# Chapter 9 Machair

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## Introduction

The machair lands of the north-western seaboard of both Scotland and Ireland represent a distinctive form of dune grassland system, unique to these areas. The machair system can be described as a flat or gently sloping, coastal dune-plain formed by windblown calcareous shell-sand, sometimes incorporating a mosaic of dunes to the seaward side and a species-rich grassland (managed by traditional low-intensity agriculture), wetland, loch and 'blackland' (mixtures of sand and peat) to the landward side. Often the dune cordon may be missing owing to frontal erosion, but a characteristic of machair surfaces is that they arc lime-rich, subject to strong, moist, oceanic winds and show detectable current or historic biotic interference from grazing, cultivation, addition of natural fertiliser such as seaweed and, sometimes, artificial drainage (Ritchie, 1976; Hansom and Angus, 2001). As a result, the term 'machair' has meaning not only in a botanical and geomorphological sense but also in its strong cultural overtones, the spatial extent of machair overlapping closely with the current core areas of the Gaelic language in Ireland and, with the exception of Orkney and Shetland, in Scotland (Hansom and Angus, 2001) (Figure 9.1). Since all of the machair lands have similarities in their land-use histories, it is likely that the present distribution and nature of machair systems owes as much to cultural factors as it does to biotic and abiotic influences.

The world extent of machair is about 30 000–40 000 ha of which 67% is found in Scotland and 33% in Ireland, although those figures are under review (Angus, 1994). Of the Scottish machair, nearly 40% has been selected for — and is protected internationally as — Special Areas of Conservation (SACs); about 80% of the Scottish resource is protected within Sites of Special Scientific Interest (SSSIs).

The following definition of machair is largely based on Ritchie (1976) and Angus (2001, 2002):

- a base of blown sand with a significant percentage of shell-derived materials lime-rich soils of pH normally greater than 7.0;
- a level or low-angled and smooth surface at a mature stage of geomorphological evolution;
- a sandy grassland-type vegetation devoid of long dune grasses and other key dune species;
- a detectable current or historic biotic interference resulting from grazing, cultivation, trampling and, sometimes, artificial drainage;
- an oceanic location with a moist, cool and windy climatic regime.

Recent work by Angus (2002) has stressed the importance of an integrated definition of machair that includes geomorphology and botany, but neither in isolation. As a result, several natural systems that in the past were identified as machair on, say, geomorphological grounds, do not fulfil the wider criteria. Therefore, such sites are deemed here not to be machair and have been included in Chapter 7 of the present volume. These sites are Sandwood and Torrisdale, both in Sutherland, and Balta in Shetland.

Hansom and Angus (2001) summarize the main features of the evolution of machair using data from a wide range of sources including Ritchie (1976), Mate (1991) and Gilbertson *et al.* (1999). Machair is in essence a sand plain produced from the normal cycle of deposition and erosion of sand dunes where a positive sand budget on the fronting beach results in coastal accretion, seaward movement of the coastal edge and landward wind-blow of surplus sand to be fixed by dune grasses. However, this developmental sequence conceals an erosional sub-cycle as the vegetation cover of the higher and older landward dunes become subject to processes (such as grazing) that may disrupt the vegetation cover and allow subsurface sand to be blown landwards (Figure 9.2). The resulting dunes lose their sand cores by deflation, the sand being removed landwards over an amorphous sand plain or machair and up cliff faces as climbing dunes. Since strong winds continue to modify these surfaces even at distance from the shore, they continue to suffer deflation, a process that halts only when the water table or substrate is reached. As a result, machair surfaces are often characterized by steep eroded escarpments located between low-lying landward-dipping deflation surfaces and higher dune surfaces.

