Luce Sands, Dumfries and Galloway

[NX 150 555]

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Introduction

Luce Sands represents an exceptional assemblage of dynamic coastal landforms and contains examples of both contemporary and Holocene marine features. In this respect, it is similar to the GCR sites of Culbin, Morrich More and Spey Bay in the north-east of Scotland (see GCR site reports in Chapters 11 and 6).

Luce Sands is the largest and most complex system of beach and dunes in the south of Scotland and the juxtaposition of landforms are unique to this site. The geomorphological interest of Luce Sands and the reasons for its selection for the GCR include a series of Holocene emerged gravel ridges, the extensive, complex and dynamic dune system of Torrs Warren overlying the gravel ridges and the diversity of the contemporary coastal features. The relatively large size of the 'soft' coastal landforms would be of interest purely as static landforms, but the highly dynamic nature of the beach system imparts especial interest. Additionally, the ongoing accretionary processes at Luce Sands (Mather, 1979; Single and Hansom, 1994) identify this site as one of few in Britain (and a minority on an international scale) that displays long-term progradation.

Description

Luce Bay is situated to the south of Stranraer, south-west Scotland, between the Mull of Galloway and Burrow Head (see (Figure 7.1) for general location). The beach of Luce Sands and the extensive Torrs Warren sand dunes occupy almost the whole of the head of Luce Bay, extending 11 km from Sandmill on the edge of Sandhead in the west to the coastline east of the Water of Luce. The site covers over 2409 hectares of land and intertidal sandflat (Figure 7.19) and (Figure 7.20).

The width of the intertidal beach varies and is greatly dependent on the state of the tide. At mean low-water springs, the beach is on average 750 m wide, but in the east the intertidal flats widen to nearly 2000 m at the exit of the Piltanton Burn. At mean high-water springs, the beach narrows to 0–10 m along much of the foreshore with the drift line skirting the toe of the backing dunes. The beach sediment is well-sorted, fine-medium-grained mineral sand (D_{50} = 0.2 mm) with a very low shell content. A series of well-developed sand-bars with intervening channels are present across the wide, very gently sloping intertidal beach. These bars and channels run along the shore in a generally shore-parallel fashion, although they are not regularly shaped features. Up to six sets of bars, which appeared to be migrating onshore, were noted in February 1993 (Single and Hansom, 1994).

The coastal edge along most of the beach has a low, subdued and accretional form. A gently sloping apron, clad in wheatgrass *Agropyron* and marram *Ammophila,* grades almost continuously from the upper beach and backshore. Although there are clear traces of short episodes of erosion during storms and unusually high tides, accretion has been the dominant process in the recent development of this part of the system, and both the scale and extent of accretion are unusual. However wave-induced toe erosion is evident on either side of the Sandmill Burn embayment in the west of Luce Sands (Figure 7.20) (Single and Hansom, 1994).

The Torrs Warren–Luce Sands dune system is the largest and most complex system of acidic dunes in the south of Scotland. The dune system at first sight appears to be chaotic, with no order to the main direction of the dune crests, blowthroughs, or dune slacks. However, closer examination shows that a general sequence of dune forms begins along the seaward edge where low accretional foredunes exist, especially at the rear of the central and eastern beach (Figure 7.20). These foredunes are arranged in a series of parallel ridges, each individually discontinuous and variable in height, rarely rising above 5–6 m. The younger and more seaward of these dunes are orientated and organized in distinct

coast-parallel lines, demonstrating that the winds responsible for their construction blow onshore from the south and south-west (Single and Hansom, 1994). The more landward dunes are securely fixed under marram *Ammophila arenaria* and heather *Calluna vulgaris* (Figure 7.21). Behind much of the length of the seaward dune ridges lie extensive areas of dune slack, which separate the low foredunes from higher dunes to landward. These poorly drained slacks extend over 6 km and are often over 500 m in width. The floors of the slacks are characterized by several low, semi-continuous ridges, composed largely of sand around which freshwater marsh has developed. Since they run sub-parallel to the main beach, they may well represent older, flooded, foredune ridges. Peat is known to exist to unspecified depths in the dune slacks, which now support dense scrub, bushes and thickets.

