# Forvie, Aberdeenshire

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## Introduction

The Sands of Forvie, north-east Scotland (see (Figure 7.1) for general location), form the fifth-largest and least-disturbed sand-dune system in Britain (Dargie, 2000). This vast site covers 810 ha and contains a remarkable assemblage of blown-sand landforms, some of which are unique in Britain, for example, the classic parabolic dunes at north Forvie and the unvegetated sand dunes of south Forvie. Others are representative of much of the dune coastline of north-east Scotland. The mode of evolution of the Sands of Forvie has sparked much scientific debate (e.g. Landsberg, 1955; Kirk, 1955; Steers, 1973; Walton and Ritchie, 1972; Ritchie, 1992). Early work suggested a series of large sand waves migrating successively from the south end of the peninsula to the north end of north Forvie (Landsberg, 1955). Although archaeological evidence supports a northerly migration of sand (Kirk, 1955; Ralston, 1983), the pattern proposed by Landsberg has been modified (Steers, 1973; Walton and Ritchie, 1972; Ritchie, 1992) in favour of a more complex theory of the 'scatter and break-up' of the northward migrating sand waves as they mount the higher altitudes of the north Forvie plateau.

## Description

The Sands of Forvie (Figure 7.37) cover 810 ha of land in a triangular shape to the north and east of the River Ythan. The region can be differentiated on the basis of geology and dune morphology on a north–south basis. North Forvie is characterized by an underlying till-covered rock platform sloping north to a height of 57 m OD, which is surmounted by a series of discontinuous dunes together with parabolic dunes facing west and south-west. The coastline of north Forvie comprises rock and till cliffs, which reach 40 m OD towards Collieston. Lying between the Ythan estuary and the North Sea, south Forvie is essentially a sand peninsula, with sand dune complexes, dynamic sandhills and sand waves running along a north–south alignment. A series of low ridges of glacial deposits and emerged beaches reaching 12 m OD underlie the south Forvie dunes. In the extreme south, intertidal and aeolian processes at the mouth of the Ythan estuary ensure a continuous supply of sand to the northward encroaching sand waves which dominate this area (Figure 7.38). Foveran, the area of dunes to the south of the estuary, is an integral part of the system in terms of sediment transfer and supply and, as such, is included within this large GCR site. The geomorphology of these three main areas is described below.

North of Rockend, Forvie is characterized by an underlying till-covered rock platform sloping north to a height of 57 m OD and surmounted by a series of discontinuous dunes and parabolic dunes. Ritchie (1992) describes the west- and south-west-facing parabolic dunes of north Forvie as good examples of this type of land-form, although notes that the mode of development differs from the classic textbook form. Nine parabolic dune complexes can be identified in north Forvie (Figure 7.39). 'To the north of Hackley Bay, a group of three (3, 4 and 5 with orientations of 237°, 242°, 230°) form part of an area of composite forms of high dunes and dune ridges. In the central and western part of the plateau lie a detached group of four parabolic dunes (6, 7, 8 and 9, with orientations of 173° 200°, 203°, 168°) together with a further two parabolic dunes (1 and 2 with orientations 251°, 211°). The orientation of the parabolic dunes contrasts markedly with the main active blowthrough orientations of the coastal dunes (which lie between 120° and 140°) and the general south-north migration direction of the great sand arcs of south Forvie (Ritchie, 1992). The extensive dune surfaces of north Forvie are mostly vegetated by acidic heaths growing over a thin sand veneer that is often less than a metre thick. The flanking dunes that form the western edge of south Forvie continue into north Forvie and have actively eroding and dissected east-facing slopes that in places merge with the parabolic dune complexes described above.

