Changes in the floristic composition of sand-dune slacks over a twenty-year period

P. H. SMITH*

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

ABSTRACT

The aim of this study was to compare vascular plant species-richness and composition in 26 dune-slacks in Birkdale Sandhills, Merseyside during 2003 with the results of a similar survey conducted in 1983. A total of 213 taxa was recorded, as opposed to 150 in 1983, a 42% increase. There is a significant positive correlation between the number of taxa per slack in the two surveys and a significant relationship between species-richness and slack area in both years.

Thirty-six notable taxa were recorded in 2003, an 80% increase on the 20 found in 1983. Fifteen taxa have undergone major increases in frequency, while seven, particularly maritime species, show major declines.

The reasons for these changes are discussed and recommendations made for the conservation of the slack flora.

KEYWORDS: compositional change, conservation, dune-slacks, notable taxa, species richness.

INTRODUCTION

In 1983, Sefton Metropolitan Borough Council commissioned a report from the Lancashire Trust for Nature Conservation (now the Lancashire Wildlife Trust) on the ecology of the Birkdale frontal dunes, a narrow strip of sand-dunes 4·23 km long and 120 to 215 m wide, west of the coastal road between Ainsdale and Birkdale (SD322164–SD300122). This dune area was subsequently added to the Birkdale Sandhills Local Nature Reserve.

The report (Smith 1983) drew particular attention to the slacks within the study area. These were considered to have special conservation interest, being rich in vascular plants, including many uncommon or rare species. In addition, several of the slacks were used for breeding by the endangered Natterjack Toad (*Bufo calamita*).

Having mapped the study area using aerial photographs, the 26 slacks present were searched for vascular plants in June and July 1983, the richest supporting 78 taxa. Fifteen slacks were considered to have an "incipient" character; i.e. recently created by wind-erosion and therefore in an early stage of vegetation development. Indeed, reference to a time sequence of aerial photographs showed that many of the slacks had formed during the exceptionally dry period of the mid-1970s. Twenty years on from the original study, it was decided to resurvey the slacks, using similar methodology, to determine how species richness and composition had changed and to make recommendations for management.

In addition to its Local Nature Reserve status, the study area lies within the Sefton Coast SSSI, a candidate Special Area of Conservation and a Ramsar site.

METHODS

Each of the 26 mapped slacks (Fig. 1) was revisited at least twice in both June and July 2003. Search time was roughly in proportion to the size of the slack but averaged about 30 minutes per slack per visit. The presence of all vascular taxa (species, sub-species and hybrids) was recorded. Care was taken to include only plants associated with the slack floor and not the surrounding areas relatively unaffected by the water-table. An assessment of slack type was made using the water-table criteria of Ranwell (1972), and the need for management was determined. Slack areas were measured using the Sefton Coast Geographic Information System (GIS).

RESULTS

SLACK HABITAT

There was no evidence for changes in slack areas, such as infill by blown sand, between the two study periods. The 26 slacks have a total area of 3·31 ha, a size range of 93 to 9856 m^2,