The conditions that favoured a positive sand budget were widespread on the Scottish coast as the Holocene rise in sea level began to slow markedly before about 6500 years BP (see (Figure 6.28)). For the first time waves were able to accomplish substantial shoreface modification and bring large amounts of sediment from the nearshore shelf onto beaches and then into sand dunes (Firth *et al.,* 1995) (Figure 9.3)a. However, the finite nature of this sediment seems to have resulted in a progressive reduction in sediment availability and a switch to deficit sometime after 6500 years BP (Carter, 1988, 1992; Hansom, 1999) and the replacement of an accreting system by an erosional system (Figure 9.3)b,c. It is likely that such a degradational cycle would be most advanced in those areas subject to high-energy wave conditions and isostatic submergence, conditions that are both met on the north-western seaboard of Scotland. As a result, erosion of the dune cordon in these western machair areas is now well advanced and in places the machair grassland itself is now suffering erosion. The positive beach sediment budgets that fed the embryo and foredunes once sited seawards of the fixed dunes and machair have long since been reversed by negative sediment budgets and the frontal dunes cannibalized (Figure 9.3)c (Hansom and Angus, 2001).

Support for the above geomorphological evidence of an initial surplus followed by declining sand supply comes from dating the sand layers in association with archaeological sites located originally within accreting dunes and now found on coasts undergoing erosion. Optically stimulated luminescence (OSL) dating of aeolian sands by Gilbertson *et al.* (1999) indicates that the carbonate sand of the Benbecula and North Uist machairs began to arrive from offshore about 8700 radiocarbon years BP and in Barra about 6800 radiocarbon years BP At Northton in South Harris, the onset of sand deposition that buried Neolithic remains occurred from 4500 radiocarbon years BP (Ritchie, 1979a). The discovery of exhumed archaeological sites within dunes is largely due to frontal erosion, although multiple cycles of erosion, deposition and deflation are concealed within this general erosional trend. However, in spite of the above, dating of the initiation of dune and machair formation in the Outer Hebrides remains problematic. Ritchie and Whittington (1994) report intertidal peats overlain by aeolian sands that date from 7800 radiocarbon years BP at Cladach Mòr in North Uist and from 7700 radiocarbon years BP at the Landing Jetty in Pabbay. Yet other sites on these islands, for example at Quinish in Pabbay dating from 4300 radiocarbon years BP and at Borve in Benbecula dating from 5600 radiocarbon years BP, suggest that the arrival of aeo-lian sand and the initiation of machair development in the Hebrides was non-synchronous (Ritchie and Whittington, 1994). However, in the low and undulating coastal landscape of the Western and Northern Isles, rock basins close to sea level are likely to be affected by rising sea lev els at different times and so the influence of local bathymetry and site factors represent important site-specific controls on the date of machair initiation (Figure 9.4).

Once established, the development of the machair plain is essentially erosion-driven, with new surfaces produced as old ones are consumed. However, there can be marked seasonal differences. For example, where deflation has exposed the water table, winter flooding may result in sand blowing onto wet surfaces and this results in a depositional flat surface rather than an erosional one. Archaeological studies provide evidence of fertile and stabilized sand surfaces around 2000 radiocarbon years BP (Ritchie, 1966). Several sites ascribed to the Iron Age and later are located on the low flat surfaces of machair that have been produced following deflation of earlier machair surfaces (Ritchie, 1979a). Gilbertson *et al.* (1996) document layers of thick organic palaeosols within the dunes and machair dating from Bronze Age to medieval times, together with periods of instability (particularly between the 9th and 13th centuries AD) as indicated from Viking settlements now buried below aeolian sand deposits (MacLaren, 1974).

Historical evidence extends the above pattern of phased instability and stability of the machair into modern times. During the 16th century machair surfaces were stable with well-established agriculture, but the 17th century brought widespread sand-blow on much of the Scottish coast and burial of machair surfaces and buildings in the Outer Hebrides (Ritchie, 1966, 1979a; Lamb, 1991; Angus, 1997). Although probably more stable than it has been in the past, Hebridean machair is still actively forming and the present-day machair surface has probably formed over the same timescale as it has in the past, that is over periods of less than 100 years (Gilbertson *et al.,* 1999). Nevertheless, the present machair system as a whole represents the latest manifestation of a continuum of essentially similar processes operating since at least middle Holocene times.