South of Rockend (Figure 7.37) the massive sand peninsula of south Forvie is underlain by low ridges of glacial deposits and emerged beaches, fronted in the east by an active beach and limited in the west by the tidal estuary of the River

Ythan (Figure 7.37), (Figure 7.38), (Figure 7.39). Marking the southern end of south Forvie is a series of dynamic spits and bars where the River Ythan enters the North Sea. South Forvie is a large sand-dune system characterized by an outer zone of active coastal dune ridges and an inner zone of great sand arcs. The active coastal dunes of south Forvie range in height from 2 to 15 m and are all dissected to varying extents. Several large V-shaped blowthroughs occur and some of the dune ridges have been completely removed by deflation. Detailed study reveals that most of the foredune face at south Forvie shows a high degree of instability characterized by general retreat and erosion (Esler, 1976, 1983), although it is unclear whether this represents a long- or short-term trend.

The exceptional, and perhaps the most distinctive, feature of south Forvie is the great dome of bare sand that covers the south end of the peninsula (Figure 7.40). This extensive ridge of sand is more than 1 km long, 200 m wide and over 25 m high; it dominates the south Forvie peninsula. Surface instability is indicated by an absence of vegetation and the occurrence of sand-wave and ripple forms that trend in a south to north direction. However, active sand transport occurs not only northwards onto the adjacent deflation plain, but also westwards towards the Ythan estuary where it cascades down steep unvegetated slopes into the estuary and enters a semi-dosed sediment circulation cell described by Wetherill (1980).

The central and northern parts of south Forvie consist of three very large arcuate sand ridges that extend across the entire width of the peninsula. The southern arc is 500 m wide and 20 m high, while the northern arc is *c.* 1500 m wide and exceeds 35 m high. In detail, the surfaces are very complex features with a series of vegetated dune ridges and bare deflation surfaces superimposed onto the main form. Parts of the south-facing slope are often severely deflated, particularly on the western side where the underlying till basement is exposed. Erosional forms (such as deep linear blowthroughs and V-shaped hollows) at various stages of activity are common. Functionally linked to the processes and forms of wind erosion are a series of depositional forms, the best example of which is a mass of bare sand that spills northwards from the north-west side of the northern arc, as a steep sand slope. These massive sand arcs are subject to rapid change and a detailed study of the northern arc showed a complex series of rapid alterations from vegetated to unvegetated status within a decade (Wright and Harris, 1988).

On the eastern side of south Forvie, the sand arcs meet the coastal dunes causing higher dune elevations that are termed 'nodes' by Ritchie *et al.* (1978). The western margin of south Forvie consists of flanking dunes with steep, eroding and actively dissected east-facing slopes, and stable, concave western slopes that grade steeply down to an emerged beach terrace above the tidal flats of the estuary.

South of the Ythan lies Foveran, a further area of beach and dunes is included within the GCR because of the intrinsic geomorphological interest and since it feeds sediment northwards into the south Forvie system and beyond (Figure 7.37) and (Figure 7.38). The area consists of a series of sub-parallel lines of massive, 10–12 m-high dunes with a well-developed wet slack between the broad coastal dune ridge and the sand-covered Holocene cliffline, which lies a few hundred metres inland. Low cliffs cut into glaciogenic deposits and emerged ('raised') beach deposits are conspicuous features underlying much of Foveran. The beach comprises a series of shore-parallel intertidal bars with intervening runnels whose migration has deflected small streams northwards. At the Ythan exit the northward drift has resulted in accretion so that the beach is now 250 m wide and backed by actively accreting embryo dunes (MacTaggart, 1998b).

In contrast to this essentially accreting area close to the Ythan exit, the area to the south is characterized by a discontinuous and severely undercut foredune. High eroded dune faces are produced along the seaward edge and extensive unvegetated sand aprons have accumulated between and behind the eroding dunes, indicat ing significant movement of sand landwards. At the north end of the beach, concrete anti-tank blocks dating from the 1940s are partially exposed by erosion of the coastal edge. Since these traps have been buried by sand accumulation prior to exhumation, then at least one cycle of accretion followed by erosion is suggested. Progradation in the north-east is suggested by the occurrence of a zone of stable dunes up to 25 m high fronted by foredunes that reach 21 m in width. Probably the most distinctive landform at Foveran is an extensive area of bare sand that extends 0.5 km inland from the northernmost fragmented foredune ridge. Ritchie *et al.* (1978) consider this area to be comparable to the more extensive bare sand area at south Forvie, its scale and height being partly determined by undulations in the underlying glaciogenic landforms and emerged, marine, gravel ridges. However, sand passing through breaches on the foredune ridge continues to migrate upslope in a northerly and north-westerly direction.