*e-mail: phil@smith1941.fslife.co.uk

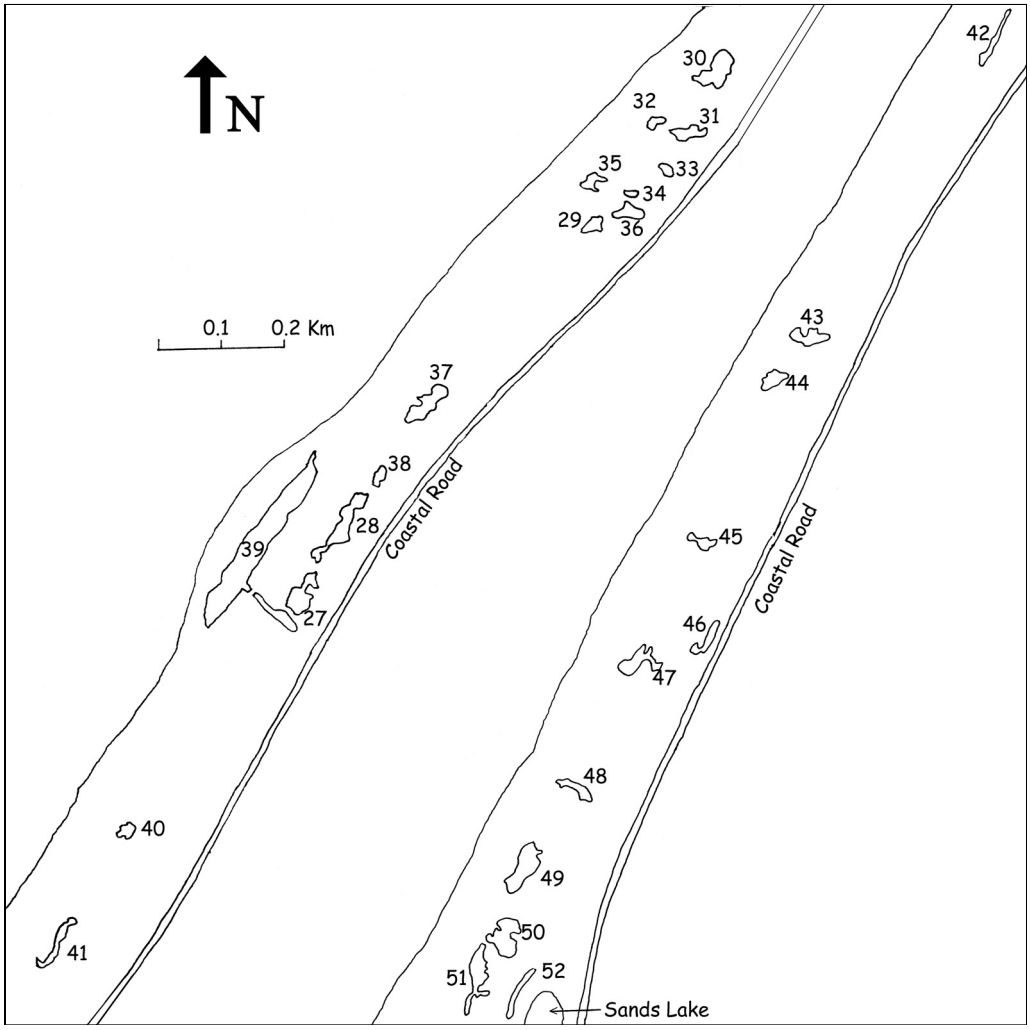

FIGURE 1. Map of Birkdale frontal dune slacks.

and a mean area of 1274 m^2. Only one slack (no. 44; 875 m^2) was considered to be incipient, having a relatively young open vegetation type, compared with 15 slacks in 1983. Using Ranwell's (1972) water-table criteria, 16 slacks were classed as wet-slacks, six as dry-slacks and four as semi-aquatic (Table 1). Twenty-five slacks have a "mature" vegetation type characterised by a near complete plant cover and a high frequency of shrubs, especially *Salix repens*. In addition, eight of the wet-slacks have a semi-aquatic component due either to scrapes having been dug for Natterjack Toad breeding pools since the first study or to the presence of an open drain outfall (slack no. 27).

SPECIES-RICHNESS

A total of 213 vascular taxa was recorded in the 26 slacks, compared with 150 in 1983, a 42% increase in 20 years. Only 22 taxa seen in 1983 were not refound in 2003, representing 15% of the 1983 flora. The range of taxa per slack was 32 to 95 in 2003, as opposed to 4 to 78 in 1983 (Table 1). Mean numbers per slack were 60·3 in 2003 and 41·8 in 1983. This difference is statistically highly significant ($t = 6{\cdot}07$; $p = 0{\cdot}0001$). On average, species-richness has increased by 18·7 taxa per slack.

