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The distribution, status and conservation of *Juncus balticus* Willd. in England

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ABSTRACT

In England, *Juncus balticus* is now restricted to a small area of the Merseyside sand-dune system at Birkdale. Here it has spread from a known three sites in 1970 to ten in 1982. This seems to be associated with the availability of new wet-slack habitat and disturbance due to public pressure.

The history of the plant in Lancashire and Merseyside is reviewed and its present habitat is described. New information is presented on the occurrence of two *J. balticus* hybrids, one of which is endemic to these counties. The conservation of these rare plants is discussed.

INTRODUCTION

Baltic Rush, *Juncus balticus* Willd., is a local plant of sand-dune slacks and other damp, sandy places, largely confined in Britain to the coasts of north and north-eastern Scotland and the Hebrides. Its world distribution includes parts of North and South America and the Far East, together with countries bordering the North Sea in Western Europe, the Faroe Islands and Iceland. In England, the species is found only in one small area of sand-dunes at Birkdale, Merseyside. There are also old records for Lancashire and the Furness coast, Cumbria.

Two extremely rare hybrid rushes, *J. balticus* × *J. inflexus* and *J. balticus* × *J. effusus* also occur in the Merseyside and Lancashire dunes, the former being endemic to this area (Stace 1972).

The presence of this small, isolated Baltic Rush population at the southern limit of its range, together with its hybrids, is of considerable scientific interest and also poses special conservation problems. Indeed, Stace (1970) predicted the extinction of *J. balticus* at Birkdale ". . . in the fairly near future". Recent observations, however, show that, far from declining during the past decade, the rush has increased considerably, colonising new sites. The two hybrids are still present, though one no longer occurs in a 'wild' state.

It was therefore considered opportune to investigate the recent change of status of *J. balticus* in its only English locality and to gather up-to-date information on the status of the two hybrids and discuss the conservation of these rare plants in the North-west.

THE DISTRIBUTION OF *J. BALTICUS* IN BRITAIN

Baltic Rush has a northern distribution in Great Britain and does not occur in Ireland. It has been recorded in 61 10-km grid squares in Scotland (46 after 1930) (Perring & Walters 1962). Most of these are coastal sites in the north, north-east as far south as Fife, and in the Hebrides. There is a pre-1930 record for square 34/26 in v.c. 69b (Furness) but Stace (1972) considers that the record is dubious. No herbarium material is available and it has not been possible to establish the circumstances of the discovery.

A second English locality at Ansdell, Lytham-St Annes, Lancashire, v.c. 60, (GR/34333.276) has been more thoroughly documented. The plant was discovered by E. S. Marshall on 10th August 1914 (Marshall 1915). Two specimens were collected at the time and further material was preserved by H. E. Bunker in 1947. Surprisingly, this is referable to var. *pseudo-inundatus* rather than the type variant found elsewhere in Britain (Marshall 1915; Stace 1972). In 1946, the colony was described as "abundant in one damp spot in the dunes" (Whellan 1948) but it was destroyed early in 1965, during

the construction of school tennis courts, and the plant has not appeared since on the Fylde coast (E. F. Greenwood pers. comm.)

Godwin (1975) mentions an outlier of *J. balticus* in Somerset but the most recent Flora of that county (Roe 1981) has no record of the plant. Thus, it would seem that the only existing English colony of *J. balticus*, and the most southerly in Britain, is at Birkdale sand-dunes, S. Lancs.,v.c. 59. The history of the plant in this area is described below.

THE HISTORY OF *J. BALTICUS* AT BIRKDALE

R. S. Adamson is credited with the discovery of *J. balticus* at Birkdale on 29th May 1913 in "one series of dune hollows in the fixed dunes." The habitat was "permanently damp but not really swampy" (Adamson 1913). Associated species included *Angallis tenella, Blackstonia perfoliata, Carex panicea, C. serotina, Centaurium littorale, Equisetum variegatum, Juncus articulatus, Parnassia palustris, Sagina nodosa* and *Scirpus setaceus*. This suggests an open damp-slack community, probably representing a fairly early stage in vegetation succession.