## Interpretation

It is uncertain when the dune system at Forvie first began to develop (Stapleton and Pethick, 1996), although archaeological evidence indicates that blown sand accumulations existed near the south end of south Forvie about 5000 years BP (Ralston, 1983). The distribution and pattern of the Forvie dunes have been the subject of intermittent research since the pioneering vegetation study of Landsberg in 1955. Landsberg (1955) postulated an evolution whereby the great arcs of dunes, including the northern group of parabolic ridges, spread northwards from the beach, bar and spit sand sources of the mouth of the River Ythan. Sand also fed into the system from the extensive North Sea beaches on the east side of the south Forvie peninsula. Landsberg (1955) identified seven arcs of sand accumulation in the region and postulated that each wave of sand formed in the south and moved northwards at a migration rate which decreased progressively to the north as a result of vegetation colonization.

Although there is evidence for a chronology of sand drifting northwards (Landsberg, 1955; Kirk, 1955; Ralston, 1983), the hypothesis of a series of northward migrating dunes has since been rejected (Steers, 1973; Walton and Ritchie, 1972; Ritchie, 1992). The formation of new sand waves to the windward of a pre-existing wave would deprive the latter of aeolian sand, leading to vegetation colonization and dune stabilization. In addition, there is only patchy morphological, historical and archaeological evidence of recognizable sand waves or sand arcs in north Forvie and so the assumption of a consistent south to north aeolian transport mechanism is likely to be over-simplified and takes little account of the dune morphology at south Forvie.

Walton and Ritchie (1972) and Ritchie (1992) suggest that whereas south Forvie may have developed in a similar manner to that proposed by Landsberg (1955), north Forvie developed by a process of 'scatter and break-up'. This envisages sand moving from south Forvie into north Forvie as a series of events with a strong northerly component to form discrete and separate dune complexes (Figure 7.39). The series of dunes and dune ridges became increasingly isolated as the sand was forced onto the higher altitudes and more open topography of the northern plateau (Ritchie, 1992). The dunes that form the groups of parabolic dunes (Figure 7.39) are thought to have been fed by the periodic migration of sand from the north end of the south Forvie peninsula. A major influx seems to have occurred in 1413 when the Old Kirk of Forvie near Rockend and the surrounding cultivation rigs are known to have been abandoned (Ritchie *et al.,* 1978). Following this major influx, the dunes spread rapidly northwards, progressively infilling two lochs in the 18th and 19th centuries (Figure 7.41) and, as chronicled by Landsberg (1955), encroached on to farmland at CoWeston around the end of the 18th century. However, the orientations of the parabolic dunes of north Forvie suggest a swing towards the east as the dunes migrated and stabilized, possibly due to vegetation colonization as the water table was exposed.

Today sand continues to spill northwards on the north-west side of the south Forvie peninsula (Wright and Harris, 1988), providing present-day analogues for past processes. The active sand movement in the north part of south Forvie suggest that similar areas were locally active in the past, providing pulses of sand that drifted onto parts of the north Forvie plateau. Separate pulses, in time and space, would facilitate the development of discrete masses of sand to then evolve into detached parabolic systems and other sand dune complexes (Ritchie, 1992).

