BRAUNTON BURROWS

V.J. May

OS Grid Reference: SS440350

Introduction

Braunton Burrows (see Figure 7.1 for general location) is one of the three largest dune systems on the west coast of Britain. The dunes extend about 6.5 km southwards from Saunton Down across the lower valley of the rivers Taw and Torridge. The dune belt is about 1.3 km wide throughout this length and is fronted by a sand beach, which, in places, exceeds 1 km in width at low tides. At the north end, the structure of the dune system is influenced by the hills of Down End, at its southern end by the Taw–Torridge estuary. Individual dune ridges, which sometimes exceed 30 m OD, are best developed in the central part of the system. Although wartime use did extensive damage, this proved to be short-lived, and the dune complex remains quite outstanding (Figure 7.9).

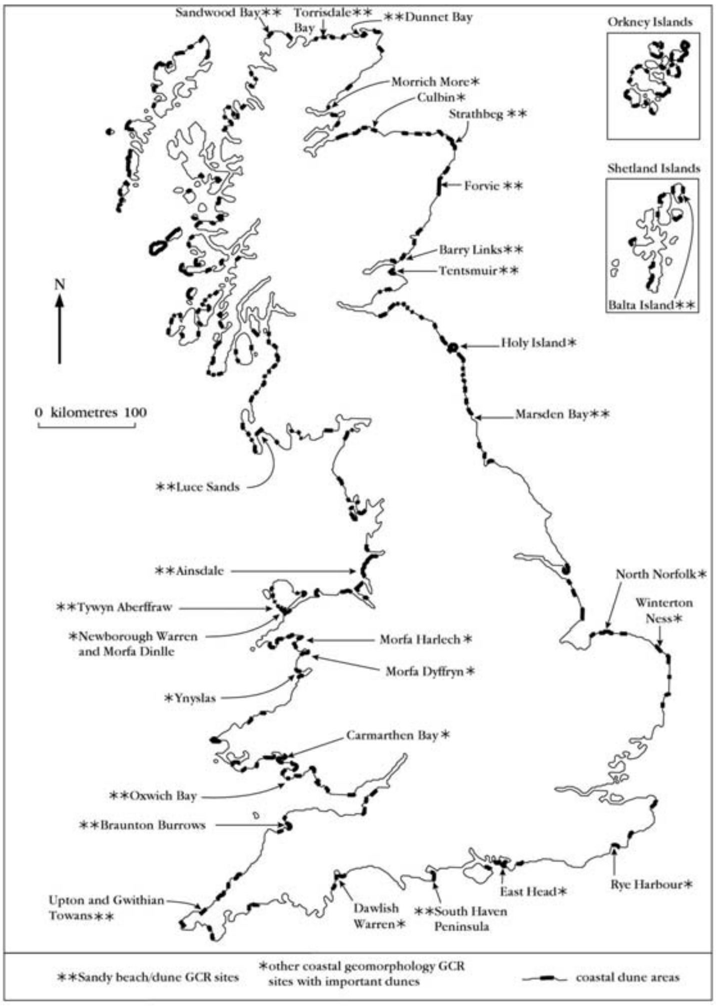

Figure 7.1: Great Britain sandy beaches and coastal dunes, also indicating the location of GCR machair-dune sites (see chapter 9) and other coastal geomorphology GCR sites that contain dunes in the assemblage.

Figure 7.9: Aerial photograph of dunes and Crow Point. 1, Westward Ho! cobble beach; 2, Taw–Torridge estuary; 3, Crow Point; 4, Airy Point; 5, Braunton Burrows showing main dune ridges and blowthroughs; 6, ridge-and-runnel beach. (Photo: courtesy Cambridge University Collection of Aerial Photographs, Crown Copyright, Great Scotland Yard.)