Towards the east of the beach complex, the damp slack grades into an extensive and well-developed dune area to landward, showing high dune relief and large blowthroughs. The scalloped residual faces of these blowthroughs rise to *c.* 15 m but few of these run shore normal as would be expected if they were controlled by an onshore wind system. The main blowthrough direction is from WNW and relates to winds blowing from this sector. Severe wind erosion has occurred in this area in the past leading to blowthrough excavation down to the water table and the development of substantial erosional slacks. Both dunes and slacks are now largely stabilized, but several areas remain active and active blowthroughs are not uncommon. Nearer the coast, the dunes have a tendency to run beach-parallel and wind-blow activity increases here.

This area of high dunes grades almost imperceptibly landwards into an inner sand plain and old sandhills. This landward part of the dune system consists of a series of rolling sand surfaces interspersed with stabilized sand plains.

This area of varied and chaotic relief has suffered severe erosion in the past, but is now mainly quiescent. Erosion appears to have proceeded from all directions, although weak alignment to the WNW can be seen that may represent an older eroded dune system now blown into a sand plain (Single and Hansom, 1994). Erosional dune forms, such as squat cones, ridges, healed blowthroughs and slacks, are now stabilized by dune heath and scrub. The resultant chaotic topography rises in places to 15 m OD and rests on top of emerged gravels at up to 11 m OD.

To the rear of the beach well-developed and striking emerged gravel ridges extend from west to east and underlie the dunes of Torrs Warren in a broad but discontinuous arc of exposure that connects an eroded Holocene cliff in the west with its eastern counterpart (Single and Hansom, 1994). The extensive windblown deposits of the Torrs Warren dune complex obscure most of the gravel ridges, but from several exposures the general features, orientations and altitudes of the ridges can be determined (Single and Hansom, 1994). Levelling of the ridges indicates a high and well-defined suite of at least 13 gravel ridges at 9–11 m OD, with the heights of the ridge crests declining to seaward. Borehole evidence and other scattered exposures of gravels indicate that a lower set of gravel ridges may exist at altitudes of between 5 and 7 m OD (Figure 7.21).

Interpretation

Torrs Warren–Luce Sands has significant potential to further the understanding of contemporary coastal processes and to establish the patterns of Holocene coastal change for this region of Scotland. To date, however, there is a clearth of detailed geomorphological process studies for the Luce Bay area. Mather (1979) describes the geomorphology of the Torrs Warren–Luce Sand beach complex. Single and Hansom (1994) go further to interpret the process regime and Holocene development of the beach complex and place the site in its wider regional context. However, there remains much scope for innovative research on this complex coastal system.

The Holocene coastal deposits of Torrs Warren–Luce Sands provide an impressive group of emerged features related to a higher sea level. Superimposed on these deposits has developed the largest Scottish dune system south of the River Clyde. Together with a beach complex that is the largest in Scotland, Luce Sands represents an exceptional landform assemblage that records continuous and vigorous coastal deposition during the Holocene Epoch. Plentiful sediment supply has been a characteristic of the Holocene development of Luce Sands. The response of gravel systems to plentiful sediment conditions is generally to add extra ridges onto the seaward face rather than to rework the gravels into even higher ridges (Carter *et al.,* 1987). With a falling sea level, this is manifest at Luce Sands by a multi-ridged strandplain that decreases in altitude to seaward. These conditions of plentiful beach sediments have continued

unchecked until the present time, although the earlier gravel sedimentation regime has been supplanted by a sand sedimentation regime producing a wide sandy beach and dunes (Single and Hansom, 1994).