Detailed studies on the dynamics of the Ythan estuary (Stove, 1978; Wetherill, 1980) demonstrate that the sand peninsula and dome of bare sand of south Forvie forms part of a semi-closed sediment circulation cell. This involves east to west aeolian transport of sand over the dune and into the estuary. River flow and ebb tides carry the sand onto the estuary mouth spits and bars for transport back onto the beach. Based largely on cartographic evidence, Wetherill (1980) suggests that the sedimentary regime of the Ythan estuary has been relatively constant for at least 150 years and that this semi-dosed sand-transport cell has ensured relative stability in the position and form of the south end of the south Forvie peninsula. Although the Forvie dune system probably originates from a period when substantially more sand was available in the Ythan outlet and nearshore sedimentary environment, the river mouth dynamics and general wave climate throughout the last 5000 years may have been essentially similar to the present day. Nevertheless the longevity of the bare dome of sand that dominates south Forvie is remarkable. The lack of pioneer plant species suggests that the unvegetated sand dome represents a landform in dynamic equilibrium with its current sand budget, the rapid throughput of sand over the surface preventing colonization. Another hypothesis is that the dynamism and efficiency of aeolian

erosional processes are such that the sand dome would have been removed long ago unless it were not underpinned by glaciogenic sediments or possibly bedrock (Ritchie, 1997). A programme of coring or ground-penetrating radar may resolve such questions and provide insights into the subsurface stratigraphy of the most spectacular remaining area of bare sand in Britain.

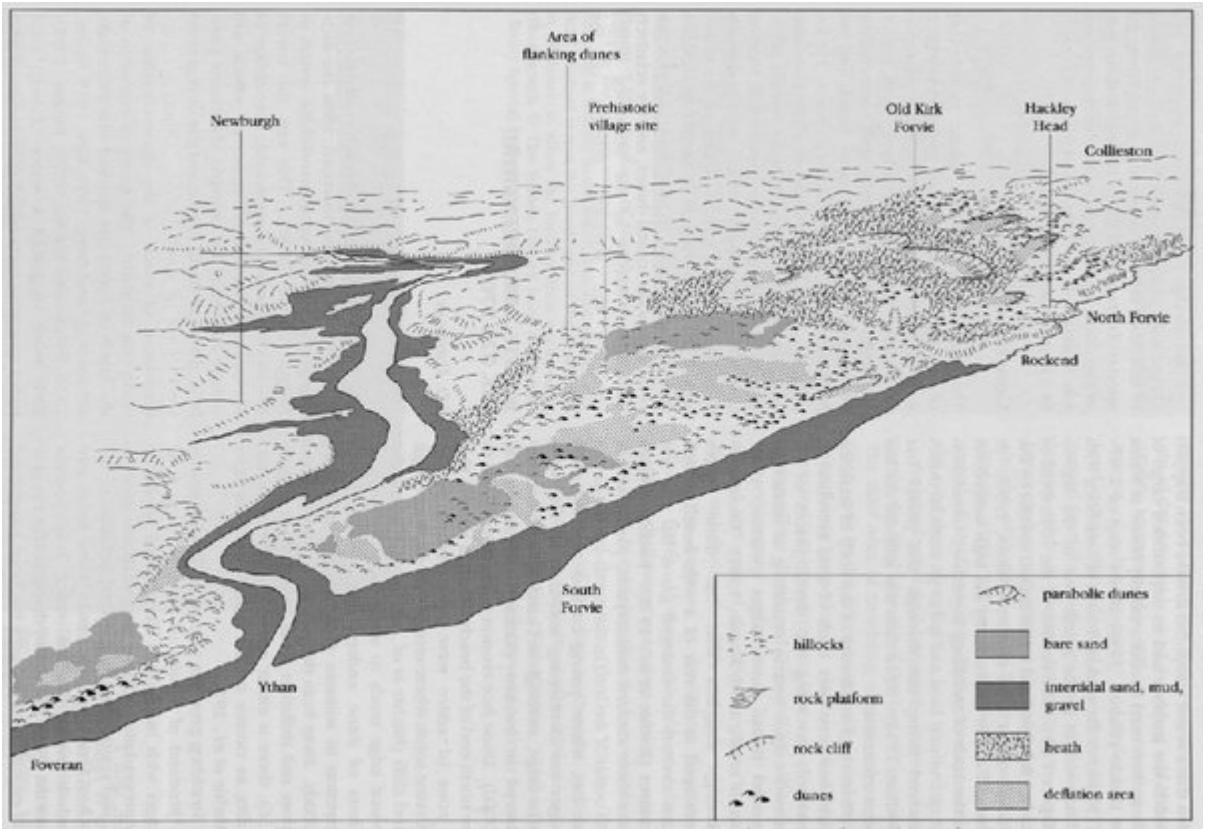
Recent experimental wind-flow measurements on the dune complexes of north Forvie provide an insight into the geomorphological processes of parabolic dune development (Robertson-Rintoul, 1985, 1990). The development of wind jets at crestal locations probably limits dune height, with eddies important on steep leeside and windward slopes affecting forward sand movements. Spiral vortex flows along the windward arms are likely to be responsible for lateral expansion of the parabolic dune.