### The conservation value of machair

The geomorphological significance, and hence the Earth science conservation value, of machair arises from its importance to our understanding of:

1. the processes of machair erosion and accumulation;
2. the interaction of sediment supply and sea-level change;
3. the interaction of sediment, vegetation and land use.

As described above, it is believed that machair grassland has been modified by humans throughout its development. Traditionally, machair supports extensive grazing regimes and unique forms of cultivation that rely on cattle-grazing and low-intensity systems of rotational cropping. This traditional agriculture sustains a rich and varied dune and arable weed flora. Some of the arable weed species are now largely restricted in the UK to these traditionally managed areas. The habitat type also supports large breeding bird populations and is particularly important for waders and corncrake *Crex crex.*

The GCR site selection rationale for machair has been to represent the range and diversity of the geomorphological features (Table 9.1). In the present chapter, sites are arranged in a clockwise order around the coast, starting with the southernmost.

### Machairs as biological SSSIs and Special Areas of Conservation (SACS)

In Chapter 1, it was emphasised that the SSSI site series is constructed both from areas nationally important for wildlife and GCR sites. An SSSI may be established solely for its geology/geomorphology, or its wildlife/habitat, or it may comprise a 'mosaic' of wildlife and GCR sites that may be adjacent, partially overlap, or be coincident. Therefore, there are some areas of machair that are crucially important to the natural heritage of Britain that have been designated as SSSIs primarily for their wildlife conservation value, but implicitly will contain interesting coastal geomorphology features that are not included independently in the GCR because of the 'minimum number' criterion of the GCR rationale (see Chapter 1). These sites are are not described in the present geomorphologically focused volume.

**(Table 9.1) Machair GCR sites**

| Machair site | Main features | Other features | Tidal range (m) |
|---|---|---|---|
| Machir bay | Beach–dune–machair, high-level machair terraces, emerged beaches | Climbing dunes | 3.0 |
| Eoligarry | Vigorous erosional machair forms large blowouts, tombolo structure | Storm beach, wide intertidal, sheltered beach, archaeological dating | 4.0 |
| Ardivachar–Stoneybridge | Machair type site, high and low machair deflation corridors | Archaeological dating gravel barrier, palaeosols | 3.6 |
| Hornish and Lingay Strands | Flat, low-lying machair, water-table effects | Superimposed small dunes, artificial drainage | 3.9 |
| Pabbay | Climbing machair, conical dunes, wet machair | No rabbits | 3.0 |
| Luskentyre–Seilebost | Large beach-dune machair remnant of former larger system, 35m high dunes; growth/decay model site | Spits, blowouts | 3.8 |
| Mangersta | Eroded and deflated formerly extensive machair, advanced stage of erosion | Water table | 3.8 |

| | | | |
|---|---|---|---|
| Tràigh na Berie | Large dynamic beach–dune–machair dune cordon intact and well-nourished | Infill of valleys and lochs, no chronic erosion | 3.8 |
| Balnakeil | Dynamic climbing machair and dune blowouts, headland by-passing of sediment | Erosion of frontal edge, sand-fall over cliff | 4.0 |

**(Table 9.2) Candidate Special Areas of Conservation supporting Habitats Directive Annex I habitat 'Machair' as a qualifying European feature.** (Source: JNCC International Designations Database, July 2002.)

| SAC name | Local authority | Machair extent (ha) |
|---|---|---|
| Coll Machair | Argyll and Bute | 681 |
| Monach Islands | Western Isles / Na h-Eileanan an Iar | 292 |
| **North Uist Machair** | Western Isles / Na h-Eileanan an Iar | 1707 |
| **Sheigra-Oldshoremore** | Highland | 222 |
| **South Uist Machair** | Western Isles / Na h-Eileanan an Iar | 1785 |
| Tiree Machair | Argyll and Bute | 510 |
| Bold type indicates a coastal GCR interest within the site | | |