Although considerable research has been carried out in adjacent areas (e.g. Prestwich, 1892) into the 'raised beach' erratics, Mitchell (1960), Kidson (1977) into the interglacial and periglacial deposits of the Taw estuary, and McFarlane (1955) and Davies (1983) into the 'buried channel' of the Taw–Torridge, little geological or geomorphological data specifically concerning the dune system at Braunton Burrows has been reported in the literature. The presence of former dunes and glacial erratics along the northern cliffed coast of the site (Campbell *et al*., 1998) raises important questions about the long-term history of the site. There is, however, an important ecological literature, which led Ratcliffe (1977) to record Braunton Burrows as one of the best-described dune systems in Europe. This includes some geomorphological information (see for example Willis *et al*., 1959a,b; Willis, 1963, 1965, 1967, 1985, 1989; Willis and Jefferies, 1963; Hope-Simpson and Jefferies, 1966; Hewett, 1970, 1971; Hope-Simpson and Yemm, 1979; Hope-Simpson, 1985, 1997; Boorman, 1993). Kidson and Carr (1960) provided a brief summary of the structure of the system in the context of the dune stabilization programme carried out mainly in the central area during the 1950s, and Greenwood (1969, 1978) examined the textural contrasts between the beach and dune deposits. A number of unpublished reports have been written concerning the aggregate extraction around Crow Point at the mouth of the Taw–Torridge estuary (Figure 7.9). Probably the most relevant in the present context is that by Blackley *et al*. (1972) on the movement of sediment labelled with tracers within the Taw–Torridge estuary area. A review of the geomorphology and management of the Taw–Torridge estuary including Westward Ho! and Braunton Burrows includes details of erosion and sedimentation (Comber *et al*., 1993).

An extensive programme of topographical surveying of the dunes was undertaken by Kidson and co-workers between 1957 and 1960, during which time the whole dune system was mapped on a scale of 1:2500. Revisions using aerial photography were carried out subsequently. A series of profiles was surveyed across the central and southern dunes annually from 1956 to 1962, primarily to monitor the effects of replanting. Thereafter surveys were less extensive and less frequent because over most of their section-length the dunes had been stabilized. Measurements of blowthrough orientation, and an investigation into the nature and periodicity of the changes in the underlying water-table, were also carried out by Kidson and Hewett, respectively, as part of the work of the Physiography Section of the former Nature Conservancy. Similarly, Kidson and Carr examined the form of the underlying rock surface by means of earth resistivity and refraction seismography, supplemented by boreholes. Very little information concerning these studies has been published. Some maps were produced for the 1964 International Geographical Congress (Kidson, 1964a), but most information remains in the form of partially processed field data. This was remedied to some extent byKidson *et al*. (1989) who contrasted the earlier surveys with further surveys carried out in 1983, although the description of the dunes that follows is based in part on unpublished English Nature data. Sarre (1989) concentrated specifically on foredune processes and the ways in which they are affected by variations in relief and vegetation.

Description

The dunes at Braunton Burrows are formed mainly of sand with grain size generally between 0.2 mm and 0.3 mm diameter (Willis, 1985). They extend from the cliffs below Saunton Down, south for some 5 km to Airy Point (SS 448 330), and thence south-eastwards for a further 1.5 km or so to the narrow strip of land that culminates in Crow Point (SS 466 317; Figures7.9 and 7.10). In the central area, where the dune structure is best developed, the Burrows consist of three ridges, separated by slacks. The ridges lie parallel to the shore and to each other, within an overall width of about 1.3 km. It is in this area that the highest parts of the dunes occur. In both the north where the dunes abut on to the high land of Saunton Down and in the south, where the shoreline trend changes in response to the Taw–Torridge estuary, the system of three ridges is replaced by a less well-defined double ridge system. Throughout the dunes, but especially in the south, there are a number of sub-ridges perpendicular to the main dune alignment and the coast. They appear to be the legacy of major blowthroughs in the main dune alignments, and may form the northern and southern boundaries of the slacks. There are a small number of parabolic dunes, particularly in the southern part of the dunes (Figure7.9).