Wheldon (1914) undertook a thorough search in July 1914, concluding that the species was restricted to the small area in which it was originally found. The exact position of this colony is now

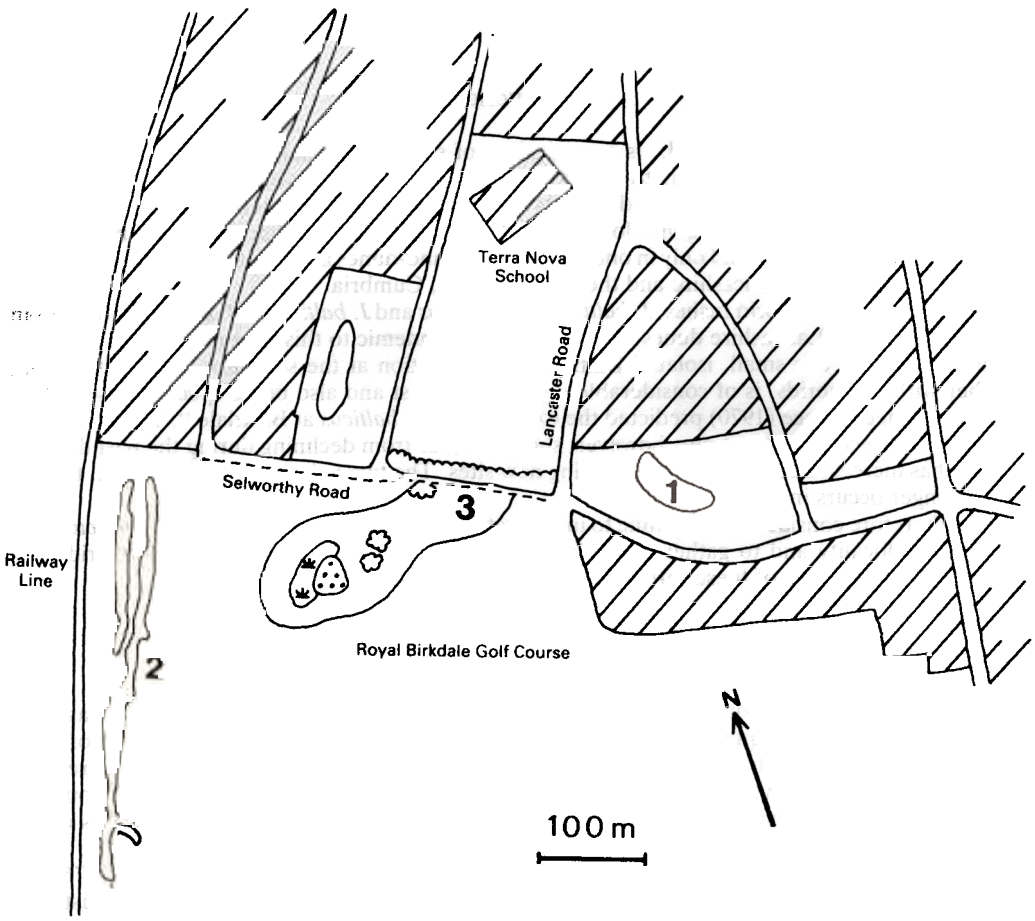

FIGURE 1. Putative locations of the earliest *Juncus balticus* sites in the Selworthy Road area of Birkdale dunes. Outline based on 1945 air photographs. Hatching indicates the extent of built development in 1928. Golf course pond stippled.
1: Adamson's 1913 slack. 2: Travis's "Hillside" site. 3: Holder's 1949 locality.

difficult to determine as the early descriptions are vague and do not include sketch maps. However, clues are available in unpublished manuscripts and letters held in LIV, from Ordnance Survey maps of 1911 and 1928 and air photographs taken in 1945.

F. W. Holder apparently visited Adamson's original site on 19th June 1928, recording in his diary: "There is a large basin in the angle and at the rear of the Terra Nova School in Lancaster Road. Near the bank in this basin Reg (Wagstaffe) showed me the baltic rush. It was frequent there but there were no tufts. In a more distant part we found a large colony in flower . . ."

By 1944, the rush had disappeared from this locality but the slack still existed despite considerable expansion of housing development in the area. Holder's diary entry for 8th July 1944 reads: "On the road back I realised that it is now some years since I last looked at the *Juncus balticus*, so we turned down bumpy Selworthy Roady where the N.E. flank has the large hollow famous to a few Lancs. botanists. We made a thorough search and came to the conclusion that the rush is extinct in its old station. Botanists have not exterminated it; the creeping willow and dried up ground are responsible."

Stereoscopic examination of 1945 air photographs reveals that two ostensibly suitable dune slacks were present just north of Selworthy Road (Fig. 1). The slacks lay east and west, respectively, of the Terra Nova School playing fields, the latter having been a mapped feature since at least 1911. The vegetation tone of these slacks indicates that they were not particularly wet, nor heavily colonised by scrub. J. N. Frankland (pers. comm.) has recently confirmed that *J. balticus* did indeed occur in the eastern slack. He remembers seeing the plant there in 1926 during a visit with F. W. Holder, J. D. Massey, W. G. Travis and R. Wagstaffe. This must surely have been Adamson's (1913) locality.