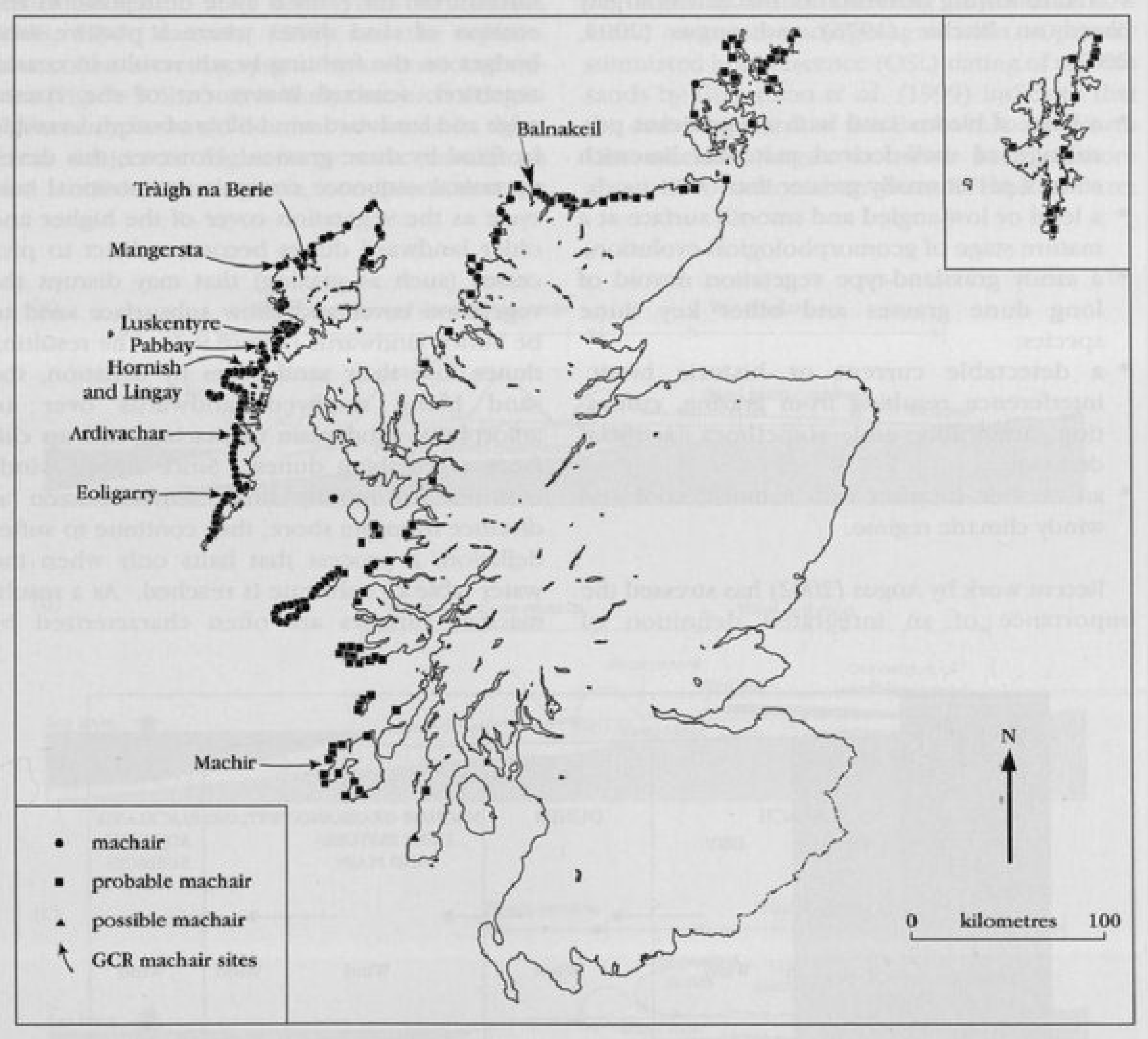
In addition to being protected through the SSSI system for its national importance, machair is a 'Habitats Directive' Annex 1 habitat, eligible for selection as Special Areas of Conservation, (see Chapter 1). Furthermore, many machairs are of international ornithological importance, primarily for breeding waders, and for this reason may be designated Special Protection Areas under the 'Birds Directive'.