The wide intertidal beach at Luce Bay is an example of a bay-head beach (Single and Hansom, 1994), produced where sediment is driven by unidirectional wave approach and accumulates at the swash limit. In Luce Bay, this process has gradually infilled the bay-head, initially by the deposition of arcuate cross-bay ridges of gravel and subsequently by the deposition of sands (Mather, 1979; Single and Hansom, 1994). The well-nourished nature of Luce Sands is enhanced by three factors. Firstly, much of Luce Bay is no deeper than 20 m (the 9 m iso-bath lies some 3 km offshore), and so the contributing area for onshore movement is great (Figure 7.19). Secondly, the floor of the bay is thickly veneered with unconsolidated material, such as glaciogenic sands and gravels that are relatively easily transported by shoaling wave activity (Figure 7.19). In addition, Luce Bay appears to function as a major trap for sediment transported along the Rhinns of Galloway coast (Single and Hansom, 1994). This sediment is moved northwards along a major tidal flood channel on the west side of the bay (Mather, 1979), where it accumulates at the bay-head in wide, well-nourished sandy beaches characterized by a positive beach sediment budget (Single and Hansom, 1994).

The Torrs Warren–Luce Sands dune system represents the latest stage in the progressive build-up and redistribution of unconsolidated sediments in Luce Bay. The most landward dunes overlying the emerged gravels are the oldest (Mather, 1979; Single and Hansom, 1994) and their formation immediately post-dates the mid-Holocene sea level fall. Since then, foredune ridges have been added progressively. The chronology of development of these foredunes, and their relationships with the dune slacks and high dune field farther landwards, are as yet imperfectly understood, but it is clear that the development has not been continuous or steady (Mather, 1979). Further research at Luce Sands may help assess the mode of dune development in conditions of plentiful, but pulsed, sediment supply.