By 1965, housing development had claimed these slacks but, fortunately, the rush had already appeared in new sites. Thus, W. G. Travis, who first visited Adamson's site in 1913, also records in his manuscript Flora: "A patch in another slack near the Cheshire Lines Railway at Hillside, July 1929." The most likely candidate for this site is a long, narrow wet-slack immediately east of the former railway line. *J. balticus* was also recorded here by V. Gordon in 1961 (Savidge *et al.* 1963), by Stace (1972) and during the present study (site 7, Fig. 2). The use by Travis of the term "Hillside" reflects the more southerly position of this slack, Hillside being a settlement just south of Birkdale.

Holder visited Birkdale dunes again on 22nd June 1949 and discovered another colony. He wrote: "For the next hour or so we examined the marsh flora around the pond on the Birkdale links. Returning to the N.E. side of the pond and while following the barbed wire fence to find a wider gap, we spotted a moderate-sized rush just within the fence. I exclaimed, 'Why it looks like our old friend *J. balticus*'. So we collected two stems of it for examination at the weekend." The identity was later confirmed.

This locality can be pinpointed fairly accurately because the pond referred to still exists at the northern end of the Royal Birkdale Golf Course, just south of Selworthy Road (Fig. 1). The area north-east of the pond appears on the 1945 air photographs as open, damp-slack vegetation. Now, however, it consists mainly of dense *Hippophae* and *Populus* scrub and the rush no longer occurs here, although it is present nearby in the marsh surrounding the pond.

In 1969/70 Stace (1972) knew of three colonies. His "locality 7" was the site recorded by Travis and by Gordon south of Selworthy Road. About 1 km to the north, his "locality 6" consisted of two colonies west of the former railway line. It is not known who found the first of these but it is thought to date back to at least the late 1930s (V. Gordon pers. comm.). The site was visited by N. A. Robinson (pers. comm.) in 1968. He noted many *J. balticus* plants widely scattered over a thinly vegetated, wind-eroded area in which the water-table was near the surface. This colony was almost completely destroyed in 1968 during the construction of a roundabout for the new coastal road between Ainsdale and Birkdale which follows the route of the old railway line. Robinson searched the area again in 1969, finding a new colony about 50 m south-west of the old one, on the seaward side of the road (Stace 1972).

PRESENT DISTRIBUTION OF *J. BALTICUS* AT BIRKDALE

I visited the Birkdale dunes in 1977, 1978 and 1980, noting the presence of *J. balticus* at several sites in addition to those described by Stace (1972). During the summers of 1981 and 1982, a thorough search was made and the positions of all colonies were mapped. In the latter summer, the area of

