TORRISDALE BAY AND INVERNAVER

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Introduction

The diverse assemblage of beach and dune landforms at Torrisdale Bay, Sutherland, northern Scotland (see Figure 7.1 for general location), is of national geomorphological importance. The dune landforms, which demonstrate various stages of development and dynamism, lie landwards of a wide intertidal sand beach and sit on top of the high, central, glacially scoured rock ridge and the terraces of the River Naver that drains into the east part of the bay and the River Borgie that drains into the west part. Dunes have formed on the hilltop at altitudes of up to 110 m OD on the central rock ridge and are of geomorphological and botanical importance. The site is also of importance from an archaeological perspective because the river terraces contain numerous cairns, hut circles and cist burials that may allow minimum dating of the landform surfaces. Despite the enormous research potential, which is enhanced by ecological and archaeological interests, the site has failed to attract detailed geomorphological research although several descriptive accounts highlight the site's significance (Ritchie and Mather, 1969; Steers, 1973; Bentley, 1996b).

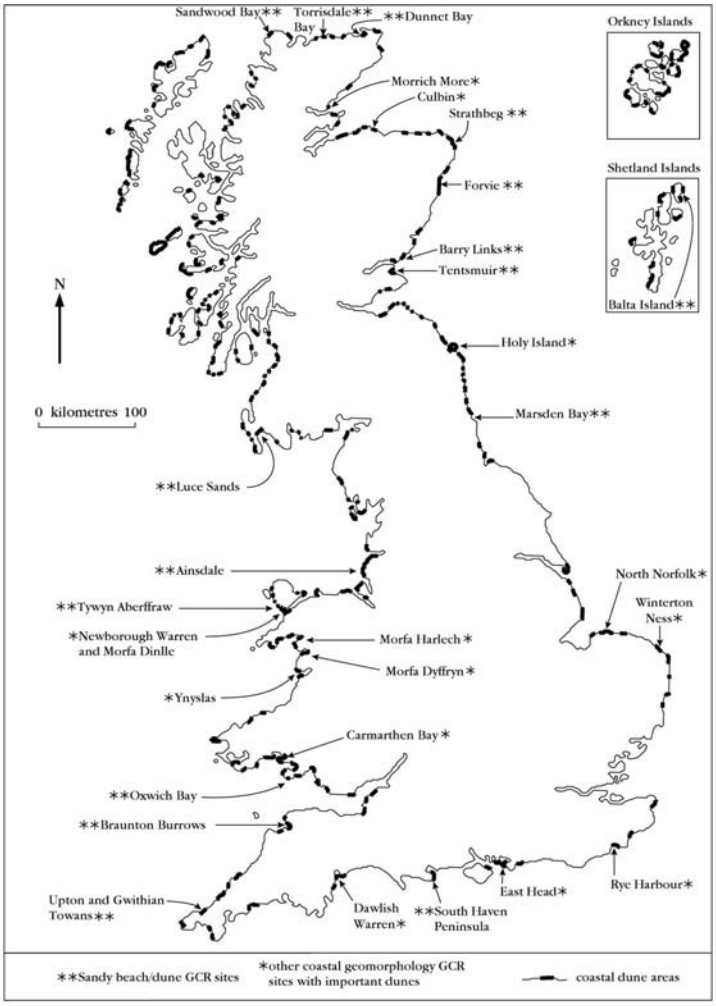

Figure 7.1: Great Britain sandy beaches and coastal dunes, also indicating the location of GCR machair-dune sites (see chapter 9) and other coastal geomorphology GCR sites that contain dunes in the assemblage.

