record in Port Roy village, 100m.
Liguliflorae compositae				30	3	Hypochoeris on machair, 50m.
Leontodon autumnalis	Leontodon autumnalis	24		2	<1	
	Luzula campestris	16				
Eleocharis				7	1	In fen, 25m.
Carex	Carex flacca	64	4	80	7	
Carex	C. nigra	96	6			
Gramineae (28-30μ)	Sieglingia decumbens	32	2			
Gramineae	Festuca rubra	88	2			
Gramineae	Holcus lanatus	24		15	1	
Gramineae	Aira praecox	32				
Gramineae	Anthoxanthum odoratum	64	2			
Poa trivialis				2	<1	In machair, 50m.

Table 3 continued

Pollen taxon	Species over 10%F or with related pollen taxon	%F	Domin value	Pollen/ spore count	% total pollen	Comments and distances to parent taxon
Gramineae (21-25μ)	Koeleria cristata	56	4	320	29	
Total pollen				1049		
Total taxa		39	24	32		
B. Off-island pollen taxa						
Pteridium				1	<1	
Botrychium				1	<1	
Abies				2	<1	Only record.
Picea				1	<1	Only record.
Pinus				10	1	
Ulmus				1	<1	
Myrica				2	<1	
Betula				8	1	
Alnus				3	<1	
Quercus				6	1	
Empetrum nigrum				3	<1	
Fraxinus				1	<1	
Sphagnum				3	<1	
Total pollen				42		
Total taxa				13		
Total A + B pollen				1091		

Butterbur *(Petasites hybridus)* as an Invading Species on Machair in North West Lewis

Andrew Currie

I visited Lewis and Harris between the 19th and 30th August 1974 in order to carry out a survey of all the sand dune and salt marsh areas of the island. One of the things that was most noticeable to me during this survey, particularly in West Lewis, was the spread of butterbur (***Petasites hybridus***) over some of these dunes (Photo 6). The species has almost certainly been introduced as a result of man's influence and is normally associated with damp woodlands and riversides on the mainland. In the situation in North West Lewis, the plant has become, in my view, a pernicious weed and is destroying very many acres of otherwise good quality machair grassland and dune formation. It contributes nothing as a grazing species but it effectively chokes out most of the vegetation beneath it. It has to my mind an unattractive appearance and particularly later in the season it can look a dreadful mess when it has become windblown and battered. It is most unpleasant to walk through, and I am surprised that the crofters tolerate it to the extent that they do, particularly in the fenced-off areas. Indeed I did enquire from crofters' representatives in the islands and discovered that on the areas where it is most widely spread the crofters do regard it as a nuisance, but do not appear to know how to deal with the problem.

It seems to me that something we in the Nature Conservancy Council could usefully consider is the carrying out of a small trial to establish the best means of eradicating this species and also to study whether the machair vegetation recovers once ***Petasites*** has been eradicated. With this in mind I would suggest that the dunes at Swanibost appear to me to present an ideal situation for such a trial. It would consist of a number of blocks and these could be quite small demonstrating the effects of different means of treating the plant such as (1) cutting or bruising annually at different times of the year, (2) spraying the foliage in the early summer with chemicals. The plant is noticeably absent on tracks, certainly totally absent where the wheels run, and present only in very poor form in the middle ridge of the tracks. This would indicate that rolling of some sort might be a good way of destroying the species. I think myself that bruising or cutting of the plant would be an effective way of reducing it and I am certain that the solution to this particular problem would be very much welcomed by crofters.

The other conservation problems in this area include pressure from grazing animals and from visitors, but these have not really become serious except in a few situations. However, I fear that ***Petasites*** is going to spread over these particular machair grasslands during the next twenty or so years and will present a very real conservation problem which we ought to resist if at all possible.

It should be noted that the extent of this potential menace is restricted to the west portion of Lewis from Uig northwards, and I am unaware of the existence of the species further south in the Western Isles.* We are dealing therefore with a plant which is causing a local problem but I believe it to be important that a group such as the Machair Discussion Group ought to be aware of this and also ought to be alert to spot the arrival of the species in any new situations. Certainly if I myself had control over these croft grazings I would make it a matter of priority to have this plant eradicated as soon as possible both from a nature conservation and from an agricultural point of view.

* Editor's Note: ***Petasites hybridus*** is also established extensively on the east coast of Lewis at Tolsta and occurs at Hosta, North Uist.

Photo 6 Extensive growth of Butterbur (Petasites hybridus) *on machair in north west Lewis. (Photo: A. Currie.)*

Machair Meeting, Aberdeen, September 1975

Attended by

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WORMELL, Mr. P.	Nature Conservancy Council, Isle of Rhum.

Contributed papers, but did not attend

CAMPBELL, Mr. R. N.	Nature Conservancy Council, Caledonia House, 63 Academy Street, Inverness IV1 1BB
HEPBURN, Mr. I. R.	Countryside Planning Unit, Wye College, Ashford, Kent.