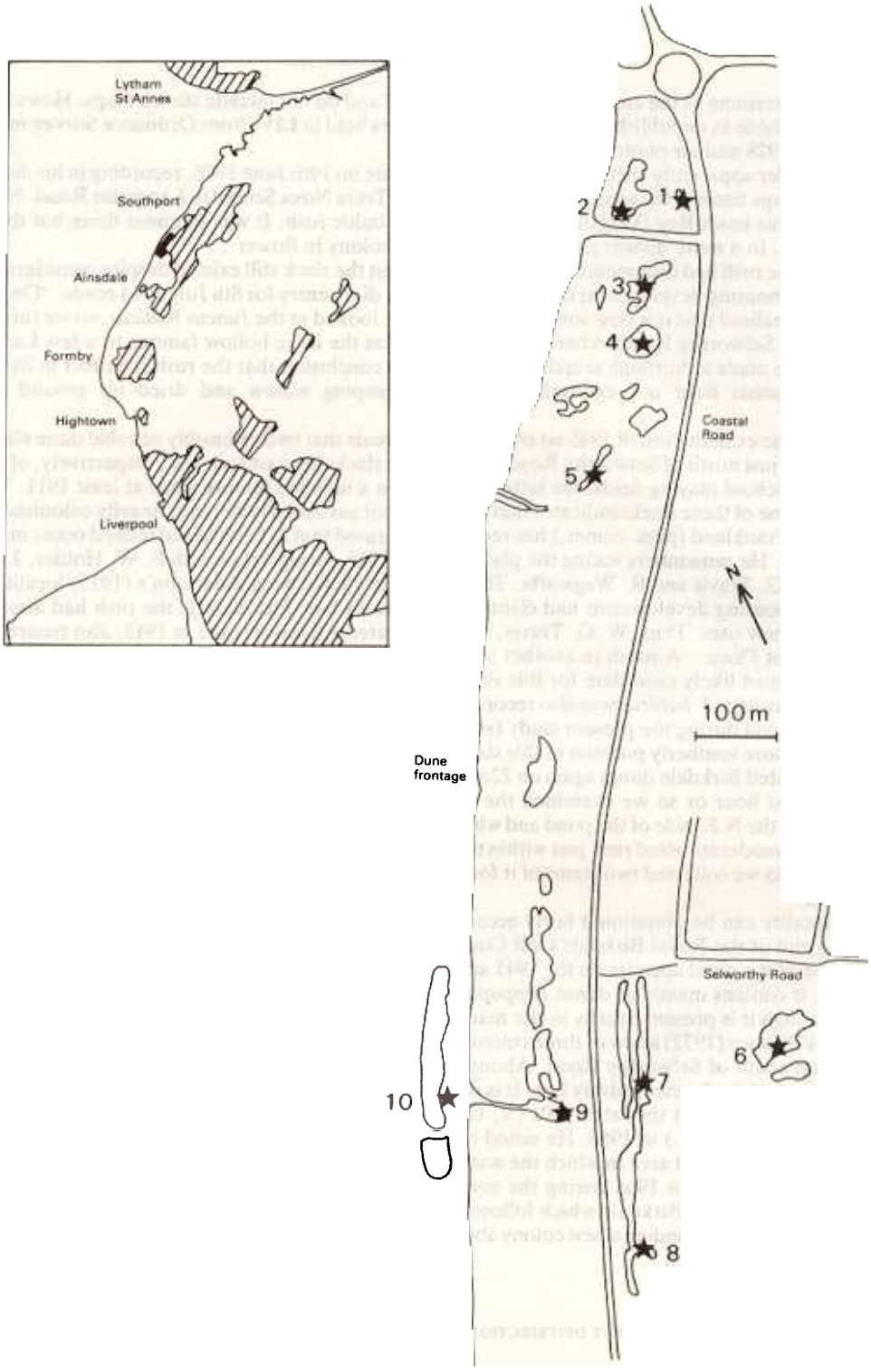

FIGURE 2. Locations of the ten *Juncus balticus* sites recorded in 1982 at Birkdale. Slack outlines and other features based on 1980 1:5,000 scale air photographs.
Inset: position of the study area (shaded). Built-up area hatched.

each rush patch was estimated by measuring two diameters, and maximum shoot height was noted for individual patches. In each slack occupied by the rush, a representative sample of vegetation and soil was described using the methods recommended for the National Vegetation Classification (Anon. 1979).

The positions of the ten colonies found are shown in Fig. 2. They form two groups. The northern group (sites 1 to 5) lies to the west of the coastal road. Site 1 contains a remnant of the colony destroyed in 1968 when the road was constructed. About 75 m to the west is a single patch of the rush in a dry slack (site 2). This may also be a survivor of the original colony. The large colony in site 3 is that discovered by N. A. Robinson in 1969. Sites 4 and 5 seem to be post-1970 colonisations, as Stace (pers. comm.) did not find them during his searches of the area in 1969 and 1970.

The southern group (sites 6 to 10) surrounds the long-established colony in Stace's "locality 7" (my site 7). V. Gordon (pers. comm.) notes that, in 1961, sites 7 and 8 were more or less contiguous but the rush has gradually decreased at site 8 since then.

The other colonies, sites 6, 9 and 10, apparently represent a recent expansion in range to the east and west. The *J. balticus* plants in the marsh around the golf course pond (site 6) are perhaps 100–200 m from Holder's 1949 station "within the wires" and the nearest existing colony to that of Adamson (1913).

Rozema (1979) has shown that for several tussock- or patch-forming *Juncus* spp., including *J. balticus*, a relation can be established between a patch's size and its age. Rozema's study area in Holland was relatively homogeneous, the populations were of known age and there was little intra- or inter-specific competition. These conditions do not prevail at Birkdale; nevertheless patch size may give some indication of site antiquity and the rate of colonisation, especially when linked to evidence from air photographs.

Patch measurements at Birkdale are summarised in Table 1. The largest one found (35.5 m^2) is in site 7, a locality which probably dates back to 1929. This slack also contains the largest area of the rush (60.7 m^2). Site 3 contains the next largest patch (10 m^2) and total area (59.7 m^2), the colony being already well-established when found in 1969. The single large patch (4 m^2) in site 2 may also be of pre-1970 origin. The golf course marsh (site 6) contains two patches, one of which is large (5.1 m^2). This colony was not found by Stace and seems to be a recently established patch growing in particularly favourable conditions.

All the other localities support very small patches which seem to have a recent origin, with the exception of sites 1 and 8. Both are old sites where the plant has regressed.

Sites 4 and 10 can be accurately dated from air photographs and personal observations. Site 4 arose from a dune blow-out which was bare of vegetation in 1976. When I visited it in 1977, there was one small patch of *J. balticus*, the slack being very sparsely vegetated. By 1982, there were 32 patches of the rush, the original one covering 2 m^2, the others being very small.