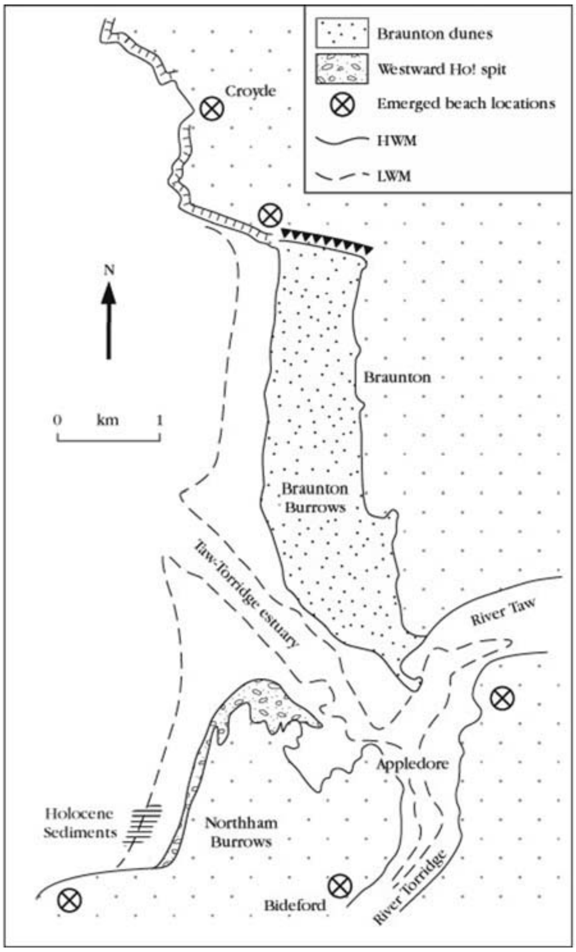

Figure 7.10: Braunton Burrows and Westward Ho! GCR sites, showing locations of emerged beaches and generalized geomorphology. See also Figure 7.11 for photograph of the area around Crow Point.

At the rear of the system, there is an extensive area of low dunes and slacks. This is best developed in the central zone; to the south, it becomes narrower, while to the north, it has been modified into a golf course. Both this low area and the slacks elsewhere may be extensively flooded during winter.

For much of its length the seaward dune ridge, usually rising to about 15 m OD, is fronted by a more or less continuous line of foredunes rising to some 4.5 m above OD. The elevation of the slacks is highest in the middle of the central zone of the dunes at about 9 m OD. Towards the north, the surface falls slightly (by the order of 2–3 m) and by rather more at the southern end. There, the lowest slack areas are at approximately 4 m OD, so that if the seaward dune ridges were breached, the slacks would be inundated at high water on spring tides (tidal range being 7.3 m). In the central zone, in particular, slacks nearest the shore are somewhat lower. Willis *et al*. (1959a) observed that the water-table underlying the system was dome- shaped, being some 6 m higher in the centre than at its margins (Figure7.11). They believed wind deflation took place down to this level. Unpublished work (by D.G. Hewett) shows that the neap-spring tidal cycle can be reflected in the water levels under the dunes for a considerable distance inland.