There is a statistically significantly positive relationship between taxon-number per slack in 1983 and 2003 ($r = 0{\cdot}595$; $p = 0{\cdot}001$) (Fig. 2);

TABLE 1. SLACK AREAS, HABITAT AND SPECIES-RICHNESS

Slack no. (N. to S.)	Area (m^2)	Slack habitat 1983	No. of taxa	Slack habitat 2003	No. of taxa
30	1924	Dry	44	Dry	50
31	694	Wet	52	Mature wet	51
32	393	Wet incipient	18	Dry	32
33	354	Wet incipient	37	Dry	56
34	124	Wet	31	Mature wet	39
35	660	Wet incipient	34	Dry	52
36	105	Dry	41	Dry	56
29	93	Wet	44	Mature wet	34
37	1649	Dry	53	Mature wet	68
38	325	Wet incipient	16	Semi-aquatic	50
28	2001	Wet	51	Mature wet/Semi-aquatic	86
27	2063	Wet	78	Mature wet/Semi-aquatic	95
39	9856	Semi-aquatic incipient	64	Semi-aquatic	93
40	462	Wet	28	Mature wet	56
41	718	Wet	35	Semi-aquatic	59
42	662	Dry	39	Dry	52
43	1021	Wet incipient	30	Mature wet/Semi-aquatic	75
44	875	Wet incipient	4	Wet incipient	44
45	372	Wet incipient	47	Mature wet	84
46	702	Semi-aquatic incipient	46	Semi-aquatic	51
47	1327	Wet incipient	47	Mature wet/Semi-aquatic	74
48	636	Wet incipient	54	Mature wet	59
49	1988	Wet incipient	54	Mature wet	65
50	2523	Wet incipient	54	Mature wet/Semi-aquatic	66
51	1240	Wet incipient	38	Mature wet	56
52	365	Wet incipient	48	Mature wet	70

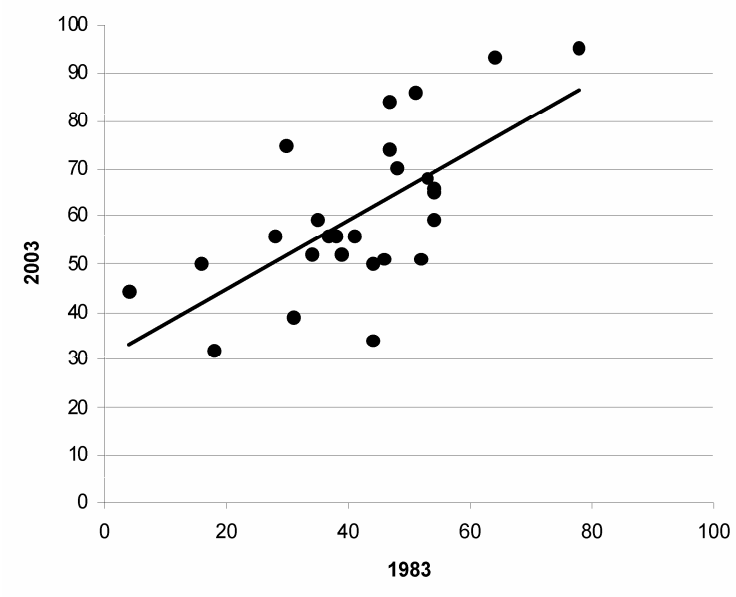

FIGURE 2. Number of taxa per slack, 1983 vs. 2003 (r = 0·595; p = 0·027).

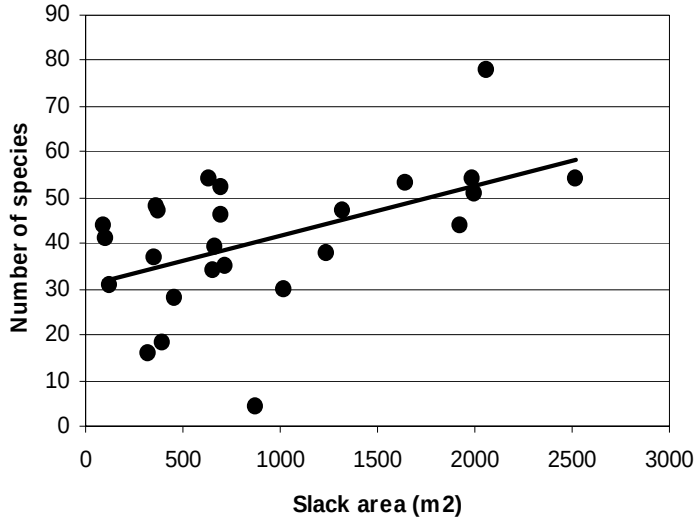

FIGURE 3. The relationship between number of taxa and slack area in 1983 (slack no. 39 excluded) (r = 0·416; p = 0·020).