Site 10 originated behind a recently-formed embryo dune ridge on the foreshore. Plants began to colonise the slack in 1978. One *J. balticus* patch was found in 1980 and this covered an area of 0.3 m^2 by 1982.

TABLE 1. DISTRIBUTION AND SIZE OF *J. BALTICUS* PATCHES AT BIRKDALE IN 1982

Site no.	No. of patches	Total area (m^2)	Largest patch (m^2)	Estimated time of establishment
1	1	0.8	0.8	late 1930s
2	1	4.0	4.0	pre-1970
3	17	59.7	10.0	pre-1969
4	32	4.9	2.0	1976
5	1	0.3	0.3	post-1970
6	2	5.5	5.1	post-1970
7	13	60.7	35.5	ca. 1929
8	2	0.8	0.7	ca. 1929
9	1	0.7	0.7	post-1970
10	1	0.3	0.3	1978

TABLE 2. SOIL AND HABITAT TYPE IN THE TEN *J. BALTICUS* SITES

Site no.	Habitat	Soil type	pH at depth 5 cm	pH at depth 15 cm
1	Dry-slack	Pararendzina	7.8	8.1
2	Dry-slack	Ground-water gley	7.4	6.9
3	Wet-slack	Peaty gley	7.0	7.5
4	Wet-slack	Ground-water gley	8.0	8.1
5	Wet-slack	Ground-water gley	7.1	8.0
6	Semi-aquatic	Peaty gley	7.6	7.5
7	Wet-slack	Peaty gley	7.6	8.0
8	Wet-slack	Peaty gley	7.9	8.0
9	Wet-slack	Peaty gley	7.8	8.0
10	Semi-aquatic	Ground-water gley	8.1	8.1

THE HABITAT OF *J. BALTICUS* AT BIRKDALE

Table 2 summarises soil profile information for the ten sites. All lie within 400 m of the coast, the relatively alkaline soils being attributable to the high calcium carbonate content of these dune sands. Profile pHs range from 7.0 to 8.1 at 5 cm depth and 6.9 to 8.1 at 15 cm.

J. balticus was found only in basin sites but water-table conditions ranged from dry-slack to semi-aquatic, according to Ranwell's (1972) criteria. Soil type also varies between sites, reflecting the differences in water-table and the age of the slacks. Site 1 shows a pararendzina profile with little indication of gleying. Ground-water gleys occur at sites 2, 4, 5 and 10, reducing conditions being particularly prevalent at site 10 which has the wettest profile. Peaty gleys were found at sites 3, 6, 7, 8 and 9, these being older slacks in which up to 7 cm of organic matter has had time to accumulate.

These variable edaphic conditions were also reflected in the diverse vegetation types in which *J. balticus* was found. Table 3 summarises the data obtained by sampling the vegetation in the ten sites. Totals of 61 vascular and nine bryophyte species were identified in 2 m × 2 m samples. The most common associates of *J. balticus* are *Agrostis stolonifera* (present in 9 samples), *Carex flacca* (5), *Dactylorhiza incarnata* (4), *Eleocharis quinqueflora* (4), *Equisetum palustre* (4), *Festuca rubra* (6), *Juncus articulatus* (8), *Lotus corniculatus* (6), *Salix repens* (7), *Trifolium pratense* (5) and *T. fragiferum* (4). Apart from the last, which is distinctly local, all are common slack species in Merseyside.

TABLE 3. RELATIVE FREQUENCY, USING THE DOMIN SCALE OF ABUNDANCE, OF PLANTS IN 2 × 2 M SAMPLES AT THE TEN *J. BALTICUS* SITES. NOMENCLATURE FOLLOWS SAVIDGE *ET AL.* (1963) AND SMITH (1978)

	2	3	4	5	6	7	8	9	10
Salix cinerea									
Salix × *friesiana*	3								
S. repens	4	4		1		4	3		
Agrostis stolonifera	4	5		5	5	5	4	5	8
Apium nodiflorum									?
Aster tripolium									
Bellis perennis				2					
Blysmus compressus									
Carex arenaria									
C. flacca		3	6						
C. serotina									
Carlina vulgaris									
Cerastium holosteoides									
Cirsium arvense	?								