The Sands of Forvie form the fifth-largest and least-disturbed sand-dune system in Britain (Ratcliffe, 1977). The blown-sand morphology of north Forvie is unique in Britain, with massive sand hills and dune complexes on the high rock plateau that appear to have migrated from the south. It is this unique evolution, which is not fully understood, that is of outstanding geomorphological interest and warrants the inclusion in the GCR. In addition, the parabolic dune forms of north Forvie are spectacular landforms (Ritchie, 1992). They provide an interesting contrast to the textbook formation displayed by the parabolic dunes at Barry Links and Morrich More. The dynamic interchange of sediment between the dunes of south Forvie and the extensive sand beach and spit complex at the mouth of the River Ythan add to the geomorphological interest of the site.

## Conclusions

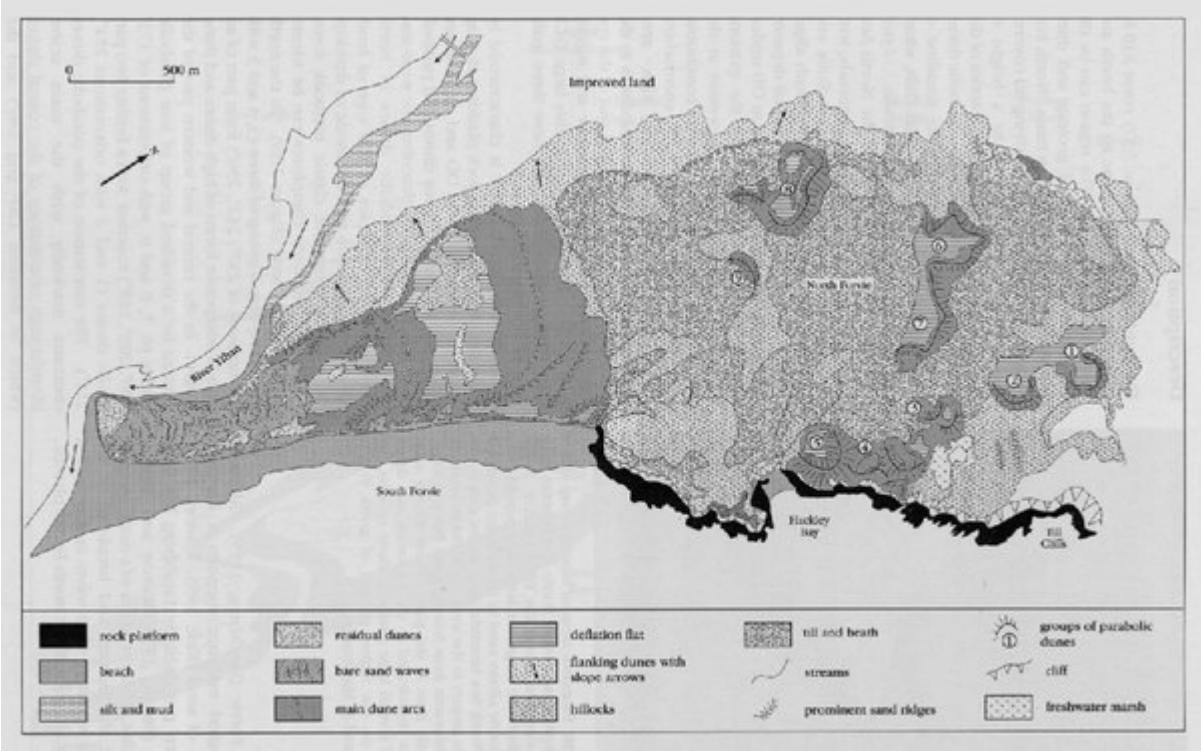
The Sands of Forvie represent a classic site for coastal geomorphology. The remarkable assemblage of windblown landforms, some of which are unique while others are representative of much of the dune coastline of north-east Scotland, are of outstanding scientific interest both individually and as an assemblage, and provide an excellent field site for innovative research at a variety of scales. The mode of evolution of this vast system, with huge volumes of sand migrating northwards from the 'normal' sand-dune complex of south Forvie onto the high rock-plateau of north Forvie, is unique. The parabolic dune forms of north Forvie are classic landforms that have developed in a different way to the classic textbook descriptions and this enhances their scientific interest.


