

Distribution, status and ecology of *Blysmus compressus* (L.) Panz. ex Link on the Sefton Coast sand-dunes, Merseyside

P. H. SMITH*

9 Hayward Court, Watchyard Lane, Formby, Liverpool L37 3QP

ABSTRACT

This paper describes a 2008 survey of the nationally declining *Blysmus compressus* on the Sefton Coast sand-dunes (v.c. 59), where it has been known since 1801. The plant was recorded in 18 sites, occupying over 3000 m², with an estimated total population of 15,000–20,000 individuals. Evidence suggests *B. compressus* has increased here in recent decades, relatively few known sites having been lost. The plant was mainly found in calcareous wet-slacks, though three sites were described as damp grassland. Most localities are of fairly recent origin and have a history of recreation disturbance and grazing, especially by rabbits. A few are winter-grazed by livestock and some are mown annually. Ninety associated vascular taxa were recorded. NVC analysis gave mainly poor to very poor fits to known dune-slack communities (SD15, SD16 and SD17) and two mesotrophic grassland types (MG8 and MG11). The conservation requirements for *B. compressus* are discussed.

KEYWORDS: communities, conservation management, dune-slacks, Ellenberg's indicator values, history, National Vegetation Classification, mowing, population, rabbit-grazing, trampling.

INTRODUCTION

Blysmus compressus (L.) Panz. ex Link (Flat-sedge) (Cyperaceae) is a far-creeping rhizomatous perennial of open vegetation in marshes and fens and in short, sedge-rich, damp grassland, calcareous flushes and stream borders that are subject to flooding, especially on base-rich rocks. The plant is a hemi-cryptophyte and a member of the European temperate flora with a continental distribution in Western Europe, extending as far north as southern Scandinavia and east to Central Asia (Foley & Porter 2002; Hill *et al.* 2004; Jermy *et al.* 2007; Walker 2008). Ellenberg's indicator values in Hill *et al.* (2004) show that this species is a light-loving plant (L = 8), associated with constantly moist to wet soils (F = 8) that are base-rich (R = 8) and relatively infertile (N = 3) and that the plant is absent from saline sites (S = 0).

DISTRIBUTION IN BRITAIN

B. compressus is widespread but localised in Britain. It is recorded for most English counties but in abundance only in the north and west, reaching a maximum elevation of 490 m in Co. Durham (v.c. 66). It is rare in lowland England, though there are still large populations on the Rivers Kennett and Thames. In Wales, this species is confined to a single site in Brecon (v.c. 42), while Scotland has no populations north of the Central Belt. *B. compressus* does not occur in Ireland (Foley & Porter 2002; Walker 2008).

This is one of the most rapidly declining vascular plants in Britain, having been lost from more than half its pre-1930 hectads by 1962 and, subsequently, from 40% of its post-1930 hectads. Its change index since 1962 is -1.28 (Foley & Porter 2002); as a consequence, it is a Red Data listed species in Britain, classified as Vulnerable (Cheffings & Farrell 2005). The plant has become extinct in South Devon (v.c. 03), Kent (v.c. 15; 16), Surrey (v.c. 17), Middlesex (v.c. 21), West Suffolk (v.c. 26), Staffordshire (v.c. 39), Shropshire (v.c. 40), Leicestershire (v.c. 55) and Nottinghamshire (v.c. 56). Similar declines have been reported elsewhere in Europe, for example, in Croatia and Finland (Walker 2008).

DISTRIBUTION IN NORTH WEST ENGLAND

There are no records of *B. compressus* for Cheshire (v.c. 58) (Newton 1971, G. M. Kay *in litt.* 2009) but in South Lancashire (v.c. 59), Savidge *et al.* (1963) record the plant as "occasional, locally common" in dune-slacks and marshes, at intervals along the coast between Hightown and Southport. They mention only one site away from what is now the Sefton Coast; a pasture near the canal at Nelson in 1926, where the plant does not seem to have been recorded since.

The *New Flora of South Lancashire Project* (D. P. Earl *in litt.* 2008) has 23 records of

*e-mail:philsmith1941@tiscali.co.uk

B. compressus from 1851 onwards in hectads SD20, 21, 31 and 39, these being situated along the Merseyside coast from Liverpool to Southport, and SD83 which includes Nelson in eastern Lancashire. In addition, there are 18 sheets of gatherings in the Manchester Museum herbarium (**MANCH**) for localities between Liverpool and Southport, most from the 19th century, the earliest on 17 June 1840 at Bootle, collected by J. B. Wood. The Liverpool Museum herbarium (**LIV**) has two earlier sheets, from 1821, from near Rimrose Bridge, Seaforth (Mr Shepherd; ex. J. Shillito) and 1801, north shore opposite Bootle (ex Liverpool Botanic Garden collection). Both these sites have been destroyed and are in the modern borough of Sefton.

B. compressus has always been rare in West Lancashire (v.c. 60), being confined historically to two nearby sites on the bank of the R. Lune at Wrayton and at the junction of the R. Greta and the Lune. It was also found in dune-slacks at Lytham St. Anne's on the north shore of the Ribble Estuary (Wheldon & Wilson 1907). More recently, the plant has been found in small quantity near these historical localities; in 1980 on Lune ox-bows north of Melling and at two adjacent dune sites at Fairhaven, Lytham, in 1998, one of these being lost to erosion by 2003 (E. F. Greenwood *in litt.* 2008). In the northern part of this vice-county, Livermore & Livermore (1987) describe it as "rare in a wet meadow", where they found only two or three plants. It is not clear whether this is one of the Lune sites. There is also an un-localised record from the "Heysham Peninsula" in the north of the vice-county by G. W. Garlick in about 1957 (E. F. Greenwood *in litt.* 2008).

The Lancashire Biodiversity Action Plan (BAP) considers *B. compressus* to be critically endangered in v.c. 60, being threatened by nutrient enrichment, a lowered water-table and physical disturbance at its coastal locality and vulnerable to drainage, fertiliser run-off and river management works on the R. Lune (Greenwood 2002). The Lancashire Wildlife Trust's *Endangered Plants Project* (E. F. Greenwood *in litt.* 2008) recorded two colonies of the plant in 2003 on Lune ox-bows about 200 m apart, the total population being only about 60 spikes. Due to multiple private ownerships, this area is difficult of access and largely unexplored. Two small colonies were found on the dunes at Ansdell, Lytham St.