Description

The Torrisdale Bay and Invernaver GCR site (Figure 7.25) encompasses two bays, at the mouths of the rivers Naver and Borgie, which drain into the east and west of the bay respectively. The two rock headlands that enclose Torrisdale Bay (Creag Ruadh on the east and Aird Torrisdale on the west) are formed of highly resistant metamorphic rocks of the Moine series (Ritchie and Mather, 1969). In the centre of the bay, a glacially scoured bedrock ridge is formed of strongly foliated Moine Schists (Ritchie and Mather, 1969). This 110 m OD bedrock ridge is cut by a series of parallel east–west-trending fractures that have been exploited by glacial action to produce a series of depressions or gullies along its flanks. These gullies form important access channels for blown sand to climb to the top of the ridge. The ridge has been extensively glacially scoured in a south–north direction and contains excellent examples of roches moutonnées, with smooth abraded surfaces on the south side (up-glacier) and rough plucked surfaces on the north (down-glacier). Smoothed bedrock surfaces abound and perched blocks, some of which are erratics, are common. Both the River Naver and River Borgie have well-developed glaciofluvial sand and gravel terraces.Ritchie and Mather (1969) suggest the terraces on the east side of the lower Naver valley correspond to different early sea levels. The most prominent is an extensive flat-topped gravel terrace on the west side of the river at*c*. 15–20 m OD (Figure 7.26). The terrace surface is pitted by a number of kettle holes up to 10 m in diameter (Bentley, 1996b). The south and east sides of the terrace slope steeply down to the valley floor and the steep seaward cliff is fringed with vegetated sand dunes above the wide intertidal beach. A flat-topped gravel terrace at a similar altitude to the extensive Naver terrace forms the eastern side of the Borgie valley.

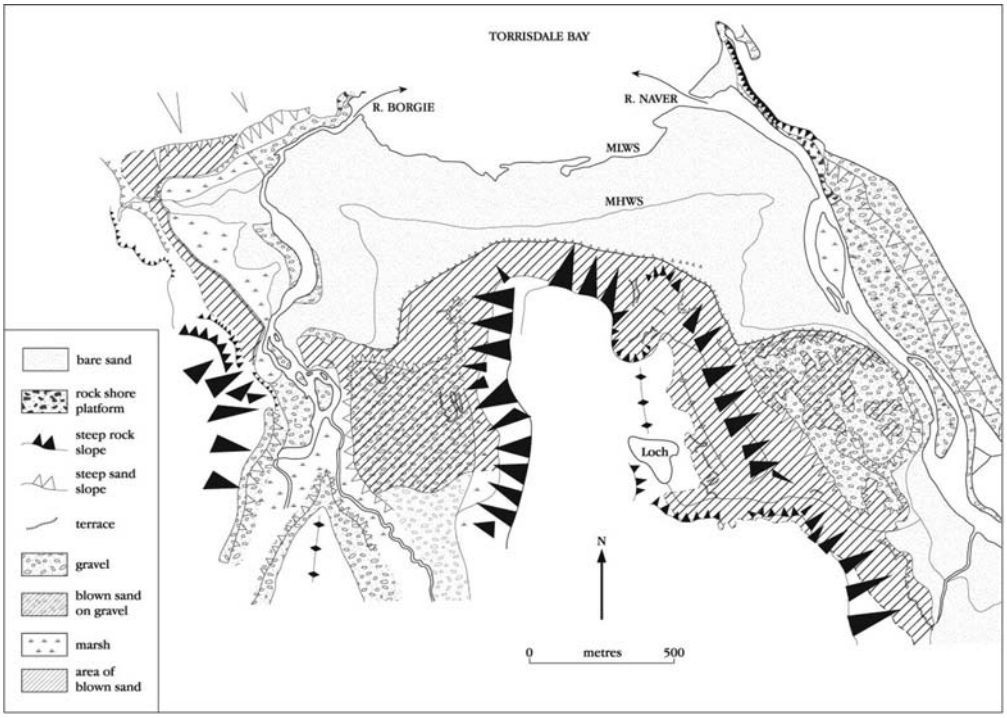

Figure 7.25: The geomorphology of Torrisdale and Invernaver is bisected by a glacially scoured rock ridge that is flanked on either side by glaciofluvial terraces that are capped by windblown sands. The unvegetated upper beach is wide and backed by low dunes. Areas of saltmarsh occur along the exit of the River Borgie. (After Ritchie and Mather, 1969.)

Figure 7.26: The large glaciofluvial terrace at Invernaver viewed from the east is flanked and capped by blown-sand deposits that also climb the ridge behind. The surface of the terrace also supports a wealth of archaeological remains including hut circles and cist burials. (Photo: J.D. Hansom.)