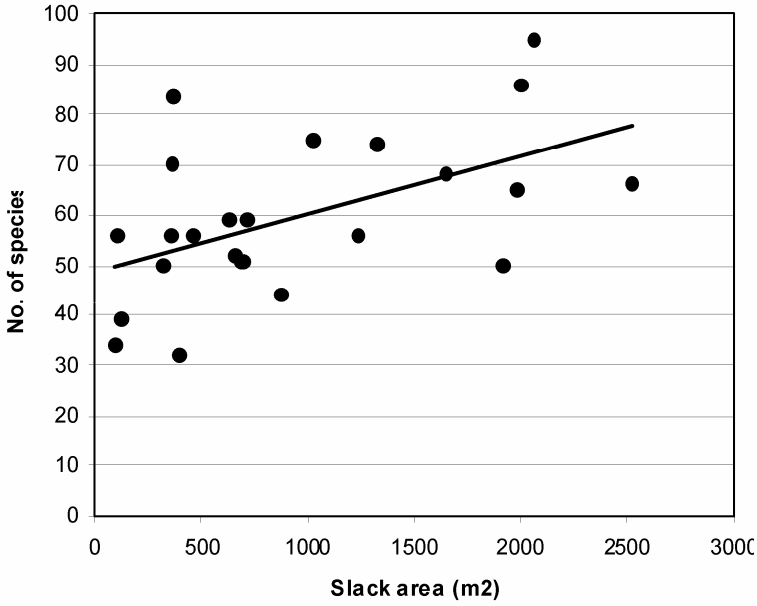

FIGURE 4. The relationship between number of taxa and slack area in 2003 (slack no. 39 excluded) (r = 0·399; p = 0·027).

in other words, the most species-rich slacks in 1983 tended also to be the richest in 2003. Thus, the slack with the highest number of taxa is no. 27 with 78 plants in 1983 and 95 in 2003. Similarly, the incipient slack no. 44 with only four taxa in1983, had 44 by 2003, one of the lowest counts in the second survey (Table 1). However, this relationship may be affected by other factors, such as slack area. It could reasonably be expected that larger slacks would support more taxa. Regression analysis shows that the relationship between species-richness and slack area is positive and significant in both years (1983: r = 0·416; p = 0·020; 2003: r = 0·399; p = 0·027). Clearly though, this relationship is weak (Fig. 3, Fig. 4). The r^2

TABLE 2. NOTABLE VASCULAR TAXA IN THE BIRKDALE SLACKS

	Occurrences per slack		Status		
Taxon	1983	2003	Nationally Rare	Nationally Scarce	Species of Conservation Importance
Anacamptis pyramidalis		3			+
Anagallis tenella		2			+
Apium inundatum		2			+
Baldellia ranunculoides		2			+
Blysmus compressus	2	10			+
Carex disticha	1	2			+
Carex pseudocyperus		1			+
Carex viridula subsp. *viridula*	11	6			+
Catabrosa aquatica		1			+
Centaurium littorale	10	13		+	+
Centaurium pulchellum	3	4			+
Dactylorhiza incarnata subsp. *coccinea*	19	23		+	+
Dactylorhiza purpurella	1	3			+
Epipactis dunensis	1	6	+		+
Epipactis palustris	14	22			+
Epipactis phyllanthes		1		+	+
Equisetum variegatum	9	3		+	+
Hippuris vulgaris		1			+
Juncus ambiguus		1			+
Juncus balticus	6	3		+	+
Juncus maritimus	3	3			+
Myosotis ramosissima		4			+
Oenanthe fistulosa		1			+
Oenanthe lachenalii		1			+
Parnassia palustris	4	9		+	+
Potamogeton gramineus		2			+
Potamogeton pusillus		1			+
Pyrola rotundifolia subsp. *maritima*	4	8		+	+
Salix ×angusensis		7	+		
Salix ×friesiana	11	9	+		
Samolus valerandi	2	9			+
Schoenoplectus pungens		2	+		+
Schoenoplectus tabernaemontani	3	9			+
Trifolium fragiferum	10	7			+
Triglochin palustris	5	6			+
Vulpia fasciculata	1	1		+	+