Because machair is a habitat unique to the north and west of Scotland and western Ireland, the UK has a special responsibility for machair, and has recently established a UK Machair Habitat Action Plan (Angus and Dargie, 2002)

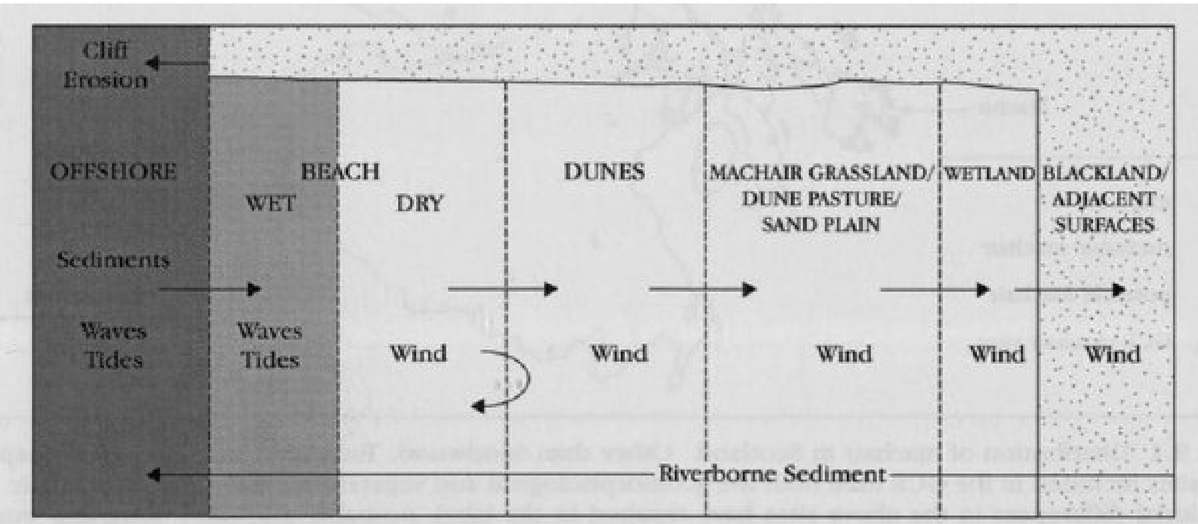
### Machair SAC site selection rationale

Site selection has taken account of the wide range of variation in physical type shown by Scottish machairs and has also been influenced by the UK's special responsibility for machair conservation. The largest sites have been selected, as these demonstrate the best structure and function and include the most diverse examples of transitions to other habitats. Sites have been selected from across the range of machair in the Outer and Inner Hebrides and on the Scottish mainland.