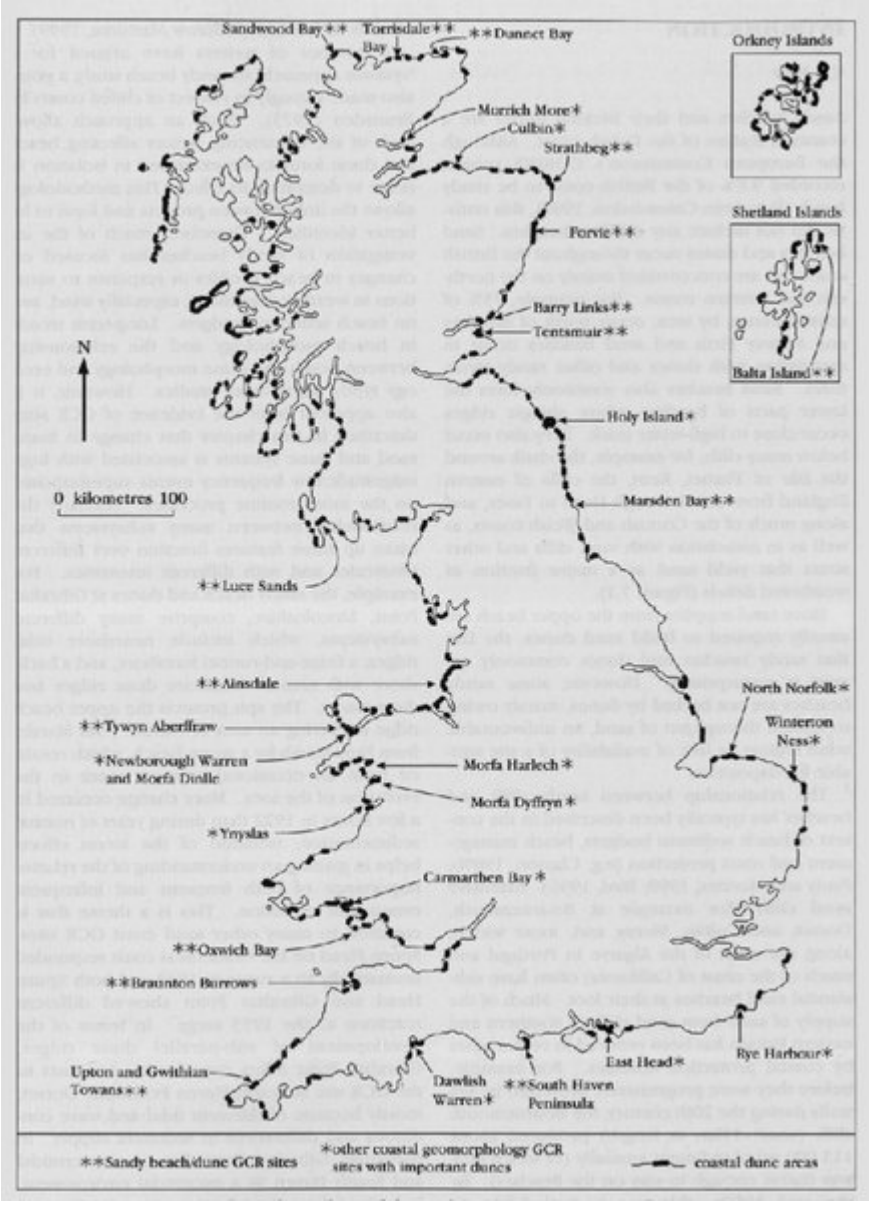
Much of the dune system of Torrs Warren, with the exception of the low accreting foredunes near the coastal edge, has been subject to phases of severe wind erosion. It is highly likely that the processes of dune blowthrough activity characterizing much of Torrs Warren are directly related to land use changes and the widespread prehistoric use of the area. Archaeological evidence suggests that removal of the original woodland cover triggered early phases of sand-blow (McInnes, 1964) and several phases of sand-blow in the old dune areas have resulted in the burial of a number of former soil surfaces (Smith, 1903; Callander, 1911). In medieval times, human settlement together with a variety of land-uses took place on Torrs Warren (Dope and Jope, 1959) and the related grazing pressures probably maintained elements of dune instability within the system. Informal grazing and sheep rearing continued until the mid-1930s and dune heath management practises of rotational burning created further instability at this time (Idle and Martin, 1975). Since the present use of Torrs Warren–Luce Sands as a Ministry of Defence (MOD) weapons range, grazing has been curtailed and the dunes are now exceptionally stable over much of the area. Forestry in the northern part of the dunes has aided this stabilization process.

Anthropogenic influence is probably also responsible for the erosion at Sandmill Burn. Here the dunes seaward of the Sandhead caravan park were levelled and a raised flat platform was built out seaward of the coastal cdgc. Rubble and stacked concrete blocks were used to protect this artificial promontory. The presence of this protected section of coast has led to flank erosion of the adjacent coastline. In an attempt to alleviate erosion, *c.* 1 km of coast has been substantially altered. For example, sand-filled plastic barrels were placed along the eroding dunes in front of both the Sands of Luce and Sandhead caravan parks in 1991 (Single and Hansom, 1994). Not only was this an inappropriate method of coastal protection but it exacerbated erosion to the east as the sand which was used to fill the barrels was dug from a now-eroding remnant dune island (Single and Hansom, 1994).