values reveal that only 17·3% (1983) and 15·9% (2003) of the variability is accounted for by this relationship and that the correlation is even weaker in 2003 than in 1983.

Interestingly, in 2003, only 17 dune-slack taxa (8%) were considered to be non-native, in contrast to about 36% in the Sefton Coast sand-dune system as a whole (Smith 2005a).

NOTABLE TAXA

Using nationally accepted criteria and those of the Regional Biodiversity Steering Group for North West England (1999), a total of 20 notable taxa was recorded in 1983, compared with 36 in 2003, an 80% increase over the 20 years (Table 2). These include 34 Species of Conservation Importance in North West England, eight Nationally Scarce and four Nationally Rare taxa. The latter comprise *Schoenoplectus pungens*, for which Birkdale is now the only known British locality (Smith 2005b), *Epipactis dunensis* and the two willow hybrids *Salix ×angusensis* and *S. ×friesiana*. These hybrids are extremely rare in Britain, the former being endemic (Meikle & Robinson 2000; Stace 1997). The Nationally Scarce

TABLE 3. A COMPARISON OF UBIQUITOUS TAXA IN 1983 AND 2003

Taxon	Frequency 1983	Frequency 2003
Agrostis stolonifera	25	25
Carex flacca	15	23
Carex arenaria	22	23
Cirsium arvense	18	25
Dactylorhiza incarnata	19	23
Festuca rubra	23	26
Hippophae rhamnoides	21	24
Holcus lanatus	22	24
Juncus articulatus	25	17
Juncus bufonius/J. ambiguus	22	5
Leontodon saxatilis	22	23
Mentha aquatica	14	22
Oenothera fallax	9	23
Ononis repens	17	24
Ranunculus repens	7	22
Rubus caesius	7	25
Salix repens	22	26
Salix cinerea	17	24
Senecio jacobaea	22	25
Trifolium repens	18	24

group includes *Juncus balticus*, a northern species whose only sites in England are at Birkdale Sandhills (Smith in press), *Centaurium littorale*, *Dactylorhiza incarnata* subsp. *coccinea*, *Epipactis phyllanthes*, *Equisetum variegatum*, *Parnassia palustris*, *Pyrola rotundifolia* subsp. *maritima* and *Vulpia fasciculata*.

Another taxon worth mentioning here, although not nationally or regionally notable, is *Carex paniculata*. This species seems not to have been reported on the Sefton Coast since before 1963 (Smith 2005a) but a single large plant was found in slack no. 45.

CHANGES IN SPECIES FREQUENCY

Smith (1983) remarked that 12 vascular taxa were identified in more than 20 of the 26 slacks and may be said to characterise the slack vegetation in the study area. This pattern was essentially similar in 2003, except that the qualifying level for a "ubiquitous" taxon was set at presence in 22 out of the 26 slacks (Table 3). In 2003, a total of 18 taxa was considered ubiquitous, five species (*Carex flacca*, *Mentha aquatica*, *Oenothera fallax*, *Ranunculus repens and Rubus caesius*) showing substantial increases in frequency over the twenty-year period (Table 3). Only two plants that were ubiquitous in 1983 have declined markedly, namely *Juncus articulatus* and *J. bufonius*/*J. ambiguus* (the latter two taxa were not separated in 1983). These species are particularly associated with the damp, bare sand of incipient slack floors.