Anne's in 2003, the first being lost by 2005. The second site had three spikes in 2007 and 100–200 in 2008 (E. F. Greenwood *in litt.* 2008). This seems to be the one described by Skelcher (2008) as "a good stand" in dune-slack vegetation north of Fairhaven Lake.

B. compressus is much more widespread in Cumbria, with records for 69 tetrads, though Halliday (1997) states that it is nearly confined to a limited area of north Westmorland (v.c. 69), where it is quite frequent in calcareous flushes and marshes and by beck-sides, particularly on ground subject to flooding. A few sites elsewhere include the edge of a salt-marsh near Bowness-on-Solway where some degree of tolerance to salinity is implied, despite the plant having an Ellenberg salinity (S) score of 0.

OCCURRENCE ON THE SEFTON COAST (V.C. 59)

B. compressus has been known from slacks in the Sefton Coast sand-dune system for over 200 years, 19th century herbarium records having already been mentioned. The earliest relevant flora is by Hall (1838) who states: "There are specimens of *B. compressus* in the Herbarium at the Botanic Gardens from the north shore of Liverpool, but I am not aware of it having been found there recently by any botanist." However, only 13 years later, Dickinson (1851) remarks: "Grassy spots on Crosby sandhills, and near Bootle Land Marks, abundant. Also at Formby and Southport". Despite the plant's unassuming appearance, McNicholl (1883) writes in his *Handbook for Southport*: "In parts of the sandhills there are tracts such as are congenial to semi-amphibious plants. Here may be gathered the *Blysmus compressus*." More recently, it is described by Smith (1978) as a plant almost confined to dune slacks within this vice-county and listed as "very local, wet slacks" in a species list for Ainsdale Sand Dunes National Nature Reserve (NNR) (Payne 1982). In the early 1980s, *B. compressus* was known from under 10 sites in the dune system (Smith 1983). Edmondson *et al.* (1993a) mention its presence in a few slacks at Birkdale Sandhills Local Nature Reserve (LNR), Lifeboat Road and Cabin Hill NNR. In a more detailed study of 26 dune-slacks at Birkdale LNR, Smith (2006a) found *B. compressus* in ten of these slacks in 2003, an increase in occurrence from only two slacks twenty years earlier (Smith 1983).

SURVEY RATIONALE

Reflecting its declining national status, *B. compressus* was added to the list of UK Biodiversity Action Plan (BAP) species in 2007 and highlighted for special study in the *BSBI Threatened Plants Project* in 2008 (Walker 2008). It is also listed as a Species of Conservation Importance in North West England (Regional Biodiversity Steering Group 1999). However, recent observations (e.g. Smith 2006a) suggest that, far from declining, this species may actually be increasing on the Sefton Coast. It was therefore thought opportune to investigate its status here in a comprehensive survey. As *B. compressus* is not mentioned in the UK National Vegetation Classification (NVC) and relatively little seems to be known in detail about its habitat requirements (Walker 2008) it was also decided to collect relevant floristic and habitat data.

METHODS

Based on detailed personal knowledge of the dune system and previous reports of survey, all known and likely sites for *B. compressus* were visited in June, July and August 2008. Populations were marked out using bamboo canes, their approximate areas measured by pacing and numbers of plants estimated. National Grid References of locations were determined using a hand-held GPS device. Distribution maps were prepared using the Sefton Coast Geographic

Information System (GIS). For each site, depending on its size, between one and eight samples of representative vegetation were recorded in 2 m × 2 m quadrats using NVC methodology (Rodwell 1991). These were analysed using a modified TABLEFIT programme to determine the degree of fit to known NVC communities and sub-communities (Hill 1996). Notes were also taken on habitat type, condition and current management. The origin and past management of sites was investigated using literature sources, maps and aerial photographs. Details of recently lost sites were investigated through contacts with local botanists and reference to the literature.

RESULTS

DISTRIBUTION OF SITES

Eighteen sites for *B. compressus* were recorded in the dune system (Figure 1). They are highly localised, falling into three distinct groupings; four at Altcar Rifle Range and Cabin Hill NNR in the south, five at Ainsdale-on-Sea, about 8 km to the north, and nine sites in the Birkdale sandhills (including Royal Birkdale Golf Course), another 2.5 km further north (Table 1). They occupy only three tetrads: SD20X, SD31B and SD31C. Despite extensive searches in 2008, no plants of this species were found in ostensibly suitable habitat elsewhere in the dunes, though a few additional historical sites are known and three came to light after the field work was completed (see below).

TABLE 1. *BLYSMUS COMPRESSUS* SITES ON THE SEFTON COAST, 2008

Site	Central Grid Reference (SD)	Habitat	Date of origin (where known)	Area of Colony (m ²)	Estimated population
Altcar Rifle Range "I" range	2888 0462	Damp grassland	After 1924	52	1000+
Cabin Hill NNR Slack 1	2828 0524	Wet-slack	1970/71	1192	10,000
Slack 3	2835 0529	Wet-slack	1970/71	54	100+
Slack 20	2826 0520	Wet-slack	1945-50	336	1000+
Sands Lake, Ainsdale	3013 1282	Damp grassland	After 1911	23	100
Ainsdale frontals Slack 49	3009 1330	Wet-slack	Early/mid 1970s	145	1000+
Slack 50	3007 1315	Wet-slack	Early/mid 1970s	384	100s
Slack 51	3002 1309	Wet-slack	Early/mid 1970s	24	100
Slack 52	3008 1309	Wet-slack	Early/mid 1970s	5	10s
Royal Birkdale pond	3159 1529	Marshy pond edge		6	10s
3rd fairway	3162 1528	Damp grassland		180	100
Birkdale Sandhills Slack 26	3143 1537	Wet-slack	1929	7	100+
Birkdale frontals Slack 27	3134 1524	Wet-slack	Early/mid 1970s	58	100s
Slack 28	3142 1555	Wet-slack	Early/mid 1970s	162	1000+
Slack 30	3202 1631	Dry-slack	Pre-1970	56	100+
Slack 31	3196 1619	Wet-slack	Pre-1969	100	100
Slack 32	3191 1614	Dry-slack	Mid 1970s	63	100s
Slack 33	3193 1614	Dry-slack	1976	170	100s