The wide and flat sandy beach of Torrisdale Bay extends over 1 km in length from the mouth of the River Naver in the east to the mouth of the River Borgie in the west. Extensive areas of intertidal sands characterize both bays and several areas of saltmarsh have developed in the inner reaches (Figure 7.27). At low tide the beach at Torrisdale Bay can be as wide as 950 m, with about 40% of the total beach area lying above high-water mark. The sand has a median diameter of 0.2–0.3 mm and has only 3–4% shell-derived calcium carbonate. Prominent sand-bars extend seawards across the mouths of both rivers. On the bar at the mouth of the River Naver, an area of low (3–4 m high) marram-clad sand dunes has experienced vigorous growth since the 1970s (Bentley, 1996b). Landwards and south of the beach at Torrisdale Bay an extensive dune system has developed, the detailed morphology of which is controlled by the eroded form of the bedrock ridge and the flat-topped glaciofluvial terraces that flank it. The Naver terrace contains a wealth of important archaeological artefacts including cairns, hut circles and cist burials. In contrast, the Borgie terrace has no known archaeological interest and is capped by an extensive (0.5 × 0.5 km) flat dune grassland surface used for grazing.

Figure 7.27: The intertidal saltmarsh and sandflats of the River Borgie exit looking north-west over the low dune area and beach of Torrisdale Bay in the middle distance. (Photo: J.D. Hansom.)

At the rear of the beach, the coastal edge is characterized by a frontal apron of young vigorous dunes that are mostly relatively stable with vigorous marram *Ammophila arenaria* growth although there is some localized evidence of erosion where the vegetation cover has been stripped. The main dune ridge extends along the back of the beach and drapes the seaward edge of the Naver terrace before curving northwards round the flanks of the central rock ridge to continue into the Borgie estuary. In places the fringing dunes extend southwards onto the Naver terrace surface itself, while farther landwards some low isolated dune features rest on the top of the gravel terrace. An extensive area of dunes has also developed on the west side of Torrisdale Bay, in the triangular-shaped area lying between the Borgie terrace and the central rock ridge (Figure 7.25). The marram-clad dunes of this area are characterized by an irregular and hummocky surface topography and have no preferred alignment. However, the dune slacks occur at a common low altitude and contain standing water or damp surfaces and probably mark the position of the water table (Bentley, 1996b). Gravel is exposed at the base of some slacks (Ritchie and Mather, 1969). This dune system drapes the northern part of the Borgie terrace for up to 50 m southwards before giving way to a much smoother and vegetated dune grassland that extends over the terrace top and thins to the south.

The steep (up to 20°) rock slopes of the central ridge are host to a diverse array of landforms including dunes, bare screes of sand and rock debris and patches of heath. On the northern part of the ridge at the rear of the beach, 9–12 m-high coastal dunes merge into the dunes that are being blown uphill. These climbing dunes are most extensively developed on the north-east and east flank of the ridge, especially where rock depressions permit deeper sand accumulation. For example, the deep gully occupied by the stream flowing east from the loch to the lower River Naver, acts as a funnel for windblown sand. A small dune area has developed near the crest of the ridge at 110 m OD. This unusually high hilltop dune is characterized by numerous erosion scars and terracettes, the result of a combination of wind erosion and sheep scraping. The dune heathland of the ridge are also of considerable ecological interest with unusual associations of mountain avens *Dryas*, heather *Calluna*, crowberry *Empetrum*, sedge *Carex* and juniper *Juniperus* (Ritchie and Mather, 1969) providing a classic example of the 'altitudinal descent' of montane vegetation (Bentley, 1996b).

Interpretation

Ritchie and Mather (1969) describe the Torrisdale Bay area as a 'bewildering melange of landform and landscape elements'. The site comprises a fine assemblage of landforms that

relate not only to the Quaternary evolution of the area but also the shorter-term dynamic beach–dune processes. Although no detailed geomorphological research has been carried out, it is possible to interpret the general evolution of this magnificent site from the morphological accounts of Ritchie and Mather (1969) and Bentley (1996b).