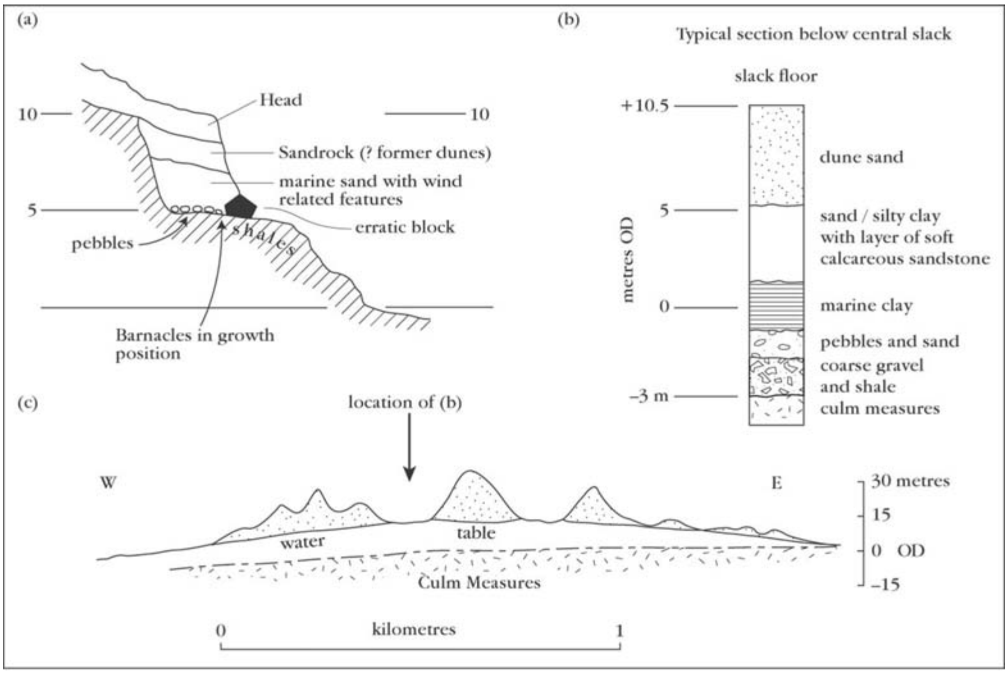

Figure 7.11: Emerged beach profile and dune features at Braunton Burrows GCR site. (a) Section through emerged beach and possible former dunes at Saunton Down; (b) section through the central slack within the main dunes, showing that the dunes lie on both marine clay and gravels and sand resting on the underlying Culm Measures bedrock.; (c) cross-section of the dunes showing the relationship of the slacks to the water table. (Based on Keene 1996; Willis 1985; and Willis et al., 1959a.)

The central zone of the dunes underwent the heaviest pressure through military usage during World War II, and thereafter. Comparison between maps made by the Ordnance Survey in 1885 and those of the Nature Conservancy produced between 1957 and 1960 indicate major topographical changes over the intervening period. These were particularly acute in this central zone where some parts showed an actual inversion of topography with slack areas in 1885 becoming the intermediate ridge of 1957. Mobile dunes continue this process and are encroaching on the slacks at present. Kidson *et al*. (1989) noted that the main dune crest moved eastwards by up to 60 m between 1885 and 1958. Between 1958 and 1983 there was a net gain of sand along the central foreshore, although the source is uncertain.

During the early 1940s, the widespread use of the dunes for military training prior to 'D-Day' (6 June, 1944) caused extensive damage, leaving a 'semi-desert of shifting sand' (Breeds and Rogers, 1998). Furthermore, mine clearance in 1946–1947 was carried out using high-pressure hoses. This destroyed foredunes and rebuilding was encouraged by emplacing brushwood or hessian fencing in the early 1950s. Similar techniques, followed by planting of marram *Ammophila arenaria*, were used to redevelop the middle and landward (main) dune ridge to a more uniform crest height (Hewett, 1970). Some 5–6% of the dune system was replanted between 1952 and 1963, but the overall impression is of a much greater proportion having been so treated. In some respects, the dunes have been over-stabilized so that the characteristic contrast between dynamic growth of both foredunes and major ridges, compared with slacks and older dunes to landward, has been reduced, greatly diminishing their geomorphological interest. This over-stabilization is also linked to the reduction of the rabbit population through myxamatosis in 1954–1955. During the inter-war years, the Burrows had been heavily disturbed by rabbit warrens. Reports in the local papers describe the need to move the (then) lifeboat house in 1857, 1862, 1882, and 1892 due to burial or erosion in the foredunes area and suggest that instability already existed prior to military use in the 1940s. All this supports Willis *et al*. (1959a) who argued that the dynamic character of the system was not solely a result of the recent military activity.

Probably the most striking change between the 1885 and 1957–1960 surveys was the increase in the area occupied by high dunes. It has been calculated that there was a 35-fold increase in the area of land in the central Burrows exceeding almost 30 m OD over that period (Kidson and Carr, 1960), while in the northern third of the system isolated areas topped the 30 m contour for the first time. The more recent survey by Kidson *et al*. (1989) suggests that this trend had continued up to 1983, with the system as a whole having a positive sediment budget.