TABLE 2. WEIGHTED ELLENBERG'S INDICATOR VALUES FOR ASSOCIATES OF
BLYSMUS COMPRESSUS

Taxon	Occ. in 51 quadrats	%	F	R	N	wF	wR	wN
<i>Carex flacca</i>	44	86.3	5	6	2	220	264	88
<i>Trifolium repens</i>	41	80.4	5	6	6	205	246	246
<i>Agrostis stolonifera</i>	36	70.6	6	7	6	216	252	216
<i>Salix repens</i>	35	68.6	7	6	3	245	210	105
<i>Mentha aquatica</i>	30	58.8	8	7	5	240	210	150
<i>Hydrocotyle vulgaris</i>	29	56.9	8	6	3	232	174	87
<i>Festuca rubra</i>	27	52.9	5	6	5	135	162	135
<i>Holcus lanatus</i>	27	52.9	6	6	5	162	162	135
<i>Rubus caesius</i>	24	47.1	7	7	6	168	168	144
<i>Juncus articulatus</i>	21	41.2	9	6	3	189	126	63
<i>Dactylorhiza incarnata</i> ssp. <i>coccinea</i>	17	33.3	9	6	2	153	102	34
<i>Carex arenaria</i>	16	31.4	3	5	2	48	80	32
<i>Equisetum palustre</i>	16	31.4	8	6	3	128	96	48
<i>Prunella vulgaris</i>	16	31.4	5	6	4	80	96	64
<i>Ranunculus repens</i>	16	31.4	7	6	7	112	96	112
<i>Cirsium arvense</i>	15	29.4	6	7	6	90	105	90
<i>Ranunculus acris</i>	15	29.4	6	6	4	90	90	60
<i>Plantago lanceolata</i>	14	27.5	5	6	4	70	84	56
<i>Eleocharis palustris</i>	13	25.5	10	6	4	130	78	52
<i>Galium palustre</i>	13	25.5	9	5	4	117	65	52
<i>Ranunculus flammula</i>	13	25.5	9	5	3	117	65	39
<i>Salix cinerea</i>	13	25.5	8	6	5	104	78	65
<i>Lathyrus pratensis</i>	12	23.5	6	6	5	72	72	60
<i>Carex hirta</i>	11	21.6	7	7	6	77	77	66
<i>Eleocharis quinqueflora</i>	11	21.6	9	7	2	99	77	22
<i>Leontodon autumnalis</i>	11	21.6	6	6	4	66	66	44
<i>Lotus corniculatus</i>	11	21.6	4	6	2	44	66	22
<i>Senecio jacobaea</i>	11	21.6	4	6	4	44	66	44
<i>Potentilla anserina</i>	10	19.6	7	7	6	70	70	60
<i>Rhinanthus minor</i>	10	19.6	5	6	4	50	60	40
<i>Vicia cracca</i>	10	19.6	6	7	5	60	70	50
<i>Bellis perennis</i>	9	17.6	5	6	4	45	54	36
<i>Juncus inflexus</i>	9	17.6	7	7	5	63	63	45
<i>Trifolium pratense</i>	9	17.6	5	7	5	45	63	45
<i>Epipactis palustris</i>	8	15.7	8	7	3	64	56	24
<i>Euphrasia nemorosa</i>	8	15.7	5	6	4	40	48	32
<i>Cardamine pratensis</i>	7	13.7	8	5	4	56	35	28
<i>Lotus pedunculatus</i>	7	13.7	8	6	4	56	42	28
<i>Lythrum salicaria</i>	7	13.7	9	7	5	63	49	35
<i>Taraxacum officinale</i>	7	13.7	5	7	6	35	49	42
<i>Anthoxanthum odoratum</i>	6	11.8	6	4	3	36	24	18
<i>Glaux maritima</i>	6	11.8	7	7	5	42	42	30
<i>Plantago major</i>	6	11.8	5	6	7	30	36	42
<i>Potentilla reptans</i>	6	11.8	5	7	5	30	42	30
<i>Equisetum variegatum</i>	5	9.8	8	8	3	40	40	15
<i>Lolium perenne</i>	5	9.8	5	6	6	25	30	30
<i>Poa pratensis</i>	5	9.8	5	6	5	25	30	25
<i>Cerastium fontanum</i>	4	7.8	5	5	4	20	20	16
<i>Cerastium semidecandrum</i>	4	7.8	3	6	3	12	24	12

TABLE 2 CONTINUED

Taxon	Occ. in 51 quadrats	%	F	R	N	wF	wR	wN
<i>Cynosurus cristatus</i>	4	7.8	5	6	4	20	24	16
<i>Parnassia palustris</i>	4	7.8	8	7	3	32	28	12
<i>Trifolium fragiferum</i>	4	7.8	7	7	6	28	28	24
<i>Triglochin palustre</i>	4	7.8	9	6	2	36	24	8
<i>Carex disticha</i>	3	5.9	8	6	4	24	18	12
<i>Centaurea nigra</i>	3	5.9	5	6	5	15	18	15
<i>Elytrigia repens</i>	3	5.9	5	7	7	15	21	21
<i>Equisetum arvense</i>	3	5.9	6	6	6	18	18	18
<i>Iris pseudacorus</i>	3	5.9	9	6	6	27	18	18
<i>Juncus balticus</i>	3	5.9	8	5	2	24	15	6
<i>Juncus gerardii</i>	3	5.9	7	7	6	21	21	18
<i>Poa humilis</i>	3	5.9	6	6	4	18	18	12
<i>Pulicaria dysenterica</i>	3	5.9	7	7	4	21	21	12
<i>Veronica scutellata</i>	3	5.9	9	5	3	27	15	9
<i>Bolboschoenus maritimus</i>	2	3.9	10	8	7	20	16	14
<i>Carex nigra</i>	2	3.9	8	4	2	16	8	4
<i>Carex viridula</i> ssp. <i>viridula</i>	2	3.9	7	7	3	14	14	6
<i>Centaureum erythraea</i>	2	3.9	5	6	3	10	12	6
<i>Dactylorhiza fuchsii</i>	2	3.9	8	7	3	16	14	6
<i>Epilobium hirsutum</i>	2	3.9	8	7	7	16	14	14
<i>Leontodon saxatilis</i>	2	3.9	5	6	3	10	12	6
<i>Pastinaca sativa</i>	2	3.9	4	7	5	8	14	10
<i>Phragmites australis</i>	2	3.9	10	7	6	20	14	12
<i>Poa annua</i>	2	3.9	5	6	7	10	12	14
<i>Sagina procumbens</i>	2	3.9	6	6	5	12	12	10
<i>Tussilago farfara</i>	2	3.9	6	6	6	12	12	12
<i>Agrostis capillaris</i>	1	2.0	5	4	4	5	4	4
<i>Calystegia silvatica</i>	1	2.0	5	7	6	5	7	6
<i>Cirsium vulgare</i>	1	2.0	5	6	6	5	6	6
<i>Dactylis glomerata</i>	1	2.0	5	7	6	5	7	6
<i>Dactylorhiza praetermissa</i>	1	2.0	8	7	3	8	7	3
<i>Epilobium obscurum</i>	1	2.0	8	5	5	8	5	5
<i>Epilobium palustre</i>	1	2.0	8	5	3	8	5	3
<i>Equisetum fluviatile</i>	1	2.0	10	6	4	10	6	4
<i>Eriophorum angustifolium</i>	1	2.0	9	4	1	9	4	1
<i>Filipendula ulmaria</i>	1	2.0	8	6	5	8	6	5
<i>Glechoma hederacea</i>	1	2.0	6	7	7	6	7	7
<i>Lycopus europaeus</i>	1	2.0	8	7	6	8	7	6
<i>Rosa rugosa</i>	1	2.0	3	6	3	3	6	3
<i>Sonchus arvensis</i>	1	2.0	6	7	6	6	7	6
Totals	798					5144	4905	3394
Means			6.25	6.25	4.37	6.45	6.15	4.25