TABLE 3 (*continued*)

	2	3	4	5	6	7	8	9	10
Dactylorhiza incarnata	1	1		1		1			
Eleocharis quinqueflora			8	9			7	3	
Epipactis palustris							2		
Equisetum arvense	2			2					
E. palustre					1	1	1	1	
E. variegatum							2	1	
Euphrasia nemorosa				1			2		
Festuca rubra	9	9	4	2		7	4		
Galium palustre					3				
Glaux maritima		1							
Holcus lanatus	3			3		5			
Hydrocotyle vulgaris					1			1	
Hypochoeris radicata		1							
Juncus articulatus		1	2	1	2	2	1	1	3
J. balticus	1	3	2	2	2	2	2	1	3	2
J. bufonius				1					4	1
Lathyrus pratensis	4								
Leontodon autumnalis				1		1	1		
L. taraxacoides		1		1			1		
Lolium perenne									1
Lotus corniculatus	1	3	4		1		1	2		
Mentha aquatica						2			1	2
Myosotis caespitosa									1	1
Parnassia palustris					1			2		
Pastinaca sativa	1									
Plantago lanceolata	2				1		1	1		
P. major		2			1					
Poa pratensis			1				1			
Polygonum amphibium									1	
Potentilla anserina						1				
Prunella vulgaris								5		
Pulicaria dysenterica								1		
Pyrola rotundifolia								2		
Ranunculus acris	1									
Rhinanthus minor							1		1	
Rubus caesius	1									
Rumex crispus										1
Sagina nodosa									1	
Scirpus maritimus						8			1	1
Senecio jacobaea	1	1								
Taraxacum officinale		1			1					
Trifolium fragiferum			2	1	2				2	
T. pratense			3		2		5	3	1	
T. repens	1	5	5		2					
Triglochin maritima										2
T. palustris						1			1	
Tripleurospermum maritimum										1
Amblystegium serpens					1					
Bryum algovicum var. *rutheanum*								6		
B. pseudotriquetrum					1					
Calliergon cuspidatum			3		3	9		1		
Campylium chrysophyllum									2	
C. stellatum								1		
Drepanocladus fuscus						5				
Pellia endiviifolia					4					
Riccardia pinguis								4		
Bare ground			1	4	1			1		5

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A small number of associates indicates the proximity of the sea, being characteristic of maritime or sub-maritime habitats. These are *Aster tripolium* (1), *Glaux maritima* (1), *Scirpus maritimus* (3) and *Triglochin maritima* (1).

Examination of phytosociological affinities shows that some samples are characteristic of dune slack communities, while others approach upper salt-marsh vegetation types (J. Rodwell pers. comm.). Samples 1, 3 and 7 are consistent with the *Salix repens-Holcus lanatus* community, an important type in west-coast dune systems. Within this type, samples 1 and 7 fit the driest and most species-poor sub-community, dominated by mixtures of *S. repens, H. lanatus, Festuca rubra* and *Agrostis stolonifera.* In contrast, sample 3 is from one of the wetter sub-communities of winter-wet and summer-dry slacks, characterised by *Calliergon cuspidatum* and *Trifolium repens.*

Samples 2, 4, 5, 8 and 9 contain little *Salix repens* and seem to be referable to the *Juncetum gerardi* (Adam 1981), a diverse association usually found on the upper levels of sandy salt-marshes in the north and. west but also sometimes in dune slacks. The tall *Festuca rubra* sub-community is represented by sample 2, while the others probably belong in the *Carex flacca* sub-community, consisting of species-rich grassland, typically on the tidal limit but with non-tidal affinities. Areas of broken ground on flushed sites often contain *Eleocharis quinqueflora*, as in the Birkdale samples.

Although sample 10 could also belong to the *Juncetum gerardi*, its dominant, *Agrostis stolonifera*, is often the major species of a rather ill-defined vegetation type of freshwater and brackish seepage-lines, puddled inland pastures, etc. This is the *Agrostis stolonifera-Alopecurus geniculatus* inundation community, to which sample 10 probably belongs.

Sample 6 is readily attributed to the *Scirpetum maritimi*, a widely distributed halophytic swamp/fen community dominated by *Scirpus maritimus*, often with an understory of *Agrostis stolonifera.*

TABLE 4. SUMMARY OF INFORMATION ON NATURALLY OCCURRING CLONES OF *JUNCUS BALTICUS* HYBRIDS

Locality & Grid Reference	Habitat	Date found	Approx. area of clone (m^2)	Fate
J. balticus × *effusus*				
Ainsdale 34/298.126	Wet-slack	1933	800 (1966)	Destroyed by holiday camp development, 1968
Hightown 34/297.033	Dry-slack	1966	0.02 (1966) 0.5 (1970)	Covered by bulldozed sand, 1974
Hightown 34/296.029	Upper shore	1973	1.0 (1975)	Washed away by high tides, 1980/81
J. balticus × *inflexus*				
Lytham-St Annes 34/313.300	Wet-slack	1966	50 (1966) 138 (1982)	
Birkdale 34/306.140	Wet-slack	1951	400 (1970) 450 (1982)	
Ainsdale 34/281.099	Wet-slack	1950/52	225–400 (1970) 300 (1982)	

BALTICUS HYBRIDS – PRESENT DISTRIBUTION AND STATUS

Stace (1972) described in detail the circumstances surrounding the discovery of the two hybrids *J. balticus* × *J. effusus* and *J. balticus* × *J. inflexus* on the coast between Liverpool and Blackpool. He recognised two sites for the former at Ainsdale and Hightown and three for the latter at St Annes-on-Sea, Birkdale and Ainsdale (Table 4).