The site lies outwith the accepted limits of the Loch Lomond Stadial and so the last ice to over-ride the site is most likely to be of Devensian age, flowing over the central bedrock ridge in a south–north direction and producing scouring, striations, and roches moutonnées (Ritchie and Mather, 1969). During the latter stages of the Devensian glaciation, the valleys of the Naver and Borgie acted as conduits for large volumes of meltwater and sediment discharged from the northern margin of the Scottish ice-sheet. As a result both the Borgie and Naver valleys contain large flat-topped terraces, that are the remnants of larger outwash terraces grading to former sea levels. The lower parts of these terraces were probably trimmed during the higher relative sea-levels of the Lateglacial period and were subsequently isolated as sea levels fell from 15–20 m OD (Ritchie and Mather, 1969). Ritchie and Mather (1969) suggest that fluvial reworking of these outwash terraces provided the sand and gravel for the large intertidal expanse of beach. However, the relative absence of gravel on the beach compared to its great abundance in the terraces may imply that offshore sources of sand were equally important in the initial development of the beach and dunes of Torrisdale Bay. This argument has been rehearsed elsewhere (Hansom, 1999, 2001) but broadly involves onshore delivery of large amounts of glaciogenic sand and gravel, at a time when the sea-level rise slowed during mid-Holocene times. The early arrival of gravel initiated development of gravel ridges that were subsequently inundated by large quantities of sand, which was then distributed into extensive dune and machair systems. However, in contrast to most Scottish beaches and dunes, Torrisdale Bay appears to be relatively stable or accreting. It is likely that the general decline in offshore sediment sources late in the Holocene Epoch has been offset by a ready source of sand recycled from the Naver and Borgie glaciofluvial terraces. The low percentage of shell-derived sand also suggests that onshore rather than offshore sources now comprise the main sand supply to the beaches and dunes.

On the main beach at Torrisdale Bay, a tendency for the beach axis to rotate clockwise over time was observed by Ritchie and Mather (1969), where sand from the east side of the beach on the Naver exit moves west towards the Borgie exit. This may be a function of westerly waves impinging on the east of the beach undergoing less refraction than the waves impinging on the west and so the energy gradient causes longshore transport of sand to the west, an area of lower wave energy. If this is indeed the case, then it may also provide a supply-driven explanation for the striking contrast in the extent and development of windblown depositional landforms on the west and east sides of the bay.

The extensive climbing dunes on the central bedrock ridge probably formed soon after the sandy beach was established, as a result of dune development at the base of the ridge being forced uphill by strong winds from the north, north-west and north-east, assisted by bedrock gullies and depressions that subsequently channelled the windblown sand to altitudes of 110 m OD (Ritchie and Mather, 1969). Dune accretion appears to be continuing today (Bentley, 1996b). The frontal edge of the coastal dunes is relatively stable with low embryo dunes to the seaward side. The wide sand beach and the area of new dunes close to the mouth of the River Naver suggests that sand is still available for dune formation (Bentley, 1996b), in stark contrast to most Scottish beach–dune systems where erosion is the dominant process. The Borgie terrace has a stable dune grassland on its surface, whereas the Naver terrace consists of bare gravel with discontinuous low dune hillocks. This is probably due to the greater exposure to onshore winds at the Naver terrace, but the frequency of cairns, cist burials, grave mounds and other archaeological features may offer another partial explanation in terms of antiquity of anthropogenic influence (Ritchie and Mather, 1969). Nevertheless, similar undiscovered features may lie beneath the dunes of the Borgie terrace.

In summary, the Torrisdale Bay site is of great geomorphological importance on account of the diversity of the landform assemblage and the juxtaposition of glacial, glaciofluvial, and coastal landforms. The combination of dunes that have been blown onshore onto glaciofluvial terraces and, blown to considerable altitude on the central bedrock ridge where dune grasslands have formed, is of considerable interest. These interests are further enhanced by the ecological and archaeological importance of the site. There is considerable scope for further geomorphological

research at Torrisdale Bay.

Conclusions

Torrisdale Bay, Sutherland, northern Scotland, contains a diverse assemblage of dune landforms draped over a complex subsurface morphology comprising a glacially scoured bedrock ridge and the glaciofluvial terraces of the River Naver and River Borgie. A wide variety of dune landforms are well developed, demonstrating various stages of evolution and stability. Individual features of particular interest are the dune forms that have developed on the terraces, and the climbing dunes and high-level hilltop dune grassland. It is the juxtaposition of impressive glacial, glaciofluvial, and coastal landforms at Torrisdale Bay that is of outstanding geomorphological significance.

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