F = moisture; R = reaction; N = nitrogen; w = weighted



FIGURE 1. Locations of *Blysmus compressus* on the Sefton Coast, 2008.

POPULATION SIZES

Estimated areas of colonies range from 1192 m² at Cabin Hill slack 1 to 5 m² at Ainsdale slack 52, the total extent being 3017 m² (Table 1). Due to time limitations, only approximate estimates were made of plant numbers. These range from under 100 spikes at Ainsdale slacks 51 and 52 to about 10,000 at Cabin Hill slack 1. Other large populations, with 1000 or more spikes, were recorded at Altcar Rifle Range, Ainsdale slack 50, Ainsdale slack 49 and Birkdale slack 28 (Table 1). Overall, a conservative estimate for the total Sefton Coast population of *B. compressus* is 15,000–20,000 plants.

HABITATS

Most Sefton Coast sites for *B. compressus* are dune slacks that have formed secondarily by wind-erosion or by sand-winning and have a seasonally fluctuating water-table. Following Ranwell's (1972) criteria, 11 are considered to be wet-slacks, flooded during the winter, and three dry-slacks, rarely holding water. All seem to accord with the Type B slack of Davy *et al.* (2006), this being a precipitation-fed slack in which water is lost by evaporation. A small colony at Royal Birkdale Golf Course is associated with the edge of a pond, while three sites (at Altcar Rifle Range, Ainsdale Sands Lake and Royal Birkdale) were categorised as damp grassland (Table 1).

The ground profile of dune-slacks often leads to different degrees of wetness from dry around the edges to semi-aquatic in the centre; at some sites this seemed to influence the distribution of *B. compressus*. For example, at Cabin Hill slack 1, the plant occupies a zone between damp conditions to the north, with much *Salix repens*, and semi-aquatic vegetation to the south dominated by *Equisetum fluviatile*. It was also noted that, within several sites, *B. compressus* plants were often concentrated in areas where the vegetation was somewhat suppressed or altered by recreational trampling or rabbit (*Oryctolagus cuniculus*) -grazing or both; for example, on the surfaces or along the edges of lightly-used informal footpaths. Such areas often show a reduced frequency of *S. repens*, a dominant plant in many Sefton Coast dune-slacks (Gateley & Michell 2004). The flower spikes of *B. compressus* were often seen to stand proud of grazed vegetation, suggesting that rabbits may avoid the plant. At a few of the more heavily trampled sites, *B. compressus* plants were suppressed, being only a few cm

tall; however, in most wet-slacks, the populations consisted of vigorous, strongly flowering individuals, some stems attaining a height of 50 cm at Birkdale slack 28, compared to the 45 cm maximum cited in Jermy *et al.* (2007).

Soil characteristics have been documented for some of the *B. compressus* sites. Smith (1983; 1984) studied soil profiles at eight of the Ainsdale-Birkdale slacks. Two are described as peaty-gleys, the others being ground-water gleys. pH values range from 7.0 to 8.8 at 3–5 cm depth and 6.9 to 8.9 at 10–15 cm, reflecting the base-rich nature of the parent material which has about 5% calcium carbonate derived from intertidal mollusc shells (Smith 2009). Such slack soils throughout this dune system have been included in the Greatstone Series defined by the Soil Survey of England & Wales, a general account of their characteristics on the Sefton Coast being given by James (1993).

ORIGIN AND MANAGEMENT OF SITES

At the southernmost site on Altcar Rifle Range, *B. compressus* is confined to wet grassland at the northern edge of "I" range, where it was first found in 2008. "I" range seems to have been laid out when the ranges were rebuilt in 1923/24 (Cook 1989). This area was added to the Altcar Sand Dunes & Foreshore Site of Special Scientific Interest (SSSI) in 1986 and subsumed into the Sefton Coast SSSI in 2000. It has been managed by mowing, this being delayed until late summer (after 15 July) since SSSI designation. Some limited rabbit-grazing may occur but this species is controlled and has low populations at Altcar.

At Cabin Hill, the slacks occupied by *B. compressus* are of fairly recent origin. Slack 20 was created by sand-winning, during the 1940s and early 1950s, which removed the largest sand-dune on this part of the coast down to the water-table. Because of a perceived threat to coast protection, a planning application for further sand removal was refused in 1952 (Crosby 2007). Slacks 1 and 3, the former now supporting the largest colony of *B. compressus* found during the study, were formed in 1970/71 when the then Mersey & Weaver River Authority constructed a 780 m-long barrier bank to act as a secondary sea-defence. The slacks are shallow borrow-pits, in the earlier sand-quarry floor, from which material to build the bank was extracted (Smith 2007a). *B. compressus* was first recorded at Cabin Hill in July 1979 in slack 20, from which it has apparently spread to the adjacent sites, being

noted in slack 1 in July 2003 and slack 3 in June 2008 (personal observations). Edmondson *et al.* (1988/89) also mention its presence in a Target Note for slack 20 in their comprehensive NVC survey of the dune system.