*(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.*

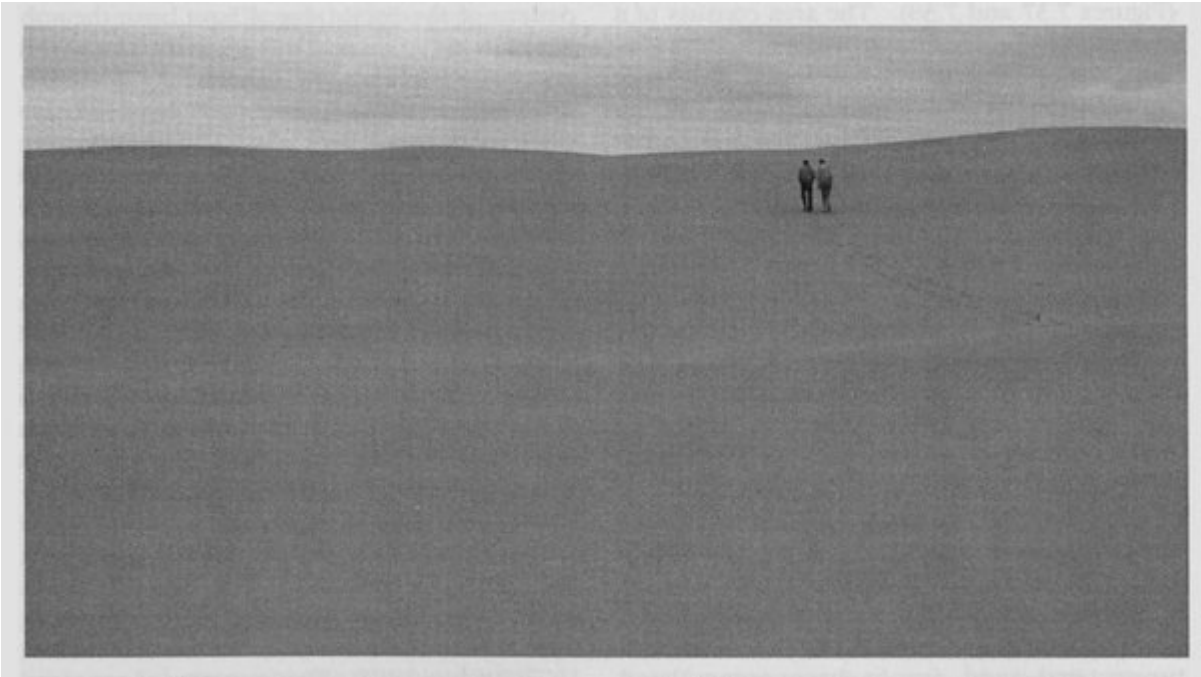



*(Figure 7.37) Oblique cartoon of the Sands of Forvie and the northern part of Foveran. (After Ritchie et al., 1978.)*