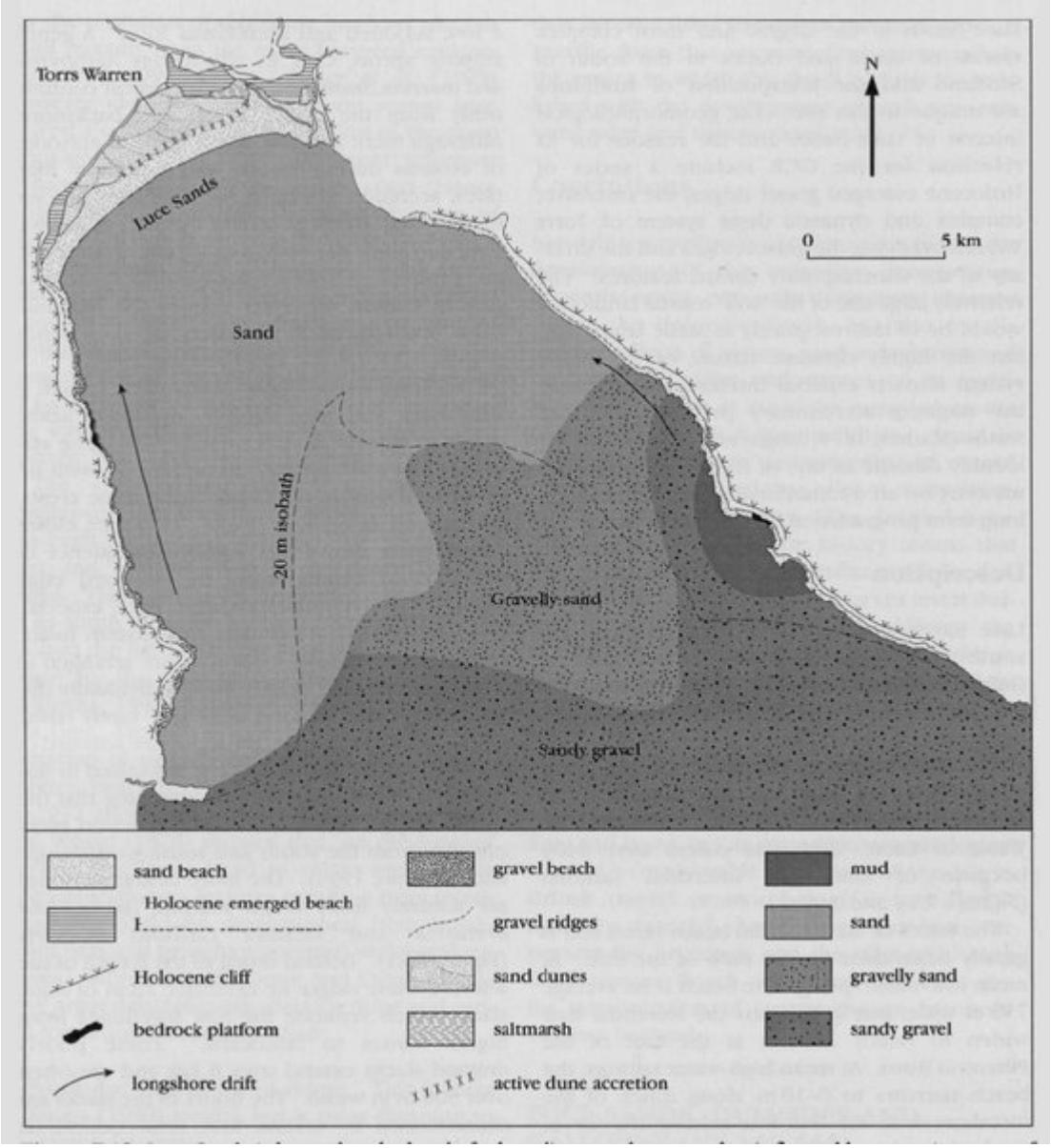
In common with several other large coastal GCR sites the majority of Luce Bay is owned and managed by the MOD and public access is restricted. With the exception of the two bombing ranges, this land use has conserved much of the site in its natural state, due to access restrictions and the limited recreational use of the beach and dunes. However, small-scale interference along the eroding stretch of coast in the west of Luce Sands may affect the long-term natural evolution of this dynamic system. Any further artificial protection of this coast may result in the reduced transfer of sediment that maintains downdrift accretion.