Willis *et al*. (1959a) describe the contrast in the soils of Braunton Burrows between the highly calcareous (pH 9) high dunes with their low moisture content, and the gley soils of the often far wetter slacks. While the slacks have a somewhat lower pH, they are still alkaline. Plant cover, which depends upon root depth, water availability and nutrient status, strongly affects the likelihood of aeolian erosion. Water availability to plants depends largely on the depth of sand above the water table. During dry periods, sand more than 0.5 m above the water table has a water content less than 5%, but sand within 0.3 cm of the water table is maintained close to saturation and between 0.3 and 0.5 m above the water-table, capillary action maintains moderately high water-content (Willis, 1985). Fluctuations in the level of the water table are strongly correlated with rainfall (Willis *et al*., 1959a). The combination of a period of lower-than-average rainfall between 1983 and 1992, deepening of the western Boundary Drain at the eastern edge of the Burrows in 1983, and drainage on the golf course, may have led to a general lowering of the water table (Burden, 1997; Packham and Willis, 2001).

It appears that underneath much of the dune system there is a relatively flat bedrock surface at approximately –3 m to –4 m OD, i.e. typically about 10 m below slack level (Figure 7.11). There is some evidence to suggest lower bedrock surfaces not only in the beach–foredune area, but also in parts of the estuary and inland. Keene (1996) suggests that surfaces lie at about –10 m OD below the Burrows either side of the estuary. However, the extreme depths (about –30 m OD) for the nearby estuary bedrock channel suggested by McFarlane (1955) have been disputed by Davies (1983) who suggested –20 m to –21 m OD as more realistic.

A borehole (Figure 7.11) sited in a slack with its floor at about 10 m OD and almost in the centre of the dunes passed through approximately 5 m of sand. Below this level, there were some 4 m mainly of sand, silt and/or clay, but including a 1 m-thick band of soft calcareous sandstone. Underlying these deposits were 2.5 m of marine clay. This, in turn, was underlain by pebbles and sand and then coarse gravel and shale; less than 2 m in total. Bedrock (Culm Measures) was ultimately reached at –3 m OD. Another borehole located at the extreme northern end of the dune passed through head before reaching a landward extension of the emerged ('raised') beach occurring in the cliff sections of Down End, Saunton. Such cliff sections may show remains of an earlier lithified analogue of the present dune system in juxtaposition to the emerged beach. A coastal platform underlies this feature, which is overlain by head. Kidson (1977) regarded the head as Devensian, the emerged beach as Ipswichian.

Interpretation

The history of Braunton Burrows, both recent and long term, raises a number questions about its origins, its long-term stability, its dynamics and resilience during recent decades of disturbance and the relationships between its ecology, geomorphology and hydrology. Packham and Willis (2001) believe Braunton Burrows to be over 2000 years old, but the Quaternary sediments along its northern fringe indicate that a dune system was here in Early Devensian times (Campbell and Gilbert, 1998), i.e. about 70 000 years ago. During the second half of the 20th century, the natural changes in the dunes have been modified by the effects of mine clearance, movements of heavy military vehicles, grazing and alterations to the hydrology.

The evidence of emerged beaches and other sediments along the southern coast of Saunton Down is important for the interpretation of the development of Braunton Burrows. The emerged beach has been the focus of attention since the late 19th century (Sedgwick and Murchison, 1840; Hall, 1870; Hughes, 1887; Stephens, 1966, 1974; Gilbert, 1996). Campbell and Gilbert (1998) have described the shore platform that extends from Saunton to Croyde as one of the finest examples anywhere in Britain. However, its three main surfaces are, as yet, of undetermined age. Erratics, which rest on the platform, indicate an origin earlier than the last glacial period. The presence of calcarenite up to 3 m thick that includes preserved flute features similar to modern wind-sculpted features in the dunes indicates the presence of earlier dunes banked against the rock slopes (Evans, 1912; Keene 1996). The fact that these possible old dunes are overlain by head (Figure 7.11) supports the suggestion of preservation of interglacial dunes but points to the area having had a similar coastal landscape to that of today. The emerged beach sequence at Saunton has been attributed an Early Devensian age (*c.* 70 000 years BP; Campbell and Gilbert, 1998). In contrast to the southern part of the bay at Westward Ho! (see GCR site report in Chapter 6), there has been only limited description of intertidal submerged forest remnants. Rogers (1946) records that an oak trunk 9 m in length was identified at Braunton Burrows in 1630 (Steers, 1946a). However, there is no record of peat beds being exposed in the seaward edge of the dunes and boreholes through the dunes have not yet proved peat. Dating of the dunes has not yet been possible as a result.