This area was leased as a National Nature Reserve in 1984 (declared 1991). During the 1970s and 1980s, sporadic grazing by small numbers of cattle and horses took place but, since 1992, the reserve has been managed by extensive winter-grazing using Herdwick sheep. There is also a large rabbit population, though only slack 3 is heavily rabbit-grazed. Slack 1 was mowed on four occasions in the 1990s and willow (*Salix*) scrub was removed in 1989 and 1990 (Smith 2007b).

The Sands Lake, Ainsdale site is difficult to date accurately but this dune area developed after the Southport & Cheshire Lines Extension Railway was built along the foreshore in 1884 (Smith 1983). The lake itself was dug by hand in 1911, the surrounding area being subject to high levels of recreational disturbance thereafter. The *B. compressus* site, of which the current population is a small relict, was first recorded in July 1979 as “a large colony of *Blysmus* at the north end of the lake” (personal observations). It was also documented in a 1988 Target Note as “Rich strip along well-used area between Sands Lake and tall mixed scrub to east. Short, dense sward has *Carex flacca*, *Blysmus compressus*, *Lolium perenne*, *Trifolium repens* etc.” (Edmondson *et al.* 1988/89). Since then, dense scrub, especially of *Hippophae rhamnoides*, together with a tall herbaceous sward of *Epilobium hirsutum* etc., has overtaken much of the site, *B. compressus*, being restricted to a 1 m-wide zone of short, weedy turf on the edge of a carpark. Here, it is subject to trampling and, probably, some rabbit-grazing. There is no formal conservation management.

To the west and north-west of Sands Lake, slacks 49, 50, 51 and 52 were formed by wind-erosion as recently as the mid 1970s when the water-table was exceptionally low and levels of recreational trampling high. Thus, they were not mapped as wet-slacks by Smith (1978) during a comprehensive survey of dune wetlands. However, by 1983, they were well-established and mapped as “incipient” (i.e. immature) wet-slacks (Smith 1983). Twenty years later, they were listed as “mature wet-slacks” (Smith 2006a). *B. compressus* has been known in slack 50 since the 1990s and was recorded in slacks 49, 51 and 52 during Smith’s (2006a) study. In slacks 51 and 52 and, to a lesser

extent in slack 50, *B. compressus* is largely confined to lightly-used informal footpaths.

This area of dunes was added to the Birkdale Sandhills LNR in 1983. Conservation management has concentrated on control of *H. rhamnoides* which spread rapidly through the slacks in the late 1980s and 1990s. From 1995, this invasive shrub was progressively removed by cutting and stump treatment, followed by herbicide spraying of young regrowth. In addition, slack 49 has been mown annually since 1996, with removal of arisings. There is no livestock grazing but rabbits are present in moderate numbers.

Royal Birkdale Golf Course was established in the sand-dunes in 1889, the pond on the southern edge of which *B. compressus* is currently found, has been present since at least 1945 (Smith 1983; 2009). The plant was first recorded here in a permanent 2 m × 2 m quadrat established in 1998 at site “I” “east of an open water-body in a damp area with lush vegetation”, being still present in 2006 (Butcher *et al.* 2006). The damp grassland east of the pond, which supports most of the *B. compressus* colony, was scrub-cleared in November 1996 and has been managed since by annual mowing in September using a tractor-mounted flail-mower with all arisings removed (C. Whittle *in litt.* 2009). There is little or no rabbit-grazing as this species is controlled on the course.

Recently, P. S. Gateley (*in litt.* 2009) drew attention to the discovery of *B. compressus* at another site on Royal Birkdale Golf Course (site “K”, SD31061528), a large wet hollow on the western side of the course between the tee and green of the 12th hole. The plant was identified for the first time in July 2008 in a permanent quadrat that had been recorded several times since 1998 using NVC methodology. This site has received the same management as slack “I”.

Just to the west of the golf course, Birkdale slack 26 was formed after the above mentioned railway line was built in 1884, Smith (1984) suggesting that it probably dates to about 1929. Aerial photographs show that it was mature and fully vegetated in 1945. *B. compressus* was first noted here in 1982 during a study of *Juncus balticus* (Smith 1984). At that time, it was more abundant in the northern part of the slack than at present, the plant now being restricted to lightly-used footpaths through the generally rank vegetation, which is not grazed by rabbits (personal observations). This slack is within the Birkdale Sandhills LNR and was subject to scrub-control in 1987 and 2001 (Smith 2007b).

Also at the northern end of the Birkdale Sandhills is a series of six frontal-dune slacks (nos. 27, 28, 30, 31, 32, 33) all of which have *B. compressus* colonies. Most of them were dated by Smith (1984) to the early/mid 1970s, though slacks 30 and 31 were thought to be a few years older. *B. compressus* was originally found here in July 1980, growing in slack 31 with *Juncus balticus*, etc. (personal observations). During the period 1978–1982, most of these slacks were churned up by illegal motorcycle scrambling (Smith 1984) but, in 1983, the frontal-dunes were added to the Birkdale Sandhills LNR and wardening introduced to control this activity. Edmondson *et al.* (1988/89) include Target Notes indicating the occurrence of *B. compressus* in slacks 27 and 31. By 2003, the plant was present in all six slacks (Smith 2006a).

Conservation management of these slacks has mainly concentrated on the control of *H. rhamnoides* which became increasingly dominant during the 1980s and early 1990s. The slacks were scrub-cleared progressively from no. 27 in 1996 to no. 30 in 2003, with subsequent annual control of regrowth (Smith 2006a; 2007b). All the slacks have well-used informal footpaths, many of which support *B. compressus*. Slack 32, in particular, is heavily trampled and rabbit-grazed, with a very short sward.