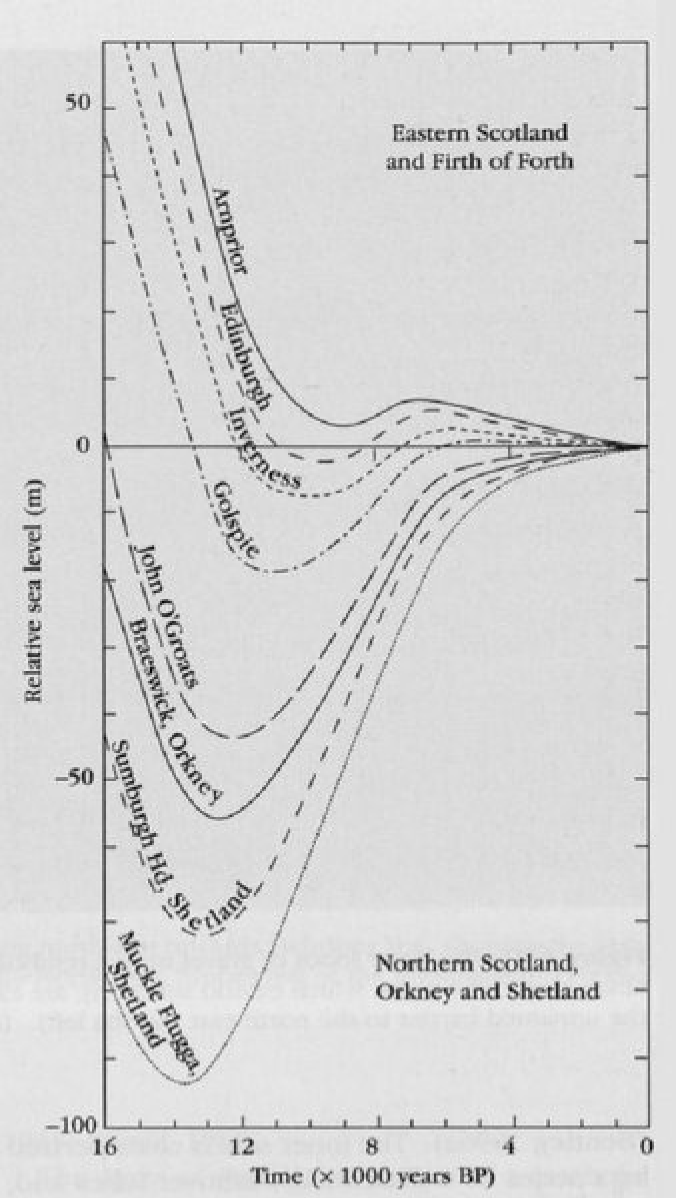
(Table 9.2) lists machair SACS, and indicates which of these sites are also important (at least in part) as part of the GCR and are described in the present chapter.