Interpretation of the more recent evolution of the site is mainly dependent upon cartographic evidence from the beginning of the 19th century. These show that over the northern two-thirds of the site the position of the foredunes is substantially the same as it was 150 years ago in spite of post-1945 destruction. However, erosion has occurred near the estuary. Sand and gravel extraction in the estuary appears to date from the 18th century or earlier, although cartographic evidence suggests that Crow Point continued to grow until at least the mid-1850s. By 1874 it was necessary to erect the first groynes on Braunton Burrows in the vicinity of the lighthouse. At a public inquiry held in 1905 evidence was given that erosion was such that high tides could virtually reach the lighthouse. Nevertheless, extraction continued to be permitted. During the decade 1960–1970, some 600 000 tonnes of sand and gravel were removed from the Braunton side of the estuary, yet the apparent cause and effect of dune erosion and estuarine extraction were denied. A tracer experiment in 1971 showed that, with waves from the north-west, sediment from Airy Point reached the extraction site at Crow Point. Since that time the Crow peninsula has been breached.

Braunton Burrows, apart from the area near the estuary, thus demonstrates a surprising degree of resilience to disturbance. Many other coastal dune systems were also disturbed by wartime military activity and post-war mine clearance operations and have also recovered, but in general they were less exposed to onshore winds than Braunton Burrows. Since World War II, the general location and breadth of the beach has changed little suggesting that despite sand migration inland there continues to be some replacement from the nearshore zone (Kidson *et al.*, 1989). The progressive expansion of more woody plants over the dunes has also added to their stabilization (Packham and Willis, 2001). It has been suggested (Packham and Willis, 2001) that the ecological significance of the site depends upon management that encourages an increase in biodiversity and this may be achieved by increased levels of sand movement. Similarly, the geomorphological interest will be enhanced by allowing more dynamism to occur. Even with the extraction at the distal point, and the associated erosion, the dunes as a whole appear to have remained in a positive sediment budget unlike some smaller systems such as Dawlish Warren.

Conclusions

Braunton Burrows is one of the three largest dune systems in western Britain, over 6 km in length, up to 1.5 km wide and attaining heights over 30 m. It is not only one of the largest and most complete dune systems on the coastline of England and Wales, but also unusual in its resilience to serious disturbance and its maintained growth. It is also one of the few such areas where changes in the dune topography have been surveyed regularly. Its ecological importance was recognized in 1964 in its designation as a National Nature Reserve, but lack of grazing decreased its nature conservation interest, and it ceased to be an NNR in 1996. Nonetheless, an agreed experimental programme of grazing was established in 1998 and the site retains its SSSI status; it is a candidate Special Area of Conservation. In terms of geomorphological interest, a conservation policy that allows greater sand mobility within the dunes will only serve to enhance its value as a GCR site.

Reference list

Blackley, M.W.L., Carr, A.P. and Gleason, R. (1972) Tracer experiments in the Tor–Torridge estuary with particular reference to Braunton Burrows NNR. Unit of Coastal Sedimentation, Report No. **1972/22**, Nature Conservancy Council, Taunton, 19 pp.
Boorman, L.A. (1993) Dry coastal ecosystems of Britain: dunes and shingle beaches. In Dry Coastal Ecosystems: Polar Regions and Europe (ed. E. van der Maarel), Elsevier, Amsterdam,

pp. 197–228.

Breeds, J. and Rogers, D. (1998) Dune management without grazing – a cautionary tale. Enact: Management for Wildlife, **6**, 19–22.