LOST SITES

Herbarium records suggest that *B. compressus* was much more widespread on the Merseyside coast in the nineteenth and early twentieth centuries; however, building development in north Liverpool, Bootle, Crosby, Formby, Ainsdale, Birkdale and Southport destroyed about 40% of the dune system (Smith 2009) and no doubt many sites were lost. Within recent memory, only three dune sites for *B. compressus* are known to have disappeared, either wholly or in large part. One was a small wet-slack at Lifeboat Road, Formby Point (SD277066), created by post-Second World War sand-winning, where the plant was recorded as “abundant” in 1978. This site was soon lost to dense poplar (*Populus*) scrub (personal observations). The Ainsdale Sand Dunes NNR archive contains a “Rare Plant Species Location Map” drawn up by K. R. Payne in 1976. It records *B. compressus* in slack 4 (SD284105), part of the Massams Slack complex near the sea, this having been subsequently lost to coastal erosion and sand-blow (A. Kimpton *in litt.* 2008). Finally, the

Sands Lake, Ainsdale site (SD302129), described above, has largely been destroyed by vegetation maturation, including the development of dune-scrub and a tall herbaceous sward.

Literature searches following the completion of field work identified two additional sites for *B. compressus* recorded in Target Notes by Gateley & Michell (2004). These are at slack 8, Altcar Rifle Range (SD285050), and slack 13, Birkdale Sandhills LNR (SD305135), in wet-slack vegetation on the margins of scrapes dug for nature conservation purposes in 1976 and 1977 respectively (Smith 1978). While both these sites have been visited since 2004 for purposes of biological recording, the presence of *B. compressus* was not suspected and it may therefore have been overlooked. Therefore, the continuing presence of the plant cannot be entirely ruled out.

ASSOCIATED VASCULAR PLANTS

Ninety vascular taxa were found associated with *B. compressus* in the 51 quadrats recorded for NVC analysis. These are listed, together with their frequency of occurrence and Ellenberg’s indicator values in Table 2. *Equisetum × litorale*, with eight occurrences, is omitted from the Table as no Ellenberg values are available for this taxon (Hill *et al.* 2004). The most ubiquitous species (with over 20 occurrences) are *Agrostis stolonifera* (36 occurrences), *Carex flacca* (44), *Festuca rubra* (27), *Holcus lanatus* (27), *Hydrocotyle vulgaris* (29), *Juncus articulatus* (21), *Mentha aquatica* (30), *Rubus caesius* (24), *Salix repens* (35) and *Trifolium repens* (34). All these taxa are characteristic of dune slacks on the Sefton Coast (Smith 2009; 2006a). Ten of the associates are notable, two (*Dactylorhiza incarnata* ssp. *coccinea* and *Juncus balticus*) being Nationally Scarce and eight (*Carex disticha*, *C. viridula* ssp. *viridula*, *Eleocharis quinqueflora*, *Epipactis palustris*, *Equisetum variegatum*, *Parnassia palustris*, *Trifolium fragiferum* and *Triglochin palustre*) ranked as Species of Conservation Importance in North West England (Regional Biodiversity Steering Group 1999).

Table 2 gives Ellenberg’s indicator values for moisture (L), reaction (R) and nitrogen (N) for vascular taxa associated with *B. compressus*. These have been weighted to take into account their frequency of occurrence. The weighted mean values (6.51, 6.21 and 4.30 respectively) indicate that the taxa favour constantly moist soils that are weakly acid to

TABLE 3. TABLEFIT ANALYSIS OF QUADRAT SAMPLES

Site (no. of samples)	NVC code	Community	Sub-community	% fit	Match
Altcar (3)	MG11a	<i>Festuca rubra</i> - <i>Agrostis stolonifera</i> - <i>Potentilla anserina</i> grassland	<i>Lolium perenne</i>	57	Poor
Cabin Hill 1 (8)	SD15	<i>Salix repens</i> - <i>Calliargon cuspidatum</i> dune slack		46	Very poor
Cabin Hill 3 (3)	SD17	<i>Potentilla anserina</i> - <i>Carex nigra</i> dune slack		49	Very poor
Cabin Hill 20 (3)	SD15	<i>Salix repens</i> - <i>Calliargon cuspidatum</i> dune slack		51	Poor
Sands Lake (3)	MG11a	<i>Festuca rubra</i> - <i>Agrostis stolonifera</i> - <i>Potentilla anserina</i> grassland	<i>Lolium perenne</i>	52	Poor
Ainsdale 49 (3)	SD16d	<i>Salix repens</i> - <i>Holcus lanatus</i> dune slack	<i>Agrostis stolonifera</i>	55	Poor
Ainsdale 50 (3)	SD15	<i>Salix repens</i> - <i>Calliargon cuspidatum</i> dune slack		47	Very poor
Ainsdale 51 (1)	No sample				
Ainsdale 52 (1)	SD16b	<i>Salix repens</i> - <i>Holcus lanatus</i> dune slack	<i>Rubus caesius</i>	58	Poor
Royal Birkdale pond (3)	No sample				
Royal Birkdale fairway (3)	MG8	<i>Cynosurus cristatus</i> - <i>Caltha palustris</i> grassland		60	Fair
Birkdale 26 (3)	SD16b	<i>Salix repens</i> - <i>Holcus lanatus</i> dune slack	<i>Rubus caesius</i>	41	Very poor
Birkdale 27 (3)	SD16d	<i>Salix repens</i> - <i>Holcus lanatus</i> dune slack	<i>Agrostis stolonifera</i>	52	Poor
Birkdale 28 (3)	SD16d	<i>Salix repens</i> - <i>Holcus lanatus</i> dune slack	<i>Agrostis stolonifera</i>	47	Very poor
Birkdale 30 (3)	SD17b	<i>Potentilla anserina</i> - <i>Carex nigra</i> dune slack	<i>Carex flacca</i>	27	Very poor
Birkdale 31 (3)	SD16b	<i>Salix repens</i> - <i>Holcus lanatus</i> dune slack	<i>Rubus caesius</i>	54	Poor
or	SD16d	<i>Salix repens</i> - <i>Holcus lanatus</i> dune slack	<i>Agrostis stolonifera</i>	54	Poor
Birkdale 32 (3)	SD17b	<i>Potentilla anserina</i> - <i>Carex nigra</i> dune slack	<i>Carex flacca</i>	36	Very poor
Birkdale 33 (3)	SD16	<i>Salix repens</i> - <i>Holcus lanatus</i> dune slack		31	Very poor

weakly basic in reaction and have intermediate fertility (Hill *et al.* 2004). Recalculation of weighted means, for ubiquitous taxa only, gives closely similar values (6.41, 6.29 and 4.36).