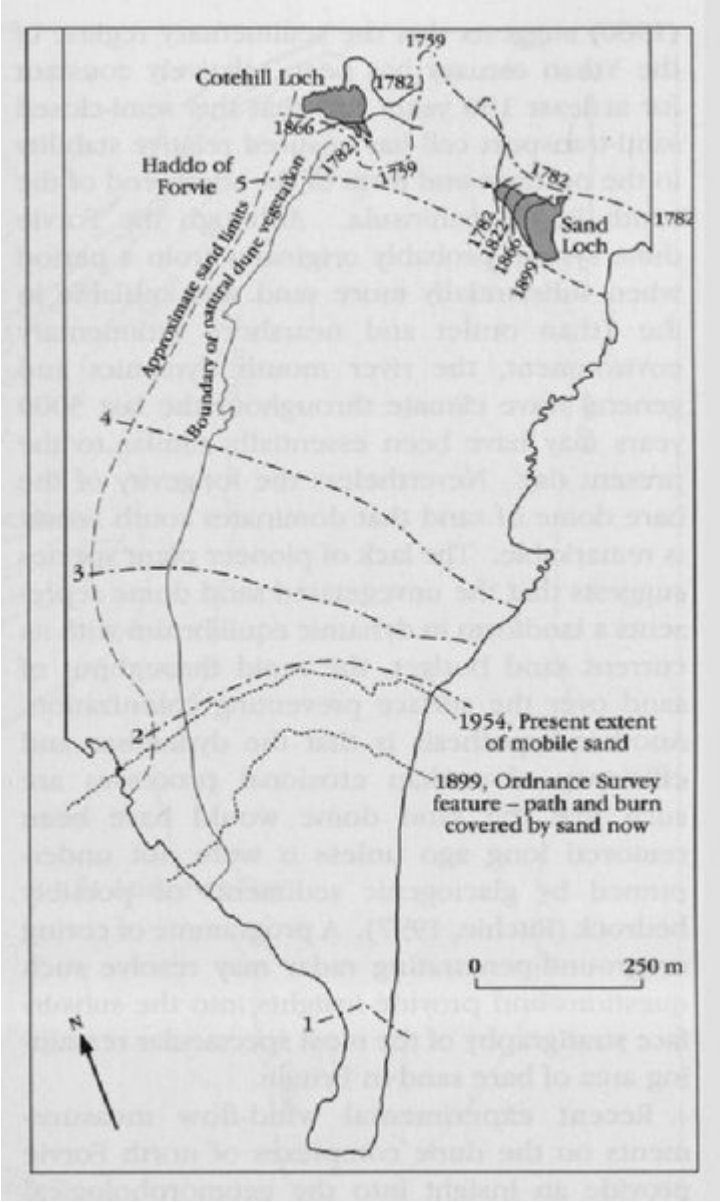
*(Figure 7.38) Extensive areas of bare sand are visible in this oblique aerial view of Forvie and Foveran looking north along the axis of the Ythan estuary. In the middle right of the image, the large unvegetated dune of South Forvie allows sand to traverse the peninsula from the North Sea intertidal area in the east to the inner Ythan estuary in the west. In addition, sand still moves northwards from South Forvie but at a much smaller scale than in the past. These former sand movements contributed to the migration and development of several large parabolic dune systems that now rest on the higher ground of north Forvie. (Photo: P and A. Macdonald).*




*(Figure 7.39) The coastal landforms of the Sands of Forvie showing the bare sand and dune-arc dominated southern part, and the largely stabilized and vegetated northern part, which also hosts the nine groups of parabolic dunes. (After Ritchie et al., 1978.)*



*(Figure 7.40) The great dome of bare sand that dominates south Forvie is subject to active aeolian activity and sand movement. (Photo: J.D. Hansom.)*




*(Figure 7.41) The postulated phases of sand movement over Forvie. The lines relate to sand limits as follows: 1 = the northern limit of sand before about 0 BC; 2 = the sand limit a few hundred years after 0 BC (there was little further northward encroachment until at least the 8th century AD); 3 = the limit of the area inundated by sand early in the 15th century; 4 = position of the sand front by the end of the 15th century; 5 = line reached by 1688. Further small advances are shown by dated boundaries. (After Ritchie, 1992.)*