Conclusions

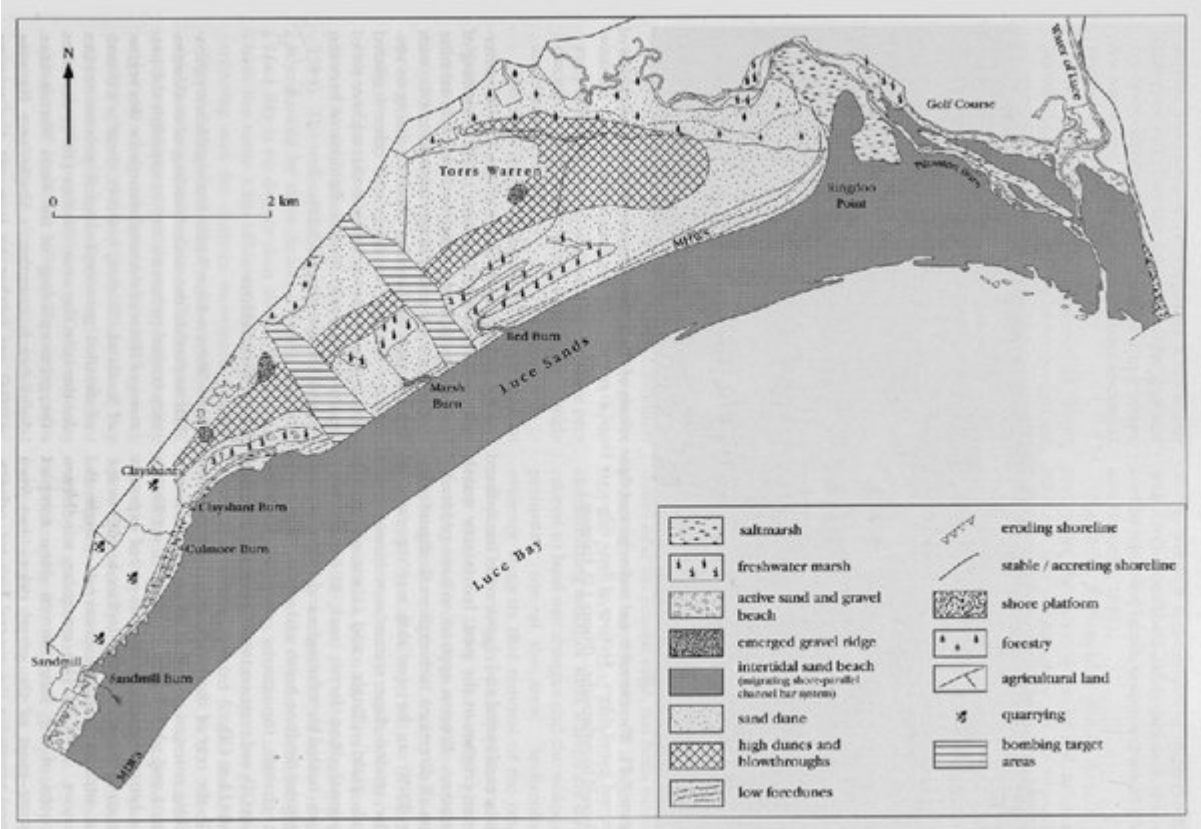
The principal scientific importance of the Luce Sands GCR site lies in the large and complex system of beach and dunes. The rich variety of contrasting dune morphology includes: low parallel foredunes, dune slacks, high transverse dunes with well-developed blowthroughs, and a complex area of older dunes overlying emerged beach gravels. The dynamic relationships between these components lead to the distinctiveness and importance of the site. The emerged gravel strandplain beneath the dunes, deposited under a higher sea level, adds further interest to the site giving insights to the Holocene development of the complex. Additionally, the ongoing accretionary processes at Luce Sands impart a wider interest as this site is one of few in Britain that displays long-term progradation.