Since Stace's study, one new clone of the *effusus* hybrid has been recorded. It was found at Hightown in 1973 by E. F. Greenwood, growing in a brackish marsh community on the upper shore dominated by *Phragmites australis* and *Scirpus maritimus*, together with some *Juncus gerardii* and *Glaux maritima*. The clone was similar morphologically (C. A. Stace pers. comm.) to the clump found by V. Gordon in 1966 in a Hightown dune-slack some 300 m to the north-east. Unfortunately, Gordon's clone was lost in 1974 when contractors working on a new housing estate bulldozed sand over the site (C. A. Stace pers. comm.).

By 1975, Greenwood's clone was flourishing and occupied an area of about 1 m^2. However, it was judged to be threatened by coastal erosion and, in January 1977, eight rhizome fragments were transplanted to the nearby Altcar Rifle Range by the Lancashire Trust for Nature Conservation. The original clump was washed away by high tides during the 1980/81 winter and I have been unable to find the plant since at Hightown. The only other known patch of the *effusus* hybrid was destroyed in 1968 during the construction of a holiday camp at Ainsdale. This, too, was transplanted but the hybrid now no longer occurs in the 'wild' state.

In contrast, the three clones of the *inflexus* hybrid still exist as vigorous, spreading patches in wet slacks (Table 4). The Birkdale clone was damaged in 1975 when a shallow pond was excavated, in error, in the slack occupied by the rush. About 20% of the patch was destroyed but it has continued to expand, invading the margins of the pond and even the fixed dune slopes around the slack. This plant exhibits spectacular hybrid vigour with shoots commonly 1.8 m high, reaching a maximum of 2 m at Ainsdale. The St Annes clone differs morphologically from the other two (Stace 1972), most shoots being about 1 m tall, with a maximum of 1.35 m (M. Jones pers. comm.).

THE CONSERVATION OF *J. BALTICUS* AND ITS HYBRIDS

Past destruction of parts of the English *J. balticus* population and some hybrid clones is attributable to building development and coastal erosion. In recent years, further losses have been largely prevented by statutory designation of dune habitat as nature reserves and by positive conservation management, such as transplanting from threatened sites.

Of the Birkdale sites for *J. balticus*, numbers 7 and 8 are within the Ainsdale & Birkdale Hills Local Nature Reserve (LNR). Site 6 is on the Royal Birkdale Golf Course but is not threatened by course management operations. The other sites are in the strip of dunes west of the coastal road. This area is not part of the LNR but its status is currently under review.

All the clones of the *inflexus* hybrid are on statutorily protected land, specifically the Lytham-St Annes LNR, the Ainsdale & Birkdale Hills LNR and the Ainsdale Sand Dunes National Nature Reserve (NNR).

Apart from the NNR and the golf course, all the areas mentioned are open to the general public on foot, and trampling, together with the unauthorised riding of horses and motor-cycles, has damaged the vegetation in several slacks occupied by *J. balticus* (Smith 1981). However, as discussed later, this may not be a threat to the plant.

Table 5 presents information on the known transplants of *J. balticus* and its hybrids from threatened sites. Some transplantation attempts in the past were not fully documented. Thus, Stace (1972) mentions a herbarium note by W. G. Travis, dated 28th October 1913, in which it is stated that rhizomes and seeds of *J. balticus* were scattered ". . . in a large slack nearer to Ainsdale where it is less likely to be disturbed". Nothing is known about the results of this operation.

Attempts to transplant *J. balticus* from Birkdale to the Ainsdale NNR seem to have been unsuccessful, whereas most of the hybrid transplants have taken. Once established, both hybrids appear to compete well with other vegetation and most of the patches have grown steadily (Table 5). The most successful transplant sites seem to be wet-slacks with sparse vegetation. Losses have occurred from the margins of an excavated pond, where a rise in the dune water-table has resulted in