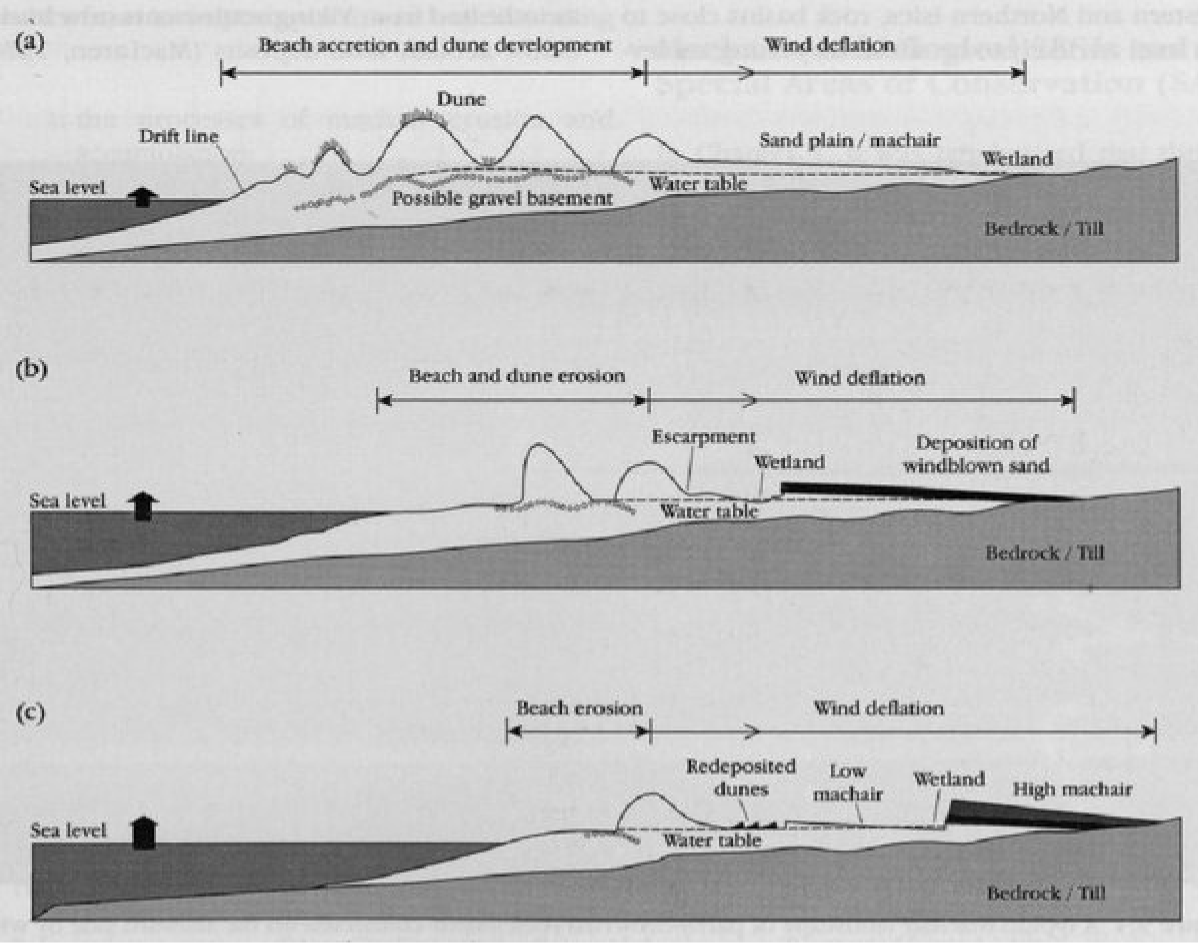

*(Figure 9.1) Distribution of machair in Scotland. Other than Sandwood, Torrisdale and Balta (see Chapter 7), all the sites included in the GCR fulfil both the geomorphological and vegetational definition of machair. Small vegetational differences in the above sites have resulted in the label 'probable machair'. Ongoing work that interprets the geomorphology and botany of machair aims to provide a definitive machair diagnostic test in the future and so the above classification will be subject to slight modification (Angus, 2003, pers. comm.). (After Hansom and Angus, 2001.)*