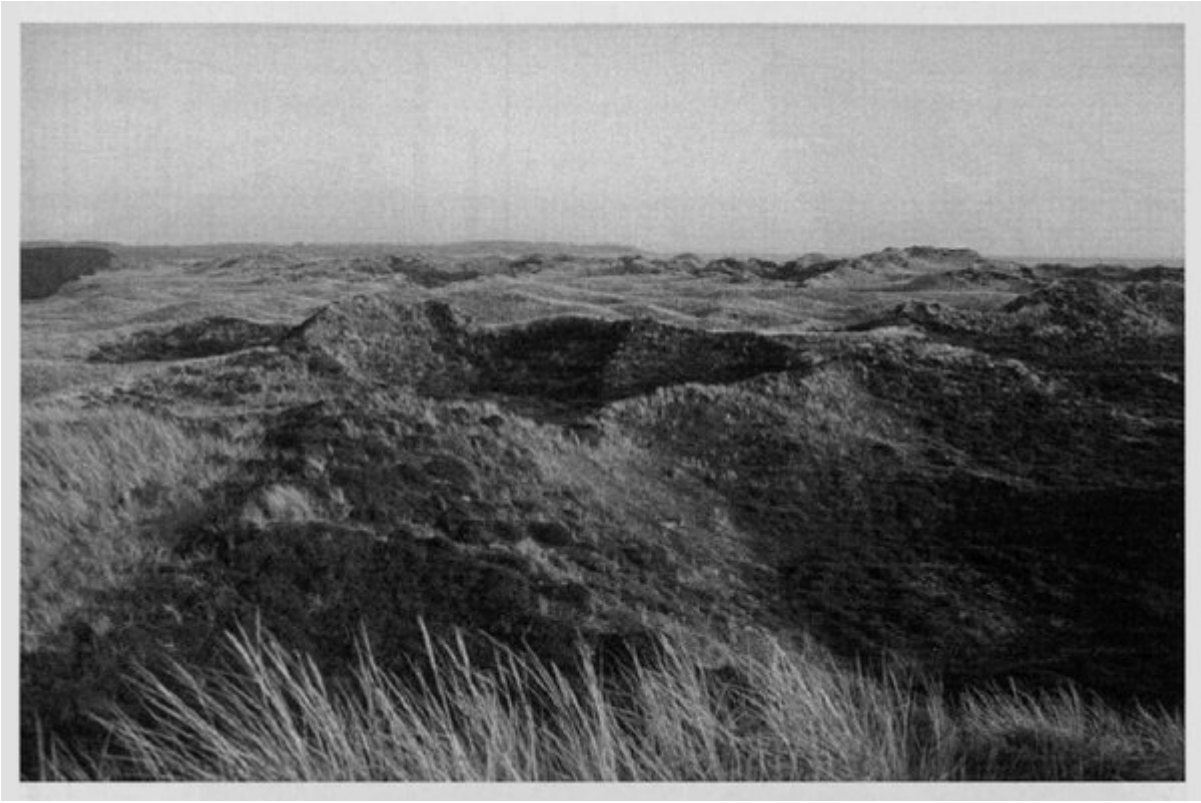
(Figure 7.1) Great Britain sandy beaches and coastal dunes, also indicating the location of GCR machair–dune sites (see chapter 9) and other coastal geomorphology GCR sites that contain dunes in the assemblage.



(Figure 7.19) Luce Sands is located at the head of a long linear embayment that is floored by extensive areas of sands and gravels. The result of unidirectional wave activity is that sediment is transported northwards on to the beach at Luce Sands. (After Single and Hansom, 1994.)



(Figure 7.20) The generalized coastal geomorphology of Luce Sands and Torrs Warren showing the wide intertidal area backed by extensive, largely stabilized sand dune. In the central section of the bay, two large areas of dune have been levelled for military use, and access to these areas and to the adjacent intertidal area is restricted. (After Single and Hansom, 1994.)



(Figure 7.21) The extensive and well-vegetated dune system of Torrs Warren has developed atop a series of emerged gravel ridges. Sections of these ridges are found in swales within the dune system and on the floors of healed blowthroughs. (Photo: J.D. Hansom.)