Table 4 shows that 15 vascular plants have undergone major increases (a factor of × 3 or more) since 1983. These include three notable taxa – *Blysmus compressus*, *Epipactis dunensis* and *Samolus valerandi*. Although *B. compressus* has severely declined nationally (Preston *et al.* 2002), its occurrence at Birkdale has increased from two to ten slacks. Colonisation by *E. dunensis* probably reflects maturation of the communities, while *S. valerandi* is often associated with the scrapes. Also interesting is the increase from one to fifteen slack occurrences of *Dactylorhiza praetermissa*, a plant which tends to appear locally when suitable slack habitat reaches an age of around 20 years (personal observations). Increased frequency of *Cirsium vulgare*, *Galium aparine* and *Sonchus arvensis* may reflect substrate disturbance and high soil nitrogen associated with recent removal of *Hippophae rhamnoides* scrub (Rodwell 2000). These three species have a mean Ellenberg value for nitrogen of 6·7 (richly fertile places) (For an explanation of Ellenberg indicator values see Hill *et al.* 2004.).

TABLE 4. TAXA SHOWING MAJOR INCREASES IN FREQUENCY (AT LEAST ×3) SINCE 1983

Taxon	Frequency 1983	Frequency 2003
Blysmus compressus	2	10
Cirsium vulgare	3	15
Dactylorhiza praetermissa	1	12
Epipactis dunensis	1	6
Filipendula ulmaria	1	5
Galium aparine	1	11
Galium palustre	1	15
Oenanthe crocata	2	11
Pastinaca sativa	1	12
Polygala vulgaris	1	8
Ranunculus acris	1	7
Rubus caesius	7	25
Samolus valerandi	2	9
Schoenoplectus tabernaemontani	3	9
Sonchus arvensis	4	16

TABLE 5. TAXA SHOWING MAJOR DECLINES IN FREQUENCY (BY AT LEAST A THIRD) SINCE 1983

Taxon	Frequency 1983	Frequency 2003
Elytrigia repens	5	1
Equisetum variegatum	9	3
Juncus bufonius/J. ambiguus	22	5
Leontodon autumnalis	4	1
Poa annua	14	2
Ranunculus sceleratus	6	2
Salix viminalis	4	1

TABLE 6. CHANGES IN TAXA CONSIDERED TO BE MARITIME

Taxon	Frequency 1983	Frequency 2003
Aster tripolium	1	0
Bolboschoenus maritimus	8	12
Glaux maritima	6	4
Juncus gerardii	8	4
Plantago maritima	2	0
Puccinellia maritima	1	0
Spartina anglica	1	0
Triglochin maritimum	11	4

Seven species show major declines in occurrence (Table 5). Of these, the most notable is *Equisetum variegatum*, which, in 2003, was found in only three slacks compared with nine in 1983. This species seems less common now than formerly throughout the dune system (personal observations) and, having a boreo-arctic montane European distribution (Hill *et al*. 2004), might be being adversely affected by climatic change. The largest rates of decline are shown by *Juncus bufonius*/*J. ambiguus* and *Poa annua*, both associated with open communities. Slacks occupied by *Juncus balticus* fell from six to three (Table 2) but the total area of patches actually increased (Smith in press).

Smith (1983) identified eight maritime or sub-maritime species, more usually associated with salt-marshes, reflecting the proximity of

the slacks to the foreshore (Table 6). They have a mean Ellenberg value for salt tolerance of 4·4 (consistent but low salinity) (Hill *et al.* 2004). Interestingly, four of these species had disappeared from the slacks by 2003, three have declined in frequency and only one (*Bolboschoenus maritimus*) has increased.

CONSERVATION

Smith (1983) made a number of suggestions for the effective conservation of the Birkdale frontal dune-slacks. For example, attention was directed to the problem of unauthorised motor-cycling which was churning some slacks into mud. Fortunately this was subsequently well controlled by the introduction of full-time rangers by the Sefton Coast & Countryside Service, and the affected slack floors have recovered well. Human trampling was also mentioned as a factor, though this was seen as being generally beneficial in helping to maintain open vegetation types which favour several of the rarer plants. This is still the case with many of the slacks having moderately well-used informal footpaths.