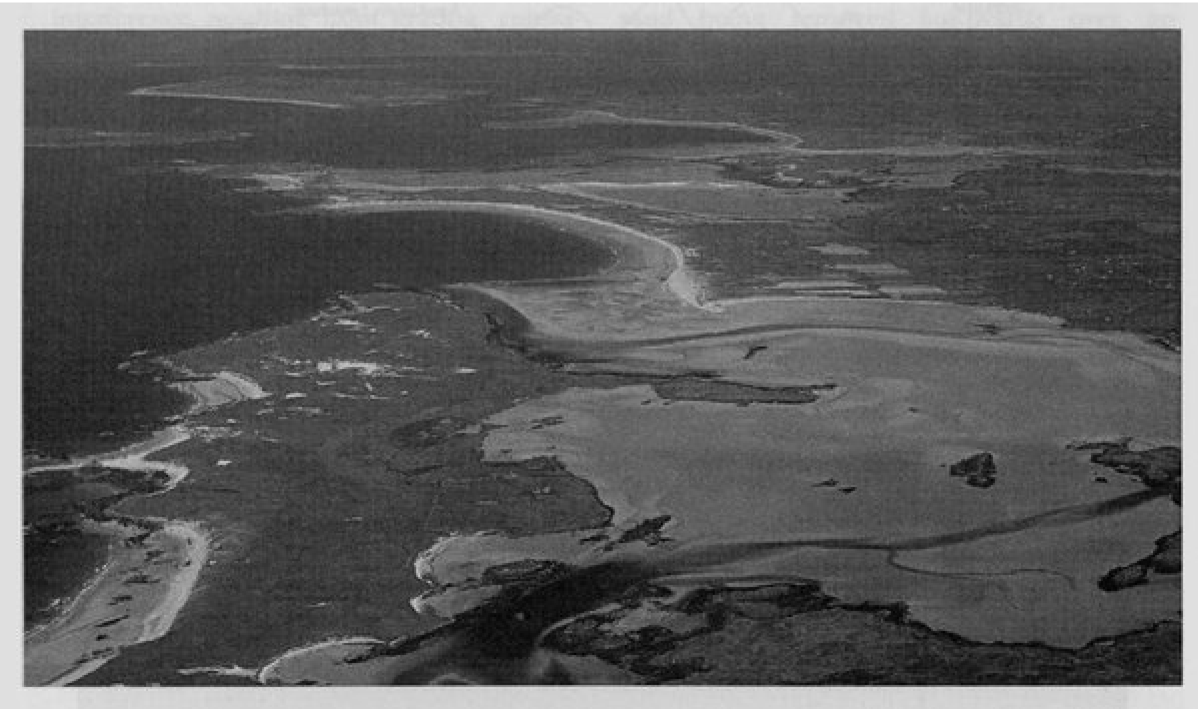

*(Figure 9.2) A diagrammatic representation of the beach–dune–machair system showing the general landward transport of sand broken by seaward returns via wind and streams. (After Mather and Ritchie, 1977.)*




*(Figure 6.28) Graphs of modelled relative sea level against time over the last 16 000 years, along a south-north transect from Shetland to the Firth of Forth. (After Lambeck, 1993; Hansom, 2001.)*




*(Figure 9.3) The Holocene development of machair from approximately 6500 thousand years ago to present, showing the switch from conditions of accretion of the dunes to erosion and recycling of dune sands into machair. (a) early–mid Holocene; (b) late Holocene; (c) present day. (After Hansom and Angus, 2001.)*



*(Figure 9.4) A typical machair landscape of partly-drowned rock basins connected on the seaward side by wide sandy beaches and on the landward side by dune cordons backed by expanses of windblown machair sand. Looking north-east from North Uist over Vallay Strand in the foreground to Hornish and Lingay in the distance. (Photo: P and A. Macdonald/SNH.)*

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## MACHIR BAY, ISLAY, ARGYLL AND BUTE (NR 210 630)

### Introduction

Machir Bay is a highly dynamic beach–dune–machair assemblage located on the exposed Atlantic coast of Islay (see Figure 9.1 for general location and Figure 9.5). The wide, high-energy beach is backed by a complex sequence of dune forms including low embryo dunes, an active foredune ridge, multi-ridged mature dunes, re-depositional sandhills and an extensive machair surface. The machair plain is of exceptional geomorphological interest as it drapes a number of topographical features including a series of high-level marine terraces, glacial deposits, talus slopes, and rock plateaux. Many streams drain through the dune and machair providing a strong hydrological control on morphology. Although several descriptions exist of the beach–dune–machair morphology of Machir Bay (Ritchie and Crofts, 1974; MacTaggart, 1996), greater interest has been shown in the emerged beaches, glacial terraces and relict clifflines that the machair partially obscures (Dawson, 1983; Dawson *et al.*, 1997).

**Figure 9.5** Geomorphology of Machir Bay, Islay, showing a mix of machair types including substantial terraces at the rear of the system covered by high machair. (After Ritchie and Crofts, 1974.)



*(Table 9.2) Candidate Special Areas of Conservation supporting Habitats Directive Annex I habitat 'Machair' as a qualifying European feature. (Source: JNCC International Designations Database, July 2002.)*