NVC COMMUNITIES

Table 3 lists TABLEFIT results for 51 quadrats supporting *B. compressus*. In almost all cases, the statistical fits to known NVC communities are "poor" to "very poor", only one (Royal Birkdale Golf Course) having a "fair" level of agreement with MG8 (*Cynosurus cristatus*-*Caltha palustris* grassland).

As expected, vegetation at most sites equates to dune-slack communities, seven being SD16 (*Salix repens*-*Holcus lanatus* dune-slack), three SD15 (*Salix repens*-*Calliargon cuspidatum* dune-slack) and three SD17 (*Potentilla anserina*-*Carex nigra* dune-slack). The *Salix-Holcus* community is characteristic of older and dryer calcareous dune slacks, rarely flooded to any great extent, and often subject to grazing by livestock and/or rabbits. Two sub-communities, SD16d (*Agrostis stolonifera* sub-community) and SD16b (*Rubus caesius* sub-community) were indicated by the analysis, the

former being found in wetter conditions (Gateley & Michell 2004; Rodwell 2000). SD15 also occurs in older slacks but is associated with more prolonged flooding. As in the case of SD16, it is widely distributed nationally and is frequent on the Sefton Coast (Gateley & Michell 2004; Rodwell 2000). Being especially associated with northern dune systems, SD17 is found in damp or wet slacks in which the water is less base-rich, perhaps due to accumulation of organic matter. This slack type is relatively rare on the Sefton duneland (Gateley & Michell 2004; Rodwell 2000).

Three sites apparently support mesotrophic grassland communities, two MG11 (*Festuca rubra*-*Agrostis stolonifera*-*Potentilla anserina* grassland) (at Altcar Rifle Range and Sands Lake) and one MG8 (*Cynosurus cristatus*-*Caltha palustris* grassland) (at Royal Birkdale Golf Course). A rare community on the Sefton sand-dunes, MG11 is a damp grassland type that seems to take the place of slack vegetation in a few disturbed and nutrient rich areas (Gateley & Michell 2004). MG8 is species-rich vegetation characteristic of periodically inundated land, usually managed as pasture and often associated with traditional water-meadows (Rodwell 1992). This community seems out of place here and was not recorded during Gateley & Michell's (2004) NVC survey of the Sefton dunes. Indeed, the Royal Birkdale site was recorded as the rather similar MG5 (*Cynosurus cristatus*-*Centaurea nigra* grassland) or MG5a (*Lathyrus pratensis* sub-community) by Butcher *et al.* (2006). This is a typical grassland of traditionally grazed hay-meadows on heavy textured lowland soils (Rodwell 1992) and is also an unlikely community to find on sand-dunes.

DISCUSSION

It seems clear that the status of *B. compressus* on the Sefton sand-dunes has changed in recent decades. It was recorded in 18 sites during the present study, having been known from under 10 sites in the early 1980s. This is, of course, a species that is easily overlooked but the fact that Smith (2006a) found an increase in occurrences from two to ten dune-slacks in careful studies at Birkdale over a 20-year period suggests that this apparent change is genuine. A continuing increase is suggested by the discovery of *B. compressus* for the first

time in 2008 in a permanent quadrat on Royal Birkdale Golf Course that has been recorded regularly since 1998. In view of the plant's rapid national decline, these are encouraging findings. Furthermore, only two known sites have been completely lost since the 1970s, one to coastal erosion and another to scrub development, while another (at Sands Lake) has shown a major decline in *B. compressus* due to maturation of the vegetation.

Most sites for, and the largest colonies of, *B. compressus* are in calcareous wet-slacks (*sensu* Ranwell), soils being gleys or peaty gleys with a fairly high pH. This accords with habitat descriptions in the rather limited literature on the ecology of this species (e.g. Burkmar 2008; Foley & Porter 2002; Halliday 1997; Walker 2008). Marshy, seasonally-flooded, base-rich sites are said to be favoured, conditions which apply in these slacks. However, small to medium-sized populations were also found in dry-slacks and damp grassland, most surprisingly in the heavily disturbed, weedy fringe of a carpark at Sands Lake, Ainsdale, suggesting that the plant can persist for some time under sub-optimal conditions.

There is a tendency for *B. compressus* populations to be associated with informal footpaths through slack basins, where vegetation height is much reduced, perhaps as a consequence of mechanical damage and, probably, enhanced rabbit-grazing. Plant composition may also be altered; for example, *S. repens* is often reduced in frequency or eliminated from such footpaths, a fact that may well be important for the survival of *B. compressus*, since dominance by *S. repens* is considered to reduce plant species richness (Edmondson *et al.* 1993b). These findings also imply that *B. compressus* is tolerant of grazing and trampling damage.

A majority of the Sefton Coast sites for *B. compressus* appears to be of recent origin. This applies particularly to the wetland supporting the largest population at Cabin Hill and the slacks in the Ainsdale and Birkdale frontal dunes, all of which are less than 40 years old (Table 1). In some cases, it has been possible to date the first appearance of *B. compressus* to about 10 years after slack formation. There are a few ostensibly older sites but here the plant is favoured either by human trampling, grazing or mowing, these maintaining a shorter, more open sward. This supports the suggestion that the plant is a poor competitor (Walker 2008) and is therefore likely to decline, in the absence

of management, as slacks age and become colonised by ranker vegetation (Davy *et al.* 2006; Smith 2009). It is interesting that *B. compressus* survived and even increased in the northern Birkdale frontal slacks after these were severely damaged by motor-cycling in the late 1970s and early 1980s; this activity created large areas of bare ground and provided sites for colonisation, not only by *B. compressus* but also *Juncus balticus* at what was, by then, its only English location. Smith (1984; 2006b) concludes that *J. balticus* is a good coloniser of young, sparsely vegetated wet-slacks and may then persist for many years before declining as the habitat becomes dryer and more heavily vegetated. These conclusions seem also to apply to *B. compressus*.

Although, *B. compressus* is currently well-established and locally abundant on the Sefton sand-dunes, its populations are highly localised, confined to only three tetrads and therefore vulnerable. Bearing in mind that this dune system is particularly well-endowed with wet-slacks (Smith 1978) and supports about 39% of all the dune-slack vegetation in England (Radley 1994), it is perhaps surprising that the plant is not more widespread here. Thus, the large expanses of Ainsdale Sand Dunes NNR (339ha) and Ainsdale Sandhills LNR (88ha), both with extensive slack habitat, appear to be devoid of *B. compressus* populations. However, many of the large slacks in these areas originated over a century ago (Smith 1978) and are densely clothed in *S. repens*. Such habitat seems to be unsuitable for *B. compressus* which is mainly found in young and/or disturbed sites.