The earlier study also noted that, although the invasive introduced shrub *Hippophae rhamnoides* was well-established, there were relatively few large clumps and the many young bushes, seedlings and suckers could easily be removed. However, it was the mid-1990s before the site managers could secure funds to tackle this problem and by then, *H. rhamnoides* had spread considerably and was threatening the biodiversity of many slacks. In consequence, this is almost certainly the reason why *Juncus balticus* was lost from four northern slacks (Smith in press). Since about 1996, *H. rhamnoides* has been systematically removed by cutting and follow-up spraying of regrowth using an approved herbicide, several slacks being cleared annually. The southern slacks, which were treated first, have recovered satisfactorily but the two cleared in the winter of 2002/03 (slack nos. 31 and 33) retained only small areas of slack vegetation, being characterised by expanses of bare ground and ruderal, nitrophilous plants, such as *Cirsium*, *Epilobium* and *Sonchus* spp. and also *Urtica dioica*. It will be interesting to follow their recovery.

In addition to *H. rhamnoides*, some slacks have been partly colonised by *Betula pubescens* and *Salix cinerea* subsp. *oleifolia*. Because of the presence of rare *Salix* hybrids, willow control needs to be approached with care but can probably still be justified. Thus, Smith (2005b) noted that *S. cinerea* bushes were restricting the growth of *Schoenoplectus pungens* in two slacks. Although rabbit-grazing is prevalent, especially in the northern slacks, scrub control will need to be ongoing, although not with the same intensity as in the recent past.

Since about 1996, two slacks (nos. 48 and 49) have been mowed almost annually. While this does not seem to have added significantly to their species-richness (Table 1), it has certainly prevented scrub invasion.

The first study recommended the excavation of two scrapes for Natterjack Toads in slack nos. 38 and 40. In the event, 12 scrapes were dug in eight slacks since 1983 and these have contributed considerably to the number of vascular plants in the affected slacks. At least six notable taxa (*Anagallis tenella, Apium inundatum, Baldellia ranunculoides, Carex pseudocyperus, Oenanthe fistulosa* and *Schoenoplectus pungens* are uniquely associated with the scrapes in the study area, the latter having been translocated here during a conservation exercise (Smith 2005b).

DISCUSSION

Smith (1983) considered that the Birkdale frontal dunes had a higher botanical interest than had been previously thought, this being partly due to the rich dune-slack plant communities. The current study shows that this interest has continued to grow during the past 20 years with a 42% gain in species-richness, an average of 18·7 more taxa per slack being recorded. Also encouraging is the 80% increase in nationally and regionally notable plants since the first survey.

A number of factors seems to be responsible for these changes. First, most of the slacks have undergone succession from an incipient to a mature phase, involving colonisation by additional vascular taxa. Relatively few species have declined during this process, those that have being typical either of an early successional stage or of maritime conditions. Their loss has, incidentally, been offset by the development of the adjacent Birkdale Green Beach, a 44 ha strip of salt-marsh, embryo dunes and dune slacks which has formed on the foreshore since 1986 and supported 217 vascular taxa in 2003 (Smith 2003). These include many maritime species and also *Juncus balticus*, 12 small patches of which were recorded in 2004 (Smith in press).

Secondly, the habitat in eight slacks has been diversified by the excavation of scrapes,

initially as breeding sites for Natterjack Toads, but providing ideal conditions for a wide variety of semi-aquatic and aquatic plants. The drain outfall from slack no. 27, though present in 1983, has been colonised by several more aquatic taxa, including the pondweeds *Potamogeton crispus, P. natans* and *P. pusillus* which are not represented elsewhere in the slack sequence.

Finally, control of *H. rhamnoides*, initiated in the mid-1990s, has reversed the trend towards the domination of slacks by scrub and has encouraged a greater diversity of low-growing, less competitive plants, including many dune-slack specialists.

The overall effect of vegetation changes, resulting in part from conservation measures, has been to produce a series of slacks which, despite their relatively small size, are as species-rich as any in the internationally important Sefton Coast sand-dune system, itself particularly well-endowed with humid dune-slacks (Smith 1999), a priority Annex 1 habitat type in the EU Habitats Directive.

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