Burden, R.J. (1997) A hydrological investigation of three Devon sand dune systems: Braunton Burrows, Northam Burrows and Dawlish Warren. Unpublished PhD thesis, University of Plymouth.

Campbell, S. and Gilbert, A. (1998) The Croyde–Saunton Coast. In Quaternary of South-West England (S. Campbell, C.O. Hunt, J.D. Scourse and D.H. Keen), Geological Conservation Review Series, No. **14**, Joint Nature Conservation Committee, Peterborough, pp. 214–24.

Campbell, S., Hunt, C.O., Scourse, J.D. and Keen, D.H. (1998) Quaternary of South-West England, Geological Conservation Review Series, No.**14**, Joint Nature Conservation Committee, Peterborough, 439 pp.

Comber, D.P.M., Hansom, J.D. and Fahy, F.M. (1993) Taw–Torridge Estuary: Coastal Processes and Conservation. Report by the Coastal Research Group, University of Glasgow for English Nature, Peterborough, 61 pp.

Davies, C.M. (1983) Pleistocene rockhead surfaces underlying Barnstaple Bay (SW England). Marine Geology, **54**, M9–M16.

Evans, H.M. (1912) Sand formation against the Saunton Down Cliff, north Devon. Report and Transactions of the Devonshire Association for the Advancement of Science, Literature and Art, **44**, 692–702.

Gilbert, A. (1996) The raised shoreline sequence at Saunton in North Devon. In Devon and East Cornwall (eds D.J. Charman, R.M. Newnham and D.G. Croot), Quaternary Research Association Field Guide, Quaternary Research Association, London, pp. 40–7.

Greenwood, B. (1969) Sediment parameters and environmental discrimination: an application of multivariate statistics. Canadian Journal of Earth Science,**6**, 1347–58.

Greenwood, B. (1978) Spatial variability of texture of a beach-dune complex, North Devon, England. Sedimentary Geology, **21**, 27–44.

Hall, T.M. (1870) The raised beaches and submerged forests of Barnstaple Bay. The Student and Intellectual Observer of Science, Literature and Art,**4**, 338–49.

Hewett, D.G. (1970) The colonization of sand dunes after stabilization with Marram grass (Ammophila arenaria). Journal of Ecology, **58**, 653–68.

Hewett, D.G. (1971) The effects of the cold winter of 1962/3 on Juncus acutus at Braunton Burrows, Devon. Report and Transactions of the Devon Association for the Advancement of Science, Literature and Art, **102**, 193–201

Hope-Simpson, J.F. (1985) Monitoring by photographs on Braunton Burrows: relevance to nature conservation purposes. In Sand Dunes and Their Management (ed. J.P. Doody), Focus on Nature Conservation, No. **13**, Nature Conservancy Council, Peterborough, pp. 175–85.

Hope-Simpson, J.F. (1997) Dynamic plant ecology of Braunton Burrows, southwestern England. In Dry Coastal Ecosystems. General Aspects Ecosystems of the World 2C (ed. E. van der Maarel), Elsevier, Amsterdam, pp. 437–52.

Hope-Simpson, J.F. and Jefferies, R.L. (1966) Observations relating to vigour and debility in marram grass (Ammophila arenaria (L.) Link). Journal of Ecology,**54**, 271–4.

Hope-Simpson, J.F. and Yemm, E.W. (1979) Braunton Burrows: developing vegetation in dune slacks 1948–1977. In Ecological Processes in Coastal Environments (eds R.L. Jeffries and A.J. Davey), Blackwell Scientific Publications, Oxford, pp. 113–28.

Hughes, T.Mck. (1887) On the ancient beach and boulders near Braunton and Croyde, in North Devon. Quarterly Journal of the Geological Society of London,**43**, 657–70.

Keene, P. (1996) Classic Landforms of the North Devon Coast, New edition, Classic Landform Guides, Geographical Association in conjunction with the British Geomorphological Research Group, Sheffield, 48 pp.