B. compressus grows here with a high diversity of associated vascular plants (90 taxa), many being characteristic of wet-slacks. However, analysis of Ellenberg's indicator values shows that, on average, the associates are adapted to slightly dryer, less basic and more fertile sites than *B. compressus*. This suggests that requirements for the latter species may be more taxing than for other wet-slack vascular plants, a finding which may also help to account for its restricted distribution in the dune system.

B. compressus is not mentioned by Rodwell (1991; 1992; 2000) and there is little published information on plant communities favoured by this species, though Walker (2008) gives some examples. Thus, in vice counties 80 (Roxburghs.) and 81 (Berwicks.), most colonies occur in a distinct habitat of short turf on a shelf below the level of stream banks. Here typical

associates include *Agrostis capillaris*, *Anthoxanthum odoratum*, *Cirsium palustre*, *Cynosurus cristatus*, *Eleocharis palustris*, *Festuca rubra*, *Bellis perennis*, *Geum rivale*, *Lychnis flos-cuculi*, *Poa* sp., *Ranunculus repens* and *Trifolium repens*; nine of these also being associated with *B. compressus* in Sefton. A typical NVC community of *B. compressus* sites in the uplands of northern England is M10 (*Carex dioica*-*Pinguicula vulgaris* mire) (Walker 2008), a calcareous flush vegetation in which small sedges predominate and which is often maintained in an open condition by grazing and trampling of large herbivores (Rodwell 1991). In southern and eastern England, *B. compressus* occurs in species-rich fen meadows, including MG8 (*Cynosurus cristatus*-*Caltha palustris* grassland) and M23 (*Juncus effusus*/*acutiflorus*-*Galium palustre* rush-pasture) (Walker 2008). The former is found on seasonally-flooded, flat or slightly sloping land by rivers and streams and was managed traditionally as pasture for cattle and horses, sometimes as water-meadow (Rodwell 1992). MG8 was unexpectedly recorded at the Royal Birkdale site during the present study. The *Juncus*-*Galium* community is especially characteristic of ill-drained and relatively unimproved or reverted pasture in the cool and rainy lowlands of western Britain; here it is maintained by grazing or, much more rarely, by mowing (Rodwell 1991). Typical associates in both these types include *Carex acutiformis*, *C. flacca*, *C. disticha*, *C. panicea*, *Cirsium dissectum*, *Dactylorhiza incarnata*, *D. praetermissa*, *Eleocharis uniglumis*, *Filipendula ulmaria*, *Lychnis flos-cuculi* and *Persicaria hydropiper* (Walker 2008), five of these being listed as associates of *B. compressus* on the Sefton Coast (Table 2).

Almost all the samples taken during this study are poor or very poor fits to known NVC communities. Similar results were reported for several of the Birkdale sites by Smith (2006b). Samples taken in 1981/82 in slacks 26, 27, 30, 31 and 33 show mostly poor to very poor levels of fit, while those recorded in 2004 for slack 27 range from very poor to fair. Similarly, Butcher *et al.* (2006) report very poor to fair fits to MG5 at the Royal Birkdale site (their slack "T") between 1998 and 2006. A possible explanation is that the vegetation of these and most other Sefton sites for *B. compressus* has a recent origin and has been disturbed by several factors, including recreational activities, grazing, mowing and scrub removal. This might result in samples failing to match known

NVC communities because the vegetation is still maturing with respect to species ingress. However, low matches are likely to be as spurious as useful (P. S. Gateley *in litt.* 2009). For example, slack "I" at Royal Birkdale is clearly neither a traditional water-meadow nor a hay-meadow but a form of dune-slack, albeit somewhat atypical.

CONSERVATION

All current sites for *B. compressus* on the Sefton Coast are protected by SSSI/Natura 2000 designations. Those at Cabin Hill lie within a National Nature Reserve, while apart from Royal Birkdale Golf Course, the Ainsdale and Birkdale sites benefit from Local Nature Reserve status. The plant is proposed for inclusion in the North Merseyside BAP.

The present study reinforces opinion (e.g. Burkmar 2007) that habitat management favouring the plant will include maintaining the hydrology of sites, avoiding eutrophication and preventing the over-maturation and coarsening of swards. The fact that the plant seems to have increased recently suggests that current Sefton Coast conservation management, including late-summer mowing (Altcar Rifle Range, Ainsdale slack 49 and Royal Birkdale), livestock-grazing (Cabin Hill) and scrub control (most sites) is being successful. Additionally, light to moderate recreational trampling and rabbit-grazing seem to be important in helping to maintain open swards and reduce dominance of slack vegetation by *S. repens*. Scrub control on the duneland has concentrated mainly on *H. rhamnoides* but attention may also need to be given to the larger willows, such as *S. cinerea*, which are slowly colonising some of the *B. compressus* sites.

Long-term studies of Sefton dune hydrology provide no convincing evidence of water-table decline, though modelling the impact of climate change suggests adverse impacts could be seen within a few decades (Clarke & Sanitwong-Na-Ayuthaya 2006). Also of concern is eutrophication by aerial deposition of nitrogen. Gateley & Michell (2004) report recent reductions in

the areas of oligotrophic vegetation types on the Sefton duneland, implying enrichment is taking place, perhaps partly from this source. Over the last 30–40 years, many British dune systems, including the Sefton Coast, have become more stable and heavily vegetated. Meanwhile, atmospheric N deposition in Europe has approximately doubled (Jones *et al.* 2004). The latter authors show a positive relationship between N inputs and above-ground biomass and a negative relationship with plant species-richness in mobile and fixed dunes, though the trends are less clear in dune-slacks. They suggest a critical load range of 10–20 kgNha⁻¹yr⁻¹ for coastal dunes in the UK.

As *B. compressus* seems to be largely absent from mature dune-slacks, management that promotes dune dynamics, including dune formation and localised blow-out development will assist the creation of suitable new habitat in the medium to long-term. The recent development of Birkdale Green Beach, a 60ha strip of salt-marsh, sand-dune, dune-slack and swamp communities on the foreshore between Birkdale and Ainsdale (Smith 2007c), provides potential future habitat for *B. compressus*, although only the related *B. rufus* has been recorded there to date.

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