TABLE 5. SUMMARY OF INFORMATION ON *JUNCUS BALTICUS* AND HYBRID TRANSPLANTS

Site of transplant & Grid Reference	Habitat	Origin of material	Date of transplant	Patch area 1982 (m^2)	Fate
J. balticus × *effusus*					
NNR Large Pond 34/303.112	Aquatic	Ainsdale	1976		Died out
NNR Slack 15 34/287.106	Wet-slack	Ainsdale	1968	37	
NNR Slack 15 34/287.107	Dry-slack	Ainsdale	1968		Died out
NNR Slack 56 34/291.113	Semi-aquatic	Ainsdale	1978	0.1	Extant
NNR Slack 118 34/286.107	Dry-slack	Ainsdale	1968	21	Extant
Altcar Rifle Range 34/286.050	Wet-slack	Hightown foreshore	1977		
J. balticus × *inflexus*					
NNR Large Pond 34/303.112	Aquatic	Birkdale	1976	2	Extant
NNR Slack 15 34/287.106	Wet-slack	Birkdale	1968	14	Extant
NNR Slack 4 & 5 34/285.105/7	Wet-slack	Birkdale	1967		Died out
J. balticus					
NNR Slack 4 & 5 34/285.105/7	Wet-slack	Birkdale	1967		Died out
NNR Large Pond 34/303.112	Aquatic	Birkdale	1971		Died out

the transplants becoming almost permanently inundated, and from mature wet-slacks where competition may have hindered establishment of transplants.

Living material from the various clones of both hybrids has been cultivated in a number of botanical gardens, including those of the Universities of Leicester, Liverpool, Manchester, Oxford and Sheffield, as well as at Kew. At Leicester, the hybrids grow as well as *Juncus inflexus* and better than *J. effusus* or *J. balticus* (C. A. Stace pers. comm.).

DISCUSSION

The origin of the *Juncus balticus* population at Birkdale, so far from its Scottish localities, can only be a matter for conjecture. Adamson (1913) remarked that the plant appeared to be "perfectly native", there being no reason to suspect a recent introduction. Stace (1972) argued that it was probably a recent immigrant because of the restricted distribution of the colonies and the absence of records before 1913. He suggested sea-borne rhizomes as a means of invasion. The fact that Adamson's colony was about 600 m inland casts doubt on this idea and it is quite possible that the plant was simply overlooked, having long been a member of the dune flora but highly localised.

The history of the rush at Birkdale during the present century suggests that it is a good coloniser of young, sparsely vegetated dune slacks and that it may then persist for several decades before declining as the habitat becomes drier and more heavily vegetated. Thus, Travis's "Hillside" slack could not have existed before 1884 when the Southport and Cheshire Lines Extension Railway was built along the upper foreshore, isolating an area of beach to form the slack. *J. balticus* was recorded there in 1929 and 1961 but, although the plant is still well-established (site 7), it has apparently declined at the southern end of the slack (site 8) compared with its status in the late 1960s.

The most recent colonisations have been mainly in the strip of dunes formed since 1884 to the west of the former railway line. Air photographs show that, with the exception of site 1, the slacks in which the rush now occurs did not exist in 1945. They were excavated by wind erosion, a process that accelerated in the early 1970s when an extremely low dune water-table permitted further wind-scouring of basin sites. Since 1973, the mean water-table has risen by about 80 cm (K. R. Payne pers. comm.), thereby producing suitably wet conditions for *J. balticus* establishment.

J. balticus produces rather sticky seeds which germinate readily (C. A. Stace pers. comm.). It may therefore be no coincidence that the recent expansion of the plant at Birkdale has accompanied a substantial increase in informal public recreation along this stretch of coastline. On summer weekends up to 10,000 cars are parked on the beach between Ainsdale and Southport (Metropolitan Borough of Sefton 1982) and the adjacent dunes and slacks contain a well-developed network of informal footpaths. That pedestrians have played an important role in spreading *J. balticus* is suggested by the fact that patches of the rush in sites 5 and 9 are situated on much-used footpaths, while the distribution of patches in the long-established sites 7 and 8 is closely related to the footpath network in that slack. The new colonies in sites 9 and 10 presumably originated from seeds or rhizome fragments carried across the coastal road from site 7 on a popular route to the beach from Selworthy Road (Fig. 2).

Another important dispersive agency may have been unauthorised and illegal motor-cycle scrambling which has taken place in the dunes since about 1970 (Smith 1981). Site 4 has been particularly affected by this activity in the past five years, during which the number of *J. balticus* patches has increased from one to 32. The rush displays considerable resistance to mechanical damage, surviving in some areas where other vegetation has mostly been destroyed. However, in such sites, the individual plants are suppressed, maximum shoot height being 17–40 cm, compared with 46–100 cm in untrampled localities.

Juncus balticus is still restricted to a small part of an otherwise large dune system. However, its recent increase, ability to colonise and persist in a wide variety of slack types and its apparent resilience to public pressure indicate that it should survive as an interesting and important component of the Merseyside sand-dune flora in the foreseeable future.

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