Kidson, C. (1964a) The coasts of south and south-west England. In Field Studies in the British Isles (ed. J.A. Steers), Nelson, London, pp. 26–42.

Kidson, C. (1977) The coast of South West England. In The Quaternary History of the Irish Sea (eds C. Kidson and M.J. Tooley), Seel House Press, Liverpool, pp. 267–98.

Kidson, C. and Carr, A.P. (1960) Dune reclamation at Braunton Burrows, Devon. Chartered Surveyor, **93**, 298–303.

Kidson, C., Collin, R.L. and Chisholm, N.W.T. (1989) Surveying a major dune system – Braunton Burrows, north west Devon. Geographical Journal,**155**, 94–105.

McFarlane, P.B. (1955) Survey of two drowned river valleys in Devon. Geological Magazine, **92**, 419–29.

Mitchell, G.F. (1960) The Pleistocene history of the Irish Sea. Advancement of Science, **17**, 313–25.

Prestwich, J. (1892) The raised beaches and 'head' or rubble-drift of the south of England: their relation to the valley drifts and to the glacial period and on a late post-glacial submergence. Quarterly Journal of the Geological Society of London, **48**, 263–342.

Ratcliffe, D.A. (ed.) (1977) A Nature Conservation Review. The Selection of Biological Sites of National Importance to Nature Conservation in Britain. Volume 1, Cambridge University Press, Cambridge, for the Natural Environment Research Council and the Nature Conservancy Council, 401 pp.

Rogers, E.H. (1946) The raised beach, submerged forest and kitchen midden of Westward Ho!, and the submerged stone row of Yelland. Proceedings of the Devon Archaeological Exploration Society, **3**, 109–35.

Sarre, R.D. (1989) Aeolian sand drift from the intertidal zone on a temperate beach: potential and actual rates. Earth Surface Processes and Landforms, **14** (3), 247–58.

Sedgwick, A. and Murchison, R.I. (1840) On the Physical Structure of Devonshire: and on the Subdivisions and Geological Relations of its Older Stratified Deposits. Transactions of the Geological Society of London, Series 2, **5**, 633–703.

Steers, J.A. (1946a) The Coastline of England and Wales, Cambridge University Press, Cambridge, 644 pp.

Stephens, N. (1966) Some Pleistocene deposits in North Devon. Biuletyn Peryglacjalny, **15**, 103–14.

Stephens, N. (1974) Some aspects of the Quaternary of South-West England; Westward Ho!; The Fremington area; North Devon; Hartland Quay and Damhole Point; Chard area and the Axe Valley section. In Exeter Field Meeting, Easter 1974 (ed. A. Straw), Field Handbook, Quaternary Research Association, Exeter, pp. 5–7, 25–7, 28–9, 35–42, 45, 46–51.

Willis, A.J. (1963) Braunton Burrows: the effects on vegetation of the addition of mineral nutrients to the dune soils. Journal of Ecology, **51**, 353–74.

Willis, A.J. (1965) The influence of mineral nutrients on the growth of Ammophila arenaria. Journal of Ecology, **53**, 735–45.

Willis, A.J. (1967) A new location for Liparis loeselii. Proceedings of the Botanical Society of the British Isles, **6**, 352–3.

Willis, A.J. (1985) Dune water and nutrient regimes – their ecological relevance. In Sand Dunes and their Management (ed. J.P. Doody), Focus on Nature Conservation, No. **13**, Nature Conservancy Council, Peterborough, pp. 159–74.

Willis, A.J. (1989) Coastal sand dunes as biological systems. Proceedings of the Royal Society of Edinburgh, **96B**, 17–36.

Willis, A.J. and Jefferies, R.L. (1963) Investigations on the water relations of sand-dune plants under natural conditions. In The Water Relations of Plants (eds A.J. Rutter and F.H. Whitehead), Blackwell Scientific Publications, Oxford, pp. 168–89.

Willis, A.J., Folkes, B.F., Hope-Simpson, J.F. and Yemm, E.W. (1959a) Braunton Burrows: the dune system and its vegetation, Part I. Journal of Ecology, **47**, 1–24.